NOFOMA 2016 - PROCEEDINGS OF THE 28TH ANNUAL NORDIC LOGISTICS RESEARCH NETWORK CONFERENCE

8-10 JUNE 2016, TURKU, FINLAND

Lauri Ojala, Juuso Töyli, Tomi Solakivi, Harri Lorentz, Sini Laari and Ninni Lehtinen (Editors)

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Dear friend of NOFOMA!

These Proceedings comprise the Full Papers and the Extended Abstracts of Work-in-Progress (WIP) of NOFOMA 2016, organized by Turku School of Economics (TSE) at the University of Turku.

During the almost three decades since the first gathering in Oslo, we have witnessed the development of the NOFOMA community and its members to reach a World Class level in logistics and SCM research and teaching that we now have in the Nordic countries.

As in NOFOMA 2012, which was also organized by us, we decided to call the Conference just by its name and ordinal number. This also reflects the wide variety of topics covered and methods applied in the 40 Full Papers and almost 30 WIP’s contained in the Conference Proceedings.

This NOFOMA 2016 also demonstrates the wide geographic and institutional coverage that NOFOMA Conferences now have. In addition to all five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) we have participants also from Austria, Belgium, Czech Republic, Estonia, France, Germany, Lithuania, Namibia, The Netherlands, Poland, South Africa, Switzerland and UK.

The participants come from about 45 different Universities or research institutions and represent about 30 nationalities, which makes this a truly international gathering.

Our keynote on Thursday by Mr. Jarno Soinila, Head of Design & Engineering at Meyer Turku Shipyard, deals with the formidable supply chain challenges of constructing some of the largest passenger cruise vessels in the World. These are no ordinary ships: one such vessel can have a sales price of USD 1,000 million or more. The elaborate orchestration that is needed to finalise such delivery projects under tight production schedules and with several hundred suppliers requires very sophisticated supply chain management skills and procedures.

On behalf of the Scientific Committee and the entire Organising Team, we would like to thank the numerous voluntary reviewers for their time and energy to make also this year’s NOFOMA possible. Overall, we can again see that the quality of the papers is high, and that there were many very promising submissions in the WIP category, too.

This gives us a very good starting point to follow the over decade long tradition, where the top papers will also appear in a Special Issue of International Journal of Logistics Management and Physical Distribution (IJPDLM) published by Emerald. Our gratitude goes also to the Editorial

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1 We are grateful for this wide coverage, and we have acknowledged it by disclosing a special educational surprise during the Conference Dinner on Thursday evening on June 9 that will be made available for each participating organization on Friday, June 10, 2016.
Board of IJPDLM and in particular to its Editor, Professor Alexander E. Ellinger Professor, who has provided his strong support to NOFOMA and its Special Issue, and to Professor Jan Holmström from Aalto University who has been assigned as the point of contact for the SI representing the journal’s Editorial Board.

As for Conference practicalities, we have placed the NOFOMA Community Meeting before lunch on Day 2 in order to maximize the participation. This should enable us to discuss matters of common interest in the best possible way.

Finally, we are indebted to our sponsors – in particular the Foundation of Economic Education in Finland (Liikesivistysrahasto) – for making this event possible. The co-operation with DB Schenker in the form of sponsoring the best paper awards is continuing, which is duly acknowledged. The EU-part-funded project HAZARD under the Baltic Sea Programme 2014-2020 has helped us to facilitate the dissemination of Conference Proceedings.

On behalf of the Conference organisers, enjoy the 28th NOFOMA in Turku!

Professor Lauri Ojala          Professor Juuso Töyli          Dr. Tomi Solakivi
Conference Chair               Chair of Scientific Committee   Head of Organising Team

and the entire Turku team of our Operations & Supply Chain Management unit:
Prof. Harri Lorentz, PhD Students Vesa Kilpi, Sini Laari and Tuomas Kiiski & Ms. Ninni Lehtinen
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PART I

CONFERENCE FULL PAPERS
MARKET VERSUS SUPPLY CHAIN VS. SUPPLY CHAIN COMPETITION: 
A SYSTEMS APPROACH TO RECONCILING THE PERSPECTIVES FOR BUSINESS

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ABSTRACT

Purpose
The purpose of this paper is to propose an integrative account of market (economic) competition and supply chain vs. supply chain competition in order to discover how both perspectives of competition might fit together within the broader encompassing notion of business competition.

Design/methodology/approach
The paper explores the potential points of alignment between the two competition perspectives from their development through to their current standings. Literatures on the evolving supply chain vs. supply chain competition as well as market competition are thus explored.

Findings
Results show that the two perspectives of competition are more similar than expected and as such market competition and supply chain vs. supply chain competition may not be described as mutually exclusive alternatives to the concept of competition.

Research limitations/implications
The suggestions in this paper have implications for the discussion on how to deal with the competition interfaces (borders) that may be present in carrying out business as usual.

Original/value
The paper presents as one of the first studies of an integration of market competition and supply chain vs. supply chain competition, and thereby contributes to furthering our understanding of competition between supply chains and the different competition regimes that may exist within the business environment. This prospect is yet to be pointed out in literature.

Keywords: Supply chain vs. supply chain, SC vs. SC, competition, systems, market competition
1. INTRODUCTION

In analyzing competition for today’s business environment, two broad perspectives may be considered. The first is the idea that views competition as the exclusive analysis of the market, with a view to determining how entities that reach and are active in the market interact with each other and with the customer. It is mainly concerned with how the results of production activities are brought into harmony with the demand for goods and services by means of an organizing mechanism such as a free market, and how dissimilarities and inadequacies of such a mechanism may impact the ultimate customer. This would constitute the first perspective and intuitively follows the economic principles of competition referred to here as market-based or perfect competition. A second perspective of competition analysis for today’s business environment is the idea of SC vs. SC competition. It is the exclusive analysis of all tactics, strategy, decisions and policies undertaken by managers and operators of supply chains to deliver best value goods and services to the ultimate customer. It is mainly concerned with the efficient integration of critical resources for the creation, retention and delivery of value for the supply chain as well as the ultimate end customer. This view of competition is referred to as SC vs. SC competition and takes place outside the traditional known locations of competition, i.e. the market. While several studies have investigated these respective competition perspectives, prospects of an integrative account between these two viewpoints are yet to be pointed out in literature.

The purpose of this paper is to propose a unifying justification of market competition and SC vs. SC competition in order to discover how both perspectives of competition might fit together within a larger framework. In other words, the paper asks how the relationship between market competition and SC vs. SC competition may be conceptualized. This relationship is important because these two perspectives - classic economic competition, by which market competition operates, and SC vs. SC competition, remain respectively; the most dominant and the fastest growing form of competition within general management literature (e.g. see Kinra and Antai, 2010). This paper is conceptual and based on literature review on systems and systems thinking in the conceptualization of the relationship between traditional market competition and SC vs. SC competition. The paper takes the view that within the broader market environment within which market competition occurs, SC vs. SC competition registers as an input. Without the occurrence of the interactions and processes that take place along the supply chain, market competition mechanism are unable to make best value offerings. And as such, the relationship between SC vs. SC competition and market competition is analyzed from a systems theory perspective in order to develop an integrative framework of the two competition perspectives.

A common critic against systems thinking is that it is superficial and excessively general and as such meaningless (e.g. Bertalanffy, 1968; Gammelgaard, 2004). However, taking this view, per se, would imply that all models with which we use to represent reality in various ways and forms are vague and not allencompassing, as the very object of the systems and its approaches is representation; “..i.e. they are models, of systems rather than the systems themselves” (Takahashi and Takahara, 1995). Because reality is so complex that in most cases it cannot be directly analyzed to obtain relevant information with which that same system may be improved, the role of systems theory is necessary and sometimes essential to the way with which we recognize and abstract essential aspects of reality. Therefore models are used to form a representation of reality. While it is not always clear to some that systems thinking is not a contradiction to the analytical approach (i.e. the process of breaking down the whole into smaller parts to better understand the function of the whole), it is actually a method that complements the analytical approach, as it would be specious to expect to understand the whole without knowing the individual parts. The business environment can be generally looked at,
from a system perspective, as a system of subsystems; interdependent and interconnected, forming a holistic system; that is made up of infrastructure that is similar across systems, regardless of physical form. This is true of the relationship between market competition and SC vs. SC competition, as we would normally tend to look at the supply chain as a single extended enterprise, running raw materials sourcing to the ultimate end customer. The following section briefly reviews the characteristics of the perspectives, which provides a basis for the paper. Section 3 discusses systems and systems thinking as a way of structuring the conceptual process of analyzing the competition perspectives discussed here. Section 4 proposes an integration account of the two competition perspectives via a systems theory approach. Finally, and a discussion and conclusion piece is presented within section 5.

2. CHARACTERISTICS OF COMPETITION PERSPECTIVES

2.1. Competition and markets

In discussing such issues as competition and markets, a first port of call is to deal with the complex issue of defining markets, as it constitutes the crude first steps to an analysis (Carlton, 2007). In ordinary discourse, a market is any arrangement, including a location, at which a collection of individuals assemble for the purpose of buying and selling goods and services either for money, barter or some other method of exchange. It is not an institution that exists as a state of nature, but rather one that has to be created through a process of social change and public regulation. However, for competition purposes, market definition has long been an area of much controversy (Massey, 2000). The definition used to depict the market is critical to our understanding of how competition is viewed, especially recently in light of the operation of supply chains. Because organizations are increasingly dependent on the flow of information on customer demands, preferences and market trends, the definition of a market in terms of its geography, mode of interaction, market behavior and regulatory responses to market activity can have several implications for the idea of competition, in light of supply chains.

An appropriately defined market outlines the scope of competition by differentiating the active competitive forces from the passive elements within the process, after market share has been established (Werden, 2013). According to Stigler and Sherwin (1985) the market is the area within which price is determined. It is that group of buyers and sellers whose trading activity establishes the price of a good or service. Markets are essential to the effective and successful operations of supply chains because markets serve as the outlet for most of the activities that are carried out within the supply chain, thus, markets create data that are necessary for determining how and what goes on in the supply chain.

A second port of call in the discussion of markets and competition is dealing with the issue of value. Value forms the basis of market competition, whether bundled in product offerings or in services offered and rendered. A significant body of experimental evidence has accrued to demonstrate how competition and value creation combine to define firm performance (e.g. Brandenburger and Stuart, 1996, 2007; MacDonald and Ryall, 2004; Lippman and Rumelt, 2003). The idea was first proposed by Brandenburger (1996) by suggesting that added value can be used to measure the ability of a firm to capture value (Chaitan, 2010). Subsequent research has not strayed too far from this context. Treacy and Wiersema (1993) define a value proposition as the implicit promise an organization makes to its customers to deliver a particular combination of standards or qualities. The delivery of such qualities or standards may require one of two modes for its creation, i.e. competition-free value or competition-based value. Competition-free value is value created in which there is no conscious head-to-head
competition between competitors to fulfil the value proposition. By simply carrying out routine production, logistics and marketing activities value can be said to be created for the end-user. On the other hand, competition-based value is one in which value is created as a result of a head-to-head competition for critical resources applied in the value creation process, and which is then passed on to the end-user. As such, value and value creation are important in dealing with markets with respect to gaining an edge in competition (Mentzer, 2004). Prior to considering an integrative description, it is apt to underline the characteristics upon which perspectives are considered for integration (Table 2.1). This is important to establish the idea that the two perspectives, while very different, perform functions to reach similar end goals.

- **Market size**: generically related to the definition of the market, and according to Stigler and Sherwin (1985) size of market is the area within which price of a service or product is determined, allowing for transportation cost. It affects the toughness of competition which then affects how partners, suppliers, customers are selected (Melitz and Ottaviano, 2008).
- **Nature of competition**: nature of competition can be said to be the way competition is carried on in a given setting. The manner, way, method of doing or experiencing something. On the one hand, some aspects of market competition can be dynamic while other aspects could be static on the other hand, as ruling laws and regulations tend to embrace both mechanisms. This is very much dependent on trends and possible paradigm shifts in the mode of product offerings to end-users.
- **Number of competitors**: the concentration of suppliers offering the same or similar products or services within a specifically defined market area. The higher the concentration of suppliers in the market, the shorter it takes for new innovation to reach the customers (Loury, 1979).
- **Intensity of competition**: refers to the degree to which entities within an industry compel and limit each other’s ability to make profit (e.g. see Porter, 1998). The intensity of competition faced by suppliers in a market depends on a number of factors, but most importantly product substitutability, increased market size, or higher entry costs (Karuna, 2007). Also innovation, marketing and government policies and regulations.

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<tr>
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<th>SC vs. RC Competition</th>
<th>Market competition</th>
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<tr>
<td>Size</td>
<td>Based on the horizontal and vertical structure of supply chain</td>
<td>Based on the definition of the market</td>
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<td>Nature of competition</td>
<td>Dynamic</td>
<td>Dynamic/static</td>
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<tr>
<td>Number of competitors</td>
<td>Higher probability of competition; bottleneck at points for critical resources</td>
<td>Positive impact for time to innovation</td>
</tr>
<tr>
<td>Intensity of competition</td>
<td>Allows for diversification</td>
<td>Substitutability, market size, entry cost, etc.</td>
</tr>
<tr>
<td>Regulatory/environmental factors</td>
<td>Mostly sustainability and environmental issues</td>
<td>Generally anti-trust regulations</td>
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• **Regulatory and environmental factors**: Because the nature of competition is to tend towards domination of the market, from an economics perspective, the main areas of concern for competition and anti-trust policies are cartels, restrictive practices, monopoly and mergers (Doern and Wilks, 1996). Also, issues revolving around forced labour, opportunism, etc. in the supply chain.

### 2.2. Competition and supply chains

SC vs. SC competition is the form of competition that takes place between supply chains and one that focuses on the struggle for critical resources, at certain critical points, that allow supply chains carry on its value creation activities for the purpose of satisfying the ultimate customer (Antai, 2011). The mostly theoretically-based background of this concept within supply chain literature has meant that little practitioner-based support for sundry conceptualizations have been undertaken. Thus, there is still a dearth of shared clarity as to what SC vs. SC competition really is to different people and disciplines, within supply chain management discipline, as well as to other disciplines that might have something to gain or lose by supply chain management.

This form of competition takes place between supply chains, and are said to be only as a direct consequence of the need for supply chains to satisfy the market (Antai, 2011). As a result, all actions and strategies occurring within supply chains are directed towards market fulfillment. This SC vs. SC competition perspective is based on the ecological niche theory of competition which stresses the commonality of shared resources as the basis for competition between supply chains. An ecological niche is the \( n \)-dimensional space that describes the characteristics of resources a species needs for survival (Hutchison (1957). Central to ecology and the competition that ensues between species, it also demonstrates an account of available scarce resources within the environment for which species may compete for (Milne and Mason, 1990). When the need for resources necessary for continued existence between species overlap, this represents the idea of ecological niche competition which can then be used to better understand how competition takes place within the concept of SC vs. SC competition. For example, overlaps in the utilization of limiting resources at such points as logistics centers, specialized service centers, strategic OEMs, etc, create a potential for competitive interaction (Figure 2.1).

![Figure 2.1 Schematic of SC vs. SC competition.](image)

From this standpoint, SC vs. SC competition conspicuously revolves around the struggle for scarce, critical resources along and within the environment a given supply chain operates.
Therefore, it is reasonable to suggest that the broader the niche of a given supply chain, the larger the amount of resources it needs to survive, and vice versa. Hence, an implication of this is obviously the idea that the scarcer a critical resource is to interacting supply chains, the fiercer the competition between those supply chains that depend on such resources for their survival. The next section introduces and discusses the concept of SC vs. SC competition, its theoretical bases and characteristics.

3. SYTEMS AND COMPETITION

3.1. Systems perspective in a relationship context

A commonly used definition is given as “a set of objects together with relationships between the objects and between their attributes related to each other and to their environment so as to form a whole” (e.g. See Hall and Fagen, 1968; Optner, 1965). Some of the key concepts of this definition are briefly introduced. A set is known to refer to any well-defined collection of objects. This is necessary in order to determine what or who the members of a given system are. Objects are simply elements of a system, i.e. the parts of which the system consists. Functionally, object could be seen as the basic functions of the system, and made of three types; input, processes and output (Schoderbek et al., 1985), where the conceptualization of SC vs. SC competition acts as input in the system (Figure 3.1). Relationships here refer to the bonds that tie the system objects together, while attribute are essentially the characteristics (properties) of the system objects and the system relationships. Finally, environment refers to all that lie outside the system as well as those entities that can affect the performance of the system (Schoderbek et al., 1985).

![Figure 3.1 Conceptual framework](image)

Systems could be closed or open; concrete, abstract or conceptual (Miller, 1978). Open systems take inputs from its environments, transforms them and returns the product of such transformation (output) back to the environment (Jackson, 2003). As such, they are characterized by a dependency on the environment, self-regulating, and organized by the flow and use of information (Skyttner, 1996). According to Bailey (1994) the plethora of systems can be differentiated by identifying the basic concepts underlying the main types of systems, e.g. basic unit of analyses. Concrete systems are non-random systems that use objects as its
basic units of analysis. Conceptual systems on the other hand are systems whose basic units of analysis are words or symbols (Miller (1978). Abstracted systems are somewhat different in the sense that it applies relationships as the basic unit of analysis. For sociological analysis influenced by systems theory, Bailey (1983) refers to the society as social systems, while Buckley (1967) defines social systems in terms of mechanical, organic, and process models. However, social systems are inherently systems of communication; acting in such a way as to simultaneously regulate the character of the communication itself, as well as the character of the system (Luhmann, 2013). On the basis of boundaries, hard systems and soft systems are recognized. Soft systems have fuzzy boundaries, are unstructured with such focused behavior that it is capable of setting its own objectives (Siriram, 2012).

Systems may be classified under three different categories of understanding of its internal working process; a black box of which the internal working processes that generate output are unknown; a grey box in which only partial knowledge of internal workings are known and a white box in which a full working knowledge of the internal working processes are known (Skyttner, 2001). The description of market competition for the purpose of this paper is of a grey box type of which only partial knowledge of the internal workings of the system is fully known and understood, while a white box system is used to describe SC vs. SC competition. A compelling reason to think along these lines lies in the internal workings of the pricing mechanism within the market structure. For example, while we generally know how the market processes of supply and demand interact to estimate the sensitivity of competition or the lack thereof, within the market; the price at which the market clears, is generally a signal of best value for customers. However, how this is determined or occurs within the context of market competition would be regarded as a grey area, an area of undefined certainty or indeterminacy between the familiar worlds of demand and supply. This underlies the argument that full knowledge of this implicit mechanism remains a grey area and may thus be classified as a grey box system.

3.1.1. Input

Refers to materials or information that enters or leaves a system over a period of time. They are the foundation material base that enables the system carry on with its operating necessities. And as such, they are variable parameters that affect the behavior of the system (Skyttner, 2001). Input can vary from information to raw materials (manufacturing process) to energy to tasks performed by people (e.g. services, etc.). According to Schoderbek et al. (1985), input can be classified into three different categories based on how the input enters the system; Serial input, probable input and feedback input. A serial input is one which occurs usually as the result of a previous system to which a focal system (present system) is directly related. This requires the identification of the various sub-systems, that might be present, whose output become input to other sub-systems. Probable inputs represent a situation where there are multiple potential inputs to a system, however one in which the focal system decides which of the available potential inputs will be used as the input. Also conceptually based on the idea of multiple sub-systems, the different outputs from a number of sub-systems have different probabilities of being chosen as input, where the probability is determined by the degree of correspondence between the input requirements of the focal system and the attributes of the available inputs (Schoderbek et al., 1985).
Finally, feedback input depicts a reintroduction of the output of a system as an input to the same system. It is very much different from the system feedback, as this has to do with input only and not of the whole system.

3.1.2. Output

Refrs to the result of the operation of the process within a system. Output may take different forms, e.g. information, document, knowledge, material, service, product, etc. Output represents the purpose for which a system exists (Schoderbek et al., 1985). Transformation process within systems can lead to a variety of output. As in the case of input, Schoderbek et al., (1985) categorize output into three classes. The first category of output is described as those output that are directly consumed by another system (as input). A second category of output is described as the portion of output consumed by the same system, usually in the next production cycle. The third category is that of outputs whose portion of the total output is neither consumed by other systems or the focal system itself but is disposed of as waste. But we also know that, based on the idea of boundaries for and by systems, systems are inherently connected, in some form or another, and even co-produce each other as insinuated by Yourdon (1989)’s principle #3. While a system may be linked or interact with a large number of other systems, the essential relationships or linkages are those that create output/input which perform input functions that enable the receiving systems carry on its own function of creating output. As such, when a
number of systems are linked to each other, output becomes even more important. When systems have such an affiliation, the relationship may be described as one of the following: symbiotic, synergistic or redundant (e.g. Doxanakis and Kefalas, 2008). In symbiotic relationships, systems cannot function alone without a contributing system. These could be unipolar or bipolar (situation in which relationship benefits go in either one or two directions). Synergistic relationships are those relationships of systems (sub-) whose combined action produces a total output greater than the sum of their independent outputs (see also Schoderbek et al., 1985). Redundant relationships of systems are relationships that replicate other relationships and are used mostly for securing reliability of systems operations.

### 3.1.3. Feedback

Often defined as the “transformation of signal from a later to an earlier stage” feedback is a strategy which allows a system compensate for unexpected disturbances (Figure 3.4), through feedback loops (Skyttnner, 2001). This means that by comparing an output with specifications of a desired output, errors can be detected; which can then be used to influence variables in the process in order to reduce errors in the output as much as possible (Wilson, 1984). As such, control in a dynamic system is achieved by feedback.

![Figure 3.4 Feedback input](image)

Thus, the idea of feedback to systems thinking is crucial and one which allows a proper explanation to be given of deviations to intended behaviour directed at the attainment of certain behavior, result or goal (Jackson, 2003).

### 3.1.4. Boundary/interface

Systems members are from a holistic view point, not meaningfully connected with each other except with reference to the whole (Emery, 1969). And as such, there is no single legitimate boundary around a system. However, that is not to say that boundaries are not important to systems. Drawing the boundaries around a system depends to a large extent on the purpose for which a system is being created or developed (Meadows, 2008). Boundaries are invented within systems to maintain a sense of clarity and sanity, even though they could be sources of problems in the failure to realize that these boundaries have been artificially created (Meadows, 2008).
3.1.5. Environment

This is the set of all objects in which a change in its attributes affects the system and also those objects whose attributes are changed by the behavior of the system (Hall and Fagen, 1956). It constitutes all that is outside the system (Schoderbek et al., 1985) and is important to consider since it can influence the system’s performance (Churchman, 1968). Connected to the idea of boundaries within systems, and the idea that “everything is connected to everything”, a system, together with its environment, constitute the universe of all things of interest within a given context. Based on the main elements of a system reviewed in preceding sections, the following section locates the competition perspectives within the systems view with a bid to developing an account of SC vs. SC competition not just as systems, but also as one whose link serves as valuable input into market competition systems.

4. RELATIONSHIP BETWEEN COMPETITION PERSPECTIVES

In order to establish how the two modes of competition come to be linked, it is necessary to understand a few basic, often overlooked, premise upon which systems thinking is built (Yourdon, 1989). First, the more complex a system, the less adaptable it will be to a changing environment. The supply chain is a very complex system, to say the least, however contrary to this first rule, supply chains have shown to be quite adaptable to a variety of academic and operational environments judging from its ability to remain holistic in the face of intense proliferation within a variety of disciplines. Second, the larger the system, the more resources is required to support that system. Third, systems often contain other systems, or are themselves components of other systems. And lastly, systems grow over time, both in size and structural complexity. These principles have been shown to be applicable to supply chains (e.g. see Helou and Caddy, 2006).

The concept of complexity has been highlighted and treated within supply chain management and logistics literature via complex adaptive systems (e.g. Choi et al., 2001; Surana et al., 2005; Ellram et al., 2007; Wysick et al., 2008). Complex adaptive systems are defined as “collections of many different components (agents) interacting in nonlinear ways in the absence of any external supervisory influence” (Sturmberg, et al., 2014). Within systems thinking, two approaches to viewing complexity can be useful. The first perspective is one that views complexity as being anything we do not understand, due mostly to the large number of interacting entities or elements (Roe, 1998). An alternative approach argues that complexity comes about as a result of a small number of controlling processes, rather than a very large number of interacting elements or processes (Holling, 2000; Gunderson and Holling, 2001). Here, complexity is of a self-regulating nature, where processes create and maintain the self-organization of systems.

Two prominent characteristics of the supply chain operations can be described as: (1) the organization and development of work to be carried out, including the identification of a variety of specialist trades/skills areas; and (2) the process of determining whether or not to subcontract or outsource portions of the fulfilment process work to identified specialists. Eccles (1981) argues that these two characteristics are somewhat interrelated in the sense that the level of specialization of an industry tends to be an important determinant of outsourcing (also Munch and Skaksen, 2009). As such, specialization is inherently important to the maintenance of relationship between the competition perspectives. One obvious outcome of the specialization trend within global business practices and supply chain environments is a realization, among major and smaller business players alike, that they have to collaborate in order to survive. In
extremely competitive markets, manufacturers, producers, service providers, etc. and their suppliers are essentially locked into a relationship of mutual dependence.

Holling (2001) argues that if we are able to understand the hierarchical structure of cycles within systems and the time scales over which they are transformed, it would be possible to evaluate the contribution of these cycles to the system, which can help to identify points at which systems are judged as being capable and the points where they are seen as vulnerable. By hierarchies is meant the different levels of interactions formed among sets of variables within the system that share similar speeds where each level interacts by communicating a small set of information or material to the next higher slower, coarser level (Simon, 1974). Soft systems are thus essentially interlinked in endless transformational cycles of growth, accumulation, reorganization, and regeneration, with each transformation occurring over totally different time scales (e.g. from seconds to centuries) and at different hierarchical levels (range of interaction speeds). Through the identification of these capability and vulnerability points, it becomes possible to use those leverage points to develop flexibility and continuity within a system.

4.1. Modes of alignment: integrative account

The preceding ephemeral overview of complexity in systems provides a starting point from which to understand the intricate relationship between SC vs. SC competition and market competition systems. One way of determining a complementary link between the competition systems under discussion here is to first establish how they may be related, and then understand how such relationship becomes integrative. First, regarding association between the two competition systems, the output relationship between the competition systems here is identified to be symbiotic and also bipolar in nature. With regards to the characteristics of the deliverables of the systems, SC vs. SC system exhibits tangible and physical deliverables such as goods and products, as well as non-tangible deliverables such as services. On the other hand, market system deliverables are psychological (value, satisfaction, etc.). The SC vs. SC competition system focuses on the cost and quality of processes and material that are used to generate the output from this system, while considering the input, via feedback from the market, into the system. On the other hand, the market competition system focuses on placing a value on products that have been produced, taking into consideration the processes and material employed via the supply chain and the competition therein.

With regards to input, this is the area where the relationship between the two competition perspectives is most pertinent. The input-output relationship could be serial, probable or feedback, depending on the hierarchy and scale of the receiving system.

In arguing for an alignment, the unit of analysis thus becomes the input–output relationship between the systems. By so doing, this unit essentially becomes abstract. Also, because these systems take place and function within the society and social space, it could well be described as social systems. Complexity varies between the two systems. While it is straightforward to understand the internal workings of SC vs. SC competition creating products that serve as input into the market competition system, it is not quite clear as to how output is reached within the market competition system. Thus, market competition remains a grey box system, while SC vs. SC competition would represent a white box system. Complexity in the SC vs. SC system is defined according to Roe (1998) as the difficulty in understanding, due to the large number of interacting entities or elements. It is argued here that in addition to these large number of interacting processes that, complexity within the supply chain competition system is also generated to a large extent by the uncertainty surrounding its myriad of customers, the environment within which it operates, as well as its relationships. Within the supply chain vs
supply chain system, it is the competition that takes place within it that is seen as the primary force that drives systems to efficiency and stability (e.g. Rothschild, 1990).

Both competition systems are regarded as complex adaptive systems, because the behavior of such a system cannot be explained by the behavior of individual elements in the system, i.e. reductionism. Complex adaptive systems are rather known to exhibit emergent behavior. As reviewed previously, a central tenet of systems thinking is the recognition that our understanding of the world is bound by our experiences, and one in which a systems’ performance is believed to be a product of the interaction between all its parts, as opposed to the sum of the performance of its individual parts. In most of the work adopting this thinking, interaction between systems have been understood to be critically important to the formation of a holistic view of the reality of problems. Having understood that, it is easy to appreciate that the essential mode of alignment between the two competition perspectives lies in the output-input relationship between them. Here, such interaction between the competition perspectives support this operating principle through having the output mechanism of one system interact with the input mechanism of another, receiving system, so that the occurrence of interaction between the systems results as an experience signal. More precisely, under this arrangement, systems are expected to be able to regulate themselves or self-organize, directing behavior in both systems via feedback.

4.2. The Value-Price relationship

Interaction between the competition perspectives is further conceptualized in two ways: i.e. the dual mechanisms that seek to reward or penalize the transfer of time (assessed in monetary terms), in the creation of value from the SC vs. SC competition system to the market competition systems. Value thus becomes the main component that ties supply chain vs supply chain and market competitions in a sort of input-output relationship. For example, the more complex the processes that supply chain competition vs supply chain systems needs to undertake in order to create value that fulfils market competition requirements (i.e. in terms of manufacturing processes, relationships, integration, collaboration, environment, etc.), the higher the marginal increase on the value of the output. Similarly, it is proposed that the higher the component of services (e.g. logistics and logistical value added services) involved in the system that acts as an input into the market competition system, the higher the marginal price of such a product will be.
In a way, the ability of the supply chain to differentiate between the two types of competition for value creation (competition based vs. competition free value) it undertakes underpins the relationship between the supply chain and the market, the competition that takes place within and how one might act as an input into the other. Therefore, the output from supply chain vs supply chain competition is essentially value. Given the nature of the receiving system, it is the task of market competition systems to convert this input into a price, which then becomes the output for the market competition system (Figure 4.1). Third, depending on the level of understanding and trust in the relationship between the supply chain competition system and the market competition system, market competition signals often determine how supply chain competition system will choose and work with partners. As long as the information of how the price is going to be determined in the market and what the best perceived value of customers will be at the point of input into the market competition systems is unknown, the system remains a grey system.

### 5. DISCUSSION, IMPLICATION AND CONCLUSION

Given the above descriptions of the different competition views, there is an instinctive temptation to view these competition perspectives as mutually exclusive alternatives that are in direct contradiction to each other. However, such a view would not only be hasty but also a mistake for at least two reasons. First, theoretically, it is important to recognize that economic competition, while dominant in many respects, was never advanced as an exhaustive account of the concept of competition; at least not in its original framing.

This is so because the theory of market competition is believed to be an “open-ended theory” that leaves room for the prospect of a new range of problems (Stigler, 1957). As is widely stated in literature, the idea that SC vs. SC competition responds to the market demand via its activities is here viewed as part of a more general support function it performs to the competition process that goes on in the market. Thus, even in its original formulation, SC vs. SC competition, are suited to explore similarities between entities, emphasize on specialization and demonstrate flexibility towards dimensionality. Further evidence of the relationship between SC vs. SC competition and market competition may be based on its ability to explore the structural make-
up of the supply chain as a ready input to supporting the definition of a market upon which market competition is dependent (Table 2.1). Where, also, the dynamic capabilities of SC vs. SC competition serves as a response into the dynamic offers upon which the market undertakes its competition.

Second, if it is assumed that the product/service value end-customers enjoy that are created along the supply chain depend on input from the market, then customers, through suppliers in competitive markets, could be said to have a large influence on the behavior of supply chains, and consequently on the way supply chains compete. Hence, the prospect of the realization that the two competition perspectives described above may have more in common than familiar conceptualizations may imply. While the race for demand fulfilment that take place along the upper and lower portions of the supply chain determines how much value is created, market competition and the information that is generated within this process in turn affects how actors along the different streams of the supply chain behave. Thus, it is apt to argue, from a systems perspective, that competition at both ends of the demand fulfilment spectrum may be viewed as complimentary rather than competing.

If this hypothesis is correct, it would help establish a clear alignment between SC vs. SC and market perspectives of competition. Taken together it provides support for the idea that supply chain management systems and market competition systems are first and foremost, linked. Further, it also supports the notion that output from SC vs. SC competition serves as input into market competition systems.

5.1. Conclusion

This paper has provided a fresh perspective on the role of SC vs. SC competition within the broader framework of competition. It has also sought to improve our understanding of SC vs. SC competition, albeit from a systems perspective.

Even though the concept of SC vs. SC competition continues to gain widespread acclaim, supply chain management literature struggle under tacit support from affiliated disciplines on how it is expected to take place and what the repercussions of this mode of competition will be on other forms of competition, sustainability and governance.

The paper sought to put forward an integrative justification between market competition and SC vs. SC competition in order to discover how both perspectives of competition might fit together within the broader encompassing notion of business competition. Today, most research on alternative/contemporary forms of competition are now closely guided by future predictions in technology advancement, changing customer tastes, environmental sustainability, etc. that are continuously evolving. But relevant mechanisms through which these advancements are translated into fulfilled value propositions, especially when it has to do with competition along the supply chain, is lacking within literature. The one single platform upon which all issues that are important to customers are present along the supply chain in one form or another. Thus, supply chains are important as a one stop shop to dealing with these issues in an integrated and systematic manner. As such, one way of trying to solve the issue of incongruency of predictions to competition would be to merge the dominant, classical and the contemporary, emerging competition systems into an integrative framework. This paper offers a conceptualization to such fusion. Moreover, studies focusing on market competition have often noted the difficulties embedded in the use or application of the traditional assumptions of market competition.
REFERENCES


ABSTRACT

Purpose
Risk identification is the first phase when trying to reduce risks within a supply network. It has been argued before that supply network structure is of relevance for risk identification. Hence, this article reviews the literature in order to find and present structure-based methods that are applied to identify supply network risks.

Design/methodology/approach
A systematic literature review is conducted. The results are presented and discussed.

Findings
Three groups of literature contributions were identified, but the body of knowledge is still limited. The first group contains articles that highlight the relationship of supply network structure to its risk or performance. The second group includes works in which methods were applied to analyse specific supply networks. Third, simulation methods have been used to identify supply network risk. Currently, there is no comprehensive understanding on how to unify existing research. Risks have been identified based on supply network structure, yet a common interpretation scheme is still missing.

Research limitations/implications
As any systematic review may have unwillingly excluded existing contributions, this holds true for this work as well. Nevertheless, it can be concluded that fundamental work has been done on this subject and that research should now continue to verify the expressiveness of risk information obtained from structural supply network analyses and extend the available methods.

Practical implications
Supply network risk management is of high importance for modern companies. This review provides the reader with a comprehensive overview on structure-based methods for risk identification and calls out for an applicable framework that allows to transfer the existing and future knowledge to practice.

Original/value
Supply network risk management has developed to be a widespread field of research, but contributions on structure-based risk identification are limited. This work reviews existing literature and identifies future research directions.
1. INTRODUCTION

Every company in modern economies exchanges goods and services. Effective supply chains form the fundament of these exchanges. Supply chain disruptions or even total breakdowns and the associated operational and financial risks are an outstanding threat to companies and a top priority firms face in today’s global economy (Craighead et al., 2007). Prominent causes in the recent past, such as natural disasters, pirate attacks or major accidents, have brought this even to the public’s attention. But smaller events, for instance, supplier bankruptcies, production line breakdowns, strikes or supply shortages have been the concern of supply chain managers for a long time. In line with the increased relevance in practice and public interest, research on various aspects of supply chain risk management enlarged widely (Ghadge et al., 2012; Wagner and Bode, 2006).

Several phase models have been suggested in order to support risk mitigation in supply chains. Norrman and Jansson (2004) point out that risk management processes differ in terminology but typically contain, first, of risk identification or analysis, second, risk assessment and, third, risk management. For instance, Ghadge et al. (2013) structure the process in three steps; namely “risk identification”, “risk assessment” and finally “risk mitigation”. Tummala and Schoenherr (2011) put forth three phases in supply chain risk management where phase I includes risk identification, risk measurement and risk assessment. The second phase subsumes risk evaluation as well as risk mitigation and contingency plans. The third and last phase aims at risk controlling and monitoring. It can be observed that the identification of risk is the fundament for all further strategies of supply chain risk mitigation. Craighead et al. (2007) argue convincingly that the structure of a supply network has a significant impact on risk. Moreover, Yan et al. (2015) point out the crucial role of so called nexus suppliers on the risk profile of a supply network. How the nexus suppliers are connected to the network and where they are positioned impacts the network’s risk. However, it appears as though rigorous methodology in this segment is limited. Hence, this review aims to identify, structure and present methods that make use of information regarding the supply network’s structure and relate it to identify risks.

1.1. Short definition of risk

The term risk in the context of supply chain management refers to the risk of an event taking place that leads to negative consequences for the supply chain’s performance. In many cases, such an event would be a supply chain disruption. A supply chain disruption is a combination of (1) an unintended anomalous triggering event materializing somewhere in the supply chain or its environment and (2) a consequential situation which significantly threatens normal business operations (Wagner and Bode, 2008). Risk and uncertainty are oftentimes used as substitutes. In decision theory, the probability of occurrence of a situation is known or can at least be soundly estimated for risky decisions. In contrast, uncertainty describes situations where the decision maker has no knowledge about the probability of occurrence (Cooke and Slack, 1991, p.164). However, this distinction is seldom followed in supply chain risk management literature; risk is usually used as the overarching term. Vulnerability is the exposition to risk. It is worthwhile mentioning that vulnerability subsumes both, the probability of occurrence of a negative event as well as its impact on the supply chain. A very common definition is that supply chain vulnerability is “an exposure to serious disturbance” (Christopher and Peck, 2004).
1.2. Supply Chain Risk Management

A wise supply chain design with a long term perspective supports companies in mitigating the effects of supply chain incidents. Robust supply chains are set up in such a way, that they sustain disturbances such that these do not impact on the supply chain’s operating performance. It is also possible to design a supply chain in a flexible manner so that at the occurrence of a disturbance, it can quickly adapt to the situation and thereby limit the negative impact on supply chain performance. Finally, supply chain resilience implies that a supply chain returns to the same or an even better performance level than before a disturbance occurred (Christopher and Peck, 2004). Melnyk et al. (2014) emphasize that the term resilience subsumes resistance and recovery abilities of a supply chain. Hence, flexibility and robustness are important preconditions for a supply chain to be resilient. Further, Wieland and Wallenburg (2012) find that in particular supply chain robustness leads to increased commercial performance.

Quite a few suggestions have been put forth in literature as well as implemented in practice in order to design resilient supply chains. Examples include the positioning of strategic stocks that enable supply chains to overcome fluctuations and disruptions (Tang, 2006; Chopra and Sodhi, 2012). The mitigating effect of this technique is limited to relatively small fluctuations and short disruptions and an overall increased inventory level generates additional costs, which has to be balanced (Manuj and Mentzer, 2008). Increased production capacity may generate a similar result (Chopra and Sodhi, 2012). Chopra and Sodhi (2012) and Tang (2006) point out that redundacy within the supply base allows to transfer orders easily if necessary. This may analogously be achieved by virtual dual sourcing (Fujimoto and Park, 2014). Tang (2006) furthermore highlights that flexibility should not only be thought of for production contexts but applies for transportation as well. Manufacturing postponement, where product differentiation is delayed as long as possible, increases supply chain flexibility as undifferentiated stocks can be used for multiple product variants. Modular design and modular production can achieve additional flexibility and can consequently create benefits (Chopra and Sodhi, 2012; Manuj and Mentzer, 2008; Tang, 2006).

The field of supply chain risk management is broad. The contributions are thematically divers and the number is vast. Consequently, several literature reviews have been conducted up to now. Table 1.1 summarizes existing literature reviews in supply chain risk management and highlights their specific foci. This reviews perspective is different as it aims to identify methods and tools that are applied for risk identification. This methodological focus has not yet been addressed.
Table 1.1 A selection of literature reviews in the field of supply chain risk

<table>
<thead>
<tr>
<th>Reference</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ho et al. (2015)</td>
<td>Comprehensive and recent overview of risk factors, categorization of general mitigation strategies, presenting of frameworks, categorizing methods used in the identified studies (mainly simulation based, fuzzy set based or programming based approaches).</td>
</tr>
<tr>
<td>Ghadge et al (2011)</td>
<td>Address the academic contribution and research questions or reviewed articles with the goal to outline a general research agenda.</td>
</tr>
<tr>
<td>Rao and Goldsby (2009)</td>
<td>The provided comprehensive typology of risks into sources and factors can serve as a guide for future research.</td>
</tr>
<tr>
<td>Manuj and Mentzer (2008)</td>
<td>Extensive presentation and discussion of strategies, focus on strategies that support companies in modern uncertain environments.</td>
</tr>
<tr>
<td>Khan and Burnes (2007)</td>
<td>Overview of risk management strategies, numerical evaluation of the research goal of academic articles, outline for future research including the need of “in-depth empirical research”</td>
</tr>
</tbody>
</table>

1.3. Complex supply networks

Due to the fact that today’s supply chains are becoming more and more complex, the linear chain perspective fails in describing the complex interrelations of a large number of partners present in a modern supply system (Hearnshaw and Wilson, 2013; Kim et al., 2015; Pathak et al., 2009; Yan et al., 2015; Wieland and Wallenburg, 2012). Interconnected and intertwined supply chains form complex networks and it is not uncommon to consider supply networks instead of supply chains. The terminology regarding supply chain and supply network is not used consistently (Braziotis et al., 2013). We will redraw to the term supply network from here on as we intend to pinpoint at the idea of complex networks that firms are embedded in. Moreover, this term appears more apt when discussing structural aspects of the supply network.

Considering supply networks as complex networks opens up parallels to other research disciplines and brings the potential to translate findings regarding the structure of networks to the supply network context. Two fundamental, abstract network models are those by Watts and Strogatz (1998) and Albert and Barabási (2002). These models describe the growth and related structure of the network and can meaningfully be translated to supply networks. For example, Albert and Barabási (2002) formulate that as a network grows, the most demanded elements will sustain and grow, referred to as preferential attachment. As the network evolves, these random changes will lead to improved overall network performance and adequate responses to changing external environmental requirements.

1 For the literature search, we have of course included the term “chain”, cf. section 2
A specific class of networks, so called scale-free networks, is characterized by a power law in the degree distribution (Boccaletti et al., 2006). Scale-free networks are particularly efficient (Latora and Marchiori, 2001). It can be assumed that supply networks equally show characteristic distributions that differentiate efficient from non-efficient networks. Scale-free networks are highly robust to random failures but is very vulnerable to targeted attacks (Thadakamalla et al., 2004). This implies that some parts of the network are especially crucial for the effectiveness of the whole system and that the criticality of these parts arises from the structure of the network. Such knowledge about networks may guide decision making regarding supply network vulnerability and is thus a relevant facet of risk identification.

1.4. Purpose of this study

In light of new challenges for supply networks in today’s global business environment the academic research proceeds and the constantly increasing output of research makes reviewing literature crucial for academic research (Seuring and Gold, 2012). Increasing turbulences in supply network operations (Christopher and Holweg, 2011) and the concept of evaluating supplier’s risks in a network context, increasingly considered by practitioners and scholars alike (Yan et al., 2015), demand for new concepts and are currently important research topics. “The [supply chain management] context has specific features that cry out for developing new network theory” (Borgatti and Li, 2009).

The body of literature on supply network risk management is wide, yet there is limited evidence regarding methods based on the structure of supply networks that is applied for risk identification. It was outlined above that rigorous risk identification is an important precondition for further strategies and frameworks that will guide managers in mitigating supply risks. Thus, the goal of this research is to identify, to structure, to present and to discuss structure-based methods that are applied in academic literature to identify critical positions and thereby risks in modern supply networks. Our specific focus lies on the supply side of the networks.

This article proceeds as follows: Section 2 expounds the methodology used in this systematic literature review. Section 3 provides basic notions of network modelling before outlining the review results in Section 4. The results are discussed in Section 5 and the final section concludes.

2. METHODOLOGY

There is a continuous growth in number of contributions in the field of supply network risk management (Ho et al., 2015). Hence searching the supply network literature for particular topics needs a systematic approach.

The research question that guided our search for literature was “what methods, techniques and tools exist / are documented that identify supply network risk arising from, induced by or amplified through the network structure?” To create this summary of methods we conducted a systematic literature review. A systematic review is a scientific, replicable and transparent process (Petticrew and Roberts, 2006).

After the formulation of the research question, our review process consists of five steps. In step 1, the data basis selection part, we used a list of journals. Preliminary searches without such a limitation led to a vast amount of articles. Hence we focused on journals that are of relevance to the logistics and supply chain management community. It can be expected that models
intended to study the structure of supply networks would be positioned in such outlets. We use a list of journals focusing on methods and concepts in the context of supply chain management. We purposely excluded journals with a specific focus on optimization models and techniques. In our preliminary search, we did not identify articles published there that contributed specific methods of risk identification. Rather, they presented models to design robust supply networks based on optimization techniques. Therefore we decided to include journals with relation to production or logistics/supply chain management topics as well as journals from the risk research community. Finally we checked the list with previous studies and recommendations of relevant journals in this particular research area (see, Ellinger and Chapman, 2011). The final list consist of 30 peer reviewed academic journals listed in Table 2.1. All of them are well perceived journals. This selection supports our search focus on concepts and frameworks of methods, techniques and tools identifying risks in a complex network environment.

The second step is the definition of the search terms. The search terms “supply chain*” and “supply network*” are the basic terms that are complemented by further search terms as listed below.

[supply chain* OR supply network*] AND

[ risk OR risks OR uncertainty OR failure OR disturbance OR disruptions OR disast* OR catastrophe* OR emergen* OR crisis OR vulnerab* OR robust* OR resilien*]

Several other aspects are covered using these descriptors. For example topics concerning supply chain/network design have to mention the terms “risk” or “disruption. Hence, the resulting list of terms represents a very broad fundament of several aspects. The term search was conducted in the title, the abstract and the keywords of articles. We searched for additional results when searching in the full text of articles but the additional articles focused on other topics and did not contribute to the research question of this review. We do not use a time restriction for the search of articles. This is not necessary because most of the articles resulting the search term search are younger than 10 years. We retrieved an amount of 1446 articles based on the descriptors from the list of journals. We reduced this amount by manually evaluating title and keywords to 331 articles. Articles with titles and keywords obviously not contributing to the research question of this review have been excluded. The abstracts of the remaining articles were thoroughly reviewed for their potential contribution to our research question. This final refinement step left us with 61 publications to analyze in detail. Based on this sample, 10 relevant contributions were identified to be presented below.
Table 2.1 List of journals included in the review

<table>
<thead>
<tr>
<th>Journal title</th>
<th>Number of articles²</th>
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<tbody>
<tr>
<td>International Journal of Production Economics</td>
<td>308</td>
</tr>
<tr>
<td>Computers and Industrial Engineering</td>
<td>59</td>
</tr>
<tr>
<td>Computers in Industry</td>
<td>11</td>
</tr>
<tr>
<td>Flexible Services and Manufacturing Journal</td>
<td>5</td>
</tr>
<tr>
<td>IEEE Transaction on Product Engineering and Production</td>
<td>0</td>
</tr>
<tr>
<td>International Journal of Integrated Supply Management</td>
<td>19</td>
</tr>
<tr>
<td>International Journal of Logistics Management</td>
<td>65</td>
</tr>
<tr>
<td>International Journal of Logistics: Research and Applications</td>
<td>36</td>
</tr>
<tr>
<td>International Journal of Operations and Production Management</td>
<td>42</td>
</tr>
<tr>
<td>International Journal of Physical Distribution &amp; Logistics Management</td>
<td>105</td>
</tr>
<tr>
<td>International Journal of Production Research</td>
<td>216</td>
</tr>
<tr>
<td>International Journal of Risk Assessment &amp; Management</td>
<td>18</td>
</tr>
<tr>
<td>International Journal of Services and Operations Management</td>
<td>22</td>
</tr>
<tr>
<td>IUP Journal of Supply Chain Management</td>
<td>19</td>
</tr>
<tr>
<td>Journal of Business Logistics</td>
<td>43</td>
</tr>
<tr>
<td>Journal of Manufacturing and Operations Management</td>
<td>0</td>
</tr>
<tr>
<td>Journal of Operations Management</td>
<td>45</td>
</tr>
<tr>
<td>Journal of Purchasing and Supply Management</td>
<td>13</td>
</tr>
<tr>
<td>Journal of Risk Research</td>
<td>9</td>
</tr>
<tr>
<td>Journal of Supply Chain Management</td>
<td>39</td>
</tr>
<tr>
<td>Logistics Research</td>
<td>4</td>
</tr>
<tr>
<td>Production &amp; Operations Management</td>
<td>79</td>
</tr>
<tr>
<td>Production and Inventory Management Journal</td>
<td>5</td>
</tr>
<tr>
<td>Production Planning and Control</td>
<td>60</td>
</tr>
<tr>
<td>Supply Chain Forum: International Journal</td>
<td>30</td>
</tr>
<tr>
<td>Supply Chain Management Review</td>
<td>26</td>
</tr>
<tr>
<td>Supply Chain Management. An International Journal</td>
<td>75</td>
</tr>
<tr>
<td>Technological Forecasting and Social Change</td>
<td>7</td>
</tr>
<tr>
<td>Transportation Research Part A: Policy and Practice</td>
<td>4</td>
</tr>
<tr>
<td>Transportation Research Part E: Logistics and Transportation Review</td>
<td>31</td>
</tr>
</tbody>
</table>

² Number of articles after using the described search terms.
3. PREFACE: A FEW WORDS ON NETWORK TOPOLOGY AND GRAPHS

Before introducing the results, a few methodological remarks on networks and graphs are necessary. A supply network consists potentially of many participating entities, partners and process steps. Klibi and Martel (2012) categorize the entities into external supplier, plants for intermediate or finished products, distribution / sales center, demand zones and transportation assets. Moreover a supply network contains flows of information, material and cash (Tang and Musa, 2011).

Supply networks can be modeled as graphs. Graphs consist of nodes and edges connecting the nodes. The adjacency matrix of a graph summarizes all edges in a graph. The entry aij represent the connection between node i and node j (Fournier, 2009). The entries can be binary or scalar. In the supply network context, typical nodes are firms, production plants or warehouses where goods are stored. Edges may represent for instance product flows. Additional information can be attached to an edge such as its capacity or its physical distance. Graph theory provides metrics to analyze graphs. The metrics can be applied for any graph-representation of a network – such as in this case a supply network. However, the specific interpretation of the metrics must be conducted carefully in the forefront of the represented network. The basic metrics include path length, degree centrality and clustering coefficient. Path length measures the distance from one node to another. In an unweighted graph this equals the number of edges between the nodes.

The average path length is the mean length of all paths within the graph. Degree centrality is the number of outgoing and incoming edges in a node (Borgatti and Li, 2009). Cluster coefficient describes how strongly the neighbors of one node are interconnected among each other (Watts and Strogatz, 1998). Another very often used measure is betweeness centrality. This measure counts the number of shortest way from other nodes through the respective node (Freeman, 1977). Mathematically it is represented by $BC_i = \sum_{i \neq a \neq b} \frac{\sigma_{ab}(i)}{\sigma_{ab}}$ the number of shortest paths and $\sigma_{ab}(i)$ the number of shortest paths through node i. Radiality of a node is defined as the sum of the reverse distances from the geodesics between every node pair divided through the number of nodes minus one. It holds: $R = \frac{1}{n-1} \sum_{i \neq j} \frac{1}{\sigma_{ij}}$ with n as the number of nodes (Mizgier et al., 2013).

4. REVIEW RESULTS

The findings indicate three categories of research that will be presented in the following. First, network analysis studies were identified that apply general methodology of network topology to the supply network context. Assumptions are derived regarding the value of specific networks and their relation to supply network risk. These contributions aim at analyzing general structural information of supply networks, introducing and transferring concepts from the field of network science. In their conclusions, these studies even go beyond risk identification; they directly connect network metrics with favorable states of the supply network such as its robustness.

The second group consist of contributions that introduce new measures and methods aiming at analyzing the supply network and its performance. These studies are presented in the subsequent section. What unites these methods is that they assume a network-oriented perspective on the supply side and – based on specific supply network knowledge – investigate the components.
And, third, simulative approaches form the third group. The application of simulations is universal and in general not specific to supply networks. However, some simulations are applied in structure-based supply network risk analysis and these are presented below.

4.1. General topological studies

Classifying supply networks
Specific classes of networks possess common properties. This knowledge may be transferred to supply networks. Nair and Vidal (2011) make use of three well-studied classes of graphs (random graphs, small world graphs and scale-free graphs) and compare them to supply networks. The authors investigate interrelations between the network topology as expressed by the graph class and the properties of the supply network. As a conclusion the authors suggest that long average path length between nodes in a supply network decreases its robustness against disruptions. They argue that shorter average distances between the nodes enable a faster propagation of products and information through the network which can help to increase the responsiveness of the supply network when facing a disruption. Hearnshaw and Wilson (2013) formulate a similar result. They argue that that a short characteristic path-length between two nodes in the graph implies that only few intermediate partners connect two firms. E.g. for information flows this implies a better and more rapid circulation of relevant information within the whole network. These results are of particular importance as they foster the idea to assume a holistic network perspective for risk management. In doing so, it becomes clear that disruptions are propagated differently, depending on where they arise within the supply network. For instance, contrary to what one might expect, it is in general not true that for supply networks with many echelons, disruptions with low tier suppliers can be neglected.

Growth models and characteristic structures
The structure of a network can be seen as the result of its growth process, as introduced above. Hearnshaw and Wilson (2013) apply this knowledge to the supply network context. They make the interesting observation that efficient supply networks demonstrate a similar “fits-get-richer” mechanism as observed for many other networks. Hence, the probability a new link is connected with a fit firm is higher than for less fit firms. This implies that firms with many connections to other firms tend to increase that number. Their critically grows within the supply network.

Network analyses using distributions of network measures
Hearnshaw and Wilson (2013) furthermore address distributions of network measures. They propose, among others, that the average degree distribution in an efficient supply network follows a power-law as this reflects the important role of hub firms in the network. Moreover, it is argued that multi-sourcing strategies, which are known to increase the resilience of supply networks, will appear as a power-law distribution in edge weights. But, as Hearnshaw and Wilson (2013) point out, there are reasons in the supply network context that this distribution is truncated, e.g., the transaction costs associated with opening up new business relations with a supplier.

4.2. Specific supply network methods

The following section presents studies that make use of structure-based methodology and apply it to concrete supply network situations. In contrast to the works presented above, where the focus is more on studying standard approaches and relating them to supply networks, these
studies come from a supply network application point of view and make use of structure-based methods to support the analysis. Nevertheless, methodological elements are overlapping.

4.2.1. Bottleneck identification with centrality metrics

Network analysis of supply networks can be helpful to identify particularly critical nodes or bottlenecks in a supply network. Kim et al. (2011) analyze three real supply networks and make use of various centrality metrics. The authors compare these centrality metrics to a qualitative analysis contributed by a previous study (i.e., Choi and Hong, 2002). This generates insights that are not revealed by qualitative methods.

A comparison of graph theoretical network measures is provided by Mizgier et al. (2013). The authors relate the centrality of a node to its impact on supply network performance. To do so, the behavior of an artificially created supply network confronted with random disruptions is simulated. The supply network’s performance is contrasted with the nodes’ centrality metrics. However, the study’s key contribution lies in comparing the simulated data with structural network information that is degree centrality, betweenness centrality and radiality. The authors show that the presented network measures allow to rank the suppliers regarding their importance for the entire network and to reveal previously unrevealed bottlenecks. The authors evaluate a supply network’s structure, refrain from in-depth simulations, and still give meaningful information regarding facets of risk in a supply network.

4.2.2. Clique identifications, Sub Groups and Cutpoints

A clustering coefficient is a graph theoretical measure that measures the local connectedness of nodes within a network. It has been observed from examples such as Toyota and Honda that efficient supply networks demonstrate a high clustering coefficient for their information flows (Hearnshaw and Wilson, 2013). Hearnshaw and Wilson (2013) explain that this observation results from the good information sharing which in the end lead to formation of a macroculture among the suppliers. Sloane and O’Reilly (2013) analyze a real supply network in depth using a variety of graph analysis methods. In addition to above mentioned metrics, this study uses a technique that separates nodes into cliques and sub-groups. The identified cliques coincide with groups of well-connected suppliers. Further the identification of so called cutpoint nodes reveals especially critical nodes. Cutpoints are nodes that, if removed, would break the network into separate parts. These cutpoint nodes play an important role in a supply network, since these nodes act as brokers or gatekeeper of information in many cases (Sloane and O’Reily, 2013).

Interestingly, by analyzing the clustering coefficient of the abstracted graph of a supply network, a global cooperation ability (or information sharing ability) can be determined. Translating the results back into the real network, these methods identify problematic parts and give an opportunity to measure an otherwise abstract term such as information sharing. All of the so gained information is a valuable basis for the subsequent risk management process.

4.2.3. Supply chain vulnerability indicators

Supply chain vulnerability indicators (SCVI) as suggested by Wagner and Neshat (2010) take the above ideas regarding bottleneck identification one step further. They calculate a specific supply network adapted metric of vulnerability and embed it in an approach to account for supply network risks. The metric is intended to depict the crucial exposition of the supply network to particular risks: its vulnerability. The authors intend to render supply networks comparable regarding their vulnerability towards negative events. The introduced SCVI use graph theory for analyzing the interrelations.
Wagner and Neshat (2010) present a four step framework for conducting such an analysis. It starts with the identification of the major drivers of supply network vulnerability. These drivers are the nodes of the following analytic steps. The factor identification may be supported, for instance, by a factor analysis or a principal component analysis. Then in the second step the inter-dependencies of the drivers have to be revealed. The authors conduct a questionnaire-based approach in which experts estimate the interrelation effects. The effects are then normalized. Hereafter the adjacency matrix is created based on the interrelation effects between driver i and driver j, each leading to adjacency matrix element $a_{ij}$. To condense the adjacency matrix to one single index value per graph, the authors calculate the adjacency matrix’s permanent. The permanent is symmetric, hence the order of the vulnerability drivers may be neglected, only the interrelations and thereby the amplifying effects influence the results. Finally the comparison follows. One can derive conclusions regarding the vulnerability of alternative supply networks by comparing and interpreting the calculated vulnerability indicators.

This approach creates the opportunity to compare quantitatively the exposure to risk respectively the vulnerability of a whole supply network. Wagner and Neshat (2012) proceed in their studies using this particular indicator by applying it to data of a large scale survey. The authors thereby identify correlations between vulnerability and the vulnerability drivers of a supply network.

### 4.2.4. Vulnerability performance indicator

Vlajic et al. (2013) suggest the vulnerability performance indicator for a supply network. Even though this terminology appears much related to the above introduced SCVI, their focus is different. The vulnerability performance indicator analyses the performance of the whole supply network or at particular nodes. The underlying idea is that network stability relates to less vulnerability. Hence, insights regarding network vulnerability may be detected as instable situations in key performance indicators (KPIs). The authors make use of the vast amount of data available nowadays regarding manifold processes. It is possible for many parts within a supply network to extract KPIs.

The first step in the calculation of the vulnerability performance indicator is the definition of a set of key performance indicators for supply network performance. Examples for potential key performance indicators are fluctuations in lead-time, backorder frequency, costs and customer service. Second, a tolerance range is defined for each performance indicator. This range defines acceptable deviations which shall not influence the performance or the functionality of the system. The narrower this robustness range is, the more stable and precise the system has to perform. Third, the key performance indicators’ data is analyzed for the number and duration of deviations. The final vulnerability performance indicator is the sum of the deviations of the individual key performance indicators.

The resulting indicator is a scalar and offers the opportunity to analyze the vulnerability with already existing data sets. Further, the comparison of different modules of the supply network is possible, as well as evaluating restructuring concepts (Vlajic et al., 2013).

### 4.3. Simulations

Supply networks are complex systems and their analytical description is beneficial in many situations. However, analytical models must reduce the complexity. Simulations are one alternative approach where complex interrelations can be represented and taken into consideration for the investigation. In the supply network context, simulations allow to depict
the network and study its behavior when confronted with disturbances. Results include in-depth studies of scenarios, identification of bottlenecks, or potential malfunctions.

We found no general framework for conducting simulations in the supply network context. The exact approach in simulating depends on the situation of the system to be simulated and the goal the simulation aims to achieve. We categorized the identified simulation approaches between three categories: First, event based approaches, then system dynamics and, third, business games. The identified articles either describe how to use particular methods in the supply network context or the simulations are used to verify assumptions.

4.3.1. Event-based approaches

Event-based simulations can take the form of discrete event simulations or stochastic simulations. Discrete scenarios or events are specified early on for discrete event simulations. Then, the behavior of the supply network is investigated for every particular scenario. This way, it is possible to compare alternative supply network configurations. To reach substantial results it is necessary that the effects of the variables are known. Further, the quality of this type of simulation depends on how realistic the chosen scenarios and events are. Coming up with realistic future scenarios to investigate supply network risks certainly is one important challenge for modelers. If there is knowledge of the probability distribution of the discrete events, it is possible to integrate these stochastic information into the simulation. Again, the results of such a simulation depend on the assumed stochastic information. Further, there is a tendency to underestimate low probability scenarios. This is especially critical in cases where the outcome of this scenario would put the entire company at risk (Knemeyer et al., 2009).

The advantage of event-based approaches is their handiness: choosing scenarios and their explicit evaluation is very tangible for decisions makers. Of course, the evaluation of the scenarios can be difficult and asks for other additional methods and techniques. Hence, this process depends also strongly on the experience of the modelers. An example for the application of a stochastic event-based approach is the VULA-Method based upon vulnerability performance indicators (Vlajic et al., 2013). It evaluates and compares alternative supply network redesign options. Future environment scenarios are defined and their probability of occurrence is estimated. The scenarios are evaluated with the help of the tracked KPIs. The supply network redesign options are then confronted with these disturbances and suggestions for decision makers are derived.

4.3.2. System dynamics approaches

Petri net applications were identified in the course of this review that can be used for modelling and simulating dynamic systems such as supply networks (Zhang et al., 2011). Petri nets are standardized models for specific components, i.e., nodes, and their interrelations. An overview of already existing petri net concepts for supply network management is provided by Zhang et al. (2011). The behavior of the components is backed up by mathematical formulations which are then simulated dynamically. The problems these concepts face is that the interrelations have to be defined very specific. Further, for many practical applications carrying out this kind of simulations is just too complex. These methods offer the opportunity to verify assumptions.

4.3.3. Business games

Business game type simulations focus on consequences of behavioral effects and can either take the form of observation of volunteers in experiments or of agent-based simulation with defined behavior. Agent-bases simulation relies strongly on sound modeling of the interrelations of the simulated agents. Our review identified the study of Nair and Vidal (2011). The authors use an
agent-based simulation model to verify assumptions about network metrics for three different types of networks. While this is a simulation application, their work was already presented above regarding topological contributions.

5. DISCUSSION

The review revealed various structure-based methods and tools to account for complex supply network risk. It is common to represent supply networks as graphs and continue to analyze this abstracted model. We identified methodology that focuses strongly on graph analysis and relates this methodology to supply networks. In many cases, these studies compare structural information of the graphs to supply network properties. Second, some approaches originate from supply network challenges and apply and enhance graph analysis tools in order to achieve their goal. For instance, supply network bottleneck identification is obtained based on graph analysis tools. Third, simulation is applied to account for supply network risk.

The topological studies lay a solid foundation for any further modelling of supply networks as graphs and analyzing their structure. Not wanting to neglect the individual contributions of the articles, what is of outstanding importance here, is that in summary these studies elucidate the relationship between the supply network’s structure and its performance vis-à-vis risks. In the forefront of that assertion, researchers can analyze supply network structure with the goal to obtain information for risk management.

The contributions in our second category are first examples where specific elements of supply network risk are identified by redrawing to graph analytical metrics. Hence it has been shown that such a structure-based approach is beneficial. But, as of now, these applications do not form a congruent approach, yet.

We were expecting to find numerous studies simulating supply network risks as this approach appears to be very common in practice. However, our findings in this area were limited. Admittedly, simulation is a relevant counterpart in optimization-based risk approaches that we excluded here. However, the limited number of documented applications of risk identification based on supply network structure may also be due to the immanent challenges when simulating and discussing supply network risks. Simulations require in-depth modelling of the underlying complex supply network as well as good scenarios (potentially including their probability of occurrence) to investigate. If both of this is achieved to satisfaction, simulation can greatly support risk analysis by creating interesting alternative views and detailed information about future scenarios.

The key observation from this review is that structure-based methodology to support risk identification is still at its infancy. There are relevant fundamental contributions as well as interesting first applications to supply network modelling. However, the issue of describing complex supply networks well and providing information on the structure of supply networks is of high importance for practical applications today. It appears as though the academic world cannot fully reply to this challenge - yet. Several future work packages result from the above: Regarding risk identification based on the structure of supply networks, there is a need for clear-cut guidelines on how to meaningfully model and descriptively analyze complex supply networks. For instance, up to now it appears common to model product flows on the arcs of the graph. However, it may turn out to be more expressive to model the available, unused capacity on the arcs in order to identify risks. Second, existing supply network investigations (as were identified in Section 4.2) currently make use of some measures that are commonly used in network analysis. However, researchers need to further strengthen this set of methods and tools.
by additional in-depth empirical research. Applying the same methods in different contexts as well as studying different metrics in the same content would provide knowledge on how to interpret the metrics. A holistic framework using and combining numerous of these measures and techniques is missing.

The structure of supply networks is important for risk identification and we need a holistic perspective to fully grasp it. But this ambition has not been reached either up to now. There is a large difference between analyzing individual nodes and their properties in a graph – which will eventually lead to an overwhelming degree of complexity – and reducing the system-wide analysis of a graph to one single metric – which will clearly limit the interpretability of the results. Suitable levels of detail have not yet been investigated. Focusing on the distribution of a metric may be a suitable option.

6. CONCLUSION

Supply networks are endangered by various types of risks. Modelling these complex networks as graphs allows to investigate their structure and potentially identify risks. A systematic literature review was conducted with the goal to highlight methods that allow to assess the structure of the supply network in order to relate this information to risk identification. Results include, first, fundamental studies on the relation of network structure and supply network performance when faced with risks. These assert that the structure of supply networks impacts, indeed, on supply network performance in risky circumstances. Second, contributions were identified that make use of and enhance graph analysis tools in order to identify, e.g., vulnerable positions in supply networks. Third, simulation studies provide insights as to alternative supply network scenarios. Assets and drawbacks for the identified methods have been pointed out. These include that information can be condensed to and discussed at various levels of detail. However, modelling assumptions are crucial to obtain applicable information. The body of knowledge in this research field is still limited even though the relevance of supply network risk management in general is uncontested in practice and academia. It is important to continue developing rigorous methods to identify the risk of the complex supply networks of today. Furthermore, there is a need for a standardized framework that can give solid guidance for practice on how to assess supply network risks; risk identification is the fundament for this.

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REFERENCES


THE SUSTAINABLE LOGISTICS INNOVATION PROCESS;
AN EXPLORATORY STUDY

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ABSTRACT

Purpose
Sustainability has become an important aspect for improving logistics, and the development of more sustainable logistics operations calls for innovative thinking. The purpose of this study is to explore how the sustainable logistics innovation (SLI) process is managed by some retailers and LSPs in order to suggest a framework for describing and analysing the SLI process.

Design/methodology/approach
Literature on general, logistics and sustainable innovation processes is studied. A multiple-case study in five Swedish retailers and LSPs is conducted. With a pattern-matching approach, the SLI processes in the companies are analysed and a framework is suggested.

Findings
A framework for the SLI process is suggested and its differences from general innovation processes are highlighted, such as the use of 3BL business cases. It shows the characteristics of the SLI process and which actors that are involved. The SLI process can vary largely and still generate SLIs. However, managerial improvement potentials were found in several phases of the process.

Research limitations/implications
This study addresses the lack of empirically based research in logistics innovation and expands it to retailers. It expands our knowledge into SLI, where the framework can be applied to structure and understand SLI processes, and to identify improvement potentials.

Practical limitations/implications
Managerial implications are found in the limited customer involvement in idea generation and the often “secret” way of evaluating ideas. As the companies can be seen as forerunners in SLI, managers can get inspiration by studying how the process is managed.

Originality/value
Very few studies are found in the area of sustainable logistics innovation.

Keywords: sustainable logistics, innovation process, case study, innovation management
1. INTRODUCTION

Innovation is a key driver to sustainability in supply chains (Roscoe et al., 2016), that is needed to address the environmental and social challenges in logistics. Logistics plays an important role in sustainable development and applications of the sustainability concepts in logistics have developed during the last years (Piecyk and Björklund, 2015). However, the level of logistics innovations is low (Wagner and Sutter, 2012), and few studies have related sustainability to innovation in a logistics context (Russo Spena and de Chiara, 2012). No definition of sustainable logistics innovation (SLI) has been found in the literature. Sustainable innovation has been argued to comprise environmental actions within in logistics service providers (LSPs) (Zailani et al., 2011). However, sustainability should include not only the environmental but also the social and economic dimensions, that is the entire triple bottom line (3BL) (Touboulc and Walker, 2015). Also logistics innovations have been described as innovations within LSPs (Rossi et al., 2013). But just looking for SLIs in LSPs’ transportation activity is a narrow approach. We want to expand the knowledge on SLI in LSPs to also include retailers and thereby consider logistics activities in other parts of the supply chain as well as a deepened understanding of the potentials of different actors. Inspired by the commonly applied definition from OECD (2005, p. 46) and by Flint et al. (2005) who mean that an innovation has to be new in the eyes of the beholder, we define SLI: “Implementation of a, for the audience new or significantly improved product (good or service), process or organization in a logistics activity, that contribute to a more environmentally and/or socially sustainable development.” Examples of SLIs can be a quiet electric night delivery vehicle or a changed logic for route planning.

If an organization wants to be innovative, it needs to be able to manage innovation (Wagner and Sutter, 2012). Busse and Wallenburg (2011) state the logistics innovation literature focus on innovation as a final result, while how innovation emerges is lacking. de Medeiros et al. (2014) make similar claims regarding sustainable innovations. Touboulic and Walker (2015) came to the conclusion that theory-building efforts within sustainable innovations are scarce. No study on managing SLI was found – does managing SLI differ from managing sustainable innovation or logistics innovation? In line with Bessant and Davies (2007, p. 70) “Innovation management is about learning to find the most appropriate solution to the problem of consistently managing this process” and Arlbjørn et al. (2011, p. 6) claiming that firms “have to build a process that facilitates their pursuit of turning new ideas into products”, we see SLI management as a process. Few logistics innovation process studies are found (Su et al., 2011), and the same is valid for sustainable innovation process studies (Roscoe et al., 2016). This study brings together the limited knowledge from these two areas in order to contribute to theory on the SLI process. Knowledge on what to do (phases), how to do it (characteristics) and by whom (actors), could build a framework for the SLI process. This would also have practical relevance; as a clear management process would imply more and better SLIs. We also contribute to the lack of empirically based research in logistics innovation (Arlbjørn et al., 2011). The purpose of this paper is to explore how the SLI process is managed by some retailers and LSPs in order to suggest a framework for describing and analysing the SLI process.

2. LITERATURE REVIEW

Due to the limited specific literature, the first section describes general innovation processes. The second goes through logistics innovation processes and the third deals with sustainable innovation processes. This literature is used to frame the analysis.
2.1. The general innovation process

In conceptualizing the innovation processes that organizations go through, large similarities can be found in the phases (stages, components, main activities). The different innovation process models show that there is a sequence between these phases, though the process is not necessarily linear. Feedback-loops and cycles can exist before proceeding through the process. Classic models of innovation have been complemented with more complex models with a sometimes parallel development process (Verloop, 2004). It seems that the first phases of the process are less linear and with more loops, compared to the later stages of the process (Tidd and Bessant, 2009). Below we present five phases commonly described in the literature.

Idea generation is the first phase with an aim to address how the organization can find opportunities for innovation (Tidd and Bessant, 2009). The innovation model by Hansen and Birkinshaw (2007) put forward three types of idea generation: in-house (within a unit), cross-pollination (collaboration across units), and external (collaboration with parties outside the firm). In a similar way Bessant and Davies (2007) state that organizations need to scan their internal and external environments to pick up signals about potential innovation. Verloop (2004) put forward a number of actors that have important roles in idea generation but also in selection of ideas and concept development: grassroots, experts, management, customers, external stakeholders as well as partners and alliances. The acquisitions of knowledge can be described as deepening (the amount of knowledge a firm gather from in a specific area) and/or broadening (the number of areas in which a firm gathers knowledge), and da Mota Pedrosa et al. (2015) suggest that these two strategies might be interrelated. Knowledge is often described as acquired from other organizations. One dimension often put forward is the importance of collaboration between functions of different organisations (de Medeiros et al., 2014). The acquisition of knowledge is relevant in all phases of the process.

Selection of ideas is described by Tidd and Bessant (2009) as a selection on what the firm will do and why. Bessant and Davies (2007) state that this is a challenge, and Hansen and Birkinshaw (2007, p. 5) claim that “In many companies tight budgets, conventional thinking and strict funding criteria combine to shut down most novel ideas”. Although Hansen and Birkinshaw (2007) continue mentioning that other companies have the opposite problem: managers do not apply their screenings strictly enough. A consequence of this is that the firm overflows with new, often underfunded and under-staffed, ideas that do not fit into the overall corporate strategy. Concept development is where the selected ideas are turned into tangible products, processes or services. This phase starts by management giving a “green light” to develop a proposed idea into e.g. an offering that can be produced or marketed internally or externally (Andrew et al., 2006). It is important to build a business case especially for the more radical innovations (do different in comparison with do better). “As we move to more radical innovation projects –which are by definition higher risk- so the ‘business case’ needs to be more strongly made …to secure ‘buy in’ from decision makers” (Tidd and Bessant, 2009, p. 317). Previous to the implementation of the innovation the organization also needs to build capacity and invest in e.g. facilities, customer understanding, and training (Verloop, 2004). The tools applied can include modelling, simulating the outcome of different scenarios, customer or market surveys, internal analyses (such as brainstorming), and external assessments (such as Delphi studies).

Implementation. Hansen and Birkinshaw (2007) point at the importance that the relevant constituencies is given within the organization to support the spread of innovations. Bessant and Davies (2007) describe this stage as the final launch of the new product, service, process or method internally or externally. According to Andrew et al. (2006) this phase ends when the innovation comes to the end of its life cycle, which is supported by Tidd and Bessant (2009)
who include re-innovation and up-scaling. **Learning** is the fifth phase. It is of importance to reflect upon all phases in the process and review experience of success and failure. The reflection is important in order to learn about how to manage the process better, and to capture relevant knowledge from the experience (Bessant and Davies, 2007). Tidd and Bessant (2009) state that even if both researchers and practitioners see the importance of learning, it is rarely done in a structural way.

### 2.2. The logistics innovation process

In their study of the LSP’s logistics innovation process, da Mota Pedrosa et al. (2015) develop a process model of four phases: idea generation, to identify unfulfilled customer needs and generate ideas for new products/services, concept development, converting an idea into a concept that can be launched, business analyses, the LSPs analyse the potential success of the innovation and decide if the change ought to be implemented and implementation, the launch of an innovation and the exploitation of additional features to improve it. This study found that the employees with customers contacts were not involved in business analyses, thus the LSPs did not acquire customer knowledge during this phase. However, acquiring customer knowledge in this phase would increase the risk that sensitive knowledge becomes public (da Mota Pedrosa et al., 2015). In this process there is only one phase, business analyses; where selection between potential solutions takes place.

The process model by Flint et al. (2005) stresses the important role of customer interactions in logistics innovation. A four phase process is suggested: setting the stage, laying a firm foundation for being innovative and create an environment based on interacting with and listening to customers; customer clue gathering, thus activities looking for clues to changes in what customer value; negotiating, clarifying, and reflecting activities: understanding what the customer actually wants, holding internal discussions of the clues found; and inter-organizational learning, learning insights and increased understanding between LSP and customer organizations, co-producing innovations with customers out of active management of inter-organizational learning. This model was validated by Flint et al. (2008), who showed that firms on average are weaker with regard to setting the stage compared to the other phases of the model. Logistics and supply chain managers have important insights into customers’ demands and can play important roles in the gathering, analysing and dissemination of customer insights. Su et al. (2011) supplemented the Flint et al. (2005) model and concluded that the logistics innovation process model also can include suppliers. Interesting results are that the processes are dynamic, that they might improve the partnership with suppliers, and that logistics innovations in the supply chain are as dependent on internal stakeholders as on external relationships. Chapman et al. (2003) mentioned the importance of managing knowledge in logistics innovation, both by acquiring it from internal and external actors, and by accumulating process knowledge and efficiency.

In her study of the development process regarding sustainable logistics services, Isaksson (2014) stresses the need to focus on better feedback, learning and replication. Examples are given on employee education as well as the need for more customer-focused thinking. This is much in line with the last phase in general innovation process models (i.e. reflection and learning), as well as the importance of customer focus in the logistics innovation process model by Flint et al. (2005). The organization structure of a company plays an important role when it comes to supporting the innovation capacity of the firm. Daugherty et al. (2011) found a positive relationship between decision-making decentralization and logistics service innovation. Their findings contradict previous research, which states a negative relationship...
between decentralization/formalization and service innovation and arguing that formalization can “stifle” innovative approaches in logistics.

2.3. The sustainable innovation process

No sustainable innovation process models with phases were found in this area, and partial knowledge is therefore brought in. Verloop (2004) claims that going from general to sustainable innovation, implies to not only select solutions out of a company perspective but also out of other societal stakeholders, including the social and environmental dimensions. Hockerts and Morsing (2008) found that bringing stakeholders into the sustainable innovation process offers important possibilities to increase financial and social performance. This is supported by Rossi et al. (2013) who argue that sustainable initiatives can strengthen the relationship with customers into more long lasting partnerships. In a review of studies addressing development methods for sustainable product innovations, de Medeiros et al. (2014) concluded that each study proposed different methods. Common traits were the need for mapping customer trends and a clear process including both different areas in the firm and in external stakeholders. Firms need constantly to improve and innovate, in order to reduce the harm to the environment and to the communities in which they operate, and this has recently reached supply chain management literature (Roscoe et al., 2016). Radical innovations may increase the economic performance of the firm, but not necessarily lead to environmental or social performance. Therefore all 3BL dimensions have to be carefully involved in decision-making. Roscoe et al. (2016) furthermore proposed a three-step typology on how to develop sustainable innovations; to build strong ties with a few strategic suppliers imply specific knowledge acquisition for the firm, to build weak ties with many non-strategic suppliers which can increase the possibilities to identify innovations and to build weak ties with suppliers that bridge gaps in the supply network. Russo Spena and de Chiara (2012) discuss on a more conceptual level how to manage innovation, to recognize the strategic importance of sustainability innovation, to involve many departments in the organization and to use sustainability indicators to measure innovation performance.

3. METHODOLOGY

This study has an exploratory purpose, as the knowledge in the area of SLI process is scarce. In such situations, empirical input with possibilities to interact with company respondents is critical. A case study approach is often appropriate for exploratory purposes (Yin, 2014), and was therefore chosen. Case studies can be of different types; this multiple-case study is conducted to learn something from particular cases. Such results could be analytically generalized to theory, and the theory could later be tested by replication (Yin, 2014). A multiple-case study of five Swedish companies is conducted. The study object is consequently the company, with the sustainable logistics innovation process as embedded unit. The studied companies represent both retailers and LSPs. They are partners in an ongoing research project on sustainable logistics, and selected for the project as they have taken interesting and often innovative actions to increasing the sustainability of their logistics systems. As they can be seen as forerunners when it comes to SLI we did expect them to have more developed management of SLI than companies in general. As a relationship already was formed with their representatives (mainly logistics and sustainability managers), we had gained their confidence which provided access to more information. Due to their understanding of the overall aim of the study, they could guide us in the selection of suitable respondents. It was decided that the respondents should represent the managerial level in their Swedish headquarters. In such large organisations, one person is seldom able to respond to every question, for which reason several
respondents per case were needed to get the entire picture. Such an approach, to use multiple sources of evidence or data triangulation (Yin, 2014), strengthens both validity and reliability of the study. The studied companies and their respondents are shown in Table 3.1.

Table 3.1 Studied companies and respondents

<table>
<thead>
<tr>
<th>Company</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retailer 1 (R1)</td>
<td>Logistics manager, CSR/sustainability manager, Recycling manager</td>
</tr>
<tr>
<td>Retailer 2 (R2)</td>
<td>Environmental and quality manager, Logistics manager, Transport operation manager, Sales director</td>
</tr>
<tr>
<td>Retailer 3 (R3)</td>
<td>Supply chain manager, Logistics and transportation manager</td>
</tr>
<tr>
<td>Logistics service provider 1 (LSP1)</td>
<td>Environmental and quality manager, Manager strategic planning, Transport and distribution manager</td>
</tr>
<tr>
<td>Logistics service provider 2 (LSP2)</td>
<td>Terminal manager, Environmental specialist, Senior project leader technology and infrastructure, Train and air freight manager</td>
</tr>
</tbody>
</table>

The data collection followed the procedures recommended by Yin (2014), such as basing the interview on the literature in order to increase construct validity. As the process models from literature contain different phases and are general, we wanted the empirical study to be central. Therefore the interview guide was more open than the literature, and was semi-structured with open-ended questions. Questions regarding the overall design of the process, addressing aspects such as the degree of formalization/centralization and documentation, and if they describe the process as sequential phases or more unstructured, were posed. Next we asked them to outline the phases that normally occur in a SLI process, following a timeline. The same guide was used for all respondents. In total, 16 personal interviews, lasting from 60 to 120 minutes, were conducted during winter 2015/2016 at the premises of the respondent. Other data sources, such as sustainability reports and control documents (method triangulation, Yin, 2014), supplemented the interviews. The respondents were perceived to be experienced in SLI and showed understanding for the questions during the interviews. Both authors participated in and took notes during the interviews, then the two interview versions were consolidated and sent to each respondent for verification. The verified interview notes, other respondents’ notes from the same company and other data built up the case descriptions. As we in general found complementing and not contradicting information from the respondents within the same company, we have chosen not to show in detail which respondent in each company said what. Also actors involved (internal as well as external) and their different roles were mapped out. In all cases but R1, the authors have put labels on the SLI process phases. Several times the respondents exemplified from the development of their SLI. We could therefore secure that this process was general in nature and not only valid for the development of e.g. new products, processes or administrative routines.

The interview guide eased the coding of the empirical data. The reliability of the study was further ensured by clearly documenting coding, decisions and questions in a case study protocol (Yin, 2014). Respondents highlighted different aspects of the SLI process, and we describe it the way the respondents did. It does not mean that aspects omitted are necessarily not present. With a pattern-matching cross-case approach (Yin, 2014), the SLI processes are compared to each other and evaluated towards the literature, and a framework is suggested. The submitted
version of this paper was sent to all respondents for verification, which just led to minor modifications. Method limitations are further discussed in the conclusions section.

4. CASE DESCRIPTIONS – FIVE SLI PROCESSES

4.1. Retailer 1 (R1)

Overall. R1 is a daily groceries retail chain that operates in 26 countries. In Sweden they have almost 3 000 employees. The SLI process and the guidelines for its use are well documented on R1’S intranet, as all other processes in this highly formalized and concept-managed company. So there is IT-support for communicating the descriptions, but not for the actual use of the process. Weekly emails to all staff are a common internal channel. R1 has released two CSR reports so far, and they also use their web and social media for communicating SLI to stakeholders. When it comes to responsibility, there is no innovation manager, instead functional managers have extensive mandate to change. Everybody in the staff are involved. The entire organization is built up around continuous improvement with meeting structures and channels. R1 put forward five phases in their SLI process:

Identifying problems. Very commonly R1 identifies a problem by looking at one of their many key performance indicators (KPIs), such as low fill rate in the trucks. Problems can also be discovered by ideas both internally and externally to R1. There are no concrete examples that consumers’ needs have initiated any SLI. The consumers are focused on the products, but R1 wishes to better communicate also logistics issues to the consumers e.g. in the CSR report.

Brainstorming ideas. Groups are formed to brainstorm ideas. The participants in the groups differ depending on the type of problems that are addressed. Since the company’s culture focuses on innovation, there is no problem in convincing people to engage themselves in different innovation processes. KPIs are compared between their sister-companies in different countries, and if their KPI differ, they investigate the reasons for the difference more in depth.

Identifying ideas for solutions. The design of this phase is much depending on the type of problem. R1 often uses university students’ degree projects to solve problems and bring in new knowledge. For innovations regarding e.g. recycling and city distribution, they work together with communities and energy companies. In a dialogue with LSPs, R1 is sometimes suggested to participate in technical tests and is almost always willing to do so. Also automotive manufacturers can be involved. It is of importance to be able to quantify the sustainability benefits here, so a positive economic result can be shown. Implementing simple solutions. The logistics manager has the mandate to implement changes within less than a week in the warehouse and in the stores. The solutions need to be simple so that everybody can understand them, related to, sometimes, low level of education and even language skills among the staff. Technical tests can result in that R1 puts additional demands on all their LSPs. R1 has also district managers, who are important channels to reach stores and consumers. They support the identification of educational needs and are used for collecting feedback. Continuous improvement. R1 has weekly follow up in order to identify what happened. They also have structures for communicating good innovations to sister-companies. A lot of control and follow up is required for the SLI process.

4.2. Retailer 2 (R2)

Overall. R2 is a global office supply retailer. In Sweden they have almost 400 employees. Innovation is seen as strategically important by highest European level. As there is no global SLI management process, there are responsibilities on different levels in the global, European
and Swedish management of the company. The sustainability and quality manager works together with the logistics management in the SLI process in Sweden. Altogether many persons with different responsibilities, and many operational employees, are involved in the process. The SLI process is documented on e.g. their intranet. R2 has several ISO-certifications that support the documentation and management of the SLI process. The company has some IT-support for the process with regard to programs that register claims and KPIs. But there is no IT-support for using or managing the SLI process in itself. The respondents describe the following phases in a SLI process valid for all types of innovation in the company.

A need for change. Such signals can come from many sources; the monitoring of the many KPIs, from employees’ suggestions, from benchmarking in the global sister-companies and from management on different levels and their deployed targets. Within the company the ideas from employees are channeled by their department manager to the sustainability and quality manager. Every internal idea is rewarded with two scratch cards/lottery tickets no matter the quality of the idea. In terms of capturing customer needs, R2 knows a lot about their customers through KPIs. The sellers capture questions, claims and deviations from customers. There is also a group that meets every second week with the agenda to lift up possible development, by asking themselves questions such as; are we keeping our promises, what do we spend most time doing, what can we improve in the Swedish logistics organization? Evaluation of ideas. The ideas are evaluated in the management team every Monday, in order to see the possibilities of realization. This implies that innovation ideas very quickly reach the management. Each idea is given feedback to the “idea supplier”, and increased rewards can be provided for ideas with e.g. implementation potentials. Building and capturing knowledge. After the evaluation of ideas an action group of 5-6 persons is established. A relevant mix of competencies is important, and also to find people that have a large interest in new ideas. Knowledge capturing comes mainly from the sister-companies in the Nordic countries or in Europe, and historically, it has been difficult to know which persons to contact and find the accurate doors to open, but as information regarding previous improvement projects now is available on the intranet, it is easy to track down persons with the knowledge needed. R2 has a long-term cooperation and development with their LSP. The transport and operations manager claims that “it is important to have a LSP that you can trust to develop together with you”. Their cooperation is described as tight and has been ongoing since four years. Building a business case. For innovations in the Swedish organization, there is seldom a need to fight for resources. It is easy to realize solutions that give an immediate cost saving, but if an investment is needed, they have to make a business case of it and handle it on European level. The business case is important as R2 bases decisions on facts. It is necessary to be able to prioritize as the action list is long. Implementation. After decision-making, ideas are implemented nationally. Projects and their implementation are passed on to the sales organization and upwards in the organization. Follow-up and learning. Good projects can be Europe-projects, so it is important to inform the European management. R2 has started to deliver “one-pages” about their innovations which are spread on the intranet. This is perceived to be a good beginning to coordinate and exchange SLI information.

4.3. Retailer 3 (R3)

Overall. R3 is a non-food retailer acting on the Swedish market with 1700 employees. R3 states that they are not that proactive in their SLI process, which means that SLIs are driven by furthermost economic interests. The process is informal and not documented. Capturing ideas. The SLI process is described as starting with the capturing of ideas. Ideas come from the employees, customers, LSPs, stores, specialists and generalists, often in the form of different meetings. Both managers state that it is perceived to be even more efficient to always have the
ears open, walk around in the organization and really listen to employees. Spontaneous
meetings, e.g. when the shifts change or when a manager walks through the warehouse, are good
arenas for such opportunities. There is a lot of knowledge and engagement in the organization.
The idea-suggestion box is however most often empty. KPIs are another way to get ideas, R3
has many relevant KPIs but they prefer to get information directly from the mentioned sources.

**Identifying solutions.** Small groups are tailored around solving problems, subsequently each
group is based upon roles and capabilities for the task at hand. A large focus is placed on
discussing development and solutions. **Calculating potentials.** R3 has good access to business
developers in the organization, and they have high competency in making 3BL business cases.

It is in the business idea of R3 to always chase low-cost solutions, so sustainable logistics
innovations must not increase the cost. “*Often, sustainable logistics is more complicated, but
we try hard even if it is difficult to quantify the sustainability benefits*” claims the logistics and
transportation manager. **Implementation.** Sometimes they solve problems ad hoc, thus
skipping the calculations in phase 3, as there is a value in the quick solution. Solutions that are
calculated as having good potentials are then implemented. Depending on the size and type of
the innovation, the implementation can be made in smaller or larger steps.

### 4.4. Logistics service provider 1 (LSP1)

**Overall.** LSP 1 is a mid-sized actor on the Swedish LSP market, owned and supplied by a
number of partners. According to the transport and distribution manager, the SLI process is
formalized and follows a specified routine in the management team. However, a manager
outside the management team describes the SLI process as being un-formalized and without a
clear structure, as the information regarding e.g. how the team ensures that all ideas are taken
under consideration is lacking. We have interpreted this as there is a formal process, but that it
is not well communicated outside the management team. Furthermore, administratively, there
is a formal, documented process for deviations and improvement as a consequence of their ISO
certifications. The SLI process is present at three organizational levels: the management team,
the two-men team: the strategic planning manager and the transport and distribution manager,
and in the partner meetings. The participation of the different levels is seen in the five phases
identified in the SLI process:

**Identifying ideas.** The first level starts with a suggestion box from the employees. There is also
a small-scale process between the strategic planning manager and the transport and distribution
manager, who solve problems and take decisions within their own mandate. Operational claims,
KPIs or need for development can also initiate the SLI process. **Analyzing ideas.** Meetings in
the management team are held once a week. It is not clear how the management team selects
ideas to work with or how decisions are made, and no protocols or formal information flow
exists. Clearer information about which criteria that increases the possibility for realizing the
idea, and feedback to the “idea supplier” is wished from respondents outside the management
team. In parallel the two-men team analyze together. They place the ideas on the table, and
enter a phase in which they analyze, test restrictions, simulate solutions and test hypotheses to
ensure the solution’s feasibility. **Budget and risk assessment.** Investment needs have their own
routine, where the business areas request funds, make capital budgets and conduct risk
assessment. Business risk can be divided between the partners; it is then assessed in the
management team and in the board. The partners are represented in the board, and they often
take the business risk. Large investments may need to be handled in partner meetings. **Testing
the concepts.** It is sometimes a hard task to decide on which partner that is most suited to test
the new solution. There is no problem in finding or convincing a willing partner. Instead all
partners are generally willing to pilot-test innovations. **Implementation.** Concepts with a
positive result from the test are then implemented in a large scale. However, the criteria for “a
positive result” are not clearly expressed and could be depending on more than sustainability potentials and economic outputs, such as available technique and knowledge.

4.5. Logistics service provider 2 (LSP 2)

**Overall.** LSP2 is a large actor on the Nordic market. As the organization is very complex, a centralized and formalized SLI process is necessary. LSP2 has educated staff in the use of an existing project management process model (Prince 2), with phases and tollgates. The model contains templates for different phases. However this model is not known by all respondents.

**Idea generation.** Ideas exist everywhere, as many employees have a long experience. Strategies deployed to targets and KPIs for all three dimensions of sustainability for each function have an important role, as well as signals from the managing director. Ideas from employees are channeled through the levels in the organization. Customer input comes via the business areas and the Key Account Managers, plus from customer networks and workshops. Environmental specialists are important speaking partners to managers on all levels. Ideas, implemented somewhere in the organization, are also spread from the central fund. **Solutions development.** Teams are built around internal competencies, who often use external experts, such as suppliers, for input. Furthermore, LSP2 has good project leaders and a strong meeting culture. It is important to secure a shared problem experience, e.g. in workshops and not decide on a solution too early.

**Financing decision.** When solutions are suggested, it is possible to directly decide on financing on the own budget. If a larger investment is needed, LSP2 has a central fund for sustainability innovations to apply to. The idea owner needs to argue for how the SLI would be in line with the overall strategical goals of the company. Thus it is not enough to show large economic, environmental and social, or 3BL, potentials. There are templates to prepare a business case for this purpose, but some respondents indicate that this cost/benefit analysis is very complicated. This fund is necessary to both control costs and encourage sustainability initiatives. **Implementation.** “We use bottom up and top down at the same time, and a lot of anchoring is required as we are in Sweden” claims the senior project leader. Dialogues are continuously held between the different countries and the central sustainability department. **Learning.** Feedback is given to the central fund and to the environmental specialists so innovations can be scaled up. The applied SLI process contains a phase for learning. After large projects, learning should be captured. This process is revised annually. The feedback from the central fund is important for benchmarking purposes but also to signal to the organization what types of projects that have been funded.

5. CROSS-CASE ANALYSIS, DISCUSSION & FURTHER RESEARCH

General innovation process studies (Verloop, 2004; Hansen and Birkinshaw, 2007; Bessant and Davies, 2007; Tidd and Bessant, 2009; da Mota Pedrosa et al., 2015) showed large resemblance with each other in terms of included phases. The studies, (especially Hansen and Birkinshaw, 2007; Bessant and Davies, 2007; Tidd and Bessant, 2009) focused a lot on how to select between ideas and solutions, indicating the need for managing a large volume of innovative ideas. Furthermore general innovation process studies encourage involving other actors in especially the idea generation, selection of ideas and concept development phases (Verloop, 2004). Actors seem mainly to contribute with knowledge and input to the phases. Logistics innovation process studies are few (e.g. Flint et al., 2005; da Mota Pedrosa et al., 2015). Looking at the phases suggested, they do not differ much from general innovation processes. We see nothing “logistics-related” or “flow-related” in those phases. The focus on selection
between ideas and solutions are not mentioned, possibly indicating that the volume of innovations is lower. We see a clearer focus on managing knowledge (Chapman et al., 2003) and learning (Isaksson, 2014). When it comes to actors involved, we see a larger inter-organizational scope, mentioning the importance of involving suppliers (Su et al., 2011) and customers (Flint et al., 2005; Flint et al., 2008). The few sustainable innovation process studies found (e.g. Hockerts and Morsing, 2008; Rossi et al., 2013; de Medeiros et al., 2014; Roscoe et al., 2016) did not describe any particular phases. The large difference as compared to e.g. logistics innovation process studies is to base selections (of ideas or solutions) on a triple bottom line (3BL) approach, bringing in not only the firm’s economic business case but also the social and environmental dimensions. This implies furthermore that other external or societal actors or stakeholders are involved, making the business cases much more complex.

The studied companies described phases with large resemblance with general innovation process literature, see Table 5.1. Their descriptions support the statements of Arlbjørn et al. (2011) and Wagner and Sutter (2012) that innovative firms need to be able to manage innovations. Overall, we found that the SLI processes are described in a sequential and linear way, which supports the findings of Verloop (2004). We have however not identified any process with parallel phases (Verloop, 2004), but we have seen parallel SLI processes on the three organizational levels in LSP1. Parallel actions within the generation of ideas phase (Tidd and Bessant, 2009) and within the reflection and learning phase are commented in each phase described below. On an overall level the empirical data from all our cases support Tidd and Bessant (2009), claiming that the first phases of the process is less linear, complex and with more loops as compared to later phases.

**Table 5.1 Summary of the SLI process phases in the literature vs in the cases**

<table>
<thead>
<tr>
<th>Phases in literature</th>
<th>Phases in the studied cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R1</td>
</tr>
<tr>
<td>Idea generation</td>
<td>Identifying problems</td>
</tr>
<tr>
<td></td>
<td>Brainstorming ideas</td>
</tr>
<tr>
<td>Selection of ideas</td>
<td>Identifying ideas for solutions</td>
</tr>
<tr>
<td>Concept development</td>
<td>Building/capturing knowledge</td>
</tr>
<tr>
<td></td>
<td>Building a business case</td>
</tr>
<tr>
<td>Implementation</td>
<td>Implementing simple solutions</td>
</tr>
<tr>
<td></td>
<td>Continuous improvement</td>
</tr>
<tr>
<td>Learning</td>
<td></td>
</tr>
</tbody>
</table>

**Overall.** Daugherty et al. (2011) put forward the importance of considering the organization’s structure as this plays an important role in supporting the innovation capacity. Their research contradicts previous research, hence both centralized and decentralized structures seem to be positively related to innovation. Our cases do put forward examples of both structures. The
concept-managed R1 is a good example of centralized decision-making, another is LSP2 with their central fund. LSP1 shows examples of decentralized idea generation, while R2 exemplified with decentralization up to a certain amount of investment.

**Idea generation.** In both R1 and R2 we noted a “pre-phase” before the identification of ideas, as they described that their SLI processes started with the identification of a problem. Thus, the ideas are then generated as a response to the problem identified. The reason for this could be that SLIs are more triggered by environmental and/or social problems than general or logistics innovations. We have included this pre-phase in the idea generation phase, supported by Bessant and Davies (2007) as they state that innovation management is about learning to find the most appropriate solution to the problem of consistently managing this process. In line with Tidd and Bessant (2009) we see the idea generation phase to be complex and with many types of input in most cases. One important input into idea generation in all of our cases is the companies’ KPIs showing weaknesses or potentials in the present logistics systems. This points at an important input area often overlooked in the innovation literature (Russo Spena and de Chiara, 2012): the role of performance measurement to support innovation. Russo Spena and de Chiara (2012) mentioned that managing sustainable innovation implies to use sustainability indicators to measure innovation performance. We find KPIs with broader scope than just sustainability indicators (as in LSP2), they are often logistics-related such as fill rates (as in R1). Furthermore the KPIs do not seem to measure innovation performance but rather sustainability or logistics performance. This is an interesting area for further research.

Using the terminology of Hansen and Birkinshaw (2007) we find in-house idea generation (in all cases), cross-pollination idea generation (in R1 and LSP2) and external idea-generation (in all cases). We see signals both from the internal and external context (Bessant and Davies, 2007; Hockerts and Morsing, 2008; de Medeiros et al., 2014). Verloop (2004) presents a number of actors that can generate ideas; we find grassroots/operational employees in all cases, experts in R3 and LSP2, management in R1, R2 and LSP2 and customers in R2 and R3. Our cases add to this list with global sister-companies in R1 and R2. The knowledge acquisition in this phase could be characterized as broadening, using the terminology of da Mota Pedrosa et al. (2015). Flint et al. (2005) and Rossi et al. (2013) have lifted up the involvement of customers, but we see limited such involvement. The customers of our studied companies are seldom the ones that directly generate the ideas, although R2 and LSP2 mention customer involvement. R1 mentions that consumers show little interest in logistics issues, but they try to also communicate logistics to consumers. Despite that Flint et al. (2008) argue that logistics and supply chain managers have important insights into customers’ demands, this is not confirmed by our empirical data. Quite the opposite, even if they are involved in the idea generation phase, they do not have any larger contact with the customers and do not claim to know their needs. Here we would encourage managers to secure that the customers’ interests are better represented in idea generation.

**Selection of ideas** is one of the phases that seem to be less structured and more based on intuition, knowledge and experience of the responsible managers. It is clear who is involved in this phase, but when we interviewed the respondents they were not able to present a clear methodology on how they select ideas. One finding from our cases is that this phase seems to be the most “company introvert” one, not involving information exchange or knowledge acquisition with external actors. For respondents not directly involved in this process (LSP1 and LSP2) this lack of insight generated a bit of mistrust for the selection of ideas phase. This was also related to their organizational level; more operational managers (still managers but not in the management team) seem to perceive less clear phases. However, they did not question the ideas selected. Here it suits to mention a limitation of the study, that just managers are
addressed. We expect lower level employees to perceive even more lack of insight. Already here selection can take 3BL dimensions into account (Verloop, 2004; Roscoe et al., 2016). This is not noted in our cases. We could also see that in all our cases the screening was strict enough, as it did not result in too few or too many ideas, a problem raised by Hansen and Birkinshaw (2007). Selection of ideas is the first phase where selection takes place in the SLI process. The managerial challenge we see here is the need to reflect on the selection criteria applied, and to communicate this to those not directly involved.

**Concept development.** We see this phase to consist of two sub-phases, solutions development and building a business case evaluating those solutions. In order to develop solutions to selected ideas, knowledge needs to be captured from many actors (Chapman et al., 2003). The knowledge acquisition in this phase could be furthermost characterized as broadening, using the terminology of da Mota Pedrosa et al. (2015). The three retailers support the important role of suppliers as put forward by Su et al. (2011) and Roscoe et al. (2016) by pointing at the importance of involving strategical LSPs in the SLI process. However, the role of suppliers is not as evident in the LSPs, here we see a difference between retailers and LSPs. We also see examples of knowledge capturing from other actors such as communities (R1), universities (R1) and automotive manufacturers (also R1). These types of external actors have not been found in the literature review.

One of the most challenging aspects in this phase, put forward by all case companies, is the building of a business case. To gain internal support and the resources needed to develop ideas into practical reality, the project owner needs to show the management team, or in the case of LSP2 the central fund, that the idea is good business also from a 3BL perspective, which is in accordance with Verloop (2004) and Roscoe et al. (2016). The importance of building business cases is also much in line with Tidd and Bessant (2009), however, our cases showed that the need for building business cases was not only depending on how radical the solution was but also the size of investment needed. Furthermore, LSP2 points at one very important aspect to consider here, and that was that the idea was in line with the overall strategical goals of the company. Thus it was not enough to show large economic, environmental and social potentials. If the change was not in line with the company’s overall goals, the idea was rejected funding. This central fund gives an overview, fairness and develops the organization’s ability to identify SLIs with strong business cases, which relates to the findings of Hansen and Birkinshaw (2007) and Russo Spena and de Chiara (2012). Despite that the information exchange also within the company is weak in this phase, it is not resulting in the same “trustworthiness issues” as the lacking information exchange in the selection of ideas phase. The 3BL business case is the second phase where selection can take place.

**Implementation.** This is the phase were our empirical investigation generated least information, the same was true in the literature review. One reason for this is most likely that it is very hard to describe the implementation in general terms, as the methods applied vary largely dependent on the type of concept to be implemented. Some valuable pieces of advice were however captured. R1 stated that it is important to consider who should realize the innovation, and to adjust the implementation to their knowledge degree. R1 has many employees in the store and in the warehouse with limited education and language knowledge. R3 stresses the need to implement very fast, something also R2 mentioned, at least in the smaller scale SLIs. In the case of LSP1, we noted the importance of having good relations with partners where they stand in line to test SLIs.

**Learning.** This phase is not described in all our cases. In accordance with Isaksson (2014) we see a need for better reflection and learning in the process. R1 mentions striving for continuous improvement and follow up. LSP2 has this phase explicit in their SLI process and mentions
feedback loops in the entire process after large projects, from the central fund and revisions annually. But we also note that our case companies discuss the diffusion of SLIs, like up-scaling it to other parts of the organization (in line with Tidd and Bessant, 2009) or exploitation of additional features (in line with da Mota Pedrosa et al., 2015), as a part of learning rather than being a part of implementation. In R1, R2 and LSP2, all successfully implemented SLIs are communicated back centrally and if they see potentials for up-scaling in sister-companies, they can develop this into one of the new concepts that all companies within the group need to follow. Also note that this exists in the larger organizations studied. As we found fairly few of such examples, could this be due to that SLIs are new and that there is not yet time for a “next generation”? Further research is needed in order to answer why this not yet has taken place. We have seen several examples on enabling increased learning by documenting and spreading successful SLIs, to make it possible to find the right persons to consult for other employees. But we have not found a lot of knowledge on how to improve the SLI process. This is another managerial challenge we see that needs further research; to find models and tools to capture such experiences and to disseminate this body of knowledge.

Based on our empirical findings, we suggest a framework, as presented in Table 5.2. The SLI process is taking place in a logistics context, in activities such as purchasing, warehousing, transport and reverse logistics. We suggest six phases, where concept development from theory is split up in solutions development and 3BL business case. We have also moved spreading of SLIs to the learning phase. The last phase, learning, can imply to “close the loop” on how the first phase, idea generation, can be handled. Each phase is characterized by what we found in the cases, and as we saw large differences in actors involved between the phases, we comment if actors involved are internal, external or both. We see that the SLI process goes in waves between being broad/external and narrow/internal.

Table 5.2 A framework for the sustainable logistics innovation process

<table>
<thead>
<tr>
<th>Phase</th>
<th>Characteristics</th>
<th>Actors involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLI idea generation</td>
<td>Identification of sustainability problems, KPIs showing sustainability and logistics performance, knowledge acquisition by broadening knowledge</td>
<td>Internal and external/employees, management, suggestions, experts and sometimes customers</td>
</tr>
<tr>
<td>Selection of ideas</td>
<td>Unstructured and experience-based phase, no 3BL evaluation in this first selection</td>
<td>Internal, managerial, closed</td>
</tr>
<tr>
<td>Solutions development</td>
<td>Knowledge acquisition by deepening knowledge</td>
<td>Internal and external/from (LSP) suppliers, universities, municipalities</td>
</tr>
<tr>
<td>3BL business case</td>
<td>Evaluation/quantifying in 3BL dimensions in the second selection, hence external actors are addressed (but not involved)</td>
<td>Internal, closed</td>
</tr>
<tr>
<td>Implementation</td>
<td>Methods described vary largely, adapt to the organization</td>
<td>Internal</td>
</tr>
<tr>
<td>Learning</td>
<td>Spreading the SLI within the company, reflecting on the SLI process</td>
<td>Internal and external/to sister-companies</td>
</tr>
</tbody>
</table>
6. CONCLUSIONS, CONTRIBUTIONS AND LIMITATIONS

The purpose of this paper was to explore how the SLI process is managed by some retailers and LSPs, in order to suggest a framework for describing and analysing the SLI process. By describing five case companies’ SLI processes and relating them to literature, a framework for the SLI process was developed. It included six phases – idea generation, selection of ideas, solutions development, 3BL business case, implementation and learning. Each phase was characterized and the actors involved were described. Despite that all case companies were successful in implementing SLIs, differences were found in the phases applied, between centralized/decentralized firms and smaller/larger firms. Differences in actors involved were found between retailers and LSPs, such as the retailers’ involvement with LSP suppliers. Thus there is not “one correct way” to manage SLI successfully. This multiple-case study was conducted to learn something from particular cases. Such results could be analytically generalized to theory, and the theory could later be tested by replication (Yin, 2014). This can be seen as the first step in theory-building, as called for by Touboulic and Walker (2015), as the framework should be further refined and validated in broader studies.

This study has theoretical implications, as it addresses the lack of empirically based research in logistics innovation, as stated by Arlbjørn et al. (2011). It brings together knowledge on sustainable innovation and logistics innovation into a framework for the SLI process. We want to especially lift up the following empirical findings that do add insights that was not present in the literature; the frequent idea generation from KPIs, retailers’ use of LSPs as knowledge providers, the use of other actors such as communities and universities in concept development, the use of 3BL business cases and the limited knowledge transfer back to the SLI process which signals a need for models and tools. The framework can be applied to structure and understand SLI processes, and to identify improvement potentials. Both in the overall process and in each phase, managerial implications and challenges are found, such as the limited customer involvement in idea generation and the often closed way of selecting ideas showing the need for a larger openness. As all companies are identified have presented several SLIs, managers can get inspiration by studying how the SLI process is managed in these companies.

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ASSESSING RESEARCH ON INTELLIGENT TRANSPORT SYSTEMS FOR ROAD FREIGHT TRANSPORT FROM THE VIEWPOINT OF DIFFERENT STAKEHOLDERS

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ABSTRACT

Purpose
The goal of this paper is to present an overview of academic research in the field of road freight related intelligent transport systems (ITS) as well as a critical reflection on these identified research findings from the perspective of different user groups.

Design/methodology/approach
We conducted a well-defined literature-based content analysis in three academic article databases (EBSCO, Emeraldinsight, Sciencedirect) and identified a sample of 21 academic journal articles. These articles were further examined from three different perspectives: research field, research method and stakeholder perspective.

Findings
Within the sample ITS for road freight transport research deals with fleet management, advanced vehicle control systems (AVCS), toll collection, systems architecture and city logistics. Research in this area is multi-disciplinary and research methods are mainly backwards oriented. In contrast to applied research results, the identified academic papers do not consider different stakeholders a lot.

Research limitations/implications
Our literature search focused on academic literature only and did not include practitioner-oriented literature.

Original/value
This paper provides a first overview as well as a discussion on existing academic literature on ITS for road freight transport.

Keywords: Intelligent Transport Systems (ITS); Road Freight Transport; Telematics
1. INTRODUCTION

1.1. Problem Background and Research Gap

Intelligent Transport Systems (ITS) refer to information and communication technology applications in the field of transport and is considered as one of the most important issues within the transport sector (Giannopoulos et al., 2012).

Within the European Union, the European Commission (Commission of the European Communities, 2008, pp. 7) published an action plan for the deployment of ITS in Europe and presented six action areas referring to the optimal use of road, traffic and travel data, continuity of traffic and freight management ITS services on European transport corridors and in conurbations, road safety and security, integration of the vehicle into the transport infrastructure, data security and protection, and liability issues and European ITS cooperation and coordination.

Taking this into consideration, ITS offer a wide field of application as Giannopoulos et al. (2012) discuss by introducing the following eight areas of ITS application: 1) traffic and travel information, 2) traffic and public transport management, 3) navigation services, 4) smart ticketing and fee collection, 5) transport safety and security, 6) freight transport and logistics (incl. urban logistics), intelligent mobility and co-modality services, environmental and energy efficiency (including electro mobility).

These areas consider both sides of the transport sector, private as well as commercial. This also includes the vision for providing for all actors in a traffic system the provision of data and information which ensure an increased mobility, safety and security. It is though interesting to see that Giannopoulos et al. (2012) identify freight transport and logistics, and here probably road freight transport, as one particular field of ITS application. This is the starting point for our research as we are particularly interested in ITS which enables improved fleet management, efficient management of freight transports on the road, an improved utilisation of ICT along the supply chain (‘e-freight’), hazardous goods control as well as automated process execution at toll, parking and loading/unloading stations (Commission of the European Communities, 2008; Giannopoulos et al., 2012).

ITS represent a thought-provoking possibility to eliminate certain problematic issues that freight road traffic is currently facing. If we take a look at the road network of many countries and cities around the world, we can observe that it is at its limit. Taking the example of Germany, 3.2 million new vehicles are registered on average every year since 1990 (Statista, 2016). As road infrastructure has not developed in the same pace, it is no surprise that there is heavy and congested traffic. Furthermore we can observe especially in urban structures a change in the delivery cycles of grocery and other retail branches towards increasing JIT-deliveries which also affect heavily the traffic situation (Crainic et al., 2009). The further developments of e-commerce and the liberalisation of freight transports are also leading to an increasing traffic situation on inner and outer city roads.

Especially an expansion of the inner-city road infrastructure is not possible in many cities as there are many structural limitations to be considered. Therefore it is important to introduce other systems which allow a more efficient and improved use of the given road capacity. Current developments of such systems refer to Intelligent Transport Systems (ITS) or telematics which are defined by Müller (2012) as process of data collection, processing and output which achieves goals by using sensor, information and communication technology and mathematical models.
As ITS also allow autonomous decision making on a vehicle basis, it is important to know how different user groups of a transport chain accept ITS and its consequences. ITS are able to set up a comprehensive dynamic network of vehicles or transport orders considering all components that are necessary to allow a suitable distribution of resources under given restrictions (Kapsalis et al., 2010).

Besides the many possibilities that ITS allow for traffic optimisation, we can also observe a lot of different actors who are taking an active role within transport and traffic networks. These actors refer to those public authorities who are responsible for setting up traffic rules and other regulations, traffic control centres, who are executing and controlling a traffic system as well as system providers, transport companies as well as professional truck drivers and the senders and receivers of freight (Bäumler, 2015).

Despite this large stakeholder group, literature has not yet dealt with their issues. When it comes to ITS for road freight transport, the discussion is focused on the perspective of the transport company. Cost aspects are discussed mainly isolated not considering the positive effects for senders and receivers of freight who have the main benefit of a faster and more efficient utilization of road infrastructure (Ehmke et al., 2012; Zeimpekis et al., 2005).

1.2. Research Questions and methodological approach

The purpose of this paper is to give a current overview of research within the area of ITS by answering the following two research questions:

- What are the topical areas within the research domain of ITS for freight road transport?
- Are there any different actors views taken into consideration in order to evaluate ITS solutions?

In order to answer our research questions we perform a content-based literature review as suggested by Seuring and Müller (2008) and Seuring and Gold (2012) who mainly refer to Mayring (2010). The major idea of our endeavour is to identify a map of research topics and their methodological foundation within the research domain of ITS. According to Seuring and Müller (2008) this approach allows the identification of currently observed research problems as well as the crystallisation of new research fields and problems. This is done by executing a literature-based content analysis which contains four steps:

1. Collection of material based on defined criteria and search terms
2. Descriptive Analysis and condensation of identified work based on formal criteria (author, year, theme, etc.)
3. Structuring of the results of the descriptive analysis in relation to the research goal
4. Analysis of the generated data in dependence of identified dimensions/categories

In regards to steps 1 and 2 we performed our literature search and descriptive analysis by searching within the data bases sciencedirect.com, ebscohost.com, emeraldinsight.com after combining the search terms “intelligent transport* system*, telematic* and freight road transport*” in title, abstract and key words. We were able to find a gross sample of 162 papers, which we reduced in regards to our further evaluation purpose (see section 3.1) to a net sample of 21 academic journal papers.

We also searched via Google Scholar in order to validate the results of our approach. However, Google Scholar does not allow such a detailed search as scientific databases are offering. Furthermore, as Google Scholars search algorithm is continuously updated, it is difficult to guarantee a reliable and objective search result. Google scholar is also not allowing a search
with normed scientific terms (Mönnich, 2013, pp. 146). While we identified a search result of over 1 million hits for ITS, the combination with „freight road traffic“ led to a significant reduction to 76 hits, and not all of them were relevant for our purpose. Considering these problematic issues we remained with our original search strategy. Regarding steps 3 and 4 we followed Sussman (2008) and FIS (2016) for identifying the application range of the categories.

1.3. Structure of the paper

The paper is structured as follows: After having introduced the problem background and the research questions, we are going to show the components of ITS. This is followed by the presentation of the methodological approach of our content-based literature review. Based on the results of our literature review we present topical areas as well as their evaluation. Afterwards these results are critically assessed and discussed from the perspective of our research questions. The paper closes with an answer to our research questions, a critical reflection of our results and an outlook for future research.

2. FUNDAMENTALS ON ITS AND METHODOLOGY

2.1. Defining ITS and telematics

Any ITS consists of several system components including a communication infrastructure, a service provider, positioning systems, end user devices and systems for external information provision (Sussman, 2008).

Global navigation satellite systems (GNSS) are a fundamental part of ITS as they allow positioning while the vehicle moves. At least four satellites are required for exact positioning for route navigation (Evers, 1998). The most prominent GNSS are the US-American GPS and the Russian GLONASS. Communication systems refer to mono-directional and bi-directional communication networks based on radio, mobile and satellite frequency. Furthermore, telematics standards include Open Service Gateway initiative Alliance (OSGi Alliance), The Motor Industry Software Reliability Association (MISRA), open systems and their interfaces for electronics inside motor vehicles in cooperation with the Vehicle Distributed Executive (OSEK/VDX), and ERTICO-ITS Europe.

Other technologies are also relevant depending on the application area. This includes on-board-units for toll collection, geo information systems, electrical odometers, automatic recognition of license plates, dedicated short range communication or chip cards. When it comes to ITS-driven parking management, other technologies are required such as internet capable end user devices or camera detectors in rest facilities on motor highways which are used to transmit free parking facilities for trucks.
2.2. Current developments in and applications of ITS for road freight transport in Germany, Switzerland and Austria

So far, we were able to identify in Germany, Switzerland and Austria some implemented ITS solutions which refer to fleet management, truck parking management, systems for searching and reserving of parking space, compact parking, toll systems and city-logistics concepts as well as load performance-based heavy load traffic fees.

Fleet management

Evers (1998) presents SKEYE Fleet as a complete fleet management system including positioning of the fleet with geographic information systems and a transmission of orders and messages between a central unit and a driver as well as theft protection. A more recent application is couplinkyourfleet by Couplink Group AG (2016) who offer different solutions for various transport areas such as logistics service providers or disposal companies. Here, a central unit capturers orders at loading and unloading stations by an existing transport software and makes arrangements for the vehicles. The transmission of data to an end device within the respective vehicle is done automatically via interfaces.

Truck parking management

EU regulation 561/2006 is regulating driving times, breaks and rest periods which drivers of freight or passenger vehicles are required to take. As a consequence road infrastructure has to consider enough parking space for vehicles. A study by BMVI (2011) shows that every fourth truck driver is not able to find an adequate parking space on German motor highways and other roads. In order to find parking space, Secure European Truck Park Operational Services (SETPOS) developed the internet-based system Truckinform which is an international reservation platform for truck parking lots. The system is currently based on the three levels of information (registration of parking lots – at the moment 2,500 registered truck parking lots in 40 European countries), navigation (for directing a truck to the respective parking lot) and reservation (Bundeministerium für Verkehr und digitale Infrastruktur, 2011). Bäumler (2015) identified other German and/or European systems for parking management including Highway-Park, System-Parken, Trucker-Jack, Truckparking-Europe, TruckYa!, Prepark or ParkMyTruck. Some of these systems are internet-based and some of them run as application
on smart phones. Especially app-based systems can be used by the users for providing additional information on current parking lot information, navigation as well as reserve options.

Compact parking

Kleine and Lehmann (2014) describe the system of compact parking as another efficient way for truck parking management, which is based on the principle of convoy parking. However, contrary to convoy parking where the vehicle is assigned to a parking lot based on the predetermined information about its sizes, a driver is autonomously deciding upon the parking lane in case of compact parking. Within Germany, compact parking is practiced at the parking area Jura-West on the German Motorway A3. There, 35 parking lanes are equipped with a variable display board as well as with a parking area detector per parking lane. Compact parking is seen as an efficient short-term and quick solution for increasing parking capacities.

City Logistics

ITS can also be used for improving the situation of inner-city freight transports. Since 2001, Dresden is using the CarGo-Tram as a mean for ‘feeding’ the Volkswagen-factory with a 60m long tram that is capable to transport 60 t of goods. The tram is using the existing track-system of public tram system. The project Kurs Expo-Region developed a computer-based truck guidance system for the German city of Nienburg and other participating cities. In Nienburg, the federal roads B6, B209, B214 and B215 are crossing and there are motorway connections to the A2, A7 and A27. So far, some freight transports need to go through the city of Nienburg as not all federal roads are bypassing the city which led to an increasing pollution and noise emission. The system foresees priority switching for trucks when approaching red lights which reduces or even avoids energy-intensive de- and acceleration drives. This leads also to a reduction of gasoline for the vehicles (Wirtschaftsverkehr in Ballungsräumen, 2016).

Toll systems

The state as main infrastructure provider requires budgets for maintaining, renewing as well as modernizing its road networks. In Austria, Germany and Switzerland, truck-based traffic is required to pay tolls depending on the distance, number of axes, weight and even emission class of the vehicle (Toll-Collect, 2016a). The German Toll-Collect system works with an OBU which is installed in the driver cabin. The OBU includes a GNSS-receiver, a digital map, a GSM module and a Dedicated Short Range Communications (DSRC)-module. The OBU determines the current position of the vehicle, the actual travelled distance as well as the respective fee. GNSS and DSCR allow compatibility with other foreign systems (Toll-Collect, 2016b). The Austrian GoMaut system is based on the transmission of vehicle-relevant data from the driver cabin towards toll bridges via DSRC. The communication is executed with an OBU which every vehicle with more than 3.5 t weight is obliged to have. While Austria and Germany collect tolls for motorways only, Swiss authorities charge vehicles with a weight from 3.5 t for the utilization of the total road network based on the current usage. The OBU is connected with the speedometer so that a special odometer is not required. GPS-antenna is needed for the positioning of the vehicle (Eidgenössische Zollverwaltung, 2013).
3. IDENTIFICATION AND EVALUATION OF LITERATURE FOR ITS

3.1. Structuring the identified research on ITS for road freight transport

We examined the content of our identified papers in three ways. First, we looked at the content from the perspective of ITS in order to identify the various application areas of ITS. Second, we discuss the research domain from a stakeholder perspective as there are different user groups who are relevant for ITS. Third, we propose a differentiation of the identified results based on the method that was used in those papers.

For structuring the results of our literature search from an ITS point of view, we use the proposal of Sussman, (2008) who suggests the following six categories: Advanced Traffic Management Systems (ATMS), Advanced Traveller Information Systems (ATIS), Advanced Vehicle Control System (AVCS), Commercial Vehicle Operations (CVO), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).

Especially AVCS as well as CVO-systems are of special relevance for freight road transport as these systems help a driver to keep control over the vehicle as well as allow improvements of productivity and security of the vehicle while operated.

Another possibility for structuring the application areas of ITS is suggested by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) who distinguish between passenger and freight transport (Michler, 2015). When it comes to road freight transport, BMVI differs ITS as follows: fleet management, toll collection and control, cargo monitoring, emergency and incident management systems in case of accidents or interruptions, control of public traffic systems, provision of traffic information surveillance of hazardous goods and heavy load transports and traffic management systems and technology for control and regulation.

The intersection of these two categorization possibilities shows that fleet management as well as AVCS may take the most important role for ITS for road freight transport. Maurer (2012) differs thereby between conventional driver assistance systems and those with machining recognition. The first group helps a driver to control the vehicle through provision of some performance indicators that are easy to measure, i.e. anti-lock braking system, tire pressure monitoring. The second group includes systems with a capability to autonomously interpreting the data. Such systems are known as Advanced Vehicle Control Systems and assist a driver by defined values to manage difficult traffic situations or negligence, i.e. emergency braking systems, lane assistance, recognition of crosswise driving or driver fatigue.

ITS are systems which generate new capacities within given infrastructures by telematics. The generated benefits depend on the user group of ITS. From a system-architecture point of view it is interesting to see the huge variety of different data structures which are encountered, i.e. data on traffic, weather, numerical as well as image data, which all contain different degrees of information. Data is provided by different databases of various system providers with different system components. Therefore compatibility is required (Behere et al., 2013; Santa et al., 2012).

Freight road transport is not only occurring on motor highways, but also in within the cities. The way in which inner-city deliveries are processed has emerged to a large task. Especially concepts such as city logistics are helping here to deal with the problems of this type of traffic. The goals of city logistics are to reduce the share of inner-city freight road transport, accelerate heavy load transport and to reduce emissions, i.e. air pollution and noise. This will then lead to an improvement of the living conditions for the urban population (Crainic et al., 2009).
However, what are the benefits for other stakeholders such as shippers, customers or transport companies? These actors can also gain advantages as their logistics processes can be improved and optimized by the provision of current data on traffic and weather conditions as well as on the condition of the cargo. A continuous control of the freight road transports also improve the short- und long term planning processes, flexibility and provide savings potentials through reductions in inventory as well as through less transport efforts. Status messages on the current position of a vehicle along with departure times, connections and waiting times allow logistics service providers and transport companies to offer a higher service quality. In case of an accident, rescue tasks can be better executed because of transmission of truck-related position information to the rescue control centre. If a hazardous goods transport has a problem the correct tools for cargo recovery can be provided because of immediate transmission of real-time data (Zajicek and Schechtner, 2005).

Taking these issues into consideration, we propose the following dimensions in order to evaluate and assess our literature base: a) research field including: fleet management, AVCS, toll collection, systems architecture and city logistics; b) research method including: quantitative primary research, qualitative primary research, quantitative secondary research, qualitative secondary research, modelling and triangulation (multi-method); c) stakeholder perspective including: transport company, professional driver, traffic control centre, shipper and receiver, public authorities and systems provider.

Out of these three components, ‘research field’ is the eliminating one, which is used to identify and to assess the literature. When it comes to ‘research method’ it is important to note that ITS is discussed from a managerial as well as from an engineering point of view. The stakeholder perspective was chosen to identify the perspectives of various actors within a transport system and to critically assess the research domain.

3.2. Current research in ITS for road freight transport

3.2.1. General findings

Our literature search revealed 21 papers that were published within the period from 1996 to 2015 which are listed in Table 3.1. The majority of these papers were published during the past six years.

When it comes to the examined ITS-topics we can observe a dominance of fleet management. Equally prominent are the research topics AVCS, city logistics and systems architecture. Many papers are discussing multiple topics as Table 3.1 shows. From a time line point of view, fleet management is present up until 2012. However, since 2013, the importance of fleet management seems to be decreasing as only 2 papers were dealing with this topic. We were not able to identify a clear research strategy or line when it comes to AVCS, city logistics and systems architecture in terms of increasing/decreasing numbers of publications during this time period. Three of the 21 papers were published in conference proceedings, the remaining 18 papers were published in the Journal of Transportation research (n=3), Procedia – Social and Behavioural Sciences (n=2) and the International Journal of Physical Distribution and Logistics Management (n=2). The other ten papers were published in different ten journals such as Journal of Systems Architecture, Journal of Transport Geography or International Journal of Production Economics.
Table 3.1 Research matrix: ITS for freight road transport

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Research field*</th>
<th>Research method**</th>
<th>Stakeholder perspective***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson et al. (1996)</td>
<td>1</td>
<td>1</td>
<td>1,4</td>
</tr>
<tr>
<td>Nijkamp and Pepping (1996)</td>
<td>1,3</td>
<td>6</td>
<td>1,2,5</td>
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<tr>
<td>Zambou et al. (2003)</td>
<td>2</td>
<td>5</td>
<td>7</td>
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<tr>
<td>Léonardi and Baumgartner (2004)</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Zajicek and Schechtner (2005)</td>
<td>1,2</td>
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<td>7</td>
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<tr>
<td>Zeimpekis et al. (2005)</td>
<td>1,3,5</td>
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<tr>
<td>Zeimpekis and Giaglis (2006)</td>
<td>3,5</td>
<td>6</td>
<td>2,4</td>
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<tr>
<td>Baumgartner et al. (2008)</td>
<td>1,2</td>
<td>2</td>
<td>1,6</td>
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<tr>
<td>Crainic et al. (2009)</td>
<td>1,2,3</td>
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<tr>
<td>Kapsalis et al. (2010)</td>
<td>1,5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Ehmke and Mattfeld (2011)</td>
<td>3</td>
<td>5,2</td>
<td>1</td>
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<tr>
<td>Ehmke et al. (2012)</td>
<td>1,3</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Iseki and Demisch (2012)</td>
<td>2,4</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Mbiydzenyuy et al. (2012)</td>
<td>5</td>
<td>5</td>
<td>1,5,6</td>
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<tr>
<td>Santa et al. (2012)</td>
<td>1,2,5</td>
<td>5</td>
<td>7</td>
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<tr>
<td>Behere et al. (2013)</td>
<td>2,5</td>
<td>6</td>
<td>7</td>
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<tr>
<td>Alam et al. (2014)</td>
<td>2</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Malecki et al. (2014)</td>
<td>1,3</td>
<td>2</td>
<td>1,5</td>
</tr>
<tr>
<td>Walker and Manson (2014)</td>
<td>3</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Hsu et al. (2015)</td>
<td>2,5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Pascale et al. (2015)</td>
<td>1</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

Legend:
* 1 = fleet management, 2 = AVCS, 3 = city logistics, 4 = toll, 5 = system architecture
** 1 = quantitative primary research, 2 = qualitative primary research, 3 = quantitative secondary research, 4 = qualitative secondary research, 5 = modelling, 6 = triangulation (multi-method)
*** 1 = transport company, 2 = professional driver, 3 = traffic control centre, 4 = shipper and receiver, 5 = public authorities, 6 = systems provider, 7 = not mentioned

3.2.2. Fleet management as single research topic

Research in this area found out that it is advantageous to have a direct line between a central unit and a driver which has been already recognized by Anderson et al. (1996). They show in their paper which advantages fleet management has as compared to having a direct line by using mobile communication. They also have shown that the investment into satellite communication technology has a decent ROI but is still recommendable thus it offers high benefits for fleet management. Léonardi and Baumgartner (2004) examined the ecological effect of ITS technology and how the driving performance per kg/CO₂ may change if fleet management is applied. Their findings show ITS were rather inadequately used which led to a poor cost/value
relation. They further identified that ITS-based route planning or the use of transmission technology for communication, positioning and navigation can help to reduce CO$_2$ emissions.

Pascale et al. (2015) analyzed the relationship between truck velocity and anomalies of traffic on motor highways. Using ITS should lead to a better vehicle scheduling or to a more efficient route planning of vehicle fleets. Their results show that floating-car-data is a better or at least equal predictor of current traffic situations than stationary traffic observation tools.

### 3.2.3. Fleet management as combined research topic

Nijkamp and Pepping (1996) examined the potential of ITS for the transport sector and its acceptance amongst public and commercial users. Based on the results of two case studies, they identified high expectations of the user groups toward the technology. At this time, transportation companies expected ITS to be a source of competitive advantage. Public authorities saw the advantages for traffic safety and efficiency. They also found out that the success of ITS depends on the acceptance of public user groups.

Zajicek and Schechtner (2005) presented in their paper an ITS for nationwide control of hazardous goods and heavy load transport. The presented system is based on a simple system architecture which also allows a cross-border application. The system requires a database for recording the type of transported hazardous goods and heavy load as well as a capable expert system for processing and integrating all required information. Zeimpekis et al. (2005) looked at dynamic fleet management systems for urban traffic. They examined typical parameters of urban traffic for making the system able to react on unexpected disturbances in real-time. This should improve the delivery of logistics service providers. The system reacts dynamically in three steps on disturbances. Baumgartner et al. (2008) examined the effects of IT-assisted route planning and scheduling as well as ITS on emission reductions. They found out that the combination of an IT-assisted route scheduling and the display of this information in the driver cabin as well as the semi-automated optimization of route planning with the display of utilization of the loading space are highly relevant for reducing CO$_2$ emissions.

Crainic et al. (2009) focused in their work on commercial vehicle operations (CVO), fleet management, city logistics and e-commerce. They examined the main problem areas, technical hindrances as well as critical success factors. The use of improved processing software that provides improved decision support significantly improves the performance of ITS. This is why an intelligent processing of existing data as well as the development of further ITS is of relevance for further research. A rule-based fleet management in combination with an event-control-action module was the focus of Kapsalis et al. (2010). This suggestion enables transparent fleet management, tracking and tracing as well as safety freight transport. The rules implemented in the module help to automatically react on certain events which improves the work of the fleet management central unit. Santa et al. (2012) examined the relation between IT and vehicle electronics and the potential to improve the performance of a total transport chain. They identify a lack of specific system architecture which allows the collaboration of many different vehicle technologies. In their work they present such an architecture which was then proven in an agricultural context with daily transports.

Ehmke et al. (2012) looked at planning systems for delivery routes and found out that most of the existing solutions work with an average delivery velocity and do not consider time of the day depending velocities. In their paper, they develop such a solution which includes fluctuating traffic intensities and showed how this application can improve delivery performances. Malecki et al. (2014) researched on the importance of ITS on the reduction of negative environmental impact factors by examining the urban traffic of a Polish city. The use of ITS in combination
of mobile decision support systems has led to improved results for route planning and navigation thus leading to a significant reduction of CO₂ emissions.

### 3.2.4. AVCS as single research topic

Zambou et al. (2003) developed in their paper a circuit structure based system on the data of all participants’ condition of a vehicle convoy which allows a fuel-efficient driving of vehicles driving in convoys with minimal gap between the vehicles. Such driving is known as collaborative adaptive cruise control (CACC). The results of their simulations show that longitudinal dynamic control of a vehicle convoy leads to a better stability of the vehicles in the convoy thus reducing the negative effects for the environment. Alam et al. (2014) thus examined driver assistance systems and their safety aspects. In their paper they suggest a system which is based on radar information and wireless communication. Their results show that a minimal vehicle gap of 2 meters was realized at worst transmission velocity of 500 thousand of a second.

### 3.2.5. AVCS as combined research topic

Iseki and Demisch (2012) looked at toll systems and the possibilities of toll collection, in particular how geographic reach and the complex toll calculation affects the use of ITS for toll collection. They found out that an automatic tolling shall be preferred instead of a manual process due to the flexibility in the automatic process. Behere et al. (2013) thus examined cooperative driver assistance systems and their systems architecture. They were interested in the required functions which enable the integrity of different system elements. They suggest a reference architecture that was tested in a commercial setting showing that such reference architecture decreases the time-to-market phase of system providers. Hsu et al. (2015) dealt with reference architecture for cloud-based ITS. Their solution includes software as well as hardware and potential services. The main ideas refer to environmental-safe driving depending on vehicle condition, traffic situation and driving behavior.

### 3.2.6. City logistics as single research topic

Ehmke and Mattfeld (2012) examined last-mile delivery from the perspective of optimal route planning based on ITS technology. They present an optimization model which allows time-dependent route planning on the bases of floating-car-data. Walker and Manson (2014) are interested to identify how ITS can support efficient decision making based on road infrastructure. The results of their work show that road infrastructure (linear, grid, radial, tributary) has a significant impact on the cost/value benefit of such ITS-based decision support systems. However, they were also able to show that in some circumstances best results could be achieved even without ITS-support.

### 3.2.7. Systems architecture as single and combined research topic with city logistics

Zeimpekis und Giaglis (2006) presented the critical success factors for using ITS from a small and medium enterprise perspective. In their work they assessed the demand of transport companies for dynamic vehicle management. Based on the results of their empirical investigation, they developed an innovative vehicle management system that is based on real-time data as well as historical traffic data for decision support which can help to reduce delivery risks. Mbiydzenyuy et al. (2012) examined system architecture of ITS and showed how the system costs are influenced by the various services such systems may offer. They provide an optimization model that helps to select the appropriate system components.
4. DISCUSSION & CONCLUSION

In our paper we wanted to identify topical areas within the research on ITS for road freight transport as well as see whether research has been done from the perspective of different actors. In the previous section, we have provided an overview for research in the field of ITS for road freight transport.

Taking our first research question, we recognised that research on ITS is multidisciplinary as research has been done from a managerial/economics, technological as well as engineering perspective. From a methodological point of view modelling and empirical research is dominating. Around a third of all papers document a multi-method approach. Especially when it comes to the appropriate systems architecture for specific ITS solutions, research shows that reference architecture seems to be relevant not only for the ITS system but also for the offered services (Hsu et al., 2015, Mbiydzenyuy et al., 2012). Most of the research effort is done so far in the field of fleet management. The focus thereby is on how to increase the efficiency and productivity of a fleet and how to react to current disturbances in a dynamic way. The use of fleet management for city logistics issues is another research domain of particular interest as inner-city traffic is not only a driver for cost but also a negative factor for environment. Especially with an increasing importance of last-mile deliveries due to e-commerce, urban traffic is expected to be even more disturbed by unpredictable factors (Pascale et al. 2015, Zeimpekis et al., 2005). Interestingly enough we were not able to observe a lot of research attention for the relationship between road infrastructure and ITS. Only the paper by Iseki and Demisch (2012) discussed this issue. Walker and Manson (2014) showed that the appropriate use of ITS may also depend on the pattern of road infrastructure. Overall, fleet management applications were discussed from the point of view of complete vehicle fleets, traffic situations as well as constructional urban activities.

Another topical area is AVCS as these are key for the realization of efficiency and productivity goals as they allow the integration of given data and real objects through processing mechanisms. This refers to drive in convoys, automatic (dynamic) identification of new routes in case of disturbances, automated payment processing while driving on tolled roads or communication with infrastructure objects. Research on toll systems seems to be covered quite well from a technical point of view. When it comes to a discussion from a different user group perspective we were able to see some deficits. Especially the beneficiaries of such systems or shippers and receivers are hardly involved in the development processes. When it comes to the second research question, we observe that the discussion of ITS research is rarely done from a different user point of view. Most of the papers discuss the specific ITS application in general and present some advantages. Only 5 out of 21 papers present the discussion from a single actor’s point of view. Only the papers by Nijkamp and Pepping (1996) and Mbiydzenyuy et al. (2012) present a multi-actor perspective in their discussions. The majority of the papers are neglecting a user-group perspective which is unfortunate as a multi-actor perspective increases the detection of factors that increase the acceptance for ITS, which Nijkamp and Pepping (1996) found out quite early.

Other research deficits refer to methodological considerations as all results are based on backwards oriented observations and/or surveys were respondents were asked on their past experiences with ITS. Nearly all papers look at a current situation and present some heuristics for improving this situation or look at a given system architecture and its improvement areas.

A limitation of our work refers to the lack of analysing the results of applied research or business practice in this field. Thereby we can see that enormous efforts are made. We can take the collaboration ERTICO - ITS Europe which consists of companies and institutions that are
involved in the production of ITS (“ERTICO - ITS Europe”, 2016). ERTICO is working in the four areas of cooperative mobility, eco mobility, safe mobility and info mobility (Rafiq et al., 2013). Another example for applied research in this area is the ITS World Congress that was held in Bordeaux in 2015. There, ITS solutions for private as well as commercial transport were presented and discussed. The topics ranged from difficulties of implementing a common ITS platform, to ITS for the service sector, intelligent systems for inter- and multi-modal transport, urban logistics and autonomous driving. The conference proceedings also show that the actors perspective plays a role there as well as safety issues for traffic participants (ITS World Congress, 2016). For the continuation of our work, we need to incorporate also results of applied research in our assessment.

In addition we propose for future research a more forward-looking methodology, e.g. Delphi-approach, which helps to examine the possible development of this very progressing technological field. Based on the notions of von der Gracht and Darkow (2010) this may allow the development of application scenarios too. In addition, we propose to include different actors in such Delphi expert groups in order to identify an actors view, which is lacking so far in this research area.

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ABSTRACT

This paper presents an evaluation model of CO₂ and cost saving potentials, which could be realized by early supplier integration. By analyzing several factors, this paper explores how CO₂ emissions and cost effects are realized by cast development partnerships. Based on the results of the analysis presented, an estimation model to forecast the CO₂ emissions and cost effects of early supplier involvement is shown. Finally, the paper presents a multiple case study analysis, covering forty-one cast product development projects of one German iron foundry which were realized together with twenty-seven different customers.

Keywords: Carbon footprint, early supplier integration, early supplier involvement, development partnerships, foundry value chain

1. INTRODUCTION

In the context of ecology and environmental friendliness, there is a growing focus on emissions of carbon dioxide (CO₂), which is by far the most important of the greenhouse gases. This
trend can also be seen in the foundry industry. There is growing customer demand for "ecological castings", or at least for products whose CO₂ footprints have been measured and published and are therefore comparable. Foundries are, among other things, known for their high rates of recycling (e.g. 90% of cast parts are produced from melting down scrap metal) (Sturm 2011). However, the melting process requires a considerable energy input. Hence, the foundry industry has the highest energy costs by percentage of total costs of all metal processing sectors. That is why energy efficiency in the foundry industry (in the casting process) has for decades been a subject of debate and discussion (see for example Lownie 1978; Herfurth 1989; Ketscher & Herfurth 1997; Huppertz 2000 and Wagner & Enzler 2006). For cast products, the focus has been on achieving energy savings by assessing and optimising casting processes rather than on potential improvements centred on the casting itself (Huppertz 2000; Kuchenbuch 2006; Institute of Foundry Technology 2013).

A number of methods have been developed over the years for assessing, selecting and involving suppliers in the product development process (e.g. Ellram 1987; Kamath & Liker 1994; Peter 1996; Petersen et al. 2005; Kirst 2008 and John 2010). These methods consider factors such as project timeline, product quality and project costs. However, there has not been a sufficiently robust theory-based investigation of energy efficiency aspects (in particular reductions in CO₂ emissions) either in cross-company casting development partnerships or within the foundry sector itself.

2. THEORY AND CASE STUDY FOR CALCULATING POTENTIAL CO₂ EMISSIONS AND PRODUCTION COST SAVINGS

2.1. Ecological casting development

Many publications address product development (Pahl et al. 2007; Ehrlenspiel 2009 and Schäppi 2005), and many focus specifically on casting development (Richter 1984; Hasse 2007 and Roller et al. 2013). There is, however, relatively little material available on cross-company cast product development; there are only brief reports from industrial practice (Hespers 2000; Vollrath 2004; duMaire 2003; Becker 2002). The projects run in this area over recent years such as the BMBF project "Wachstumskern Precision Cast - Verbundprojekt: Entwicklung einer virtuellen, integrierten Technologieplattform für Guss-Konstruktion und -Fertigung (viTeG)" ["Deployment of a virtual and integrated technology platform for construction and manufacturing of castings (viTeG), subproject: precision cast - development process for foundry network"] have addressed the development of computer-aided design guidelines and explored casting simulation (Getzlaff 2010). They have not focused on integrated business processes, and the specific ecological implications of casting development.

A wide range of terms and methodological approaches are used in the field of ecological product development, for example design for sustainability (Jaafar et al. 2007), design for the environment (Ashley 1993), life-cycle design (Kölscheid 1999), eco design (Fuad-Lake 2002), environmentally conscious design (Myer 2007), design for environmentability (Navinchandra 1991), eco effectiveness in product development [ökoeffektive Produktentwicklung] (Frei 1999), sustainable value engineering (Stahlmann 2006) and green design (Mackenzie 1991). These terms and approaches are all closely related, and offer many potential starting points for optimisation, in particular if they are employed at an early stage in the product development process across roles and companies (Clarke & Gershenson 2007, pp. 70; McDonough & Braungart 2006, pp. 39; Giudice, La Rosa & Risitano 2006). Around 80% of a product's environmental impact depends on decisions taken at the start of the product creation phase.
The particular environmental significance of the early product development phases and their increasingly scientific analysis has been explored by authors including Zhou and Schoenung (2009), Kölscheid (1999), Alting, Hausschild & Wenzel (2007) and Baumann, Boons & Bragd (2002). One aspect of particular relevance to cast parts is the attempt to produce less mass-intensive products ("lightweight components") (on "demassification", compare e.g. Fiskel 2009 and Hitchcock & Willard 2009). Less mass-intensive products mean, for example, less energy for preparing the smaller amounts of raw materials, less energy for melting, more environmentally friendly transport and a lower environmental impact after the (initial) use phase, i.e. reducing mass and weight generally offers benefits at all stages of the life cycle (Fiskel 2009). Reducing energy consumption also reduces emissions, in particular CO₂ emissions.

### 2.2. The increasing importance of energy consumption and CO₂ emissions in the foundry industry

Increasing attention has been paid over recent decades to the serious effects to be expected from global warming (WMO 2014). Investigations have focused on global changes in greenhouse gas emissions, and in particular emissions of carbon dioxide (CO₂). Growing concerns not least in the fact of a rise in natural disasters (storm tides, droughts, etc.) are increasing pressure on companies to reduce their environmental impact, and that not just for a specific sector, but along the entire value chain (UNEP 2014). Companies are increasingly also taking responsibility for the environmental problems of their suppliers (Koplin, Seuring & Mesterharm 2007). A number of studies and company surveys, for example "Nachhaltigkeitsmanagement in Unternehmen" ["Sustainability management in businesses"] conducted by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, have shown that companies are increasingly recognising the economic benefits of sustainable processes (German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2007). A study by the German Engineering Federation states that the German mechanical engineering sector alone could achieve a reduction in CO₂ emissions of 198 million tonnes over ten years through the increased use of innovative processes and methods (VDMA 2009).

According to the World Energy Council, energy costs currently account for a global average of 10 % of production costs; this percentage is forecast to rise to over 25 % over the next 10 to 15 years (Robison 2011). In Germany, industry is responsible for more than 40 % of total energy consumption (Neugebauer 2008), and the foundry industry is particularly energy-intensive. Energy savings are therefore an important factor in profitability and sustainability for German foundries (Trauzeddel 2009). Energy consumption in foundries varies significantly depending on the material cast, the process and the measuring methods and specifically also on the defined areas for measurement (cf. Figure 2.1).
Significant differences in consumption strongly indicate that considerable potential remains (Coss et al. 2015). On average, e.g. 60 to 70% of a foundry's total energy consumption is in the melting process (Bührig-Polaczek, Michaeli & Spur 2014). German iron foundries use an average of 40 to 55% of total energy on melting (Bosse 2012). An assessment of the energy consumption of an iron foundry should not be limited to the melting process, as around half of the total energy is used in upstream and downstream processes in a foundry (Spall 1997). A standard, consistent and quality-assured tool is needed for measuring and evaluating energy and cost effects in casting development.

2.3. Case study of an IT tool for early assessment of CO₂ emissions and production costs

A review of the available literature offered a number of aspects to explore in terms of how foundries could address environmental issues (e.g. Spall 1997; Huppertz 2000; Kuchenbuch 2006). None of the studies, however, directly addressed the CO₂ emissions in the casting process that are directly connected to the cast parts themselves. Building on the previous work in the field, a detailed process analysis was conducted for a German iron foundry (Fandl, Held & Kersten 2014). In line with the defined areas of measurement, detailed material and energy flow data were collected as inputs and outputs of the various steps in the production process, and clearly distinguished from non-integrated material and energy flows. Data were collected in part on the basis of ISO 14040 (life cycle assessment) and VDI 4600 (cumulated energy demand), with additional data where required. Information on the energy consumption of all machines and technical equipment in the case study foundry was collected (a total of 282 items of equipment) (Fandl, Held & Kersten 2014).

A more in-depth process cost analysis was required in certain areas for an analysis of production costs (Kuchenbuch 2006). The IT tool developed on the basis of this analysis allows the development and design department of the iron foundry in question to assess both CO₂ emissions and production costs systematically. The difference in emissions between customer specifications and finalised development can be established by calculating the CO₂ emissions and production costs for a casting both on the basis of specifications from the customer (e.g. using customer 2D/3D models) and after conclusion of the joint, cross-company development.
process. As far as the authors are aware, the tool is the first to allow CO₂ emissions to be calculated specifically for castings without using an extremely simplified breakdown of total company emissions. It was found that castings of a similar mass can produce very different levels of CO₂ emissions, and that previous breakdowns, for example of energy consumption on the basis of component weight, are an oversimplification. Using a sample casting (support arm for a paper rolling machine), Figure 2.2 shows how the IT tool offers considerable potential for reducing CO₂ emissions by drawing on casting development expertise. Production costs were also reduced by around 24 percent in this development project.

![Figure 2.2 Functionally identical castings: product development by the customer only (on the left) and with collaborative optimization (on the right) (Pictures: Heidenreich & Harbeck GmbH)](image)

In the course of development of the IT tool, it became clear that there are many potentially important factors effecting cross-company product development partnerships. Further analysis was then required to identify what factors significantly affect a product development partnership and their impact on potential for CO₂ emissions and production cost reductions (Fandl & Held 2015a).

3. DESIGN OF THE STUDY

3.1. Scope of the study

A case study is a useful way to analyse cross-company development partnerships in the context in question here (Yin 2003). The case study discussed below allowed in-depth analysis and theoretical replication (Eisenhardt 1989; McDonough 2000; Lamnek 2005; Miles & Huberman 2014). As shown in
The document analysis conducted covered the following:

- Development requests
- Development contracts
- Company profiles of development partners
- "Activity profiles" of all the people involved in the development project (e.g. analysis of all project e-mails)
- Technical specifications and drawings: in particular: detailed analysis of all changes in computer-aided design (CAD)-models during project time
- Interview protocols and status reports
- Final development reports

The document analysis was complemented by interviews of experts involved from all customers as well as the casting house.

<table>
<thead>
<tr>
<th></th>
<th>Number of customer interviewees (27 customers)</th>
<th>Number of foundry interviewees (iron foundry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchasing</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>Sales</td>
<td>19</td>
<td>13</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>46</td>
<td>42</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>112</td>
<td>80</td>
</tr>
</tbody>
</table>

Figure 3.1, the present study used guided expert interviews (on the right) with staff at the iron foundry in question and its customers, as well as document analysis (on the left) as data collection methods (e.g. Mayer 2013; Prior 2003). Cross-company casting development was defined as follows for the analysis: it starts when a customer first informs the foundry of a new development project and ends when the foundry hands over the development report with the final technical drawings and specifications to the customer.

The documents analysed (all e-mail communication, all CAD models in various stages of development, specifications, etc.) were supplemented with semi-structured interviews with experts involved in the relevant development projects at the customer end. 192 customers and foundry workers from purchasing, sales, research and development and production were interviewed face-to-face, and the interviews were then transcribed (Rubin et al. 1995).

The iron foundry in question is a medium-sized company in northern Germany. Its core business is the production of cast components for the mechanical engineering industry. The foundry currently supplies cast components developed and casts to high quality standards, which are in some cases provided ready for installation. Materials are cast in weights of e.g. 50 to 8,000 kg in small-scale and medium-scale series production in accordance with DIN EN 1561 and DIN EN 1563. The iron foundry is certified in accordance with DIN EN ISO 9001 and DIN EN ISO 50001. The research and development (R&D) department uses 3D CAD software, finite element method (FEM) calculation tools and development tools for topology optimisation and casting simulation.
All development projects in the iron foundry in question for the period from 2006 up to and including July 2014 were recorded. There were a total of 78 development projects in this period. Restrictions, for example on the basic material (the iron foundry casts materials in accordance with DIN EN 1561 and DIN EN 1563), production processes (only sand cast products) and project type (this study only covers new development projects), meant however that 39 development projects were excluded from further analysis. An analysis was conducted to determine the change in CO$_2$ emissions and production costs for cross-company casting development for the remaining 39 new development projects at the iron foundry.

The 39 case studies cover a total of 27 large and medium-sized customer companies in the mechanical engineering industry that all operate German R&D departments.

3.2. Analysis of data

In the light of the challenges outlined at the beginning, the aim of the study was to establish which factors could improve sustainability in cooperation between casting suppliers and buyers (primarily CO$_2$ and cost savings). This article therefore aims to answer the following two research questions (RQ):

- RQ A: What factors influence casting development partnerships?
- RQ B: How could an evaluation method for casting development partnerships be designed?

A combination of qualitative and quantitative methods (mixed method research design; see for example Schreier & Odag 2010 pp. 271) particularly suited to exploratory questions was used to answer these research questions (Foscht, Angerer & Swoboda 2009 pp. 256).

First, the qualitative data (from the expert interviews, document analysis and literature research) was coded and converted to quantitative data. Thereby, the data collected were collected in figures and mapped using statistics software SPSS 22 (Schendera 2012; Field 2008). For a better understanding of the available data on cross-company casting development, the absolute frequency and percentage for each factor in the 39 development projects were then mapped with univariate statistics (Bortz 2010; Bühner & Ziegler 2011; Mayer 2013; Rasch et al. 2014). Factors were categorised as either customer or project factors; the project factors were then broken down further (e.g. characterisation of castings developed in partnership; communication and information).

The relationships between factors and changes in CO$_2$ emissions / production costs were then examined using bivariate analysis. A particular focus was on the strength of the relationship, for example to changes in CO$_2$ emissions. On the basis of the information obtained from the univariate and bivariate analyses, an explanatory model was then developed for predicting future CO$_2$ savings [and production costs] in cross-company casting development, using, among other things, multiple analytical methods (for example univariate and multiple regression).
4. DEVELOPMENT OF A METHOD FOR EARLY ASSESSMENT OF POTENTIAL CO$_2$ AND COST SAVINGS IN CROSS-COMPANY CASTING DEVELOPMENT

4.1. Findings of the first statistical analyses

The IT tool (see 2.3) was used to calculate both changes in CO$_2$ emissions and changes in production costs for all development projects analysed (cf. Figure 4.1). Cross-company development partnerships had overall a significant positive effect on CO$_2$ emissions. The average change in CO$_2$ emissions for all development projects analysed was -14.39 % (median -11.61 % CO$_2$ emissions); the standard deviation was $s = 14.81$. The changes in production costs amounted on average to -23.18 % (median of -20.94 % production costs); the standard deviation was $s = 21.78$. The IT tool developed was used to calculate the changes in CO$_2$ emissions and production costs in the development projects analysed, which were implemented in a development partnership involving the iron foundry. A number of other measurements were also made, including the change in weight for the castings evaluated. It was found that this figure was not identical to the CO$_2$ savings or cost savings; a more detailed examination of individual design drivers and factors was therefore essential.

![Figure 4.1 Changes in CO$_2$ emissions and production costs in the cross-company development projects analysed](image)

First, factors potentially affecting cross-company casting development and CO$_2$ emissions [and production costs] were identified and derived. A total of forty-eight such factors were identified (using, among other things, four cases studies and a comprehensive and more in-depth study of the literature). A top-down approach was used to narrow down these factors, for example through interviews with over one hundred experts from industry and research (Fandl & Held)
In this way, thirty-four factors affecting cross-company casting development were identified for further analysis. Univariate analysis of the individual factors was then conducted, in part to better understand the available sample and to restrict further factors.

For the subsequent bivariate analysis of relevant factors, hypotheses were developed on the basis of the expert interviews and a comprehensive document analysis. For example, the following hypotheses (H) were formed: "The higher the number of full-time staff at the customer, the lower the potential CO2 savings in cross-company casting development (H3)"; "The earlier casting supplier is involved in the casting development process, the higher the potential CO2 savings in cross-company casting development (H20)." Figure 4.2 below gives an overview of the hypotheses formed on the factors affecting the change in CO2 emissions.

<table>
<thead>
<tr>
<th>Customer parameter</th>
<th>Project parameter</th>
<th>CO2 savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: Value chain position</td>
<td>H12: Number of cores</td>
<td></td>
</tr>
<tr>
<td>H2: Management systems of customer</td>
<td>H13: Difficulty in moulding</td>
<td></td>
</tr>
<tr>
<td>H3: Customer company size</td>
<td>H13a1: Difficulty in core making</td>
<td></td>
</tr>
<tr>
<td>H4: Customer's R&amp;D department size</td>
<td>H13a2: Difficulty in moulding</td>
<td></td>
</tr>
<tr>
<td>H5: Geographic distance</td>
<td>H13a3: Difficulty in feasibility</td>
<td></td>
</tr>
<tr>
<td>H6: Management systems of customer</td>
<td>H14: Trust between casting supplier and customer</td>
<td></td>
</tr>
<tr>
<td>H7: Customer company size</td>
<td>H15: Number of cores</td>
<td></td>
</tr>
<tr>
<td>H8: Customer company size</td>
<td>H16: Complexity in comparison to other casting projects</td>
<td></td>
</tr>
<tr>
<td>H9: Cast development duration</td>
<td>H17: Development know-how of the customer</td>
<td></td>
</tr>
<tr>
<td>H10: Project targets</td>
<td>H18: Development tools of the customer</td>
<td></td>
</tr>
<tr>
<td>H11: Quantity</td>
<td>H19: Development tools of the customer</td>
<td></td>
</tr>
<tr>
<td>H12: Support of the customer management</td>
<td>H20: Time of involvement</td>
<td></td>
</tr>
<tr>
<td>H13: Support of the casting supplier management</td>
<td>H21: Data and information at project start</td>
<td></td>
</tr>
<tr>
<td>H14: Type of component</td>
<td>H22: Change of requirements</td>
<td></td>
</tr>
<tr>
<td>H15: Type of component</td>
<td>H23: Change of requirements</td>
<td></td>
</tr>
<tr>
<td>H16: Complexity in comparison to other casting projects</td>
<td>H24: Contact person</td>
<td></td>
</tr>
<tr>
<td>H17: Development know-how of the customer</td>
<td>H25: Number of face-to-face meetings</td>
<td></td>
</tr>
<tr>
<td>H18: Development tools of the customer</td>
<td>H26: Frequency of communication</td>
<td></td>
</tr>
<tr>
<td>H19: Development tools of the customer</td>
<td>H27: Number of methods, guidelines and standards</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.2 Cross-company parameters with a potential impact on CO2 savings when foundries are involved in cross-company casting development

The next step was in-depth analysis of the relationships between influencing factors and CO2 reductions. An initial, "simple" binary analysis showed that the CO2 reductions achieved with customer companies "with fewer than 250 full-time staff" were on average -16.63 %, in other words greater than customer companies "with more than 250 full-time staff" (average of -12.09 % reduction in CO2). Table 4.1 gives examples of three more of the twenty-seven factors investigated for cross-company casting development.
Table 4.1 Simplified presentation of CO\textsubscript{2} emissions reductions with selected factors

<table>
<thead>
<tr>
<th>H\textsubscript{2}: Management systems of customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of CO\textsubscript{2} savings</td>
</tr>
<tr>
<td>Customers without DIN EN ISO 14001 certification</td>
</tr>
<tr>
<td>-16.17%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H\textsubscript{14}: Casting weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of CO\textsubscript{2} savings</td>
</tr>
<tr>
<td>Castings with &quot;low mass&quot; (&lt; 2,000 kg)</td>
</tr>
<tr>
<td>-11.25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H\textsubscript{20}: Time of involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of CO\textsubscript{2} savings</td>
</tr>
<tr>
<td>Idea phase</td>
</tr>
<tr>
<td>-21.52%</td>
</tr>
</tbody>
</table>

Building on the results above, boxplot and scatter diagrams were used to visualize more detailed bivariate relationships between the relevant factors and the change in CO\textsubscript{2} emissions. The hypotheses formed were tested (see above); and e.g. hypothesis 3 was confirmed by comprehensive binary analysis. A subsequent analysis of the relationships between all influencing factors found largely (in 92.3\% of cases) "very low" to "low" correlations between the individual factors. Only in 5.9\% of cases there were "moderate" correlations, and in only 1.7\% of cases the correlation coefficients were greater than 0.6.

To summarise, many factors affected cross-company casting development, but only twenty-seven were suitable for in-depth analysis of their impact on changes in CO\textsubscript{2} and cost savings (response to research question A). The change in CO\textsubscript{2} emissions found in the bivariate analysis gave a clear initial indication of potential factors impacting on sustainable cross-company casting development.

**4.2. Full-model regression**

A number of different models were then developed to explain the change in CO\textsubscript{2} emissions overall. The factors with the highest adjusted R squared were mapped starting with the first model (cf. Figure 4.3).
The influencing factors examined in the univariate regression analyses were first correlated using "all-subset selection" (Albers et al. 2009, pp. 225; Field 2005, pp. 169ff.). Following the best model in each case with the highest adjusted R squared, further models were then also calculated.

On the basis of the requirements for regression analyses (see for example Albers & Skiera 2000; Jann 2005) the fourth model was selected as the most suitable (cf. Figure 4.3). This significant \( p < 0.05 \) model covers four factors and shows that earlier involvement, a high level of mutual trust, the number of cores and a smaller customer R&D department in particular can have a positive effect on cross-company casting development. However, only the relationship for the time of involvement was individually significant at the 5 % level. The relationships for the size of the R&D department and the number of cores had a tendency to significance at the 10 % level. The model explained over 28 % of total variance in CO\(_2\) reductions through cross-company casting development (cf. Figure 4.3, equation above).

The explanatory model then underwent another correlation analysis and multicollinearity was examined. The relationship between the factors was examined first; no increased positive or negative correlation was found. A number of methods were used to test for multicollinearity; there was no multicollinearity.

### 4.3. Limitations of the model for predicting future CO\(_2\) reductions

This section reflects critically on a number of aspects, such as the method applied, the factors affecting the empirical study and the robustness of the findings. The definition of the evaluation period and evaluation method was examined. The evaluation period ran from 2006 to 2014. Both shortening the evaluation period and extending the evaluation period by several years could have led to different results. The study considered all development projects at the case study foundry: complete data were not available for development projects prior to 2006.

There were various aspects to be considered in terms of the number of factors. The study started by addressing a wide range of possible factors affecting cross-company casting development. The large number of factors was due in part to the many expert interviews conducted. Other
interesting potential factors were ruled out of the study in subsequent qualitative and quantitative analysis. There were many factors other than those discussed here which could be investigated in research in this field.

A comprehensive inductive statistical analysis was conducted to analyse the robustness of the results of the empirical study. Studies on heteroscedasticity and on special cases were also carried out as part of this process with outlier analyses. The findings of the regression analyses were found to be extremely useful and, in line with the scope of the sample, reliable.

5. PRACTICAL IMPLEMENTATION AND SUMMARY

On the basis of the method developed (see 4.2), an IT tool was created for the evaluation model. This tool was designed to assess the scope of possible ecological potential – i.e. changes in CO\(_2\) emissions – offered by changing cross-company casting development. Design was followed by operational implementation of the IT tool using MS Excel.

The IT tool was then used by the head of the development and design department at the iron foundry on the basis of the data from two verification development projects. Table 5.1 shows the results of the ex ante forecast of changes in CO\(_2\) emissions in cross-company casting development at the start of the verification development projects. The findings of the forecast with the evaluation model were then compared with those from an evaluation of the actual castings (cf. Table 5.1).

<table>
<thead>
<tr>
<th>Verification development project</th>
<th>Forecast of changes in CO(_2) in cross-company casting development [%]</th>
<th>Actual saving [%]</th>
<th>Difference in [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base frame</td>
<td>-8.98</td>
<td>-8.4</td>
<td>-1.26</td>
</tr>
<tr>
<td>Machine base unit</td>
<td>-11.29</td>
<td>-9.87</td>
<td>1.45</td>
</tr>
</tbody>
</table>

Table 5.1 above shows a -1.26 % deviation between the forecast and the actual change in CO\(_2\) emissions at a "base frame development project". The CO\(_2\) savings of just under -11.29 % mean that a total reduction of 2.3 tonnes CO\(_2\) emissions could be achieved with the number of castings planned. The verification development project "machine base unit" showed a +1.45 % deviation in the difference. In the light of total output, this means savings of nearly one tonne of CO\(_2\) emissions.

Testing the IT tool developed allowed an ex ante forecast of the CO\(_2\) emissions saved by cross-company casting development (response to research question B). Collecting comprehensive data on material and energy flows in the various steps in the production process at a German iron foundry provided the basis for the development and implementation of an IT tool to assess energy consumption / CO\(_2\) emissions and production costs (see 2.3). This IT tool was then used to assess the changes in CO\(_2\) emissions [and production costs] in thirty-nine cross-company development projects using the expertise of the foundry. The first step towards evaluation was a qualitative study of influencing factors in case studies and a preliminary bivariate quantitative
analysis at a German foundry (see 4.1). The multivariate analyses presented (see 4.2), supported by the statistical analysis conducted and based on a large number of expert interviews and extensive document analysis, found that the main factors affecting changes in CO$_2$ emissions at the iron foundry investigated were as follows:

- the time at which a foundry's customers involve it in cast part development;
- the level of trust between cast part customer and foundry;
- the number of cores at the start of development;
- the size of the cast part customers' R&D department.

This set of factors is both customer-related and project-related and interacts with other factors. A final decision on long-term collaboration or on the scale of and resources provided for a cross-company product development partnership should always be taken on a situational basis for each individual development project; the assessment model developed can be used as a supporting tool. In future, we can expect the German foundry industry to seek to investigate and evaluate the entire life cycle of its cast parts in the light of continuing competitive pressures and the growing importance of material and resource efficiency. The assessment of large-scale series production, for example for the automotive industry, is not the only focus here. Another important area is single and large cast parts, in which the requirements are becoming ever more complex.

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TWENTY YEARS AFTER MENTZER: 
A POLEMIC ON LOGISTICS RESEARCH RIGOUR AND RELEVANCE TODAY

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ABSTRACT

Purpose
This paper is a polemic that explores the overarching issue of rigour and relevance in logistics and SCM (LSCM) research today. The starting point for this paper is Tom Mentzer’s publications beginning twenty years ago about the need for rigour and relevance in LSCM research. The purpose of this paper is to stimulate thinking and debate among colleagues in the LSCM academic community about these issues and remind them of the need to keep them at the forefront of their own research.

Design/methodology/approach
The authors used an autoethnographic approach to examine this issue, based on their collective sixty years’ experience in academia. After a review of appropriate literature on the topic, data was collected from discussions among the paper’s authors as well as recounting open discussions with other academics and editors of LSCM journals to collate their observations.

Findings
The changes in the academic environment towards a ‘publish or perish’ culture have altered the landscape of LSCM research as it appears in journals. It has led to ‘salami-slicing’ of research to the extent that novelty in papers has been reduced to a minimum. Further, parts of research are reported in a way that fits journal expectations rather than noting the research approach and methods as they were actually applied in the research. Ultimately, this may undermine groundbreaking findings in LSCM and lead to a stagnation of the discipline.

Research limitations/implications
This paper is based on personal observations and experiences of the three authors as well as open-ended discussions with others in the LSCM community.

Practical implications
Practical implications are provided for LSCM academics in their roles as authors and journal editors.
Social implications
Encouraging the LSCM academic community to improve the rigour, relevance and quality of research will result in better impact and outcomes for society at large.

Original/value
The value of this paper is in stimulating thinking and debate amongst LSCM academics to come back to core issues in the discipline and seek both rigour and relevance.

Keywords: Logistics, Supply chain management, Research, Rigour, Relevance, Academia

1. INTRODUCTION

Over twenty years ago the late Tom Mentzer, in conjunction with different co-authors, began publishing a series of papers about the need for research rigour, relevance and the proper use of appropriate theories and frameworks in several logistics and supply chain management (LSCM) and marketing journals (for example Mentzer and Kahn, 1995; Mentzer and Flint, 1997; Mentzer et al., 2001; Mentzer et al., 2004; Mentzer, 2008). That work stimulated other authors to also discuss issues in logistics and supply chain theory, methodology and methods up (for example New and Payne, 1995; Näslund, 2002; Grant, 2004; Spens and Kovács, 2006; Halldórsson et al., 2007; Flynn, 2008; Halldórsson et al., 2015). However, there has been less published about these issues for almost a decade while at the same time the global academic landscape has shifted more towards a ‘publish or perish’ environment, which used to be considered the preserve of the US. We have seen several distressing behavioural effects in this new landscape.

Firstly, the concept of being a professional academic and providing service to the wider academic community, inter alia reviewing and examining PhDs, has waned as academics keep their heads down to write for publication and research grant funding applications. Also, such behaviour favours ‘gaming’ and ‘salami-slicing’ as publishing strategies, with a dearth of ground-breaking research or with meaningful results being cut up into minuscule contributions to warrant numerous publications, reporting fractions of a study instead of the various elements of its research process, leading to a lack of chain of evidence in publications. Finally, an increase of submissions to academic journals has forced editors to seek reviewers far and wide to undertake reviewing tasks, and send out manuscripts that might be better rejected at the desk but which slip through due to the volumes that are being processed.

As a result, we are concerned as logistics and SCM (LSCM) researchers, reviewers and journal editors that there is less rigour and relevance in some of today’s publications in our discipline, notwithstanding claims to the contrary by journal editors and publishers. We consider this topic very relevant given antecedent pressures that LSCM and other academics face today, and thus present this paper to stimulate thinking and debate among LSCM academic community colleagues about these issues as a reminder of the need to keep them at the forefront of their own research so that our collective integrity and credibility is not impaired in future. We did not actively look at any other disciplines other than some corollary disciplines to LSCM. Our objective was to focus on LSCM and not be accused of incorrectly commenting on practices in disciplines where we do not work – we can only comment on things we know and understand.

This paper is structured as follows. After discussing the methods used we look at the purpose of academia and academics, focusing on research as a major part of academic activities and the academic landscape in the 21st century as an antecedent or inhibitor of some types of behaviour. Then, we discuss the nature of research and publishing in the context of rigour and
relevance from the perspectives of journal authors and editors. We next discuss the issues affecting this nature and conclude the paper with suggestions to improve the state of academic research generally and LSCM research specifically.

2. METHODS

This paper is a *polemic* that explores the overarching issue of rigour and relevance in LSCM research and is meant to stimulate debate among colleagues in the LSCM academic community about these issues and remind them of the need to keep them at the forefront of their own research. As such it is not a traditional paper that develops or empirically tests theory. However, that does not imply that this paper has not adopted a rigorous approach.

We used an analytical autoethnography approach for this paper. Ethnography is a well-known and rigorous approach qualitatively analysing institutional contexts and is well suited to providing researchers with rich insights into human, social and organizational aspects in such contexts (Harvey and Myers, 1995). Autoethnography is an autobiographical form of ethnography where the ethnographer is “[1] a full member in the research group or setting, (2) visible as such a member in published texts, and (3) committed to developing theoretical understandings of broader social phenomena” (Anderson, 2006, p.373). This posits that autoethnographic research is socially constructed, includes explicit and reflexive self-observation, and uses qualitative methods (Näslund, 2002; Grant, 2000).

After a review of appropriate literature on the topic, data was collected from discussions among the paper’s authors as well as recounting open discussions with other academics and editors of LSCM journals to collate their observations. The authors of this paper have a collective 60 years’ experience as logistics academics that includes journal paper authorship and reviewing, journal editing, research grant application submission and reviewing, and conference organisation. In that regard, this polemic is based on our personal observations and experiences, combined with being very involved in the LSCM academic community and discussing these issues over time with logistics academics but also national and international ranking institutions. We only report general details of examples and instances of behaviour that we have encountered over the years, and do not provide names of academics, editors or journals unless such encounters are in the public domain. We do believe that ‘naming and shaming’ would be counter-productive to our intentions.

3. THE ACADEMIC LANDSCAPE IN THE 21ST CENTURY

The purpose of universities has been discussed since their inception in medieval Europe. Newman’s work originally published in 1852, and recently reprinted (Newman, 2008), represents a classical view whereby his discussion of a ‘liberal education’ set-out a range of ideas about people, knowledge and intellectual communities. In Newman’s view, universities were dependent upon the Church for their integrity. His notion of the Church’s involvement reflects the historical evolution of universities, which were first founded and run by the Church in the days before the modern printing press allowed wider dissemination of knowledge.

Notwithstanding, winds of change were already blowing in the nineteenth century and universities were increasingly under threat as they came to resemble, in Newman’s words, “a foundry, or a mint, or a treadmill” (Newman, 2008, p. 145). A more contemporary view came from Veblen (1918), who considered that the university’s place in modern life related to industrial arts and technology, and that the scheme of knowledge should also consider the
pursuit of business. A counter argument to this view comes from Collini, who noted “that subjects which were initially introduced for broadly practical purposes have outlived those purposes and gone on to establish themselves as scholarly disciplines in their own right” (2012, p. 53).

However, the genie was out of the bottle well over a century ago and today the university encompasses more than simply the liberal arts; indeed our own ‘discipline’ of LSCM (in single quotations reflecting some views that this topic is not a real academic discipline) is very much applied and business-orientated. This view, where “some great men” insisted “that Education should be confined to some particular and narrow end, and should issue in some definite work, which can be weighed and measured” has led us to the situation in the 21st century where we are now “making Education and Instruction useful, and Utility has becomes their watchword” (Newman, 2008, p. 154).

Cue decreasing funding for universities from governments and rising managerialism in university administration coupled with various performance measurement schemes and key performance indicators (KPIs) that have come into use at universities from the business sector during the last decade (Graeber, 2015; Jump, 2015). What then for rigour and relevance, and coupled with that, what is the role of a ‘professional academic’ in today’s universities and how does that role enhance or inhibit rigour and relevance? We next turn to the latter issue.

In our view, being a professional academic has two purposes: creating knowledge through research, particularly with organisations in the LSCM discipline or from externally-funded research projects; and sharing that knowledge through teaching and dissemination through publication in academic and other types of journals, books, etc., as well as engagement with the public square, policy makers and organisations that might make use of the research and knowledge. However, the new environmental pressures noted above, which academics operate under in many countries, has in our view led to a narrowing of focus amongst some academics with an attendant and subsequent decrease in the rigour and relevance we all seek.

A professional academic, in addition to his/her teaching and research obligations, should perform some elements of ‘service’ to his/her university (aka administration) and to the wider academic community. The latter includes inter alia reviewing for journals, conferences or funding bodies, providing seminars for other academics and none-academic organisations, and external examining teaching programmes or post-graduate degrees, e.g. PhDs. And yet, as there is little recognition given in university appraisal for such activities, i.e. academics’ KPIs do not include such activities, we have seen a decrease in the willingness of academics to undertake this ‘service’, which has a knock-on effect in several areas. The one we are most concerned with here is reviewing for journals.

Since academics are required to publish in top-quality journals, the ability of those journals to provide high-quality and timely reviews is dependent on other academics being willing to provide them. However, at a workshop in summer 2015 hosted by Aalto University and Hanken School of Economics in Helsinki, editors of three of the top LSCM journals: Journal of Business Logistics, Journal of Supply Chain Management, and Supply Chain Management: An International Journal, remarked that it was difficult to get reviewers to do so. One editor noted that it sometimes takes fifteen attempts to find the three reviewers the journal aspires to for each submitted paper. That ratio expends a lot of time on behalf of the journal and the editors and also affects time of the academics solicited.

At the same time, authors, reviewers, and editors all belong to the same group of academics who just take different roles at different times (Gilmore et al., 2006). One could even call this a rather closed-loop supply chain. Authors not contributing to the review process as reviewers
4. RIGOUR AND RELEVANCE IN LSCM

It has long been held that dissemination through academic journals should be both rigorous, i.e. theory or evidence-based and properly executed, and relevant to those who might read and use the research. This belief is in many non-LSCM disciplines such as marketing and retailing and general management (for example Van de Ven, 1989; Whetten, 1989; Piercy, 2002; Lundberg, 2004; Corley and Gioia, 2011), as well as LSCM (for example Mentzer and Kahn, 1995; New and Payne, 1995; Mentzer and Flint, 1997; Grant, 2004; Spens and Kovács, 2006; Flynn, 2008; Mentzer, 2008; Fawcett and Waller, 2011; Harland, 2013. Mentzer’s work provided theoretical and practical guidelines for academics to ensure their work was properly rigorous and relevant.

Huynh (2013) argued that three theories are primarily used in LSCM research: the resource-based view (RBV) of the firm (15.4%), transaction cost economics (TCE) or transaction cost theory (8.9%) and game theory (7.7%). These three, together with eleven other theories that all are less than 5% each, comprise 60% of all theories used (Huynh, 2013). Halldórsson et al. (2007) argued that besides RBV and TCE the other two theories that could assist LSCM research are network theory (NT) and principal-agent theory (PAT). Looking at a specific subset of LSCM, humanitarian LSCM, we find that inventory control theory and systems theory comprise 6.8% of all theories used, no other theory exceeds 2% (Tabaklar et al., 2015).

This lack of theoretical diversity, depth, and application in LSCM research might be due to what Halldórsson et al. call ‘conceptual slack’, which they consider is a divergence in “analytical perspectives and methodological approaches and boundaries” related to other disciplines such as “operations management, purchasing, quality management and industrial networks” (2015, p. 574). Research in LSCM as an independent discipline in business and operations has only been undertaken since the 1960s. Thus, “compared to older and more established disciplines... logistics does not have as rich a heritage of theory development and empirical research” (Stock, 1997, p.515).

Mentzer et al. considered that “logistics researchers have made little effort to build a unified theory of logistics” (2004, p. 606) and presented a “comprehensive view of logistics capabilities within a unified theory of logistics” that they considered “important to the logistics discipline as the scope of the discipline expands from operational issues into such strategic issues as customer service, customer value, and relationship management” (2004, p. 622). One editor at the Helsinki workshop referred to above noted to one of the authors that a review of the last twenty years of their respective journal revealed that theoretical consideration did not comprise a part of many papers during the first ten years. The editors reinforced the notion that theory is an important cornerstone of any research to provide rigour and will continue to be so in future.

But what comprises research rigour? Mentzer and Kahn (1995) argued that logistics research lacked a rigorous orientation but posited that as logistics research was founded in the positivist paradigm, and proposed a framework for research that follows the scientific method and a quantitative paradigm to assist researchers in developing rigorous research. Their framework was not unique as it used a basic format of idea generation, literature review, hypothesis formulation, data collection and analysis that has been proposed by many others for conducting quantitative and empirical research.
However, the context of LSCM research is beset with issues regarding its epistemology as well as its theoretical underpinnings, and which impacts its managerial or practical relevance. New and Payne argued “logistics is one of the sub-fields of management which like to wallow in its own obscurity” and follows existing trends by “evolving into integrated logistics or strategic supply chain management, or any other label which can be generated by combining managerial buzzwords” (1995, p.60). This argument may be a reflection on the practitioner orientation of some logistics research and publications and is not without merit.

Research in logistics is also difficult as the scope of the domain keeps changing such that “it becomes less clear what differentiates the subject as a distinctive field and what constitutes valid research questions and investigative strategies” (New and Payne, 1995, p.61). This epistemological concern reflects an ongoing debate about LSCM being part of other disciplines, such as purchasing and procurement, operations management, operational research or management science, and marketing. Notwithstanding, New and Payne supported Kent and Flint (1997) and Stock (1997) by arguing that LSCM researchers should utilise theories and models from other disciplines to help define and differentiate their discipline. This notion has since been picked-up by Halldórsson et al. (2007, 2015).

New and Payne (1995) presented two issues that might affect the proper implementation of a positivist methodology and quantitative approach. The first is the notion that research is socially constructed, which leads to the dichotomy where academic research that scores high on ‘rigour’ and ‘cleverness’ may have a low connection to ‘real’ problems. This dichotomy between an ‘abstract’ approach to academic rigour versus relevance to ‘real issues’ is illustrated in Figure 4.1.

![Figure 4.1 Academic research: Abstract versus real issues (New and Payne, 1995, p. 62)](image)

New and Payne’s second issue is “formulation of presumed causal links” which are important “because they determine the underlying justification of research questions” (1995, p.64). They provided an example of three possible frameworks with different a priori assumptions regarding three dimensions of logistics: practice, performance and environment. The three frameworks and their respective paradigms are shown in Figure 4.2.

Further, as Spens and Kovács (2006) discovered, how research is reported is not necessarily how it has been conducted. For example, longitudinal studies and also abductive research is reported in its various parts rather than including the entire journey to its findings. This posits
two problems: First, rigour suffers as the conformity with reporting standards means that the study cannot be replicated – mostly as it has not been done in the first place the way it is described in the paper. Second, ‘salami-slicing’ means that instead of relevant ground-breaking findings, it is only incremental novelties that find their way into publications.

While not unique to LSCM, this behaviour is not necessarily replicated in other disciplines. The management and marketing disciplines have tried to counteract ‘salami-slicing’ through the requirements of multiple studies to be reported on in the same articles, which does in part achieve the point of rigorous and relevant research being published, though in other parts, it raises the bar for authors to conduct more studies for fewer publications. Another editor at the Helsinki workshop argued that LSCM researchers need to conduct more longitudinal and combinatory studies to provide more methods rigour and generalisability of findings.

![Figure 4.2 Example frameworks for empirical research (New and Payne, 1995, p. 64)](image)

But instead, there has been a preponderance of papers simply presenting systematic literature reviews (Seuring and Gold, 2012) which are considered by their authors as providing rigour because they are systematic and relevant as they address an important research topic. However, these papers are more conceptual and one of the reviewers for this paper noted this trend “is a sign that something is wrong with the average papers that are being published in the sense that they are too narrow and ‘boring’”, which may indicate there is no meaningful contribution by them. We tend to agree and in fact argue that this paper, being a polemic, may provide more of a contribution to LSCM knowledge despite another reviewer for this paper considering that “it is interesting to read [our] opinions yet that’s all it is, [our] opinion [sic]. It is hardly a relevant AND rigorous research paper”.

The foregoing issues and concerns are acute in LSCM research because LSCM has to “address the issue of operational systems which span organizational boundaries” and “present a set of commercial and managerial issues which goes beyond the technical issues of material and information flow” (New and Payne, 1995, p.67). LSCM researchers are therefore challenged to properly design and apply units of analysis in complex logistics contexts and to properly delimit a study’s boundaries. Moreover, LSCM research designs should also consider social and human involvement in LSCM activities and not just consider mechanistic modelling and simulation.
Brownlie and Saren (1997) argued that embedded in the culture of relevance is an understanding that theory and practice are somehow different and that there is a real gap between them that must be closed. They argued that relevance is a quality that is attributed to research that is perceived to bring the worlds of theory and practice together. Piercy contributed a useful line of reasoning for the rigour versus relevance debate, truncating it to two simple points: “if research is not rigorous, then by definition it cannot be relevant because no-one can rely on results” and “if research is not relevant, then by definition it cannot be rigorous, because it fails to meet the basic laws of science and metatheory pertaining to pragmatism” (2002, p. 357).

However, recent papers we have seen as reviewers seem to indicate that some LSCM and related academics are not adhering to these practices. For example, one author recently reviewed a paper considering an under-researched LSCM phenomenon with three empirical ‘case studies’ that comprised three semi-structured interviews of three ‘experts’ who were not identified in accordance with good research practice, but whose expertise was not discussed in any way to provide credibility and appropriateness for their selection. The paper also had some other serious flaws such as ‘within-case’ and ‘cross-case’ analyses of the three interviews which led to a rejection by both reviewers for further publication consideration.

The author of this paper who was one of the reviewers queried if the paper should have been desk-rejected in the first instance. The editor responded by saying it wasn’t desk rejected as the intention was to provide an early-career researcher with an opportunity to obtain reviews. Due to the poor quality of the submission, we wonder where mentor or internal peer review was in this situation. We don’t believe journal reviewers should be in the business of doing that task.

In another example, a huge database collected by a survey undertaken almost ten years ago has been used to generate almost ten journal publications which contain individual ‘tweaks’ in the modelling and analysis that are not based on theory or evidence but mathematical manipulation of constructs and variables. Two publications have appeared in the same journal within a space of three years, and we wonder why the second paper wasn’t spotted and carefully examined by the editor or reviewers before the review process was complete and the paper published. This latter example also raises issue of ethics as one might consider that the authors are ‘salami-slicing’ the data to get more publications that simply do not meet the test of rigour, let alone relevance if the data are simply being manipulated.

In a third example, one of the authors recently reviewed a paper that provided a Cronbach’s Alpha for a two-item construct. The author had to advise that there is no such thing for two items (or measures), only an inter-item correlation which is noted in a seminal handbook on scales and measurement by Carmines and Zeller (1979).

In yet another paper, some citations and references were incorrect in that they included the journal editor or special issue editor as an author of the referenced papers. There is a unique anomaly in Google Scholar whereby it sometimes includes editors in a paper citation. We have to wonder whether the paper’s authors actually read and properly used these references or just inserted them to bulk up their reference list to either give the appearance of better quality or respond to an editor’s request to provide citations from that particular journal.

Finally, an article (Brown and Dant, 2008) in the Journal of Retailing was proud of the fact that much of the empirical work undertaken in this highly quantitative and modelling-based journal was built on student survey responses at universities – hardly a representative sample of the wider population.
The issues behind these examples are supported by others in related areas such as operations management (MacCarthy et al., 2013) and non-related areas such as psychology (Brinner and Rousseau, 2011; Burke, 2011) and the natural sciences (Sarewitz, 2016). We now take up the various points related to the journals in the next section.

5. THE ROLE OF THE JOURNALS

For those academics that have a narrow focus and only interested in publishing their work the issue of journal importance becomes paramount. In the UK the research excellence framework (REF) provides a review every six years of the research quality in various units of assessment across a university’s faculty. Every research-active academic must submit four journal publications for consideration by a review panel that applies an individual GPA score for each publication averaged for all publications and academics in the unit of assessment for that university. The GPA scores, in decreasing order of quality, are 4*, 4, 3, 2 and 1.

The UK government provides research quality funding to the university for the period between these exercises based on a formula that takes into account only 4*, 4 and 3 rated research as well as the number of academics submitted (REF, 2016). This has led to interesting behaviour at some UK universities, for example one LSCM colleague at a London-based university noted that every professor must publish four-3 rated and two 4* or 4-rated papers during this assessment period which will end in 2019 or 2020. The ratings are awarded through internal peer review as opposed to the UK Association of Business School (ABS) listing, which is not only used in the UK but has become a surrogate benchmark in other European countries and universities.

The question of what is a quality journal has led to various ranking systems across many countries, e.g. the UK, France, Germany and Australia, and journal publishers have been eager to ensure that their stable of journals are considered to be in the upper categories. LSCM journals have typically not fared well in some of the rankings (McKinnon, 2013) despite ongoing analysis of them by LSCM academics (e.g. Menachof et al., 2009). LSCM academics, including this paper’s authors, have worked with the publishers and rating associations to ensure that LSCM journals are fairly considered. In fact, some think that ranking lists should be scrapped as there are other ways of assessing journal quality such as impact factors. For example, the REF panel that considers LSCM research in business and management looked at the ratings given to 1,000 random papers compared to the ABS journal list and found that the ABS list generally overrates journals (Tourish, 2015).

However, impact factors are also used in journal gamesmanship. Some journals have let clouded judgment get in the way of their own rigour in a ‘holy grail’ pursuit to be considered a 3, 4 or 4* journal. Some have been exposed for techniques to increase their impact factors or citation rankings by self-citations or ‘citation stacking’ (Davis, 2012), either through regular or special issues, and have been temporarily suspended from Thomson Reuters’ Journal Citation Report—including the International Journal of Production Economics in 2014 (Davis, 2014).

In 2012 a meeting of biologist academics, unsatisfied with journal impact factor rigour, produced the San Francisco Declaration on Research Assessment (DORA) that asks the entire research community to not use journal-based metrics as a surrogate measure of the quality of individual research articles, assess an individual scientist’s contributions, or use in hiring, promotion or funding decisions. The publisher Elsevier responded to DORA and agreed with a statement made by Thomson Reuters in 2008 that perhaps the most prominent misuse of the journal impact factor is its misapplication to draw conclusions about the performance of an
individual researcher (Plume, 2013). Nevertheless, the practice continues as one this paper’s authors received a ‘revise and resubmit’ from an ABS 3 rated journal in mid-April 2016 with comments from reviewers to enhance the literature review with papers from the journal.

The timing for the review process can also be an issue that impacts authors and editors. Some research funders are anxious to see disseminated results quickly and those authors trying meet short deadlines may not put forward a rigorous and complete effort of the research undertaken. However, it adds to the litany of less rigorous offerings in print when the paper is published. On the other hand, the long lead times that many authors face from journals might be an inhibitor to ‘waiting it out’ to publish a better version. Such lead times may or may not be the fault of the editor or the journal, viz. the comment above about going out many times to find suitable reviewers, however lead times have not gone unnoticed by some funders. Maukola (2016) reported on a Finnish research study into publication output and citation rates for more than 1,800 projects funded by the Academy of Finland between 2005 and 2015. The study found that on average academy funding generated three publications during the grant period and up to one year afterwards, which the authors concluded was a low publication rate. One Finnish academic described the study as correct and rational within the parameters it was designed to assess, but suggested that one improvement would be to look at output for a longer period to assess work published more than a year after a project had ended.

The pressure on editors to ensure their journals are considered high-quality and to respond quickly to author submissions, and the volumes of submissions their journals receive, indicates that some quality control checks may be slipping through the cracks. The new electronic manuscript submission and reviewing software is usually set-up to contact reviewing academics on a regular basis to advise them that their review is due in a week, due today, and overdue. Everyone appreciates that reviews should be done in a timely manner so that authors get feedback, however one of this paper’s authors wonders where is academic freedom in light of such continual reminders? That may be an additional ‘turn-off’ regarding the reviewing process for some. On the other hand, the use of such electronic systems with automatic hierarchical reviewer selection tools helps editors to deal effectively with today’s increased volumes of submissions. However, some of the editors have advised that many reviews appear in the week after a ‘one-week to go’ reminder, suggesting that LSCM academics truly believe in the just-in-time principle.

Notwithstanding, LSCM journals have worked hard for a long time to improve the image of the discipline and the ranking status of their journals. This has finally led to their inclusion in international ranking systems including such as Thomson Reuters ISI, Scopus, Scimago, etc. However, more recently two trends have become apparent: Early rankings of some journals, i.e. less than a five-year period, have skewed their perception and subsequent ranking towards being better than is generally attributed by researchers in their own discipline. On the other hand, now that ‘salami-slicing’ has become such a trend, citation rates per article are decreasing, and overall there is a downwards trend in the actual citation indices of LSCM journals. If the disciplines continue like this, we will manage to undermine the intentions of improving the image of the field overall.

6. CONCLUSIONS AND SUGGESTIONS

The issues we have highlighted in this paper are not going away anytime soon. Academics, journal editors and reviewers will continue to receive pressure from various sources to ‘do more with less’ but also ensure that journal articles and journals are top-notch quality. Such pressures
have led some academics to strike up as ‘one-man bands’ and become isolationist for their peers in the academic community, while some journals struggle with limited resources and may take unnecessary short-cuts. These actions inhibit the research and dissemination process and if continue unchecked may become a downwards spiral that will lead to real credibility issues for both academics and journals that will reflect badly on academia as a whole.

How then can the academic community address these issues? For academics, we suggest developing better time management skills in terms of their workloads so that they can carve out sufficient research time without compromising their duty of care to the wider academic community. Academics, beware that publishing is indeed a supply loop, with authors, reviewers and editors coming from, and contributing to, the same community. Academics can also ensure that they are working efficiently in other aspects of their academic life. A former colleague of one of this paper’s authors once remarked that he was teaching one-half of eight courses one year with another colleague teaching the other half so that they both had some variety. That is not an example of an efficiency strategy.

For journals and editors, we suggest to spread the burden of reviewing and editing more evenly, without creating additional steps in the review process that just prolong it. That way the main editor or editor can maintain a closer overview of the process, particularly special issues, and ensure that quality control is paramount. At the same time, perhaps we should follow other disciplines that require entire studies, or several studies to be reported on in the same article – as to say, ensure that there is significant novelty being reported on.

As all papers, even polemics, there are limitations in this offering. One is that the three authors have similar views towards these issues and so came together to write this paper. Despite our best efforts to avoid it, the small sample of contributors might have led to some ‘group-think’ in our observations. Another is that we cannot properly evidence some of our examples nor the reviewers’ comments (which were provided in e-mails to the authors). However, that is a necessity due to our adherence to an anonymity policy. Finally, we were not cast our net wide to collect observations from others due to time considerations for the NOFOMA 2016 conference. To address these three issues we believe that a substantial piece of research should be developed to more deeply investigate these issues to confirm or refute our observations and inferences.

As academics we do not ‘produce’ anything except knowledge, as noted in section 3. The principles underlying that production and its subsequent dissemination are rigorous and relevant research derived from a strong theoretical background. The proper adherence to these principles will lead to quality outputs and demonstrate our integrity to others. Our integrity is the only thing we can possess and control as academics, and similar to Zara’s fast-fashion strategy for production and retail distribution, ‘when it’s gone, it’s gone’ as far as the rest of the academic community is concerned. There is a litany of academics who have lost their employment or indeed their PhDs from the loss of their integrity or who have been banned for life from publishing in certain journals due to their practices and procedures, and we believe it’s high-time some academics took a hard look at themselves and others so we can root out and then self-police such behaviour before we are all ‘tarred with the same brush’. We owe that to the memory of Tom Mentzer, who inspired many of us and also led the way in addressing these issues in LSCM research.
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THE NECESSITY OF AN INTEGRATIVE APPROACH FOR BUSINESS SERVICE EVALUATION FROM A BUYER’S PERSPECTIVE

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ABSTRACT

Purpose
This research aims to observe different evaluation procedures for business services that are applied by buying companies; revealing the necessity of an integrative evaluation approach.

Design/methodology/approach
Based on a systematic analysis, explorative case study research – regarding five Swiss multinational companies – is used. In addition, the research also provides a structured literature overview of existing evaluation procedures.

Findings
Next to specific and business service related difficulties, the research observes different phases – named “levels of integration” – in which the evaluation process takes place within a company: (1) preparation, (2) acquisition as well as (3) an operational phase.

Research limitations/implications
The paper is limited to a qualitative research approach addressing only five case selections from Switzerland. However, assuming the results are generalizable, future research on service evaluation should always distinguish between the different phases of evaluation.

Practical implications
For practitioners, it is shown that a company’s ability to consider information and experiences from all levels of integration is highly related to its capability to ensure a successful service purchasing performance. Therefore, the research provides practical support for the purchasing process to ensure highly efficient business services.

Original/value
As research on business service evaluation barely exists, this paper is the first known work that addresses the different phases of an integrated service evaluation.

Keywords: Service purchasing, business services, purchasing capability, service evaluation, performance measurement
1. INTRODUCTION

Essentially, business services\(^1\) appear to be crucial for the value creation of companies. Reasons can be found in a company’s intent to focus on core competencies (Bhagat et al., 2010), in a lack of required expertise (Gotzamani, 2010) as well as in volatile capacity availability. Furthermore, this importance is reflected by a firm’s large amount of externally procured business services (Sonmez, 2010, van der Valk, 2008). Although the significance of business services is noticed within a company, the majority of purchasing managers still struggle with an efficient procurement and evaluation process (Rottmann, 2015). As indicated by several researchers, such problems are often induced by specific characteristics of services (de Oña et al., 2014, van der Valk, 2009, Hallikas, 2014). Due to immaterialism, heterogeneity, and external factors, the purchase of business services as well as the related evaluation can be considered as a challenging task (Sitar, 2012).

While goods purchasing is a well-known process, the purchasing and evaluation of business services is still underachieved in both a theoretical and a practical context. With a view to an increasing significance of business services within a company – on average up to 40% of a firm’s overall purchasing volume is related to business services (Ellram et al., 2007, CAPS, 2003) – structured evaluation processes are required to enhance the overall purchasing capability and firm performance. Existing approaches mainly consider monetary items, whereas qualitative aspects are often neglected. Major objectives are seen in the identification of cost savings, the creation of market transparency, and the procurement of reliable business services (Hallikas, 2014, Min, 2010).

Despite the tremendous potential an efficient evaluation for business services may have on a firm’s purchasing capability (Fredendall, 2005), there is lack of research on existing evaluation procedures in comparison to goods (van der Valk, 2009). An aspect that is often neglected addresses the different phases of an evaluation of services. It is assumed that evaluation appears not only at different points of time but also conducted by various entities within a supply chain. Therefore, it is implied – but so far not scientifically observed – that an evaluation procedure for business services must always consider different integrative phases – named by the authors “levels of integration” (LOI)\(^2\) – in which the evaluation takes place: (1) preparation, (2) acquisition as well as (3) the operational phase.

With the intention to pursue and to fill the indicated research gaps, this paper explores evaluation approaches applied by practitioners using case studies from five Swiss international operating companies. More precisely, the following research questions are analysed in more detail:

- **RQ1**: To what extent do buying companies evaluate business services and which factors are considered essential for the overall purchasing capability?
- **RQ2**: From a buyer’s perspective, is the level of integration related to an increased evaluation and purchasing capability?

According to Eisenhardt (1989) and Yin (2003) case study research is appropriate as the conducted research is of explorative nature – trying to explore a new theory. Analogue to the recommendation of Yin (2003), section two provides an initial literature review on existing

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\(^1\) Business services are created by companies and bought by other firms (e.g. logistic services, marketing services, facility services, etc.) (Axelsson and Wynstra, 2002).

\(^2\) The LOI is not to be confused with SCM integration (integration between SCM partners). The LOI indicates how many different purchasing phases are integrated or considered within the business service evaluation procedure.
evaluation procedures as well as on well-known and approved success factors during the purchasing process. Subsequently, section three provides insights into the applied methodology and the underlying conceptual framework that was used. Conclusively, section four presents a detailed overview of empirical research results. The last section summarizes the outcomes not only with a view to their managerial and theoretical contribution but also with an indication of limitations and proposed future research areas.

2. LITERATURE REVIEW

Initially, the research presents a literature review that aims to provide an overview of consolidated findings on business service evaluation. Existing evaluation approaches as well as related evaluation criteria and influencing variables during the evaluation are revealed. As a result, the current research gap and addressed research questions are stated.

2.1. Business service evaluation and purchasing capability

In comparison to goods purchasing and its evaluation, the acquisition of business services and the related evaluation is very difficult (Min, 2010, Behara, 2001). Essentially, this is caused by the intangible and often heterogeneous characteristic of services. More precisely, business services can rarely be tested beforehand and a transaction is typically based on experiences and trust between the business partners (Axelsson and Wynstra, 2002). Ancillary, services are not transportable and their consumption and creation occurs simultaneously (Van Looy et al., 2003). This leads to the fact that volatile demand of business services cannot be compensated by inventory. Caused by a specific design of acquired business services, the interaction between the service provider and the buying company might always appear as a unique and hardly replicable process. From a practical viewpoint, companies demand a generalizable and applicable business service evaluation method. This importance is reflected by a steady increase of purchased business services within a company (CAPS, 2003). However, Bruhn (2003) points out that there is no prevailing practice in the field of business service evaluation. Moreover, he revealed the complexity regarding different definitions for the term “quality” as well as the diversity of interpretations quality management for business services might have.

Kopperger (2004) notes that in the field of business services purchasing a supplier change is more unlikely in comparison to goods purchasing. This might be related to a lack of information regarding business service costs, their related value structure as well as the comparability with alternative service providers. While the costs of a purchased business service are comparable in terms of agreed subjects within a service contract, the quality evaluation and consideration during a purchasing decision appear to be more challenging (Sonmez, 2010). Consequently, the acquisition of business services with an optimal cost-quality ratio can often not be achieved.

With the intention to allow a more objective evaluation and assessment, Phillips and Louvieris (2005) suggest to use performance measurement systems as a basic instrument for business service evaluation as they provide a fundamental structure of a cost-breakdown. Moreover, such systems combine quality aspects with existing cost measures. However, the measurability of service quality can be seen as a more important endeavor in the purchasing process, as a quantitative approach would allow more objective decision-making (Marchthaler et al., 2011). Given these facts, Hofmann and Locker (2009) argue that a proper value analysis in a supply chain might help to reduce costs, to improve quality, and to increase the functionality of business services. In that respect, the value management as part of a firm’s service management is mentioned in existing literature (Yang et al., 2014, Naoum and Egbu, 2015).
Whereas the business service quality is a critical success factor for any service providing company, it also influences the performance of a buying company (González-Benito, 2007). As a basic structure, Figure 2.1 shows a framework for the purchasing process, basically, adopted by Dobrzykowski (2012). As a final output variable in this basic framework, the buying firm’s performance is used. Several researchers argue that an overall purchasing capability is positively associated with firm performance (Song et al., 2012, Danese and Romano, 2011, Paulraj et al., 2006). It is described and assessed in several papers by a combination of the same variables – operational, financial, and market performance (e.g. Zimmermann and Foerstl, 2014, Golicic and Smith, 2013, Chin-Chun et al., 2008, McNaughton et al., 2002, Cousins, 2008). However, as our study aims to explore additional success factors for the business service evaluation, it primarily focuses on an assessment of purchasing capability rather than on firm performance.

**Success factors**

With a view to the purchasing capability of buying companies, many conducted studies reveal the integration of both internal customer and supplier as positively related to the purchasing capability (Danese and Romano, 2011, Coppini et al., 2010, Zhao et al., 2002, Lin et al., 2002). In this context, the term purchasing capability is used synonymously with the expression purchasing performance in several literature (Danese and Romano, 2011, Emiliani, 2010).

The item internal customer describes staff – normally directly employed at the purchasing company – who are assigned as an essential user of acquired business services. In literature, not just communication or information sharing but also cooperative partnerships are named as positive enablers (Chin-Chun et al., 2008). For the second item, supplier collaboration, positive enablers were found in the variables communication (Chen et al., 2004) and shared company goals (Fredendall, 2005). Claassen (2008) named information sharing between both entities as a crucial factor for a successful supplier collaboration. With a view to business service purchasing, the term service provider is used interchangeably with suppliers of acquired services.

**Purchasing capability**

As outcome variable, the purchasing capability is observed in more detail. According to Ordanini and Rubera (2008), capability can be operationalized with a two-item construct
capturing the costs and the quality of business services. Even though this effect is verified in existing research, none of these publications exclusively focus on business services.

With the intention to provide reliable solutions for a quality assessment, Parasuraman et al. (1988) coined the term SERVQUAL as a fundamental theory in the context of service evaluation. In this gap-based approach – primarily focusing on B2C-services – a customer’s perception of service quality was compared with an initial expectation. In contrary, perceptions-only measures were used for the evaluation by various authors neglecting the original expectations (Brandon-Jones, 2010). Pan and Kuo (2010) capture basic elements from such approaches and aim to develop a new key performance index for measuring service quality. However, these approaches focus on a retrospective evaluation after the initial purchase and neglect a pre-evaluation as a part of a purchaser’s decision-making. Whereas some authors provide industry-specific recommendations for business service evaluation and provider selection (Axelsson and Wynstra, 2002, Grönroos, 2000), a generalized method for different types of business services is currently missing.

Due to accompanying moderators that may have an impact on the outcome variable, contingent factors need to be addressed. In the context of business service purchasing and evaluation, Haensel and Hofmann (2016) observe different types of business services that are consumed and evaluated by different entities within and outside a company at various times. This fact reveals the type of business service as a contingency that significantly influences the evaluation procedure as well as the purchasing capability.

2.2. The necessity of an integrative approach

In general, the purchasing process of business services can be described as a decision process with several consecutive phases. In this context, Gallouj (1997) suggests a conceptual procedure for selecting and evaluating service providers. He introduces an evaluation process that is divided into four phases: (1) search for general information, (2) pre-selection of potential service providers and tendering, (3) evaluation of tenders and shortlisting as well as (4) presentations by selected service providers and the final choice. Although specific problems in this process are addressed, e.g. the asymmetry of information between the service provider and the client, the evaluation method does not cover all of the required evaluation phases.

As described before, existing research regarding evaluation procedures aims to measure the service quality. Therefore, Grönroos (2000) differentiated between technical quality (e.g. basic and core benefits of the business service) and functional quality that can be assessed before, during, and after the business service deployment. Normally, existing approaches assume that a quality evaluation of business services is done by a purchasing manager even though the business service is used by different departments within the company (e.g. production or logistics department). While Axelsson and Wynstra (2002) provide a basic example for an evaluation approach from a buyer’s perspective, Arshad (2015) points out that an efficient business service evaluation must also combine experiences from different users of purchased business services (e.g. internal, external, or end-customer). This fact is already partially considered by Robinson et al. (1967) who provides one of the first existing descriptions of a purchasing process, differentiating between eight buying phases. More precisely, Van Weele (2009) describes a pre-purchase process and an “aftercare” process – both involving employees (internal customers) from within the company. In this context, it becomes explicit that not only purchasers or internal customers are responsible for a business service evaluation but also the external customers or other parties in a supply chain (e.g. the end-consumer). As Zablah et al. (2010) distinguish between previous experiences of the purchasing manager (e.g. acquiring a business service the first time, as a rebuy, or as a modified rebuy), the necessity of an internal
consumer integration may vary. However, an integrative evaluation approach for buying business services – that addresses pre-purchase processes (e.g. goal-setting, strategy, and requirements) as well as follow-up processes (e.g. quality assessment by the essential users) – is needed but has not yet been described or developed in existing literature.

2.3. Resume of the literature review and research gaps

As the measurement of performance in business services is frequently named to be more difficult in comparison to that of goods; literature in this area is incomplete. The existing research in the field of business service purchasing calls for standardized methods to detect potentials for cost savings and quality improvements. As existing publications also describe this incompleteness and point to the research gap, no satisfying solutions are yet offered.

For the aforementioned reason, several key challenges in the acquisition and evaluation of business services – also identified as research gaps – are summarized:

- **No standardized evaluation approach**: Although industrial-specific approaches are described in literature, so far no holistic evaluation procedure exists.
- **Retrospective business service evaluation**: Existing evaluation approaches focus on a retrospective evaluation but provide no support for the purchasing process.
- **No integrative evaluation focus**: It is assumed that a highly efficient evaluation approach needs to consider different phases (LOI) in which the assessment of quantitative and qualitative variables takes place. Hitherto, there is no consideration of this in existing research.

3. METHODOLOGY

It is shown in the literature overview that the topic of business service purchasing and evaluation is relatively under-researched. More specifically, a profound wide-angle view that considers several phases of business service evaluation (LOI) is very uncommon. With the aim to provide solutions for the revealed research gap and to present answers for the research questions, the following section gives an overview of the applied methodology and the conceptual framework of this research.

3.1. Study design and conceptual framework

Generally, a qualitative case study methodology is employed to answer the research questions and to develop a profound understanding about business service evaluation. This qualitative proceeding seems appropriate, due to the fact that this research is explorative and trying to develop a new theory (Eisenhardt, 1989, Yin, 2003). Miles and Huberman (1994) outline qualitative research as highly appropriate during early research stages, whereas case study research initially focuses on the investigation of little-known phenomena (Marshall and Rossman, 2014).

With a view to the research questions – focusing on a business service evaluation from a buyer’s perspective – an identical single-view perspective for the conceptual framework is applied. Based on the findings from the conducted literature review, two variables were identified as significantly influencing the purchasing capability: supplier collaboration and internal customer collaboration (Danese and Romano, 2011). With the LOI, this research aims to introduce a new variable that influences the purchasing capability. However, it is assumed that the LOI not only influences the purchasing capability but also impacts the existing variables.
All interviews were conducted with purchasing-related employees, including purchasers, commodity managers and executive staff members (e.g. heads of global purchasing). Altogether, ten systematic interviews – each with a length of three to five hours – were carried out by the same researchers in the summer of 2015 in Switzerland. All conducted interviews were recorded, transcribed, and reviewed by the interview partners for correctness and completeness. Therefore, the applied interview guideline consisted of four main sections. While the first section asked for general company data (e.g. firm size, demographic data, and purchasing capability), section two focused mainly on the three different LOI. An excerpt of the interview guideline is shown in Table 3.1.
Table 3.1 Excerpt of the interview guideline used for data collection

<table>
<thead>
<tr>
<th>1. Initial situation of the firm with regard to their purchasing capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>• How would you describe your purchasing capability in general (and differentiated by goods and selected business services)?</td>
</tr>
<tr>
<td>• According to your applied evaluation procedures, are there any differences between goods and business service evaluation?</td>
</tr>
<tr>
<td>• What kind of business services is your firm purchasing on a regular basis and is there an explicit difference in the applied evaluation procedure?</td>
</tr>
</tbody>
</table>

Continued on the next page.

2. Scope and configuration of the applied evaluation procedure for business services

   I. Preparation phase
   • In which way does a structured collaboration with internal and external customers with regard to acquired business services occur? |
   • To what extent does your company consider make-or-buy decisions before acquiring business services from an external service provider? |
   • Is there a clear, company-wide understanding about the requirements for business services and about their contribution to a service value creation? |

Acquisition phase
• To what extend is your company applying qualitative and quantitative criteria for the evaluation of business services?
• How would you describe the market transparency regarding, for instance, market knowledge, specific price structure, or value composition of business services?
• Are there any standardized contract templates for business services applied and to what extent are specific requirements addressed during the preparation phase?

Operational phase
• To what extent do purchasers consider experiences and impressions of internal and external customers with regard to acquired business services?
• Are there any quality management practices for business services applied that are considered on a regular basis for future purchasing activities?

3.2. Case selection and sampling

In order to get a wide variety of examined business cases, selected firms (1) operate in different industrial branches and (2) can be differentiated according to their firm size. In concrete terms, a pharmaceutical producer, a machine and a plumbing manufacturer, a producer of tobacco goods as well as a postal service provider from Switzerland were chosen. Subsequently, a differentiation is applicable regarding the firms operating scope considering Trans-European, domestic but also worldwide operating companies. With the intention to allow a manageable complexity but, at the same time, to ensure a wide range of different types of business services, the research focuses primarily on logistics, marketing as well as on information and communication technology services (ICT). According to suggestions from Eisenhardt (1989) and Yin (2003), the applied diverse case selection leads to an increased external validity and ensures a more generalizable research approach.
As proposed by Seawright and Gerring (2008), a two-step analytical sampling approach was applied. Therefore, a relatively homogenous sample – considering origin and firm size – was selected, in order to guarantee a similar legal and competitive market environment. However, the researchers assume that differences in the evaluation procedure might occur depending on firm size. Consequently, our research neglects small firms and focuses primarily on medium to large scale companies. In a second step, different companies with regard to their LOI were chosen. The research suspected that not a firm’s size but rather the accomplished LOI during the evaluation procedure affects purchasing and evaluation capability. Table 3.2 presents an overview of the selected cases. As anonymity is mandatory, abbreviation are applied for firm identification using A1, A2 and A3 for large firms and B1 as well as B2 for medium sized companies.

### Table 3.2 Case overview

<table>
<thead>
<tr>
<th>Study perspective</th>
<th>Case characteristic</th>
<th>Number of interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case</td>
<td>Selection criteria</td>
<td>Size</td>
</tr>
<tr>
<td>A1</td>
<td>Large-scale, world-wide turnover and service purchasing, mass production</td>
<td>Large</td>
</tr>
<tr>
<td>A2</td>
<td>Large-scale, domestic turnover and service purchasing</td>
<td>Large</td>
</tr>
<tr>
<td>A3</td>
<td>Large-scale, world-wide turnover and service purchasing, customized production</td>
<td>Large</td>
</tr>
<tr>
<td>B1</td>
<td>Medium-scale, trans-European turnover and service purchasing</td>
<td>Medium</td>
</tr>
<tr>
<td>B2</td>
<td>Medium-scale, trans-European turnover and worldwide service purchasing</td>
<td>Medium</td>
</tr>
</tbody>
</table>

### 3.3. Data analysis

In a first step, the collected data was analyzed in more detail using an structural analysis approach proposed by Corbin and Strauss (1990). Therefore, a within and a cross-case analysis
was conducted. While the within-analysis allows a better understanding of evaluation procedures, addressed criteria, and the applied scope of evaluation (LOI), a cross-case analysis helps to identify patterns among the observed cases. To support the data examination and the construct validity, data triangulation was applied – examining data from interview transcripts, internal company documents (e.g. evaluation templates and service contracts), and from several site visits. However, the content of the semi-structured and open-ended interviews appear to be the main source of analyzed information. As a final step, applied evaluation procedures, evaluation criteria as well as other influential factors were examined in more detail.

4. KEY FINDINGS FROM THE EMPIRICAL RESEARCH

The fourth section provides an overview of conducted observations and gives insights into the empirical and explorative case analyses on business service evaluation. With the intention to give answers to the pre-defined research questions, conclusively, four propositions are made and discussed. Next to specific and business service related difficulties the research confirms, as mentioned before, different phases – named “levels of integration” – in which the evaluation process takes place within a company: (1) preparation, (2) acquisition as well as (3) an operational phase.

As suggested, the research reveals that a company’s ability to consider information and experiences from all levels of integration is highly related to its capability to ensure a successful business service purchasing performance. With the intention to get a better understanding about the correlation between the LOI and the purchasing capability, the interviewees were asked to rate the companies’ purchasing capability on a five-point Likert scale differentiating between logistics, marketing, and ICT-services. In addition, the LOI of each individual business service was assessed by the research team and compared with the stated purchasing capability. As suggested, a positive correlation between both items was confirmed for all of the three types of business services. However, differences appear regarding marketing services, as an effect of the LOI on the purchasing capability was less viable in comparison with logistics and ICT services. Nevertheless, as a positive correlation is certain, this research proposes:

*Proposition 1: The consideration of all LOI during the purchasing and evaluation process of business services leads to increased market transparency, to a better understanding of requirements and offerings, and, therefore, to an enhanced purchasing capability regarding business services.*

In this manner, company A3 can be seen as a good example as purchasing capability and the applied business service evaluation appears to be the best observed during the research. The head of global purchasing stated, “*Purchasing does not simply start with the acquisition and bidding. Especially when buying strategic services, several meetings with our internal customers are conducted to set goals and to define service requirements. You could say, we employ experts at every step of our purchasing process. We consult the legal department for contract closings, offer negotiation trainings for our purchasers and conduct meetings on a regular basis [before and after the acquisition phase] with internal customers.*” While similarities were revealed at the other firms but also with existing literature (e.g. Axelsson and Wynstra, 2002), this research revealed ten different subsections that were considered during the purchasing and evaluation process (Figure 4.1). However, the selection makes no claim to be complete.
The first section, (1) goal setting, can be described as an initial determinant for the applied evaluation procedure in later phases. The director of corporate procurement of company B2 noted, “Due to a limited budget, we cannot apply extensive evaluation procedures to all of the externally sourced business services.” Therefore, the companies differentiate between several acquired business services, e.g. addressing the contract duration or a service’s contribution to the firm strategy. With sub-section two, (2) make-or-buy, a critical reflection – addressing internal capabilities and resources – is required. However, the logistic purchasing manager from firm A3 reveals, “Although internal resources were available [in-house service provider], an inner perspective was often neglected in the past. Recently, management applied initiatives for a systematic consideration of both internal and external service providers.” As last subsection, (3) qualitative and quantitative requirements for acquired business services need to be specified. This can affect core benefits (e.g. service level, capacity, or quality expectations) as well as specific requirements (e.g. brand reputation, sustainability confirmation, etc.). In either way, not the purchasing manager but the internal consumers are named as responsible for the required setting. The head of indirect purchasing of company B1 clarifies this fact: “Our guys [from the purchasing division] can be described as intermediary between the departments and the service providers; we set the agenda, we negotiate, and we sign the contracts. However, specific requirements for the services are determined by the departments. I mean, how shall we know what these guys need?” In accordance with insights from Arshad (2015) and Van Weele (2009), the following proposition summarizes the statements from the interviewees and revealed insights of the preparation phase:

**Proposition 2:** An early reflection with internal capacities and required specifics of business services – considering internal customers as well as executive staff members – allows a more precise understanding of the market, the business services, and the service provider evaluation in subsequent phases.

With the fourth subsection, (4) the acquisition, a tendering process is initialized. Therefore, predefined requirements from the preparation phase are captured and contextualized for the tendering. However, as stated by the head of service purchasing from company A2, problems may occur on a regular basis, “In theory, this task sounds quite easy. The problem is, when buying, e.g. marketing services, people normally do not know what to expect. How shall we address specific requirements without knowing the output?” Another aspect is described by the head of global purchasing as he notes “[...] differences occur in the context of public tenders as a part of our purchases is governed by public law.” In this context, contracting authorities

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**Figure 4.1 Different phases of business service evaluation**

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are bound by specific procurement regulations (e.g. principal of non-discrimination, transparency, or equal treatment) that need to be considered.

At the fifth subsection, (5) bidding, obtained offers from potential service providers are selected, evaluated and compared to each other. Typically, this section describes a cost analysis in which buying companies compare prices regarding offered service conditions (Yusuf, 2012). Assuming, a business service is purchased for the first time; a buying company can at most assess quality aspects regarding the service provider (e.g. appearance, professionalism, or responsiveness) rather than the quality of the business service. Contextually, the head of global warehousing from company A1 stated, “We do assess a bunch of quality aspects at this stage [acquisition phase]. But don’t get me wrong, without our tremendous amount of past experiences, a comprehensive quality assessment based on biddings would not be possible.” More precisely, the head of indirect purchasing from company B1 notes, “If a logistic service provider assures a delivery performance [adherence to delivery dates] of above 98%, we cannot call it a quality aspect but only a promise of performance, comparable with other biddings. If a service provider continuously demonstrates its capability – e.g. in the past with other companies or recently with us – we call it a quality aspect considerable during the purchasing process.” For the aforementioned reasons, it is proposed:

Proposition 3: Next to the aforementioned consideration of all LOI, evaluation procedures for business services must obtain but also clearly distinguish between offered service conditions (comparable by a cost-break-down) and quality aspects from both service provider (before the purchase) and business service (after usage).

With the next subsections, (6) negotiations with preselected service providers are initialized before a contract with a chosen tenderer is concluded (subsection 7). As processes during the seventh section need to be as accurate as possible, all observed company’s state the “[...] use of standardized templates for contracting [...]” and the necessity of “[...] legal advice from internal or external experts.” With the intention to allow a proper negotiation, all large-sized companies applied frequent trainings for their purchasers. However, the head of global sourcing from company A1 points out that, “Although we have applied trainings for purchasing managers addressing negotiation tactics and skills, experience shows that these trainings are mostly insufficient without a profound understanding of market and price conditions obtained during the preparation phase.”

The last LOI, the operational phase, appears to be the only phase in which a quality evaluation of the acquired business services is possible (subsection 9). In this context, one must distinguish between the decisions made during the acquisition phase. Even though inputs from the operational phase are considered, e.g. experiences or references, the actual evaluation and data collection occurs during the essential usage of a purchased business service (subsection 8). Coherently, essential users appear to be both internal customers (employees) and external customers (distributors, traders or end-consumers) as stated by the head of global purchasing from firm A2, “As a purchasing manager we need to consider objectives from other departments [internal customer] but also requirements of end consumers [external customer]. If we want to acquire, for example, a website for our customers – where our products are presented and customizable – representatives from different departments are involved. Additionally, external service providers [ICT] and their experiences regarding consumer perceptions and wishes are consulted if necessary [supplier collaboration].” Subsequently, the last section, (10) lessons learned, can be described as the most essential element for the quality evaluation of business services as gathered experiences from the usage are systematically analysed and communicated with the purchasing department. Therefore, the head of global operations from company B2 stated that “[...] the collaboration with the internal customer as
well as with the end-consumer along the supply chain is crucial [...]” for a comprehensive business service evaluation. Moreover, information on pre-evaluated service providers becomes expandable and therefore more substantial for future acquisitions. Consequently, the last proposition is made as follows:

**Proposition 4:** As the efficiency of the entire purchasing and evaluation process is correlated with the LOI, the integration of both service provider and internal customer is also strongly dependent on a widespread consideration of all described main phases and subsections.

5. **CONCLUSION**

With a view to globalization, shortened product life cycles and increasing outsourcing rates, it is essential for firms to be aware of both service requirements and service quality measurements. The goal is always to improve product quality, to reduce costs, and to ensure highly reliable business services. Therefore, the conducted research provides some detailed insights on business service evaluation revealing the level of integration as a crucial factor to consider for future research on this topic. For both researchers and practitioners, a consideration of information and experiences from all phases is required and therefore recommended to ensure an efficient business service evaluation as well as the desired purchasing capability. However, the research reveals that differences occur regarding both the type of purchased business service as well as the industry in which the business takes place. Conclusively, further research is required as the characteristics of different types of business services as well as the environmental setting may influence the implications made in this paper.

**ACKNOWLEDGEMENTS**

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ABSTRACT

Purpose
The purpose of the paper is to explore the planning processes of Logistics Service Providers to identify barriers that are hindering effective planning of transport resources. Information- and communication technology (ICT) frameworks have been adapted to provide a structured approach for the analysis and future studies.

Design/methodology/approach
Empirical data has been collected through a case study and a series of interviews (structured and semi-structured) with three of northern Europe’s’ leading Logistics Service Providers and two motor carriers. Secondary data was collected from documentation from said companies. Additionally, a literature study was conducted to provide a frame of reference and theoretical support.

Findings
The empirical data show a number of barriers that are hindering effective planning of transport resources in Logistics Service Provider terminal networks. These are mainly related to lack of collaboration, transparency, and information sharing. Furthermore, the paper provides insights of how stakeholders interact, and how the service buyers behave when ordering transport services.

Research limitations/implications
The main research contribution is providing a depiction of Logistics Service Providers’ the current issues or barriers that are hindering from efficient planning of transport resources. A secondary contribution is a proposed approach of how to systematically identify and remove barriers, and evaluate the impact.

Original/value
This paper fills a part of the theoretical gap in where future research of Logistics Service Providers can be focused to improve their planning process. The barriers investigated are described and explained as to how they cause issues or planning ineffectiveness, and in which way they directly impact the economic sustainability for Logistics Service Providers. Removing or overcoming these barriers should positively affect long-term economic situation and growth.

Keywords: Freight Transportation, Transport Planning, Logistics Service Provider, ICT
1. INTRODUCTION

Freight transport services is a commodity, with operators facing fierce competition in most of Europe and North America. A major factor heavily affecting both financial and environmental sustainability of freight transportation is fill rate (European Commission, 2014), and increasing fill rate it is high up on the agenda of both authorities and companies. Yet, efficiency of road haulage operations is typically considered low and empty running in Europe accounts for 27% of the road based transports (Vilkėlis & Jakovlev, 2013). The problem is compounded by operators spending, or affording to spend, very little on development of their operations (Wagner, 2008).

Defining efficiency is inherently difficult (Shaw, 2009) and road haulage is no exception. Various single and compound measures of efficiency have been tested (e.g., Simons et al., 2004), yet fill rate is typically regarded as the most important factor in measuring efficiency (Lumsden, 2006). In a less-than-truckload (LTL) road freight system for general cargo, in which either direct or hub and spoke shipment control is employed, every regional terminal transports goods to and from every other terminal in the system. There is rarely day-to-day operational optimization using capacity planning for, and execution of, long haul transportation between terminals (Arnäs et al., 2013). A quantitative study has previously been conducted by the author (Hagen, 2013) that measured resource utilization of a large amount of line haul departures (750+) in LTL networks from three major terminals of the three largest Logistics Service Providers (LSP) in Sweden. This study by found that the average resource utilization in terminal network operations were 91.8% for deck area, 61.9% for volume, 67.2% for load height, 64.3% for paying weight, and with an overall average fill rate of 71.8%. This leaves considerable room for improvement if the theoretical maximum is 100% of each measure of utilization, and show a lot of potential for improvement.

In the search for higher fill rates (transport network efficiency), previous research has highlighted an effective planning process as a key factor (e.g., Crainic, 2000, Tjokroamidjoko et al., 2006, Arnäs et al., 2013). Arnäs et al. (2013) outlined time constraints regarding terminal operations and service characteristics such as late deadlines for accepting new orders as major factors affecting fill rate. Several papers have used, e.g., modelling and simulation to quantify the benefits of a more sophisticated planning of road freight haulage. There are many theories and models ranging back to early 1980ies (Barker et al., 1981; Powell & Sheffi, 1988; Samuelsson & Tilanus, 1999; Crainic, 1999; Grünert & Sebastian, 1999; Krajewska & Kopfer, 2006, Wong et al., 2007) that in a number of different ways could theoretically help the freight transport industry improve their operations and increase transport resource utilization if implemented.

Europe general cargo LTL is mainly carried out by large LSPs that mainly rely on tens of thousands of motor carriers to operate the legs in their distribution networks (Stefansson, 2006, Klaas-Wissing and Albers, 2010). In comparison to the US the European LSPs use a number different contractual models, e.g., purchasing transport capacity from motor carriers for use in specific routes or regions, or income sharing business models from specific routes or regions. The main impact of this is the level of control that the LSP has over the resources of the motor carrier.

Not having direct control of the vehicle fleet makes it more complex to plan and operate the networks and processes. However, it also reduce the risks and costs related to owning a vehicle fleet. The problem is that relinquishing control of the fleet increase the complexity of planning and controlling the freight transport operations (Sternberg et al, 2013). This increase the need for stakeholder integration and collaboration in order to plan operations, and the need for IT
enhanced information sharing and collaboration tools (ibid). This applies regardless of whether the transportation companies or networks are governed cooperatively or corporately (Klaas-Wissing and Albers, 2010) as they face many of the same difficulties. The various approaches to how the procurement of transport resources are handled may vary, but they have in common the difficulties of balancing and matching transport capacity with actual demand.

LSPs should be able to increase resource utilization if they can accurately plan operations by knowing the demand for their services in order to procure the amount of transport resources necessary to perform at, or as close to, optimum as possible while still maintaining the necessary flexibility and reliability in the terminal networks. However, that requires that the criteria Sternberg et al (2013) outlines are fulfilled.

Caris et al. (2012) outlines a new research agenda for intermodal transports based on gaps in previous research, and a part of that is the highlighted need for more research in terminal network design. While network design is important the planning processes that lead to the use of the terminal network and transport resources are also arguably of great importance explore and analyze. The complex transport systems of the LSPs in Europe could remove many of the existing problems by becoming better integrated and collaborate more in their networks as outlined by Sternberg et al (2013).

How the LSPs plan their operations and interact with other stakeholders is important to investigate in order to better address some of the larger issues, such network design etc. Crainic & Laporte (1997) touched upon some of these very issues in 1997, but little seem to have been written since although there seems to be plenty of opportunity for improving resource utilization as outlined earlier.

There is a gap in current theoretical literature as little has been written specifically about which issues that exist in transport planning processes and how they affect the resource utilization of transport resources in road based transport operations. As such, this paper attempts to start bridge this gap in literature by exploring the connection between LSPs transport planning processes and resource utilization levels. The point of departure is finding out why LSPs seem unable to accurately plan their operations capacity. The purpose of the paper is to elucidate what is causing the LSPs line haul operations’ resource utilization levels, and if it could be possible to leverage information technology in order to improve upon the effectiveness of the planning processes.

2. DELIMITATIONS

The case companies in this paper are three large global logistics service providers and multimodal freight logistics service providers and two of their regional motor carriers. This paper is limited to their road based freight transport operations in Sweden. The focus is on the planning processes and the related information, data, activities, and how they plan the capacity in their national networks.

3. METHODOLOGY

The empirical evidence has been collected through a qualitative case study of the transport planning processes, with the particular focus of line haul operations. The case study include three of northern Europe’s’ leading Logistics Service Providers and two of their subcontracted
motor carriers. The empirical data collected in this paper is related to the previously mentioned study (Hagen, 2013) and meant to follow up on those findings.

The paper has utilized a system approach as it was important to understand the system components and the relations between the components. The components were studied in their natural relation to each other and in their causal relations (Arbnor and Bjerke, 1997). The study focus on the case companies’ planning processes to identify what is affecting the LSPs from achieving optimal fill rates and resource utilization. The main method for data collection was semi-structured interviews that were documented using a case study template to create study protocols and a database, and the secondary was investigating documentation from said companies. To ensure reliability of the results and making sure data collected from all companies followed the same procedure, documentation in the form of templates were developed based methodology described by Yin (2003). This also makes it possible to replicate the same type of study in the future which is of importance for future according to Eisenhardt (1989).

It should be possible to both internally and externally validate case studies to ensure the integrity of the study. The verification and validation of the collected data in the case study was an iterative processes that was carried out based on Chung’s theories (2003) and Bank’s (2001) methods. Da Mota Perdosa et al. (2012) has criticized the transferability, truth value, and traceability in case study based articles. Based on their conclusions this paper strives to achieve the highest possible levels of transferability, truth value, and traceability without revealing specific individual case companies’ operations by presenting the empirical data on an aggregated level.

Table 3.1 Overview of the various roles of the personnel interviewed in the 5 case companies

<table>
<thead>
<tr>
<th>ROLE</th>
<th>LSP 1</th>
<th>LSP 2</th>
<th>LSP 3</th>
<th>CARRIER 1</th>
<th>CARRIER 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRATEGIC NETWORK PLANNER</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>TRANSPORT PLANNER</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TERMINAL MANAGER</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LINE HAUL MANAGER</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>TERMINAL FLOOR MANAGER</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>SALES MANAGER</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>PROJECT MANAGER(S)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>X</td>
</tr>
<tr>
<td>IT MANAGER (TMS)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>TRANSPORT OPERATIONS MANAGER</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VEHICLE DRIVER(S)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

All activities and the information/data used and generated in the planning processes was mapped. The planning process starts when a LSP receives a customer order and ends when the weekly or daily capacity planning is completed. The reason for mapping the this process was to gain a firm understanding of how the service consumers behave, which stakeholders are involved in the planning processes, and what their different roles are, and how they affect the outcome of the planning processes.

A number of different roles and positions in the case companies have been interviewed (X), and have been categorized in the table below. Some of these roles were either not available (N/A) for interviewing, or did not have any equivalent role in the case company.
A group of researchers (Rodrigues et al., 2008) created a model designed to identify and locate uncertainties in the transportation triad from a supply chain perspective. These were split into 5 categories, namely the supplier, the customer, the motor carrier, the control systems used in the supply chain, and external factors.

One of the stated research limitations is the conceptual nature of the paper and the uncertainty model. In the context of this paper its usefulness lies is in the way it provides a structured way of collecting empirical data about the planning processes in order to evaluate the potential improvements of freight transportation from an ICT perspective.

Because there could be any number of barriers hindering both individual transport companies and the transport industry as a whole from adopting more ICT tools a structured approach to investigate them is necessary for this paper. This has been touched upon in a number of EU project reports and research publications and Harris et al (2014) has outlined a number of them. The research conducted by Harris et al provided a structured approach for this paper to collect empirical data regarding barriers from an ICT perspective.
A number of barriers that are hindering ICT adoption were categorized into user-related, policy-related, and technology-related barriers by Harris et al (2014). Some of these are general problems that the transport industry has been struggling with for a long time. With this as a base the study focused on the outlined lack of coordination, standardization and harmonization, and large barriers for widespread ICT adoption. Harris et al (2014) also evaluated where ICT efforts are currently focused and deployed in general, and their estimated impact on the three categories of barriers, which was useful for the analysis.

4. FRAMEWORK - PLANNING IN A TRANSPORT NETWORK CONTEXT

Planning of operations is necessary for all organizations. The degree of planning needs and capabilities differs greatly between types of organizations, types of industries and size of companies (Jacobs et al., 2011). Uncertainty of future demand is obviously a major contribution to forecasting failures in capacity needs and many attempts to improve accuracy fall short. The fundamental management components of Supply Chain Management (Lambert & Cooper, 1998) are broken down into two main categories: physical & technical (planning and control methods, work flow/activity structure, organization structure, communication & information flow facility structure, and product flow facility structure), and managerial & behavioral components (management methods, power and leadership structure, risk & reward structure, and culture & attitude). The majority of these components can be seen in transport chain contexts, albeit in different forms and structures due to different characteristics due to being a service industry.

There are several frameworks for collaborative planning within various industries. Two common models are the Efficient Consumer Response organization (ECR) and is developed by the Voluntary Interindustry Commerce Standards Association (VICS), the Collaborative Planning, Forecasting, and Replenishment (CPFR) model. The mission of CPFR is to improve
the partnership between trading partners through collaborative processes and shared information and has become an influential approach to managing the supply chain and many large retail companies in the US are involved in CPFR utilization (Andraski, 2001; Esper & Williams, 2003). These frameworks contribute to increased accuracy and affect the mutual supply chain planning capabilities (Fliedner, 2003; Holmström et al., 2002; Steermann, 2003) (Mason and Lalwani, 2006, Sanchez-Rodrigues et al., 2008).

Many planning theories’ and models have been developed related to freight transportation. Literature presents a wide range of planning models for operations management and supply chain management (Narasihman and Santosh, 2004; Ma and Davidrajuh, 2005; Jacobs et al., 2011). A number of valuable and interesting research contributions are listed and briefly summarized in the table in appendix 1. This table was assembled by reviewing literature with models or theories related to modelling and simulation of quantifying the benefits of using more sophisticated planning in road freight haulage.

Despite the existence of many planning models, no transport planning model is as established as the go-to model for the transport operations planning, such as MPC for production contexts. However, some similarities can be found where planning is divided into Strategic planning, Tactical planning and Operational planning. The division into these three areas have been widely applied in transport planning, not the least by Crainic and Laporte (1997) and contributions he, his collaborators, and others have published in recent decades.

4.1. Improving transport operations and planning processes from an ICT perspective

Previous research has outlined structured methods or frameworks for structuring research and methodically improving processes, supply chains, operations and a number of other application areas. Stevens (1989) developed to one of the early key contributions in the area through his systematic approach to developing and integrating the supply chain. His approach include three phases: 1. Competitive environment evaluation (identify customer needs); 2. Supply chain diagnostic review (determine options); 3. Supply chain strategy development (organize options into an integrated supply chain strategy).

Lalwani and Mason (2006) followed in the footsteps of Stevens (1989) by adapting Stevens’ model and further developing the structured approach by creating a tool specifically for transport integration in supply chain management. An overview of the framework along with examples of tools that could be used can be viewed in the figure below.

A significant part of Mason and Lalwanis contributions were in-depth descriptions of number diagnostic tools that could be used to assess performance and level of transport integration. Lalwani and Mason used other previous key contributions from other researchers, such as the Overall Vehicle Efficiency (OVE) by Simons et al. (2004), mapping tools, supply chain diagnostic tools and simulation tools to name a few. These were aggregated into the overall framework, and provide a good baseline for a structured approach to mapping operations in order to assess and diagnose issues or hindering barriers.

ICT has been widely hailed as the solution to many common problems, such as reducing uncertainty, in the transport industry. ICT enables information sharing between transportation stakeholders, something that is important for performing activities such as accurately planning operations. However, a substantial amount of research publications are purely of theoretical or conceptual nature (Sternberg & Andersson, 2013). Sternberg & Andersson (2013) reviewed 38 research publications related to transportation and ICT, and classified 34 as conceptual papers. Out of the remaining 4 papers only 2 were non-empirical numerical experiments and the last 2
two were prototype studies. The lack of empirical evidence suggests there is little to study, and that very few companies in the transport industry have been able to use or implement many of the proposed ICT solutions.

The lack of empirical evidence of usefulness or value of ICT in transport context is problematic. However, if some of the current trends identified by Harris et al (2014) continue, then the barriers hindering the transport industry from adopting some of the ICT solutions or concepts will decrease over time. Development and introduction of IT in other industries or sectors will help mature technology, and could over time also create benefits for the transport industry by removing or lowering some of the barriers. Although that is the general assumption more research has to be conducted, especially research that either pinpoint where and how ICT could specifically help, or research on how, where, or how much ICT actually improve operations.

5. LOGISTIC SERVICE PROVIDERS AND PLANNING PROCESSES

This chapter contains the empirical data. The companies’ processes are not shown individually mapped or are individually analyzed to keep them anonymous. Instead how they operate and function is depicted with an aggregated description. There are relatively few and relevant differences operational differences, but those differences could identify a particular company. The companies’ only agreed to participate in the study if they were not potentially exposed to their competitors. As such this paper presents a general overview of how these logistics service providers perform their transport operations and planning processes, without singling out any one specific companies’ specific issues. Differences in business and contractual models create some unique issues and barriers which could make for interesting future studies.

In the terminal network freight shipment process there are four main subprocesses. These are depicted in the figure below.
The figure outlines the overall activities that are related to the planning processes, and show where the empirical data has been collected. The four represent the beginning of the planning process and where it ends.

5.1. Transport operations process mapping

Historic data combined with contracted or explicitly implied capacity need is what provides the input for daily and weekly forecasts as to what each particular day/week, route and customer will require. The contracted or explicitly implied capacity requirements functions as a sort of capacity allotment, and is estimated to normally be around 30% of the planned capacity. Due to inconsistent or incomplete data availability during planning there is also normally extra capacity planned to avoid any ambulatory transports or unnecessary delays.

All the various activities, decisions, physical movements and the related information that is created, used or sent to different stakeholders are shown in the process mapping figure below.

It depicts the entire transportation process for shipments passing through the terminal network, in a chronological order. The actual timeframe for each parcel or shipment may vary, therefore no specific time indication is shown. Lateral connectivity indicates they are connected to the same activity or step in the process while horizontal indicates the order of step in the process. For direct delivery operations the process is similar, except it normally skips the terminal activity steps.
5.2. Customer orders and shipment data communication

Generally there are two main ways transport services orders are communicated. The first category is the customers that have automated their communication, and communicate their needs through EDI, directly from their information systems to the LSPs information systems. The second category consists of a minority of small to medium sized companies that manually communicate their orders which mainly use a web booking system provided by the LSP.

The level of IT integration and automation of information exchange is mainly differentiated by size of the customers company. Large organizations tend to favor using automated EDI orders while medium and especially small sized companies generally tend to use the web booking system. Regardless of method of communication the information about the assignment and attributes of the consignment are always the same, and specified as unit type (i.e. pallet, bulk, parcel, etc.), weight and dimensions. One issue the LSPs have in common is that this information is often ignored, guesses, or incorrect.

The communication is mainly electronic and estimated by the LSPs to generally have at minimum 90-95% of their communication electronically received, but a small amount orders are generated by phone, fax, or due to ad hoc pick up. Generally this type of communication tend to only occur under special conditions for the customers, such as when their automated systems are not working, they are unable to access the web based systems, or for emergency transport orders.

Users of the pick-up and distribution transport services normally communicate their orders the same day they want shipments picked up. This occurs often as late as an hour or two before desired pick-up. Typical customers with this behavior are often companies that have specific customer service goals and short lead times such as those promising to ship orders the same day as they are received. Many of the companies with these behavior profiles normally have to indicate their estimated daily capacity requirements in their contracts, and are supposed to give notice in advance if they know they will differ a lot from their estimated capacity requirements. However, this behavior is not unique to those companies. Most other customers tend to communicate very late as they have no incentives or reason to be transparent or collaborate with the LSPs. This stems from the general overcapacity in the road based transport industry and it is almost always possible to find available capacity on short notice. The total contracted or implied capacity is estimated to be 30% of the daily orders, and 60% of the total amount of shipments.

Direct delivery (full truck loads) orders have different communication patterns. The customers’ needs and requirements means ordering further in advance and with more accurate information due to the nature of their more specific demands i.e. requiring entire vehicles, bulky goods, etc. They normally book transportation at least 1-2 days in advance, and about 60% of the full truck load orders are communicated at least one or more days in advance for mid-sized shipments. Very large shipments that require multiple vehicles are communicated even further in advance, and the rule of thumb is that the larger the shipment is the further in advance it is booked.

6. IMPACT ON PLANNING PROCESSES AND RESOURCE UTILIZATION

Some customers provide incomplete or erroneous input data when booking transport services. This is done both intentional and unintentional, but it can create planning issues. An example is defining the shipment as the wrong unit type i.e. declare a pallet as a parcel, declare wrong
weight, or provide the wrong dimensions. Having missing, incomplete or erroneous data about any one of these could lead to planning issues such as insufficient vehicle capacity, unused capacity, or charging the wrong fee for the service.

Lack of transparency between stakeholders in combination of having incomplete or unreliable data about actual customer needs and requirements leads to constantly planned overcapacity to be able to meet variation in transport demand. The result of this tend to lead to lower-than-optimal resource utilization. Depending on the contractual model of the LSP this could affect the motor carrier in different ways. If the logistics service provider itself is not responsible for the resource utilization, such as in the cases where only rent capacity of vehicle, it is up to the motor carrier to fully utilize any unused capacity on their vehicles. For example, by actively searching for more assignments in the vicinity. Short-term benefits are likely gained by the LSP, but the long-term implications are that the costs could increase as the motor carrier has fewer options as to how to maximize resource utilization compared to a logistics service provider.

A lot could be done in order to fully utilize the transport resources if demand was known in advance. Then resources of the correct capacity could be used or repositioned accordingly. By using more detailed data in the planning process, which is almost fully automated, it could be possibilities to create more balanced load profiles.

According to the interviewees weight is very rarely any issue, and vehicles are almost never close to the maximum capacity. This means that weight would rarely be of any concern, and the focus could be on maximizing volume as well as area. It would be necessary would be to investigate what the actual costs of loading the vehicles differently. There is relatively little time to unload and load vehicles at the terminals due to system restraints. This could be an issue when considering how to achieve higher resource utilization in more than the area aspect as it might not even be possible to do so while still maintaining the fast throughput times.

Many issues have been outlined are that are hindering the planning processes from leading to effectively utilizing most of the transport resources. As such, improvements that improve planning so that resources are better used could lead to reduced costs, or increased profit. But in order to do so the stakeholders need to become better integrated and communicate better. ICT can in many ways reduce or remove the various issues if applied correctly.

7. FOCAL AREAS FOR BARRIER REMOVAL

Previous work by Crainic & Laporte (1997) indicates that transport planning operations would benefit from learning from manufacturing theories and methodology. So what happened? Did the research community then failed to convey the lessons and knowledge to the industry? Or were there were barriers hindering implementation of new planning tools and methods?

One such barrier is currently lack of data or information sharing and integration between different stakeholders. As technology and information systems keep maturing and being developed there should now be much better conditions for advanced solutions than those that were previously possible to put into practice. Collaboration, transparency and visibility of the needs, requirements and behavior of both customer and the customer’s customer could greatly improve the planning effectiveness, which would be a crucial part in achieving the best possible resource utilization. Efficient transport operations depend on the three different focal areas of barriers have been identified through literature and though empirical data collection:
Overcoming these barriers are the key to achieving better resource utilization and making the outcome of the planning processes more effective. In order to do so the three focal areas Planning & Control, ICT, and Collaboration must all work in synergy to be able to plan more transport operations more efficiently. In this paper’s empirical data a number of issues have been outlined a number of issues and challenges in freight transport operations. Many of the issues the logistics service providers are facing are directly related to lack of information and collaboration which is causing problems with planning and control.

### 7.1. Planning & Control

Planning & Control is the first of the three focal areas for barriers. It is separated into four different sub areas: strategic planning, tactical planning, operational planning, and contract agreements.

The key problem areas in strategic planning are service design and tariff policy, network design, and service demand forecasting. Forecasting the demand is difficult because it is only based on historical data without input from service buyer or user. There are neither carrots nor sticks that create any demand visibility or transparency within the transport chains. Designing services and deciding tariffs is difficult when the future demand largely unknown. Decisions about network design has to be based on inaccurate forecasts.

On a tactical planning level the problems continue when the number of terminal links and terminal capacity has to be decided, while having no visibility of the transport demands. The operational planning issues are mainly created due to order timeliness. Most of the services are booked after the transport resources have been allocated, and the actual customer delivery requirements are often completely unknown for the LSP. Additionally, the shipment characteristics data is unknown or inaccurate which makes it difficult to assess the actual transport resources required until all the shipments have arrived at the terminal.
All the LSPs have in common that they do not operate or own any vehicles, and utilize motor carriers to conduct their transportation. Contract agreement models vary between the three LSPs, but the problems remain largely the same. Transport resources have to be decided too far in advance, or is out of control of the LSP depending on whether the LSP or the motor carrier is responsible for resource allocation. In the study by Hagen (2013) the transport resource utilization end result was largely the same for line haul departures regardless of whether the LSP or motor carrier was responsible for planning the resources. The cost of utilizing the resources could, however, potentially significantly vary between the LSPs depending on how close they collaborate with the motor carrier. Depending on whether contracts are based on profit sharing or not the incentives and cost structures for regular and ambulatory transports services could vary wildly.

### 7.2. Information & communication technology

Common for the three LSPs is the same relative use and maturity of their information and communication technology. All three do not have any significantly advanced IT system solutions or support.

Figure 7.2 Planning & Control barriers

Figure 7.3 Information & communication technology barriers
Because of the inflexible and old systems there are difficulties supporting planning processes on all levels, and the operational support is limited. The data the systems they do have can utilize is limited and riddled with inaccuracies, or simply outright missing. Because they never were designed to do so, and have a limited amount of tools and processes in the terminals, the systems have problems tracking actual transport resource utilization. This should not be mistaken for the economic utilization of the transport resources.

Having old systems and technology makes it difficult and expensive to integrate and automate processes with transport service users. Because of that the information sharing between stakeholders in the transport chain is limited, and there are few good tools available to create or use what information or data there is. This lead to a lack of transparency in the transport chains.

### 7.3. Transport chain collaboration

The level of collaboration between transport chain stakeholders, and the LSP and motor carriers, is different for the three LSPs. The level of vertical or horizontal collaboration with the stakeholders can have a large impact on both planning and operation processes.

![Figure 7.4 Transport chain collaboration barriers](image)

Agreeing on service levels or differentiating customers is important for all the stakeholders. But being able to do so in practice requires more sophisticated tools than those available, and has to be conducted manually, and often on-the-fly when unforeseen events occur. This leads to the typical “black boxing” where the operations are conducted as usual without much regard for the actual current demand and supply for transport services.

The level of horizontal collaboration affect how and by whom level of transport resources are decided, controlled and allocated. Depending on the process integration between i.e. the LSP and motor carrier can lead to discrepancies in the expected demand and affect profitability or risk for both parties.

### 8. APPROACHING THE ISSUE OF REMOVING THE BARRIERS

Common supply or transport chains include four stakeholder roles: supplier, customer, logistics service provider, and motor carrier. The number of stakeholders of the different roles and
network complexity of these can depend on the context, and in some cases stakeholders can have multiple roles.

Regardless of the context it is important to understand the interactions and information flows between the stakeholders. The transport process could include a number of different activities performed by different stakeholders, and change depending on the complexity of the transport operation.

The approach proposed by Mason & Lalwani was not found ideal to use in a transportation context as it is meant for supply chains. After collecting the empirical data it was difficult to use the existing model as-is. In addition one of the outcomes of conducting the study was that attempting to apply ICT to solve the issues found was difficult. The difficulty lies in proving how and where any improvements could have measurable impact after application or integration. In order to systematically identify these types of issues, ICT solutions, and later assess their impact in a transportation context a new approach is proposed.

This new structured approach was created by aggregating the approaches, frameworks and models by Stevens (1989), Douglas, Lambert & Cooper (1998), Mason & Lalwani (2006) and Harris et al (2014). The new approach is meant to help provide a systematic approach to identifying issues or barriers related to planning in a transport context. It also helps to identify solutions to issues or how to remove barriers, create a strategy for implementation, and assessing the improvements afterwards.
9. CONCLUSIONS

The literature shows that successful collaboration in supply chains is built upon long term relationships and trust between stakeholders. This applies especially to markets where competition is tough. The transportation industry hardly ever has such long-term relations, and is mainly based on relatively short-term, arms-length relations. Transport service buyers do not need to secure long-term transport capacity as transport services are highly commoditized.

In addition, information sharing is vital for successful collaboration and long-term economic stability in the businesses. Information availability is important for execution of processes and it is also a condition for successful planning and as input to forecasting activities. Unfortunately, the evidence from the case study shows that information and data exchange is kept at a minimum. Not only is it kept at a minimum but the information exchange takes place very late in the process. It most often takes place the day before execution for direct delivery operations and for pick-up and delivery operations in most cases only a couple of hours before pick-up. Additionally, the information that is shared is often inaccurate and unreliable. This is troublesome from both an economic and environmental perspective as in many cases it results in suboptimal resource utilization. Also it might also help to explain why many companies in the transportation industry constantly struggle for survival.

Unpredictable behavior or unknown demand for transport services is resulting in LSPs mostly acting reactionary almost in real time, and that leads to less than optimal resource utilization of freight transportation vehicles and trailers. Not fully utilizing the available resources is a problem stemming from the planning aspects of the transport operations such as the dimensioning of the network, terminal connections, and transport resources to name a few. Incomplete or erroneous planning of operations is causing unnecessary costs due to having to maintaining a system with unused resources, i.e. overcapacity. This in turn also leads to additional and unnecessary strain on the environment.

There is a lot of potential for removing many of the current barriers and solving issues with using ICT to create transparency and enable collaboration. If used correctly ICT might also help remove some of the current issues such as having to rely on unreliable or incorrect data for capacity planning. Closer collaboration and integration between stakeholders and possibly find incentives to change the behavior of both the transport buyer and their customer would go a long way towards transforming the economic ecosystem of the transportation industry to a healthier and thriving environment.

It is difficult to approach how to identify, remove, and assess the impact of removing the barriers or solving the issues. There were many useful frameworks that provided a good point of departure for creating the foundation of a new approach in a transport operation context. This paper and the proposed approach will hopefully help fill some of the current gaps in literature. A methodological and structured approach is necessary, and attempts at using existing frameworks for other contexts were insufficient in this context.

REFERENCES


### Appendix 1: Overview of important research papers and their contributions

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Brief summary of research paper contents</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Barker et al., 1981</em></td>
<td>Highlights a number of issues and shows a number of models that can help amend the profitability and service issues for motor carriers.</td>
</tr>
<tr>
<td><em>Powell &amp; Sheffi, 1988</em></td>
<td>Describes design and implementation of an interactive optimization system for freight routing in less-than-truckload motor carrier networks.</td>
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<td><em>Samuelsson &amp; Tilanus, 1997</em></td>
<td>Proposes a general framework efficiency model for regional less-than-truck load goods transportation.</td>
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<td><em>Crainic, 1999</em></td>
<td>Reviews service network design modelling efforts and mathematical programming developments for network design.</td>
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<td><em>Grüner &amp; Sebastian, 1999</em></td>
<td>Identifies how to address planning tasks and defines optimization models for long-haul operations of postal and express shipment companies.</td>
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<td><em>Stank &amp; Goldsby, 2000</em></td>
<td>Proposes a framework that positions corporate transportation management within the integrated supply chain environment and portrays initial transportation decisions such as strategic long-term decisions in the SC transportation system.</td>
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<td><em>Giaglis et al., 2004</em></td>
<td>Investigates how to build upon trends in Vehicle Routing research and propose a system architecture for urban distribution and real-time event-driven vehicle management.</td>
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<td><em>Krajewska &amp; Kopfer, 2006</em></td>
<td>Presents a model for collaboration among independent freight forwarders based on combinatorial auctions and operational research game theory.</td>
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<td><em>Wong et al., 2007</em></td>
<td>Formulates an airfreight forwarder's shipment planning problem and proposes a mixed 0-1 LP model in addition to describing managerial issues related to integration and consolidation of shipments.</td>
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<td><em>Krajewska et al., 2008</em></td>
<td>Combines routing and scheduling issues with cooperative game theory and analyzes horizontal cooperation among freight carriers.</td>
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<td><em>Günther &amp; Seiler, 2010</em></td>
<td>Presents operational transportation planning problems for consumer goods industry and analyzes freight costs and opportunities for efficiency gains.</td>
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<td><em>Caris et al., 2012</em></td>
<td>Identifies research themes concerning decision support for intermodal transports and has found a number of models for policy support, terminal network design, intermodal service network design, intermodal routing, drayage operations and ICT innovations.</td>
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<td><em>Drexl, 2012</em></td>
<td>Reviews vehicle routing literature and provides an overview of a study of commercial vehicle routing software to identify research gaps.</td>
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<td><em>García et al., 2012</em></td>
<td>Complexity issues in intermodal transportation, and description of a new hybrid approach to address problems.</td>
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ABSTRACT

Purpose
Contemporary market environment is considerably dynamic and it puts high demands on enterprise management systems. The supply chains of particular industrial branches are getting, in consequence of markets globalization, more complex and material flows streaming in them are getting more bulky. The bulky material flows in inner or in outer supply chains should be effectively planned, managed and controlled in context of long-term sustainable socio-economic development and living environment protection. Well, enterprise management systems – one of them is also distribution management system; should be designed so that it’ll be possible to reach required level of stability and simultaneously to reach required level of flexibility.

Design/methodology/approach
The article deals with up-to-date issues of enterprise distribution system design based on progressive prognostic sub-system of independent demand. Well, in the article it’s firstly presented developed methodology of independent demand forecasting sub-system creation. Further it’s stated developed methodics to design distribution system of an enterprise.

Findings
Main findings are stated in the conclusion – e.g. for design or optimization of current enterprise management systems it should be applied new methodics or methodologies with the usage of process management principles and system approach. The distribution management systems based on accurate forecasts should be more effective in cost and eco-friend way and thus they should enhance long-term sustainable growth, stability and flexibility of present supply chains.

Research limitations/implications
The enterprise management systems – one of them is also distribution management system; should be designed to reach required level of stability and simultaneously to reach required level of flexibility with the usage of independent demand forecasting system.

Practical implications
The developed methodology and methodics are applicable in any industrial company to develop progressive management system based on independent demand forecasting.
Social implications
The bulky material flows in inner or in outer supply chains should be effectively planned, managed and controlled in context of long-term sustainable socio-economic development and living environment protection.

Original/value
The developed methodology and methodics intended for industrial companies to enhance their management systems and also for organisations of tertiary sphere.

Keywords: Distribution Systems, Supply Chain Management, Sustainability, Demand Forecasting, Methodology, Methodics

1. INTRODUCTION

The design of effective distribution systems represents the one of the foundation of the supply chains of particular industrial branches within the context of long term sustainable growth and living environment protection. There is especially on the one hand to reach required level of flexibility and customer service level and on the other hand to reach required level of stability. The current distribution systems should be based on progressive prognostic sub-systems of independent demand, when all distribution processes would be effectively realize and thereby causing a minimization of negative externalities to living environment.

The effective management of material flows within the frame of the supply chains and their parts represent by distribution systems should have a positive impact on socio-economic development of society and living environment protection.

In terms of the distribution systems, it should be paid due attention to planning, management and control processes, which should be based on accurate forecasts of sales or consumption in given business regions or areas. (Rushton et al., 2010)

Well, the improvement of prognostic methods and the design of prognostic sub-systems of enterprise management systems are in current strongly globalized and considerably dynamic business environment entirely on site.

The contemporary supply chains show substantial degrees of complexity and dynamics. Well, prognostics and planning processes of the companies should be appropriately innovated with the aim to reach required level of efficiency and effectiveness of a planning, management and control of inner and outer bulky material flows.

In the Figure 1.1 it’s illustrated practically linear growing trend of development of basic development indicators of world’s economy over the last 14 years, namely gross domestic product, total world’s merchandise trade, total world’s import and total world’s export.

This fact is one of the proofs of the supply chains material flows volumes enhancement, when the up-to-date distribution management systems should be designed in an appropriate manner – an increase of efficiency and effectiveness requirements, an enhancement of stability and flexibility requirements and also an improvement requirements of the living environment protection.
The article at the beginning briefly explains the notions such as supply chain, forecasting, distribution and system approach, subsequently states the general case study, how can be in company designed or innovated the distribution systems based on prognostic sub-system of independent demand. (Hart et al., 2016)

2. SUPPLY CHAIN DEFINITION

The notion a supply chain can be defined as a network composed of bundles which are represented by primary or secondary production companies, central distribution warehouses, wholesales, retails and customers. The integral element of a supply chain is transport or the flows which stream within a supply network – material, financial and information. The supply chain is unique for each industrial branch or each company. One can speak about internal and external supply chains. A general supply chain and its particular parts are illustrated in Figure 2.1. (Lenort et al., 2009)

The internal supply chains are representing by material flows within the frame of production and distribution areas. The external supply chains are representing by supply chain networks among production companies and customers in the form of particular types of distribution channels – direct and indirect distribution. (Schönsleben, P., 2012)

Deeper development of a supply chain composition started in 1950s and it was closely connected to growing trends of global market globalization. 21st century is characteristic by experience of a formation of new markets, for instance the common EU market, new markets of developing countries (China, India); supply chains are typical for their complexity, volume and number of the flows streaming in them. (Hart et al., 2016) The processes of planning, management and control are difficult in such dynamically developing supply chains; and thus new methodologies, methodics and methods should be developed in order to simplify management of a complex supply chain. Contemporary supply chains should be balanced from the view of two opposite criteria – flexibility and stability.
In some supply chains nodes the inventory can be accumulated, in others the shortage can occur and then it can result in a customer loss. Another very important feature of present supply chains is their vulnerability regarding various types of crisis situations – for example a decrease in demand, economic crisis connected with natural disasters, security threats, etc. (Benton, 2014)

Management systems of supply chains or company's management systems should be able to respond lively to changing markets requirements, particularly to a changing demand and to potential crisis situations. These systems should also represent basis to ensure material flow stability, thus the effectiveness and the efficiency of a supply chain. Therefore, on the basis of what has been stated above, effective supply chain management systems or company's management systems should have a positive impact on the quality of society and on socio-economic development and that can be applied to both regional and global extent. (Giljum et al., 2014)

Even the level of living environment protection is related to the quality of the above stated management systems. (Giljum et al., 2014)

### 3. DEMAND FORECASTING

Both the character and level of a demand play a significant role at managerial decision making at all functional levels of a company or at all parts of supply chain. The accurate demand forecasts or a consumption are necessary for creation of effective master plans which can be applied to all managerial processes related to internal material flow and external material flow, and then for the supply chain management. Prognostic methods can be classified into two main groups, namely the quantitative methods and qualitative methods of forecasts creation. It is possible to combine both of the method groups with the aim to reach more accurate prognosis of demand or consumption development.

The more variable a demand is, the higher weight should be given to qualitative forecasting methods. (Hart et al., 2015)
Selection of a suitable forecasting method is particularly determined by a demand pattern. Various demand patterns are illustrated in Figure 3.1.

![Image of demand patterns](image)

**Figure 3.1 Essential demand pattern (Hart et al., 2015)**

A leap demand is featured by leap changes in a demand level at particular time periods; rather a stable phase of a demand pattern can succeed after a change in a demand level.

The following example can be stated: a demand for a production machine spare part; with an increasing rotation speed, there is a growing need for changing a machine spare part and vice versa. Other examples of a leap demand can express obsolescence or crisis situation occurrence. For example rapid electronic component obsolescence can cause a leap change of some product demand in the market. When a crisis situation occurs, a demand increases for instance medical supplies.

Regular demand is characterized by more or less stable course of time. A demand for basic groceries such as basic pastry, milk or meat and e.g. a demand for basic toiletries can be stated as the examples. Seasonal demand is characterized by a positive increase or negative decrease in the given time period. The ice cream demand during summer time can be stated as an example. Further example can be increased demand for vitamins and medicines during fall flu period. Irregular demand is typical for casual changes in level at occasional time intervals. Spare parts consumption can be mentioned as an appropriate example. Other example can be a demand for special medicaments when some kind of epidemic occurs. With current dynamic development of market and social-cultural environment, the knowledge of a demand pattern and its level is becoming more and more important; that fact can be applied to the context of both regional supply chains and global supply chains – management systems. Further on, we can distinguish between a dependent demand and an independent demand where the knowledge of the independent demand is crucial for deriving the dependent demand. Next, with respect to time, it is possible to talk about a continuous and non-continuous demand. (Levenbach et al., 2006; Makridakis et al., 1998)
4. DISTRIBUTION

The distribution is one of key factors to reach high level of efficiency and effectiveness for any type of industry or tertiary sphere organization. High-quality designed distribution systems also minimize the negative externalities to living environment.

Well-designed distribution system enhances a change of a company to sell its products or services. The company which distributes its product portfolio in wider business market scope with high speed and at lower costs, so it achieves competitive advantage in the form of increased profit, which can be subsequently used e.g. for raw material price rise coverage, working power or energy, etc. (The Economic Times, 2016)

The structure of distribution system is defined through localization of the central distribution shed, by the amount and location of transshipment points and by the journeys and by the plans of material items transportation by lorries. (Rushton et al., 2010)

The distribution system is possible to define as total setting and integration of logistics processes, analytical – synthetic methods of process management, technical equipment and buildings, designed for effective run of material flows, their planning, management and control from the resources points to the end users. (BusinessDictionary.com, 2016)

The basic processes of distribution system are:

- **Warehousing and manipulation** – there’re the issues of warehouses localization, the determination of the amount and the size of the distribution depots, a choice of warehousing type and technical – handling equipment.
- **Packaging, identification and unification** – there’s a question to create packaging pyramid for particular distributed items and the design of wrapping and transportation means, when the wrap should perform 3 essential functions, namely security, marketing and information function.
- **Inventory management process** – there’s especially a question of inventory types, storage zones determination and optimal inventory level.
- **Transportation** – there’s a choice of freight transportation means according to a character of transported items, a choice of particular types of transport operations, a creation of effective loading plans and distribution channels scheduling with the aim to reach required level efficiency and effectiveness.
- **Information and control processes** – the right designed prognostic, information and control sub-systems are the basis for effective distribution system.

5. SYSTEM APPROACH AND DISTRIBUTION SYSTEMS

System approach, which is represented by a visualization process, by a detail description of real system and its transformation to common system, it’s crucial to solve the issues related to contemporary supply chains and their parts including distribution systems as the one of main element of supply chains. The system approach to solve the real issues is constituted by the development of new methodologies, methodics and methods.

Methodology comprise a list of methods, their detail description and wide principles or rules on their basis the methods or procedures may be applied to solve different problems within the scope of a particular discipline. In contrast to an algorithm, the methodology is not a formula but a set of practices. (Hart et al., 2014)
Methodics or methodical approach can be defined as a set of points through which a researcher can reach determined goals. In simple terms it is a sequence of steps to reach a desired goal.

A method can be defined as a scientific–systematic procedure to reach an aim or gaining a required output with a required accuracy and efficiency. Achieved results should evince the desired level of validity and reliability.

Thus, the system approach can be comprehended as system thinking that emphasizes the interdependence and interactive nature of elements of both the internal and external analysed system or, more precisely, of an organization.

To work out a problem nowadays requires usually usage of both systematic approach and modelling while the real systems need to be transformed to general systems with mathematical–statistical visualization and expression. (Hart et al., 2014)

As far as the issues concerning current supply chains – e.g. simplicity, processability, integrability, flexibility, stability, resilience, security, etc., the issues of the distribution systems should also be systematically solved using the system approach and principles of process analysis.

A distribution system can be defined as an organized set of production–manipulation (machines) and labour capacities and then a set of material, information and financial flows.
distribution channels and also for compact notion on material flows character and their right quantification.

The increase in effectiveness and efficiency of industrial companies’ distribution systems as a part of a supply chain can lead in final consequence to:

- increase in supply chain material flows fluency,
- flexibility improvement and stability of supply chains,
- supply chain effectiveness and efficiency improvement,
- enhancement of socio–economic development of society,
- cost optimization,
- increasing competitive advantage,
- reinforcement of a supply chain resilience against crisis situations,
- reduction of negative impacts of supply chains on the living environment.

(Moon et al., 2013; Benton, 2014)

6. GENERAL CASE STUDY

An industrial food company optimizes its distribution management system in accordance with current development of regional and global business markets, thus also in compliance with up-to-date development of supply chains. After performing an analysis of a current state of the distribution management system within the frame of solving a distribution management system optimization project, it has been decided that firstly it is necessary to innovate the company forecasting subsystem which will supply input data for high-quality managerial decisions in a particular distribution department of a respective industrial company. For these purposes, the methodology has been used to create an independent demand forecasting system which has been developed in the dissertation thesis by Hart, published in 2010.

The methodology for creating an independent demand forecasting system in an industrial company (199 pp.) can be briefly described mentioning the following 8 consecutive essential points:

1. **Company description** or more precise specification of production plants for which a forecasting system of demand or consumption is to be created,
2. **Visualization of supply chain** – inner and outer flows,
3. **Determination of order penetration point** or points within the scope of a company supply chain – identification of a demand with independent or dependent character,
4. **Segmentation of extensive inventory portfolio** (e.g. final product, semi-finished product, raw materials) accumulated in order to penetrate a point or points,
5. **Analysis of existing systems** for independent demand forecasting,
6. **Determination and statistical processing of input data** for a demand forecasting (demand, consumption, sales),
7. **Essential analysis of demand pattern** – trend, seasonality, increase, decrease,
8. **Finding a process of the best-fit models to forecast** independent demand for single inventory segments accumulated in order penetration point or points of a company supply chain. (Hart, 2010)

Briefly described methodology has been subsequently applied in the food company with the aim to innovate; it means with the creation of a new forecasting subsystem. Based on a newly created forecasting subsystem the forecast for a total monthly demand of final products has been made as the main prognostic outcome.
Thus, within the frame of the best-fit model finding process has been subsequently build-up 10 forecasting models, when the best one with the lowest value of mean absolute percentage error (MAPE) has been mixed-model consisting of 70% by ARIMA (2, 2, 2) model and 30% by expert judgement. Entire process to find the best forecasting model is summarized in the table 1 and the forecast – main output; for the total monthly demand level of final products manufactured in the company is stated in the Figure 6.1.

Table 6.1 The survey of the forecasting methods used to find the best one for given time series and MAPE indicator (Hart, M., 2015)

<table>
<thead>
<tr>
<th>Rank</th>
<th>The forecasting method</th>
<th>MAPE [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Box-Jenkins [2, 2, 2] + expert judgement - mixed model 70%/30%</td>
<td>0.85</td>
</tr>
<tr>
<td>2</td>
<td>Box-Jenkins [2, 2, 2]</td>
<td>1.15</td>
</tr>
<tr>
<td>3</td>
<td>Decomposition Seasonal Multiplicative</td>
<td>2.13</td>
</tr>
<tr>
<td>4</td>
<td>Decomposition Seasonal Additive</td>
<td>2.56</td>
</tr>
<tr>
<td>5</td>
<td>Holt-Winters’ Multiplicative</td>
<td>3.14</td>
</tr>
<tr>
<td>6</td>
<td>Holt-Winters’ Additive</td>
<td>3.58</td>
</tr>
<tr>
<td>7</td>
<td>Double Moving Average</td>
<td>10.15</td>
</tr>
<tr>
<td>8</td>
<td>Double Exponential Smoothing</td>
<td>12.17</td>
</tr>
<tr>
<td>9</td>
<td>Single Exponential Smoothing</td>
<td>15.68</td>
</tr>
<tr>
<td>10</td>
<td>Single Moving Average</td>
<td>16.24</td>
</tr>
</tbody>
</table>

The newly created prognostic subsystem is designed to generate accurate forecasts as the input data for first-rate managerial decisions at particular functional parts, which should have the main positive effect on entire company running.

After the innovation of the company prognostic subsystem, particular subsystems and processes of a company distribution system including the layouts of industrial zone and semi-finished...
products warehouses have been consequently innovated as well, with the aid of created methodics to design distribution management system in a company.

The methodics to design distribution system in a company can be summarized into 7 following points:

1. sales forecasts in particular business territories,
2. a determination of distribution centres and warehouses number,
3. distribution network setting – a choice of freight transport modes and the distribution channels,
4. a setting of distribution – manipulation processes,
5. a staffing,
6. a setting of information and control sub-system,
7. a setting of maintenance sub-system.

There have been innovated planning, management and control of sub-systems of the distribution–handling and labour capacities.

Further on, there have been realized the optimization of semi-finished products inventories and the optimization of material flows within the scope of the mentioned company distribution system.

Data of an innovated company prognostic subsystem is further used for the needs of effective planning, management and control of all distribution capacities, flows, inventories and processes as generally illustrates the Figure 6.2. Well, the prognosis stated in the figure 5 is the base for all managerial decisions at distribution functional management level.

![Figure 6.2 Demand forecasts data as the input for distribution managerial decision making (Hart, M., 2016)](image)

7. CONCLUSION

Considering contemporary global world market, the effective material flow management within the scope of the supply chains of particular industrial branches is becoming one of the essential prerequisites for long-term sustainable socio-economic development and living environment protection. To minimize negative externalities of logistics activities both in regional and global supply chains – thus to achieve the right level of flexibility and stability of supply chains, it is necessary to apply prognostic subsystems of an independent demand to plan effectively.

The main factors which have impact on up-to-date logistics systems and they should be therefore taken into account to design logistics systems are:

- a competition influence,
· a product innovation and shorter life cycle,
· an increase of financial performance, an inventory reduction,
· often changes of distribution channel actors,
· high requirements to supply chain vision creation and a cooperation,
· redesign and innovation of logistics systems – effectiveness and efficiency,
· improved communication and information technologies,
· improving material – handling and transport technologies,
· a change of the regulations and the laws,
· an increasing demands on customer service.

This paper described current character of the supply chains. There was stated knowledge of demand forecasting, system approach, which is important to design the distribution systems. Effectiveness and efficiency of the distribution systems represent main presumption to reach a long-term sustainable development both in regional and global scale.

Effective management of distribution systems should be based on prognostic subsystem of an independent demand which would supply input data – the forecasts for high-quality managerial decisions as it is stated in the case study of this paper.

At present, the distribution systems should be designed to meet the following fundamental presumptions:

· flexibility,
· stability,
· resilience against crisis situations,
· security.

If the distribution systems meet the 4 above stated prerequisites at a required level and they are based on subsystems of an independent demand forecasting, they should significantly enhance the stability of economy in regional or global scale.

The implication for the future research based on this paper could be a development of the new methodologies and the new methodics, how to design in practice integrated company’s logistics management systems – purchasing, manufacturing, distribution and reverse material flow management; whose keystone should be independent demand forecasting system to supply accurate data to effectively plan, manage and control.

REFERENCES


ABSTRACT

Purpose
To determine the heavy vehicle fleet required to satisfy South Africa’s projected road freight transport demand.

Methodology
Total freight flows are projected through the gravity modelling of a geographically disaggregated input-output model. Three rail market share scenarios are defined over a fifteen-year forecast period. The heavy freight vehicles required to serve the resulting projected road market share is calculated for different vehicle application types.

Findings
South Africa has a high and growing transport demand of which the largest portion will remain on long-distance road corridors. The road truck fleet is therefore expected to continue its rapid growth, placing severe strain on already impaired road infrastructure. Continuous innovation in road technologies and intermodal solutions therefore remain on the critical path. In addition, future research should enable a growing acceptance of the need to reduce transport demand.

Research limitations
Due to data constraints this study considered only line-haul freight movements. Short distance urban deliveries and pick-ups add a considerable burden to the total road transport task and require more investigation.

While the methodology used in the study can be applied to other countries, the input data is country-specific and therefore the findings cannot be used to make assumptions about the effects of similar scenarios on the transport demand of other countries.

Practical implications
Implementation of performance-based standards is essential to reduce the impact of road freight, both in terms of pavement quality and externalities. This should be supplemented by innovative solutions to increase intermodal-friendly freight and, ultimately, to reduce transport demand.

Keywords: Logistics; freight flows; infrastructure; railway; road; market share; intermodal; heavy truck fleet
1. INTRODUCTION

South Africa is challenged with high freight logistics costs, a total of 12.8% of the country’s GDP, while logistics costs as a percentage of transportable GDP is approaching 50% (Simpson and Havenga, 2012). The high costs can be linked inter alia to the disproportionate transport demand relative to the size of the economy due to inland mining activity and related industrial development far from the country’s coastal ports (Havenga and Simpson, 2013). An added challenge, however, is the modal imbalance between road and rail due to rail’s investment backlog of the past two decades and limited road-rail collaboration (Simpson and Havenga, 2012). To plan for future infrastructure development and transport equipment needed to support economic development, role-players need a view of the future transport demand and the possible modal composition thereof. Significant effort was extended to inform the National Development Plan (South African Government, 2012) of South Africa’s physical infrastructure needs as well as rail rolling stock, but no information exists on what is a key logistics asset, i.e. the heavy vehicle truck fleet. The purpose of this study is to determine the size of the heavy vehicle fleet that is required to satisfy South Africa’s projected road freight transport demand.

2. LITERATURE REVIEW

The logistics infrastructure of a country forms the backbone of economic growth. High costs associated with an inefficient transport system constrain national growth potential and international competitiveness (Jankauskaite et al., 2013). As mentioned in the introduction, freight logistics is a challenge to the competitiveness of South Africa in the global economic landscape (Rossouw, 2012). The country’s road network is under pressure inter alia because of unsophisticated load and delivery scheduling, limited opportunities for return loads, and a lack of capacity aggravated by insufficient performance and coverage of rail transportation (Jankauskaite et al., 2013). The lack of intermodal collaboration between road and rail is however seen as one of the biggest problems limiting logistics industry performance (Simpson and Havenga, 2012). The total impact of growing road freight is also not evident because of the lack of comprehensive road pricing systems to manage the use of the transport network more efficiently through e.g. linking charges to truck road wear and productivity, safety and environmental characteristics, and providing incentives for the use of low-impact vehicles (Christensen, 2010).

To improve the competitiveness of the country and address current logistics challenges, integrated planning for national infrastructure development is required to deal with land freight transport as a strategic priority (Viljoen, 2012). South Africa’s National Development Plan is supported by Transnet’s Market Demand Strategy (which commits to creating rail, port and pipeline fixed and moving infrastructure ahead of demand), and SANRAL’s strategic plan for the management of the country’s national road infrastructure. The size of the heavy vehicle fleet that is required to satisfy South Africa’s projected road freight transport demand has however not been determined. Understanding future vehicle fleet requirements is of strategic benefit to policy development (specifically freight transport and environmental policies), infrastructure planning and to project fuel demand requirements and concomitant exposure to oil price risks (Hernández-Moreno and Mugica-Álvarez, 2013).

Road vehicle fleet forecasting can be approached from many perspectives. Business Monitor International (2013) states that the future market share of each transport mode depends on trends in historical modal split data, government policy favouring selected transport modes and investment in infrastructure to support the transport modes. Piecyk and McKinnon (2013) adds
that technological developments, such as higher capacity vehicles, and market shifts, such as an increased demand for low-density goods, will impact road vehicle fleet forecasts.

Given South Africa’s logistics costs challenges, the forecasting approach in this paper focuses on solutions to improving logistics efficiency and managing logistics demand as this will have a direct impact on the heavy vehicle fleet size (Havenga and Simpson, 2013; Pereseina, 2014). This includes (1) reducing the environmental impact of the transportation through improved vehicle utilisation, improved fuel efficiency, efficient driving methods and cutting the carbon content of fuel and (2) modal shift to rail. A third aspect, reducing the demand for transport through, for example, reshoring, falls outside of the scope of this paper, but is important to note for future research.

The first-mentioned solution relates to the development of performance-based standards (PBS). This initiative was initiated in Canada approximately three decades ago to simplify and harmonise heavy vehicle regulations, while improving safety standards and environmental performance (Woodrooffe, 2012). PBS is based on the principle that a modern regulatory framework can improve compliance by providing flexibility to enable these improvements, i.e. the end, not the means, are specified. Many higher capacity vehicles have equivalent or even better intrinsic safety characteristics than most ‘workhorse’ trucks (Christensen, 2010; Australian Capital Territory, 2014). PBS hold great opportunities to increase transport efficiency in conjunction with modal shift imperatives. PBS demonstrations illustrated fuel efficiency improvements, reduced road wear, larger payloads and reducing the amount of truck traffic on the road (Kotze, 2012). The specific goals in South Africa are for PBS to improve system efficiency by optimising truck payloads, improving truck safety and protecting road infrastructure through innovative vehicle design and technologies (Nordengen et al., 2008).

With respect to modal shift, transport markets that consist of limited, dense origin-destination pairs that are separated by long distances create opportunities for intermodal solutions (Van Eeden and Havenga, 2010). Domestic intermodal transport can reduce transport costs, increase productivity and ease the load on road infrastructure. Freight flows that exploit the core strengths of both road and rail must be identified to promote intermodality (Havenga et al, 2011).

The purpose of this research is to determine the impact of these solutions on the future demand for heavy freight vehicles in South Africa. The related research methodology is described in the next section.

3. RESEARCH METHODOLOGY

The research made use of a quantitative data set that estimates surface freight transport demand for the selected forecast period. This includes data from South Africa’s National Freight Flow Model (NFFM) and Freight Demand Model (FDM) (described in subsequent sections). The study only considered surface freight transport by road and rail because of the insignificant market share size of other modes. Demand was calculated considering different scenarios for rail market share. The future national truck fleet was calculated using the resultant road market share figures. The study accounted for new developments and initiatives that could have an effect on the future truck fleet size and structure.
3.1. **Surface freight transport demand estimates**

The methodology used to estimate future surface freight transport demand depends on four information sources. (1) Transport supply is measured through observing truck movements and obtaining actual rail data. (2) Transport demand considers the flows of commodities between production or imports, and consumption or exports. (3) Segmentation divides these freight flows into categories to determine modal shift opportunities. (4) Scenario development evaluates the impact on future road surface freight transport demand of different market shares for rail transport.

Supply was measured according to the NFFM. This model defines surface freight transport based on tonnes and tonne-kilometres as measures of flow to give a comprehensive description of South Africa’s surface freight flow market space (Havenga and Pienaar, 2012). The market segments include corridor, rural, metro and rail export machines. Inputs for the measurement include South African National Roads Agency traffic counts to determine road freight flows and actual rail data for rail freight flows, enabling market share analysis per segment. The possibility exists for correlation analysis with GDP and related macroeconomic parameters making the model useful for forecasting.

Demand measurement made use of a Freight Demand Model (FDM) that has commodity granularity to supplement the NFFM (Havenga, 2013). Freight flows were derived via gravity modelling from a geographically disaggregated I-O (input-output) table according to commodity type. Five-yearly forecasts of the I-O tables were done up to 15 years and converted into volumetric terms. The model produced a representation of supply and demand by weight, modes used for transport, typological movements of the freight and the type of commodities involved. The FDM includes observations for freight flows observed on 22 corridors (bidirectional), within 7 metropolitan regions and within 10 rural regions. The cargo type transported was identified according to nine different cargo types, namely agricultural dry bulk, heavy break-bulk, light break-bulk, liquid bulk, mining dry bulk, open skip bulk, palletised, refrigerated and roll-on/roll-off (RORO).

Segmenting the total freight of the South African transport industry was done using a model developed for categorisation of the billion tonnes of freight transported annually across the country’s transport network. The segmentation process for all freight was based on rail economic fundamentals which are line and system density needed to exploit rail’s attributes of bearing, guiding and coupling. Based on these rail-economic principles, freight flows with high density over longer distances were earmarked for transportation by rail (Havenga, 2012).

Three scenarios were developed based on different rail market shares:

- **Scenario 1** assumed rail market share per segment remained the same for the entire forecasted period. Of the total transport task of 362 billion tonne-km in 2013, road and rail general freight accounted for 260 billion tonne-km, the rail export lines for 90 billion tonne-km contribution, and the remainder was transported by pipelines, conveyor belts and coastal shipments. Of the total transport activity, rail tonne-km market share was 36% (Stellenbosch University, 2015).

- **Scenario 2** assumed rail transport would grow its market share to include all freight in line with rail-economic principles, thus high density over longer distances. A high-level analysis indicates feasibility to shift 50% long-distance heavy intermodal and siding-to-siding break-bulk potential traffic onto the rail network with large cost saving opportunities (Havenga, 2012).
In Scenario 3 rail retained its current freight volumes and remained stagnant. General freight and rail export lines combined add up to 129 billion tonne-km for 2013 (Stellenbosch University, 2015).

The future national road transport demand can now be estimated, as described in the next section.

3.2. Quantification of fleet for expected road surface freight transport demand

The actual transport task each combination of vehicle type and configuration are able to complete can be calculated based on payload, annual kilometres travelled and load factor. These parameters are used to determine the annual vehicle capacity in tonne-km. The parameters related to annual vehicle capacities are validated according to research done by the Road Freight Association of South Africa (2013). The vehicle parameters were used to convert the surface freight transport demand for road transport from a transport task to estimated vehicle quantities required for the fleet. The vehicle fleet for 2014 to 2030 in five-year intervals was calculated, and grouped according to corridor, metro and rural transport activity. Distinctions were made between directional flows of traffic on corridors, illustrating the imbalance of cargo flows, and ultimately demand for road transport on various routes.

Change drivers that could influence the actual fleet required to meet future transport demand was identified in section 2. Through quantitative analysis of the base data set, opportunities for promoting the change drivers were identified, as described in the next section.

3.3. Analysis of change drivers

3.3.1. Domestic intermodal transport activity

High density, long distance corridor freight flows are attractive candidates for intermodal transport. Previous research by Van Eeden and Havenga (2010) identified the Durban-Gauteng and Cape Town-Gauteng corridors as most attractive for intermodal solutions. Both these corridors indicated high densities with relatively low current rail market share. Cargo suitable for intermodal solutions was identified as rail-friendly freight with the ability to be easily consolidated into standardised units (Havenga et al., 2011). Standardised forms include palletised and containerised cargo.

3.3.2. Implementation of performance based standards

In the South African market, the main vehicle classes of relevance to obtain PBS benefits are the 6-axle articulated vehicle configuration and the 7-axle interlink configuration. To obtain PBS benefits a minimum of one axle was added to each configuration; the corresponding PBS configurations will therefore consist of a quad axle semi-trailer and tridem-tandem interlink respectively. The assumption is that only 20% of the vehicles in these relevant vehicle classes will be able to benefit from PBS due to inter alia abnormal load regulations limiting the use of these extra heavy vehicles to national roads (Viljoen, 2014). The truck fleet size was calculated accordingly.

The advantage of PBS was accepted as an average 15% payload increase for the above-mentioned vehicle configurations (Nordengen et al., 2008). The vehicle parameters were adjusted to incorporate the increased payload capacities for the relevant vehicle configurations. The larger capacity (tonne-km) for the proposed PBS configurations was calculated based on the same load factors and annual kilometres travelled while increasing the payload by 15%.
3.3.3. Vehicle utilisation improvements

For the purpose of this study, load factor and annual amount of kilometres travelled per vehicle were used as parameters to measure vehicle utilisation. A theoretical load factor was calculated for each scenario to consider different levels of vehicle utilisation. The calculation also considered higher annual kilometre estimates to evaluate the combined effect of kilometres travelled and load factor on overall vehicle utilisation.

A theoretical load factor was calculated for each corridor per vehicle application type based on the transport capacity required to complete the transport task in each direction of the 22 different corridors. Unbalanced directional freight flows will negatively influence the theoretical load factor. Flow balance was not based on pure commodity-type flows considering that a single vehicle type can transport an array of different products. The freight flow balance was compared for each scenario. The 22 corridors were used to calculate a weighted average load factor for each vehicle application type based on the size of the transport task per corridor. The weighted average will reflect the highest possible theoretic load factor. The weighted average load factor will be used together with the vehicle parameters referred to in section 3.2 to calculate the fleet size required to complete the transport task should the best possible load factor be achieved for each scenario. Due to the absence of directional flow information for the rural and metropolitan regions, load factor calculations included only adjustments based on corridor flow observations. Flow balance was calculated through comparison of the demand for different vehicle applications only. The comparison process therefore assumed the total fleet required will consist of the optimum combination of different vehicle configurations to achieve the theoretical load factors. The theoretical values compared to current weighted average load factors assumed by industry did not indicate prominent trends that can provide opportunities to improve vehicle utilisation based on load factor. Vehicle utilisation with respect to actual load factors seems to be on par with what is theoretically possible.

The distance travelled per annum by road freight service providers are considered a component of logistics cost. The higher South African logistics cost is therefore partially due to the lesser distance transport operators are able to achieve within the borders of the country per annum. The average distance travelled in Europe by road transport operators are 200 000km compared to 120 000km in South Africa (Kotze, 2012). The actual distances travelled for vehicles doing planned line-haul as considered in this study can be much closer to the 200 000km mark. The industry average of 120 000km is influenced by the very low amount of kilometres travelled by vehicles doing unplanned short distance tasks. For the purpose of this study, the truck fleet was quantified based on a moderate 30% increase in annual distance travelled by 2030 as part of vehicle utilisation improvements.

3.4. Heavy vehicle fleet ideal future

In order to incorporate the change drivers, an ideal future for the heavy vehicle fleet was defined. This is compared to the status quo in the results section.

- The status quo refers to the road transport task for 2014 which was modelled at 161.2 billion tonne-km (a 64% road tonne-km market share); the PBS benefits and vehicle utilisation improvements had not taken effect.
- The ideal future modelled a road transport task for 2030 at 190.9 billion tonne-km, where the national railway gains its ideal market share as per scenario 2 in section 3.1 (which includes the domestic intermodal change driver described in section 3.3), and road PBS benefits and vehicle utilisation improvements are implemented, as described in section 3.3.
4. RESULTS

4.1. Quantification of the base case demand for road transport

The road transport task for each rail market share scenario was determined for five-year intervals from 2014 to 2030, as illustrated in Figure 4.1. The corridor market share is expected to remain around two thirds of the road transport task.

![Figure 4.1 South Africa’s current and projected road freight transport task in tonne-km](image)

The South African economy continues to include a large transportable GDP driven by commodity trade, manufacturing and increased consumption by the growing middle-class population. Transport demand therefore showed positive growth across all scenarios for the forecast period 2014 to 2030. Demand growth ranges from minimum 12% to maximum 31% over a five-year period. The highest growth rate was forecasted for the first five-year period in each scenario compared to the last 10 years. This can be an indication of the South African economy reaching more mature levels of economic activity and experiencing a reduced contribution by the transportable GDP as the intangible services sector grows. Although the economic landscape and composition thereof will change during the forecasted period, it is unlikely that the South African economy will reach a decoupling situation where economic growth is achieved without corresponding demand growth for road freight transport activity.

This is not unique to South Africa. The freight transport task is growing rapidly in most regions globally and road haulage is deemed most suited to serving much of the demand (Christensen, 2010, in reference to the EU; Australian Capital Territory, 2014, in reference to Australia).
4.2. Estimated truck fleet

The relatively small possible reductions in road transport demand should railway gain its ideal market share as described in scenario 2, illustrated that a considerable portion of rail-friendly cargo is already transported by rail while the additional new market share gains for rail transport seem limited. According to the analysed data, for the period 2014 to 2030, the growing transport demand will translate into a growing demand for road transport under all three scenarios, with the biggest demand remaining on the corridor routes. The national truck fleet is therefore guaranteed to grow. A graphical illustration of the estimated national truck fleet required for each of the outcomes is shown in Figure 4.2. The truck fleet was quantified based on the number of axles required to complete the task as unit of measure for each vehicle application.

![Figure 4.2 South Africa's current and projected road transport fleet size](image)

In order to take the change drivers of increased intermodality, PBS benefits and improved vehicle utilisation into account, the heavy vehicle fleet per vehicle application type for the ideal scenario (defined in 3.4) was calculated. This resulted in a total estimated fleet size of 315 572 axles for 2030, compared to the 2014 status quo fleet size of 349 172 axles. The top contributors to the national transport task are heavy break-bulk, mining dry bulk and palletized goods, which results in a national truck fleet dominated by tippers, volume vans, flat decks and drop sides with a combined market share of approximately 85%. Figure 4.3 illustrates the estimated fleet size for the status quo and ideal future grouped according to vehicle type.
4.3. Data validation

To validate the accuracy of the forecasted data a comparison between the 2014 model forecast and actual 2015 trailer fleet in South Africa was done. Similarity between the sizes of these two fleets will confirm the accuracy of the data.

The line-haul freight considered in this study when allocated to vehicles for scenario 1 in 2014, results in an 82,821 trailers requirement. When also considering the collection and distribution freight of just over 70 billion tonne-km which was not considered in this study, with average annual tonne-km of 40% of that of line-haul (due to much shorter distances and slower speeds), an additional 76,033 trailers is required. Cumulatively, the Freight Demand Model data estimates a total requirement of 158,854 trailers. This is approximately 10% less than the recorded number of 177,815 for October 2014 which includes all trailers, even those not roadworthy or those not in use. This comparison between the derived volumes and the recorded number is thus seen as sufficiently close to justify the use of this data for this purpose. In order to align with the base data it can be assumed that the granularity of the model is sufficient to represent the correct industry structure, but undercounts by 10% due to higher efficiency on all parameters.

5. CONCLUSION

The results in the study confirmed the dependence of the South African economy on the transport industry. Road transport demand showed positive growth across all scenarios during the forecast period up to 2030. The national truck fleet is therefore guaranteed to grow, notwithstanding the modelled impact of (1) intermodal transport activities on high-density long-

Figure 4.3 Summary of South Africa’s estimated truck fleet – 2014 vs 2030
distance routes, (2) the implementation performance based standards and (3) initiatives aiming to improve vehicle utilisation. The combined benefits related to the new developments will assist in relieving the transport burden of South Africa although the results are limited to specific corridors and applications. Corridor market share is however expected to remain around two thirds of the road transport task. The top future contributors to the national transport task will be heavy break-bulk, mining dry bulk and palletized goods, resulting in a national truck fleet dominated by tippers, volume vans, flat decks and drop sides. This situation is not unique to South Africa – the freight transport task is growing rapidly in most regions globally and road haulage is deemed most suited to serving much of the demand.

More innovative regulations can assist in preventing misuse and damage to infrastructure and be used as drivers toward more efficient and sustainable use of the available infrastructure. In reality, this will require collaboration and support from all stakeholders to establish a national freight transport system that is capable of handling the transport task without sacrificing competitiveness. Investments need to be based on a balance of productivity benefits, infrastructure costs, and safety and environmental costs and benefits. Road and rail infrastructure and rolling stock investments therefore need to be developed concurrently (Christensen, 2010). In the longer run, the irresponsible use of transport resources should be addressed through a culture of more sustainable consumption, the impact of which should be included in future research. In this regard, the internalisation of externality costs can be play a significant role in cost trade-offs and modal shift, impacting on the vehicle fleet forecast.

5.1. Practical implications and contribution to body of knowledge

The practical implications of the research results affect both government and industry. From an industry perspective, it encourages the implementation of collaborative road/rail solutions, and the continuous focus on the implementation of PBS by road freight transport operators to ease the burden on transport infrastructure. However, the growth of road freight is inevitable and significant given the current demand trajectory and, over the long term, probably untenable, not least from a space constraint and environmental impact point-of-view. This supports the growing global discourse to move towards different measures of progress and well-being, with one of the end goals a reduction in final consumption demand (Havenga, 2015). It also indicates that the road vs. rail discussion has a much broader scope than simply the competitive freight transport landscape – it could both be a driver of or an obstacle to sustainability.

This methodology underscores the value of systemic national freight transport demand modelling as it enables (1) joint, transparent planning across all modes and (2) the quantification of context-specific trade-offs between, for example, technological developments (such as PBS) and policy interventions (such as modal shift) to facilitate an informed macro logistics debate. It also supports the view that infrastructure forecasting cannot be divorced from long-term demand projections given the long lead times for infrastructure investments and, if the results of these forecasting efforts are unsatisfactory from a macroeconomic point of view, it creates the impetus for scenario modelling and the development of interventions to attain the desired scenario.

5.2. Summary of next steps

The following research areas have been identified for future research:

- Short distance urban deliveries and pick-ups add a considerable burden to the total road transport task and require more investigation.
• Modelling the impact of the internalisation of externality costs on modal shift and resulting vehicle fleet requirements.
• Identifying and modelling options for reducing the demand for transport through, for example, reshoring, final consumption reduction, spatial reorganisation etc.

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DIFFERENTIATED ACCESS MANAGEMENT:
THE CASE OF HAULIER OPERATIONS IN INTERMODAL FREIGHT TRANSPORTATION

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ABSTRACT

Purpose
The purpose of this study is to design a framework for differentiated access management in intermodal transportation that makes evaluation of the efficiency of access management possible.

Design/methodology/approach
Based on a literature study and empirical data collection (semi-structured interviews with haulier operators, port operators and terminal operators), the term access management is defined and described from a road haulage perspective. Methods for improving access management are discussed.

Findings
This study has defined an access management framework has been defined and contains a ranking scale with seven levels: from 0 (no access management) to 6 (excellent access management). In addition, the empirical findings show that trucks have the worse developed access management compared to train and vessels.

Research limitations/implications
The access management framework helps decision makers with two particular tasks: firstly, identifying their own level of access management, and secondly, describing how to improve it. Improved access management allows decision makers to prioritise resources and make better decisions.

Original/value
The defined framework will give researchers and decision makers indications of the levels of access management a certain access management method has. With the identified potential effects of four existing methods (in use by industry), this framework can help decisions makers to improve their access management.

Keywords: access management, operational effects, real-time interaction, haulier operations, intermodal freight transportation
1. INTRODUCTION

The worldwide trend of CO2-emissions from fossil fuel combustion shows an exponential increase since 1870 (International Energy Agency, 2015). Since 1995, freight transport work measured in tonne-kilometres in Europe shows an increase by 22.3% (European Commission, 2014). Road and sea transportation have the largest increase, which leads to more congestion and environmental problems, especially in intermodal freight terminals where the transhipment of intermodal transport units (ITUs) is performed between transportation modes ((Zhao and Goodchild, 2010); (Chen et al., 2013)). Additionally, congestion problems in intermodal freight terminals may lead to inefficiencies and bottlenecks (Islam et al., 2013), especially when trucks are arriving unnoticed (Phan and Kim, 2015). In other words, a large number of trucks may arrive at the same time, which can be difficult for intermodal freight terminal operators to handle. More congestion and longer waiting times for trucks might also arise due to inefficient carrier operations (Sternberg et al., 2012b).

One possible reason for inefficient carrier operations could be poor information flow between the carriers, as noted by (Buijs and Wortmann, 2014), who noted that information exchange between carriers is critical for efficient operations. Another reason could be lack of high quality, real-time data. Without this, carrier operators are forced to make decisions based on “old” data, previous experiences, or incomplete data (SteadieSeifi et al., 2014), which might also lead to inefficient carrier operations. This becomes even more important when disturbances (i.e. accidents, weather changes, etc.) occur in the intermodal freight transport system. Many studies have pointed out that good interaction and collaboration between carriers are the key success factors in improving the efficiency for carrier operations in intermodal freight terminals ((Bisogno et al., 2015); (Sternberg et al., 2012a)).

Improved information flow between the involved stakeholders can enable better real-time information flow between hauliers and terminal operators, which might lead to improved Access Management (AM). In this study, AM is defined as “the management of resources regarding interoperability between hauliers and intermodal freight terminals.” In addition, AM includes the management of different digital real-time methods that serve to obtain or offer access to resources (e.g. a specific time slot or a physical piece of the intermodal freight terminal such as a faster lane). Of special interest are the methods that operate in real-time. In the existing literature, four existing methods (in use by industry) to improve AM are identified: Automated access management ((Choi et al., 2006a); (Choi et al., 2006b); (Marchet et al., 2012); (Dekker et al., 2013)); Pre-notification services ((Stefansson and Lumsden, 2009); Pre-booking systems ((Zhao and Goodchild, 2010); (Islam et al., 2013); (Chen et al., 2013); (Phan and Kim, 2015); (Hall, 2001)); and Transaction and support systems ((Buijs and Wortmann, 2014); (Macharlis et al., 2008)).

AM encompasses a larger scope than just access control (e.g. gate security) and the purpose of this study is to specify a framework for differentiating between levels of access management and thereby help researchers to analyse access management systems and decision makers to understand their access management and to improve or align to their operations.

This paper presents such a framework, derived from a list of identified methods (existing in industry). Seven interviews are used to test the framework as well as potential for improving AM, here called Differentiated Access Management (DAM).

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1. Intermodal Transport Units (ITUs) - standardised unit loads such as containers, semi-trailers, or swap bodies
2. A carrier is an actor who performs the transport and the movement of ITUs between transport modes in and between intermodal freight terminals (Stefansson, 2006).
This paper has the following structure: firstly, the review of relevant literature is presented, which includes descriptions of haulier operations in intermodal transportation, information flows, AM, and the potential methods to improve AM. Secondly, the methodology of this study is explained. Thirdly, the results are presented. Finally, the conclusions section contains descriptions of how the findings are related to prior research as well as a discussion of potential future research.

2. REVIEW OF RELEVANT LITERATURE

This section presents a literature study with relevant background information about haulier operations in intermodal freight terminals and the flows to and from terminals. Thus, in order to define and explain how hauliers’ contemporary accesses are managed to intermodal freight terminals by identifying the actors, activities, resources and processes. In addition, this section covers a list of existing AM methods with their advantages and disadvantages.

Figure 2.1 System view of AM adopted from (Wandel et al., 1992), (Lumsden, 1998), and (Woxenius and Bärthel, 2008).

A system view of AM can be seen in Figure 2.1 and shows how access can be managed between haulier and intermodal freight terminal. The following sub-sections (Section 2.1, Section 2.2, and Sections 2.3) describe this figure in more detail.

2.1. Carrier operations in intermodal freight transportation

One of the important components in the transportation industry is intermodal freight transportation ((Rodrigue et al., 2006); (Lowe, 2005)). In previous research, “intermodal
transport” is defined in many ways (Bontekoning, 2004). This research uses the definition from the (UN/ECE, 2001), which is “The movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transportation without handling the goods themselves in changing modes”.

A structured approach to analyse intermodal transportation is the Industrial Network Approach (INA) by (Gadde et al., 2003). INA is defined by actors (people or organisations), resources (material or immaterial owned by the actors), and activities (actions that are performed by actors based on particular resources). INA focuses on the exchange of products and services between two organisations, and describes how they organise the flows of ITUs and information between them. This model is previously used to describe the intermodal transportation systems ((Woxenius, 1998); (Woxenius and Bärthel, 2008); (Sternberg et al., 2013); (Sternberg, 2008)). Figure 2.1 shows some of the identified actors (in boxes), resources (in circles) and activities (labelled as italic text). Here, drivers, haulier’s transport operators and terminal’s transport operators are seen as resources (and not actors) when it comes to sharing their knowledge about for example road haulage and transhipment activities, and information. In transportation, road haulage is the transportation of ITUs on roads (Woxenius, 1998), and transhipment is the movement of ITUs from one mode to another done in a terminal (Bontekoning, 2004).

The conceptual framework of (Wandel et al., 1992) with its three layers (material flow, transport operation, and transport infrastructure) describes how nodes and links are related in the transport system. The latter two layers are of interest since the transport operation layer contains the flow of loads and vehicles between nodes and the transport infrastructure layer contains the management and physical parts the infrastructure (e.g. how to allocate different parts or areas of the terminal to improve AM, see Section 2.3). In addition, Figure 2.1 illustrates how the flows of resources (shown as black-wide arrows) are performed between haulier and the actors, for the activities and how they are distinguished within these two layers. The information layer in is further described in the next sub-section.

### 2.2. Information flows

There are typically four communication facets between actors: frequency, direction, modality, and content (Mohr and Nevin, 1990). The first one, frequency, is a measure of how much contact is necessary in order to perform a successful information flow between the actors. The second one, direction, can be “intra-organisational” or “vertical”, where the information flow occurs within one specific organisation, or “horizontal” or “inter-organisational”, where information flows between organisations ((Peng, 2011); (Lumsden, 1998)). Producers and consumers need to exchange information like different requirements such as specifications of functions, coordination times (horizontal information flow), etc.. This creates a need for information about the goods, the status of the resources, and the physical location. Such status information is important for the planning and controlling of the goods (vertical information flow). Thus, the horizontal information flow creates a need for the vertical (Lumsden, 1998). In this study, the horizontal information flow is the information exchange between intermodal terminal and haulier as can be seen in Figure 2.1. The vertical information is collected and produced by different sources (actors, resources and activities as described above). The information flows (both horizontal and vertical) are illustrated in the figure as red-dotted arrows. Finally, the direction can also be unidirectional (information flows in just one direction) or bidirectional (information flows in both directions). The third one, modality, is the medium used in the communication between actors. For example, modality can be categorised as digital, electronic, video-conference, telephone, or face-to-face. In addition, modality can also be shaped in either a formal (regular and structured) or in an informal (non-regular and
spontaneous) way. The fourth one, content, refers to the actual message that is communicated between the actors. The message shall preferable contain structured data that can be exchanged between actors in an efficient way without potential misunderstanding, contain sufficient data to support the activities in question and not too much data to generate a data overflow that cannot be processed (Stefansson et al., 2008).

2.3. Access management (AM)

The objective of more efficient and effective AM is to help solve some of the problems (e.g. inefficient carrier operations, deficiencies in the interaction between the actors, and lack of high quality real-time data) identified through real-time observations and conversations as well as through prior research in existing literature ((Marchet et al., 2012); (Buijs and Wortmann, 2014); (SteadieSeifi et al., 2014); (Islam et al., 2013)).

In this study, the term “access” means to provide or obtain use of resources (as described above). For example, the resource may be a physical section of an intermodal freight terminal (e.g. loading and unloading locations), get or give access to a specific time slot for use of resources, etc. The term management means to organise and coordinate those resources and use them more efficiently and effectively, which contributes to more economically, socially, and environmentally sustainable transportation system. Furthermore, (Fayol, 1966) defined five management functions: planning, organising, commanding, coordinating, and controlling. AM can then be defined as “the planning, organising, commanding, coordinating, and controlling of resources regarding interoperability between hauliers and intermodal freight terminals.” Hence, AM goes far beyond ordinary control and security activities typically performed in terminal gate access. AM can be seen as the overall functionality as shown in Figure 2.1 above.

2.4. Existing methods for improvement of Access Management

In modern industry, access is managed in various ways, with varying degree of success. In the literature, four existing methods (in use by industry) to improve AM have been identified: automated access controls; pre-notification services; pre-booking systems; and transaction and support systems.

The first method, automated access controls, is based on automated gates that minimize the number of unnecessary stops for the trucks in intermodal freight terminals where the truck drivers provide relevant information at the right place without stepping out of the truck ((Choi et al., 2006b); (Marchet et al., 2012)). In addition, the inspection of the ITU regarding its condition might be automatic (Choi et al., 2006a). Furthermore, with automated gate methods, there is no need to read the numbers on the ITU manually, since a scanner is able to do this automatically (Dekker et al., 2013). Finally, with automated gates, the purpose of the staff is transformed from an administrational role to a monitoring role. This, in turn, provides faster handling of the throughput of the trucks in the terminal.

(Stefansson and Lumsden, 2009) defines different pre-notification services regarding arrival procedures. These include the Missing Goods Notification service (MGNS), the Transport Delay Notification Service (TDNS), and the Arrival Notification Service (ANS). MGNS is used to send notifications if failures, such as missing goods from shipment, have been exposed. In other words, this service might be useful to inform the hauliers if their ITU to be picked up has been left out from the freight train or vessel. The second pre-notification service, TDNS, enables the truck to send a notification to the terminal when delays (e.g. due to congestion or

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3 Adapted from the definition in http://www.businessdictionary.com/definition/management.html
changed road conditions) emerge along the way. ANS uses geofence technology to send pre-arrival notifications to the terminal. This pre-arrival notification message is sent from the vehicle (i.e. truck or a freight train) to the terminal automatically when the vehicle passes the boundaries of a pre-defined location.

There are a number of pre-booking systems that are based on timeslot allocation systems, including Truck Appointment Systems (TAS) ((Zhao and Goodchild, 2010); (Chen et al., 2013); (Phan and Kim, 2015)), Vehicle Booking System (VBS) ((Islam et al., 2013); (Islam and Olsen, 2014)), and Truck Scheduling (TS) (Hall, 2001). The last one, TS, is more specialised for the interaction between road and air transportation, improving both the on-time arrivals of trucks at the airport as well as efficient sorting. TAS and VBS, on the other hand, negotiate arrival times between hauliers and intermodal freight terminals. In addition, TAS and VBS allow hauliers to reserve a timeslot to perform different activities, like loading or unloading the ITU, at the terminal. The advantages of TAS and VBS are increased efficiency (decreased turnaround times in the terminal), environmentally friendly practices (reduced carbon emissions), and improved social sustainability (better planned workload and less stress).

(Buijs and Wortmann, 2014) defines three different transaction and support systems, including Real-Time Systems (RTSs), Decision Support Systems (DSSs), and Transaction Processing Systems (TPSs). RTSs operate in real-time to monitor physical variables such as audio, video, text, and numbers via sensors. DSSs can ensure that carrier operators have much greater visibility of applied rules and regulations, and that the transactions they perform become more accurate and effective (Macharis et al., 2008). Both RTS and DSS enable vertical information flows within an organisation. TPS is a transport management system application that records changes where particular business perspective events occur (e.g. arrival at a destination, loading/unloading, or changes in orders). Additionally, TPSs are updated by data from RTSs. TPSs can enable bi-directional horizontal information flows from one TPS implemented in one organisation to another TPS installed at another organisation.

Table 2.1 shows an overview of these different AM methods with their advantages and disadvantages. This table might help decision makers better understand these methodologies and drive them to invest.
Table 2.1 The potential effects of the four identified methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Potential advantages</th>
<th>Potential disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated access control</td>
<td>Increased efficiency and productivity; decreased turnaround times ((Choi et al., 2006a); (Choi et al., 2006b); (Marchet et al., 2012); (Dekker et al., 2013))</td>
<td>Systems with integrated intelligent technology might be expensive to implement (Stefansson and Lumsden, 2009).</td>
</tr>
<tr>
<td>Pre-notification services (MGNS, TDNS, and ANS)</td>
<td>Ability to reschedule timeslots and unloading activities (Stefansson and Lumsden, 2009).</td>
<td>The vehicle must be equipped with certain IT-systems (i.e GPS, digital maps) and these systems might be expensive to implement (Stefansson and Lumsden, 2009).</td>
</tr>
<tr>
<td>Pre-booking systems (TAS, VBS, and TS)</td>
<td>On-time arrivals; decreased turnaround times; reduced carbon emissions; better planning of the workload to create less stress. ((Zhao and Goodchild, 2010); (Islam et al., 2013); (Chen et al., 2013); (Phan and Kim, 2015); (Hall, 2001))</td>
<td>To have a significant impact on the efficiency a large share of all trips need to use the system. (Giuliano and O’Brien, 2007). System implementation essentially relies on providing truck drivers with incentives and clear benefits (Morais and Lord, 2006).</td>
</tr>
<tr>
<td>Transaction and support systems (TPS, DSS, and RTS)</td>
<td>Better visibility of carrier operations; safer, more accurate, and effective transactions ((Buijs and Wortmann, 2014); (Macharis et al., 2008))</td>
<td>These systems have difficulties in exchanging unstructured real-time information between different organisations (Buijs and Wortmann, 2014).</td>
</tr>
</tbody>
</table>

3. METHODOLOGY

According to (Yin, 2013), case studies are the preferred strategy when the focus is on the contemporary phenomenon within a real context. The purpose of case studies is to explain a causal relationship, describe an intervention, explore situations where the invention has multiple outcomes, and generate a meta-evaluation (study of evaluation). In addition, (Yin, 2013) states that case studies are decent and well-known research methods of theory building. Furthermore, both (Ellram, 1996) and (Eisenhardt, 1989) argues that case studies will help to better understand the collected data and provide explanations for “best practices.” Finally, (Eisenhardt, 1989) explains that case studies can combine different empirical data collection methods such as interviews, observations, archives, and questionnaires.

Table 3.1 shows the study objects within this research study, including two different road hauliers, Road Haulier A (RHA) and Road Haulier B (RHB); one port, Port Operator C (POC); and one intermodal terminal, Terminal Operator D (TOD). RHA is a small haulier servicing POC and TOD. RHB is a large haulier and has offices throughout Sweden. However, in this study the authors focused on RHB’s services to POC and TOD.
Table 3.1 Information about the study objects

<table>
<thead>
<tr>
<th>Study object</th>
<th>Number of employees</th>
<th>Number of vehicles</th>
<th>Type of business</th>
<th>Weekly volume (ITUs per week)</th>
<th>IT Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHA</td>
<td>9</td>
<td>31</td>
<td>Haulier</td>
<td>650</td>
<td>Alystra, Dynafeet, Catos</td>
</tr>
<tr>
<td>RHB</td>
<td>182</td>
<td>50</td>
<td>Haulier</td>
<td>300</td>
<td>Alystra, TX Connect, Scandibre</td>
</tr>
<tr>
<td>POC</td>
<td>438</td>
<td>8 ITU cranes; 2 railway cranes, 40 straddle carriers</td>
<td>Port operator</td>
<td>10000</td>
<td>Arrivals and Departures, Catos</td>
</tr>
<tr>
<td>TOD</td>
<td>38</td>
<td>2 ITU cranes; 2 fork lifts</td>
<td>Roadrail operators</td>
<td>750</td>
<td>Hogia, “Here and now”</td>
</tr>
</tbody>
</table>

The methodology of this research is described in Figure 3.1. As can be seen in this figure, the results are achieved through a literature study containing four parts (see sections 2.1, 2.2, 2.3, 2.4). The first two parts (sections 2.1 and 2.2) partly focus on describing the characteristics how contemporary access is managed and the different information flows from hauliers’ perspective in intermodal freight transportation. This knowledge is important input to defining AM (section 2.3) and then how AM could be improved by identifying existing methods, systems, and services (section 2.4).

Figure 3.1 The methodology of this research

The AM framework (section 4.1) is defined based on the knowledge gained from the literature study. By using the developed framework, the AM levels of the study objects (achieved from the empirical findings) can be identified. The empirical data collections are conducted to gain a better understanding from real-life situations (section 4.2) and consist of 7 semi-structured interviews: two with RHA, two with RHB, two with POC, and one with TOD. The focus is on how AM for road haulage works in intermodal transportation system. Interviews are also conducted with representatives for other modes of transport (in addition to road haulage) to determine whether there were interesting AM for improving AM in road transportation.

4. RESULTS

This section describes the defined Access Management framework, the main empirical findings of the seven interviews with the study objects, as well as the effects of Differentiated Access Management.
4.1. AM Framework

An improved AM would include different methods to enable real-time interaction between hauliers and intermodal freight terminals to improve the coordination, communication, and collaboration among them. Some form of AM is now present in most transportation modes, but AM operates in different ways for various transportation modes at different levels of efficiency. In other words, AM could be distinguished between different levels of efficiency in order to identify whether a specific AM method operates for example in a “good” or “poor” manner.

The purpose of the developed framework is to provide decision makers with a tool that gives them an overview of their AM. In addition, this tool would also help them to see how they might be able to increase the efficiency of their AM by implementing or using a more advanced AM method.

Table 4.1 The AM framework

<table>
<thead>
<tr>
<th>Level</th>
<th>Category</th>
<th>Information flow</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td>No AM</td>
<td>None</td>
<td>No management of access.</td>
</tr>
<tr>
<td>Level 1</td>
<td>Very poor AM</td>
<td>Uni-directional</td>
<td>The haulier can get minor information from the terminal in terms of queuing status at the terminal via a web browser or can check Google maps or any other traffic information web site. The information flow is uni-directional since the terminal only provides information and is not able to receive any information from other actors.</td>
</tr>
<tr>
<td>Level 2</td>
<td>Poor AM</td>
<td>Uni-directional</td>
<td>The level of information flow is equal to the one in Level 1. The level of AM method is a bit more advanced. Example of method is automated access control.</td>
</tr>
<tr>
<td>Level 3</td>
<td>Satisfactory AM</td>
<td>Uni-directional</td>
<td>At this level the information flow is improved: The vehicles must be able to send a pre-notification message to the terminal regarding their approximate time of arrival. Example of method is pre-notification services (MGNS, TDNS, and ANS).</td>
</tr>
<tr>
<td>Level 4</td>
<td>Good AM</td>
<td>Uni-directional</td>
<td>The level of information flow is equal to the one in Level 3. The level of AM method is more advanced, where the vehicles can book a time slot for loading or unloading at the terminal. Example of methods include pre-booking systems (TAS, VBS, and TS).</td>
</tr>
<tr>
<td>Level 5</td>
<td>Very good AM</td>
<td>Bi-directional</td>
<td>Exchanging of information between actors in real-time. Example of methods are transaction and support systems (RTSs + DSSs + TPSs).</td>
</tr>
<tr>
<td>Level 6</td>
<td>Excellent AM</td>
<td>Bi-directional</td>
<td>Differentiated access to fast lanes and specific timeslots based on price, urgency and/or liability (e.g. dangerous goods etc.). Example of method is DAM (see Section 4.4).</td>
</tr>
</tbody>
</table>

Table 4.1 shows an AM framework with seven different ranking levels, where Level 0 encompasses the least developed AM methods and Level 6 the most developed. A 7-point Likert scale with its labels (none, very poor, poor, satisfactory, good, very good, and excellent) has been kept in mind when defining the framework. In addition, the levels are defined based on the information flows (see section 2.2) and the identified AM methods described in section 2.4.
The four facets of communication (frequency, direction, modality, and content), as previously described, are all considered when the AM framework is defined. The frequency is the same for all levels within the AM framework: the communication is established when there is a need for information during a truck’s access to a terminal. The direction of information flows of the AM framework will only be limited to the interaction between organisations. This means that the AM framework will only consider communication directions that are horizontal, and either uni-directional or bi-directional. Actually, every level (except for Level 0) will cover horizontal information flow directions. Therefore, this information will be left out and only information about whether the levels use a uni-directional or bi-directional communication link. As shown in Table 4.1, only the improved AM methods that belong to “Level 5” and “Level 6” use a bi-directional communication link between organisations. The medium used within the AM framework is digital for all levels (except for Level 0, where there is no information flow). The content within the communication should be kept to a minimum, exchanging as little information as possible. There is no reason to exchange more information than necessary.

Each level is also defined regarding the four identified methods and categorised according to the grade of intelligence and advanced technology of the corresponding AM method. Higher levels exhibit more intelligent methods with more advanced technology. In addition, higher levels of AM also require a more advanced information flow when it comes to the directions of communications (none, uni-directional, and bi-directional).

4.2. Empirical findings

Empirical data is collected through seven interviews: two with RHA, two with RHB, two with POC, and one with TOD (see Table 3.1 for details). The focus of the interviews is to gain a better understanding on how contemporary access is handled, how the communication works between the actors, and what methods or systems they use. The purpose of the interviews with other transportation modes actors is to learn from them. Thus, to see whether any of their processes, activities or techniques could be transferred to road transportation in order to achieve improved AM.

4.2.1. Truck access to POC

All trucks that arrive at POC must go through different steps before they will be able to load or unload their ITUs. All steps are manual and force the truck driver to step out of the truck at several locations within the terminal. Some of the locations are waiting area, border control and checking control (for the ITU).

The communication between POC and all arriving trucks is poor (including the communication between RHA, RHB, and POC). POC provides information regarding the truck entrance to the terminal via a web browser. A web camera monitors the parking and waiting slots at the entrance of the port area; statistical diagrams illustrate the waiting times for a specific day; and the mean waiting times both for a specific day and the following day are also available. This information helps the hauliers to better plan their pick-ups of ITUs at POC.

4.2.2. Truck access to TOD

All trucks (including the ones from RHA and RHB) that access TOD come unnoticed. This means that TOD never knows exact arrival time when the truck plans to load or unload its ITU. Neither RHA nor THB do use or can get access to the IT systems of TOD. Currently, there is no communication between RHA, RHB, and TOD. TOD does have information about when the freight trains arrive and whether changes have occurred during the
trip, but does not provide this information to other parties. In fact, TOD needs to receive a request from the haulier to provide this information. In other words, there is no information available except when the haulier requests it. From a haulier’s point of view, it would be interesting and helpful to get such information to avoid empty runs, which would save them time and money. In addition, having this information accessible would make it easier for hauliers to plan their pick-ups in the terminal.

4.2.3. Train access to POC

Freight trains use slot allocation mechanisms and all freight trains follow a planned time schedule. Both POC and the freight train use the same IT system, called CATOS.

When a train is delayed, POC has direct communication with the train driver via telephone. However, once a freight train gets delayed, it takes several days before it returns to the correct schedule. Additionally, the situation can get even more difficult and force POCs to seek alternative routes when the railway is out of order. CATOS does not provide the POC with an exact location of the freight train, only that the train is located on a specific link between two intersections. Complicating the picture, there is no information available about the speed of the train or possible problems it may have encountered during the trip.

4.2.4. Train access to TOD

Public passenger and freight trains follow pre-planned schedules. A number of different freight trains access the terminal every day. Each train operator uses its own IT systems. Several of the train operators force the terminal operators to update information (such as when the unit arrived, when it is loaded or unloaded, etc.) directly to the IT systems of the train operators. As a result, this may mean that a terminal operator must be capable of dealing with a number of different IT systems (one for each train operator).

The communication for the “train access to TOD” is as follows: train drivers <-> train operators <-> terminal operators. Thus, the terminal operators do not normally have direct contact with the train driver. Instead, the communication goes usually through the train operator. Often, the communication between train drivers and train operators is only conducted via phone and does not use any digital real-time IT systems. When deviations occur and the train does not arrive in time, which happens more often than not, the terminal operator can follow the train’s location using an IT system.

4.2.5. Vessel access to POC

The ships have arrival time windows that they must follow. Smaller vessels have 10-12 hour gaps in their schedule, while larger ones have only a 2-hour arrival time slot and normally stay in ports for 24 hours. However, they do arrive earlier or later depending on how much cargo they bring and changes in the weather conditions.

The communication between the terminal and the vessel is good. First, the skipper of the vessel informs the terminal with a specific timeslot. It is important for them to keep the timeslot since they are dependent on the pilot. Vessels that do not keep their own time slot can be fined. Therefore they plan their route accurately to be on time for the arrival of the pilot. They have to report no later than 5 hours prior to the pilot. To avoid fines due to delayed arrivals, the vessels are normally good at arriving within their planned time window. Regardless, the terminal planner must have specific details on arrival and goods 8 hours before the ship docks at the quay. One week before arrival, the terminal planner receives information on
approximately how much cargo a vessel will bring, but exact information on the amount of cargo and alerts about being late must be provided 24 hours before the vessel arrives.

4.3. Analysing the AM levels for the study objects

To analyse the empirical results above the AM framework might be a feasible option. Each of the mentioned access is analysed one by one by using the AM framework.

The first one, the truck access to POC, would be scaled as Level 1 - very poor AM, since POC only can provide rather poor information about the terminal’s queuing status and no more advance AM methods are contemporary used.

The second one, the truck access to TOD, is located as Level 0 - No AM since there is no communication between the involved actors and there is no common advanced AM method in use. In other words, it is possible to access TOD but there is no management of the access.

The third one, train access to POC, can be put at Level 4 - Good AM since the trains to POC have booking procedures and they follow predefined time schedules. However, there is actually no dynamic functionality to rebook the time slots if the trains for some reasons get delayed. But they do communicate the delay to the terminal. So, for these reasons Level 3 - Satisfactory AM would be a more feasible level of AM.

The fourth one, train access to TOD, operates from an AM point of view in a similar way as the train access to POC. Also in this case, as the trains follow pre-planned schedules and they cannot be updated dynamically if changes would appear, the level of AM is Level 3 - Satisfactory.

The fifth one, vessel access to POC, could be position as Level 5 - Very good AM since the communication between the vessel and terminal is good and the vessel can send updated estimated time of arrivals when alerts occur.

4.4. Differentiated Access Management

The disadvantages of the identified AM methods in Table 2.1 are that they might be expensive to implement, most involved actors need to use the same system in order to achieve efficiency, and the digital real-time interaction via these AM methods between organisations is difficult. Furthermore, more than 80% of the total number of haulier fleets in the EU and the US have fewer than 10 trucks (Sternberg et al., 2013), so these companies have limited resources to investigate larger IT systems that might be expensive and complicated to implement.

These limitations spawned the idea of defining a new AM method that is easier, less costly to implement, and more suitable for smaller actors like most of these hauliers. In addition, this method should take advantage of the haulier’s existing IT systems, but use them more efficiently. The method should be able to interact with other carriers by sharing data and other vital information in real-time. The haulier would then be able to send a notification in advance of its arrival to the intermodal freight terminal that, in turn, would be able to respond to the notification and prepare the ITU for pick-up. In addition, this method could also further develop the real-time interaction between the carriers by sharing other data and vital information like estimated time of arrival (ETA), traffic info, emissions, eco-driving educated drivers, etc. to obtain certain kinds of prioritised access as previously described. For example, a haulier can qualify for access to an intermodal freight terminal by presenting the right data or information, which can come from, for example, the sensors in a vehicle, the infrastructure, or another authority. After receiving access, the vehicle can be given a slot time for loading or unloading. The idea is that the digital real-time interaction should be performed by using web-based
applications installed within for example a smartphone. This proposed method is called Differentiated Access Management (DAM).

The advantages of DAM mean that a small investment can give carriers great benefits by sharing only the data that is necessary and only with the carriers involved, providing a cost effective solution. Additionally, by making better use of resources, this method might reduce energy consumption, shrink the carbon footprint of the relevant companies, and reduce congestion, thereby creating safer and more environmentally friendly intermodal transportation. For example, from a haulier perspective, DAM could help reducing some of their empty runs as have been stated in the interviews with RHA and RHB. Finally, DAM can grant prioritised access for ITUs that must be loaded or unloaded within a specific time window, for whatever reason.

The disadvantages of DAM are that it has not been tested in real-life scenarios and might just improve the AM for involved actors only.

5. CONCLUSIONS

This research is focused on defining and distinguishing access management (AM) for road haulage operations in intermodal freight transportation. In this study, AM is defined as “the planning, organising, commanding, coordinating, and controlling of resources regarding interoperability between hauliers and intermodal freight terminals.” Distinguishing means to identify and differentiate how “good” or “poor” an AM is according to a pre-defined scale, i.e. the AM framework suggested here. Then, it is easier to see what actions are required to improve AM. Improved AM could enable better real-time interaction between hauliers and intermodal freight terminals, which could lead to many potential operational benefits for these actors and help them alleviate some of the problems they face like inefficient carrier operations (Sternberg et al., 2012b), crucial information exchange between carriers (Buijs and Wortmann, 2014), and lack of high quality real-time data (SteadieSeifi et al., 2014).

The managerial contribution of this study is the suggested AM framework that can support hauliers and terminal operators to distinguish their AM operations and provide a method to improve their AM and align with their existing or future AM strategy. Not only does this framework provide managerial contribution, but theoretical as well. The framework can be used to analyse the different AM systems and rate based on the level classification suggested. The empirical findings in this study describes briefly how information is exchanged and updated for five different cases when trucks, trains and vessels are about accessing two different intermodal terminals. In addition, their AM are also analysed according to the AM framework. Currently, the communication between carriers, including exchanging information simply and efficiently, is an important issue making intermodal freight transportation more efficient (Buijs and Wortmann, 2014).

The major limitation of this study is that it only focuses on collaboration between hauliers and intermodal freight terminal operators, ignoring other actors within the supply chain, including shippers, receivers, logistics service providers, and logistics service intermediaries (Stefansson, 2006). In addition, aviation has received no attention, largely because the applicable study objects have limited connection with the aviation industry for the time being.

Future research should start the investigation of improving AM. For example, more empirical data needs to be collected to, firstly, get better understanding about the trucks and gate operations, and secondly, to identify the inefficiencies at intermodal freight terminals. In order
to recognise these efficiencies, before-and-after measurements should be conducted. For example, measures on how much a particular method might improve the AM would be interesting. Furthermore, the AM framework should be further expanded by including aviation and vertical information flows. Finally, DAM needs to be implemented and tested in real-world environments to better measure its efficiency.

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SUPPLY CHAIN STRATEGIES IN HUMANITARIAN LOGISTICS:
A REVIEW OF HOW ACTORS MITIGATE SUPPLY CHAIN RISKS

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ABSTRACT

Purpose of this paper
This paper links humanitarian logistics (HL) and supply chain risk management (SCRM) to provide understanding of risk mitigation strategies (RMS) humanitarian organizations use, or could use, to improve their logistics preparedness.

Design/methodology/approach
Based on systematic reviews of RMS in SCRM and supply chain strategies (SCS) in HL literature, we develop a framework and use this to review published case studies in HL.

Findings
We found that humanitarian actors use a number of the strategies proposed in the framework, in particular those related to strategic stocks, postponement, and collaboration.

Research limitations
The study is based on secondary data, and could be further developed through case studies based on primary data. Further studies should explore the generalizability of the findings.

Practical implications
The study provides greater understanding of the use of RMS. Practitioners can use the results to identify potential new strategies to use for risk mitigation. The study can be used for training, discussion, and deliberation.

Societal implications
The results can support improvements in humanitarian supply chains, thereby providing affected people with rapid, cost-efficient, and better-adapted responses.

What is original/value of paper
The paper connects SCRM and HL to develop a framework and review how humanitarian actors mitigate supply chain risks.

Keywords: Supply chain strategy, supply chain risk management, risk mitigation, humanitarian logistics, case, review, logistics, preparedness

1. INTRODUCTION AND PURPOSE

“Where is the Crisis Management Component of [Humanitarian Operations]?”
This paper links humanitarian logistics (HL) to supply chain risk management (SCRM). Extant research is concerned with differences between commercial and humanitarian supply chains (e.g., Dubey and Gunasekaran, 2016), but conclude that concepts, models and tools can be applied also in the humanitarian context (e.g. Day et al. 2012; Oloruntoba and Gray, 2006; Swanson and Smith, 2013, van Wassenhove, 2006). SCRM was developed for the commercial context and is concerned with assessing, mitigating, responding to, and monitoring normal and abnormal risks (disruptions). We focus mitigation. The aim is to provide greater understanding of how humanitarian organizations use, or could use, supply chain strategies (SCS) to improve their logistics preparedness by reducing and handling risk. Better preparedness improve response (van Wassenhove, 2006; Jahre and Heigh, 2008), even if there are challenging trade-offs between cost efficiency and flexibility (Day, 2014; Jahre and Fabbe-Costes, 2015; UNDP, 2015). SCRM points to similar trade-offs, i.e. return on investments in safeguarding against disruptions (e.g. Sodhi and Tang, 2012; Nooraei and Parast, 2016). Research on logistics preparedness concern mainly network design and warehouse location (Kunz and Reiner, 2012). More understanding of how the humanitarian community improve their logistics preparedness is needed (Jahre et al. 2016).

While SCRM is a vastly expanding area (Ho et al. 2015), few studies have linked SCRM with HL. Wild and Zhou (2011) are concerned with ethical procurement in relation to risk. Iakovou et al. (2014) suggest dual sourcing as a proactive risk mitigation sourcing strategy. Scholten et al. (2014) show the importance of collaboration, supply chain re-engineering, agility, risk awareness, and knowledge management. Kóvacs and Tatham (2009) discuss the use of vendor managed inventory, public-private partnerships, joint warehouses for resource pooling, and postponement. None of these, however, relate the strategies to an overall framework.

SCRM frameworks suggest to categorise RMS by different dimensions, including redundancy vs. flexibility (e.g. Chang et al. 2015; Kleindorfer and Saad, 2005; Talluri et al. 2013); reducing vs. coping (e.g. Ghadge et al. 2012; Knemeyer et al. 2009; Simangunsong et al. 2012); monitoring vs. collaboration (e.g. Hajmohammad and Vachon 2016); and depending on what risks they are to handle (e.g. Chopra and Sodhi, 2004; Ho et. al 2015; Lavastre et. al 2014; Manuj and Mentzer, 2008; Ritchie and Brindley, 2007; Sodhi et al. 2012; Sodhi and Tang, 2012; Tang, 2006a). Using Tang (2006a) as a basis, combined with a systematic review of papers discussing supply chain strategies in the humanitarian context, we conduct a review of case studies published in HL literature. Publications in HL focus specific strategies, and much evidence is anecdotal. We identified no study presenting an overall framework. This is the gap we aim to fill.

We propose a revised framework for use in research and practice. We found case studies on the use of strategic stocks, postponement and collaboration in particular. This study is based on secondary data. We suggest further research based on primary data with data collection instruments developed directly from the framework. Future studies should explore the generalizability of the findings, and test and further develop the framework.

This study provides an initial understanding of humanitarian organisations’ use of RMS to improve preparedness. Practitioners can use the results to identify potential new RMS. The study can be used for training, discussion, and deliberation. The results can be used to support improvements in humanitarian supply chains, thereby providing affected people with rapid, cost-efficient, and better-adapted responses. Starting with the research design, section 3 continues with the literature review and resulting framework. Section 4 presents the analysis and discussion, before Section 5 conclude and suggests further research.
2. RESEARCH DESIGN – DATA COLLECTION AND ANALYSIS

The review constitutes three literature streams: (1) SCRM mitigation strategy frameworks; (2) HL and humanitarian operations (HO) literature on SCS for logistics preparedness; and (3) Published case studies. A systematic review (Bryman and Bell, 2014) was conducted to identify relevant papers (see Appendix 1 for details):

a) Four databases - Business Source Complete, Emerald, Science Direct, and Wiley - were selected to cover all articles published by 2016 in international refereed logistics, supply chain and operations management journals.

b) For SCRM frameworks, we searched abstracts using ‘supply chain risk management’ + ‘framework’ as search terms. The articles were screened to select general frameworks, excluding those for specific risk types and contexts.

c) For SCS, we searched abstracts using ‘strategy’ + ‘humanitarian operations’/‘humanitarian logistics’. Conceptual and empirical studies were screened to identify those concerned with preparedness, disaster relief and logistics, excluding papers on response and other ‘operations’.

d) Based on results from b) and c) we developed a framework for RMS in the humanitarian context.

e) Case studies of humanitarian organizations’ SCS were then identified searching abstracts using ‘case study’ + strategy + ‘humanitarian operations’/‘humanitarian logistics’. Papers published in logistics, operations management and supply chain management journals were screened to identify relevant cases, i.e. those reporting in-depth case studies of organisations’ SCS for logistics preparedness in disaster relief.

f) The case studies were reviewed using the framework with the purpose to get an overview of empirical HL research and what strategies humanitarian organisations seem to be focusing today.

A limitation in the study is the use of published cases only. Organizations may use strategies that have not been reported in the scientific literature. However, the data still gives indications sufficient for demonstrating the use of the framework and provides a basis for further research using other research designs and data sources. Another limitation is that the case studies were undertaken and published for purposes other than the analysis presented here. This is a weakness in using secondary data (Bryman and Bell, 2014), which was mitigated by spending time to get familiarized with the data, and selecting only studies published in refereed journals to secure data quality (p.328). Most of the case studies concern big international organizations making it difficult to generalize to the whole population of humanitarian actors. Some strategies for particular organizations are reported in more than one case study, for example, use of pre-positioning in the International Federation Red Cross Red Crescent Society (IFRC). To capture more depth and breadth, further research should collect primary data with data collection instruments developed from the framework, conduct more case studies, particularly of other types of organizations, and do cross-sectional studies.

3. FRAMEWORK

3.1. Risk mitigation strategies in SCRM

SCRM concerns how abnormal/unanticipated risks and normal risks, often called anticipated delays are mitigated in the commercial context (Chopra and Sodhi, 2004; Lavastre et al., 2014; Tang, 2006a). Delays often occur when it is difficult to respond to changes in demand caused
by a lack of flexibility. Other problems can be poor quality in own plant or those of suppliers, difficult border crossings, and transportation challenges. Abnormal risks, i.e. unpredictable and rare disruptions, include natural disasters (for example, volcanic ash over Europe in 2010, and the Japanese disaster in 2011), financial crises, breakdowns in important supplier facilities, labour strikes, and terrorism, etc. Ho et al. (2015) use the term macro risk factors to represent abnormal risks, while micro risks represent normal risks and are related to the organisation’s supply, demand, manufacturing, and infrastructure. Using Tang (2006a) as the starting point,

Table 3.1 presents results from the review.

Table 3.1 Risk mitigation strategies identified in the SCRM literature

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Explanation and examples</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralisation</td>
<td>Stocks, production, distribution</td>
<td>Lavastre et al. (2014)</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Risk sharing, supplier development, information sharing</td>
<td>Chang et al. (2015); Ghadge et al. (2012); Lavastre et al. (2014);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lavastre et al. (2014); Ritchie and Brindley (2007); Simangunsong et al. (2012); Talluri et al. (2013); Tang (2006b);</td>
</tr>
<tr>
<td>Dynamic assortment planning</td>
<td>Can be used to influence choice and demand, and to entice customers to purchase products that are widely available when certain products are facing supply disruptions.</td>
<td>Simangunsong et al. (2012); Tang (2006a; b)</td>
</tr>
<tr>
<td>Economic supply incentives</td>
<td>Encourage additional suppliers to stay or enter into a certain market in order to avoid monopolistic situations, and to secure multiple sources, should a disruption occur.</td>
<td>Tang (2006)</td>
</tr>
<tr>
<td>Flexible manufacturing process</td>
<td>Allow for adjustments in quantity and quality produced in their network, for example, varying between plants and/or production lines</td>
<td>Chopra and Sodhi (2004); Kleindorfer and Saad (2005); Lavastre et al. (2014); Simangunsong et al. (2012); Sodhi and Tang (2012); Talluri et al. (2013); Tang (2006b); Tang and Tomlin (2008)</td>
</tr>
<tr>
<td>Flexible supply base</td>
<td>Multiple sourcing options available, thus allowing for alternatives should one source be disrupted. One way of doing this is to develop a supply alliance network with suppliers in various countries. Also called hedging</td>
<td>Chang et al. (2015); Chopra and Sodhi (2004); Ghadge et al. (2012); Kleindorfer and Saad (2005); Knemeyer et al. (2009); Lavastre et al. (2014); Manuj and Mentzer (2008); Simangunsong et al. (2012); Talluri et al. (2013); Tang (2006a; b); Tang and Tomlin (2008)</td>
</tr>
<tr>
<td>Flexible supply contracts</td>
<td>Agreements with suppliers allowing the customer to adjust order quantities depending on need.</td>
<td>Chopra and Sodhi (2004); Ghadge et al. (2012); Manuj and Mentzer (2008); Simangunsong et al. (2012); Sodhi and Tang (2012); Tang (2006b); Tang and Tomlin (2008)</td>
</tr>
<tr>
<td>Strategy</td>
<td>Explanation and examples</td>
<td>Authors</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Flexible transportation</td>
<td>Multi-modality, multiple carriers and/or multiple routes.</td>
<td>Chopra and Sodhi (2004); Kleindorfer and Saad (2005); Lavastre et al. (2014); Tang (2006)</td>
</tr>
<tr>
<td>Make-and-buy</td>
<td>Combination of in-house and outsourcing, which allows more flexibility in case of a disruption. Include vertical integration,</td>
<td>Chopra and Sodhi (2004); Kleindorfer and Saad (2005); Manuj and Mentzer (2008); Simangunsong et al. (2012); Tang (2006a)</td>
</tr>
<tr>
<td>Postponement</td>
<td>Utilizes product or process design concepts such as standardization, commonality, modular design, and operations reversal to delay the point of differentiation in products, services, movement and other value-adding activities.</td>
<td>Ghadge et al. (2012); Manuj and Mentzer (2008); Simangunsong et al. (2012); Tang (2006a; b); Tang and Tomlin (2008)</td>
</tr>
<tr>
<td>Revenue management</td>
<td>Dynamic pricing and/or promotion</td>
<td>Chopra and Sodhi (2004); Simangunsong et al. (2012); Tang (2006a; b); Tang and Tomlin (2008)</td>
</tr>
<tr>
<td>Silent product rollover</td>
<td>‘Leak’ new products into a market without making formal announcements</td>
<td>Tang (2006a; b); Tang and Tomlin (2008);</td>
</tr>
<tr>
<td>Speculation</td>
<td>Opposite of postponement such as forward placement of inventory, forward buying and early commitment to the form of a product</td>
<td>Manuj and Mentzer (2008)</td>
</tr>
<tr>
<td>Strategic stock</td>
<td>Inventories at certain ‘strategic’ locations (warehouses, logistics hubs, distribution centres) that can be deployed quickly in case of a disaster. Often shared by multiple supply chain partners, e.g. vendor managed inventory.</td>
<td>Chang et al. (2015); Chopra and Sodhi (2004); Ghadge et al. (2012); Knemeyer et al. (2009); Lavastre et al. (2014); Simangunsong et al. (2012); Talluri et al. (2013); Tang (2006a)</td>
</tr>
</tbody>
</table>

### 3.2. Humanitarian supply chain strategies

Humanitarian organizations experience both types of risks when they prepare for, and respond to, natural and/or man-made disasters. Compared with commercial supply chains, they are more subject to disruptions because their supply chains are set up, and operate, in disaster-prone areas (Day et al. 2012). Preparing for disruptions is therefore of major importance (van Wassenhove, 2006). Accordingly, we are concerned with SCS humanitarian organizations use to mitigate risks and thus improve their logistics preparedness. Based on the RMS identified in SCRM, Table 3.2 lists examples of humanitarian SCS. References in the second column represents example papers on each strategy type.
### Table 3.2 Supply chain strategies identified in the humanitarian logistics literature

<table>
<thead>
<tr>
<th>RMS</th>
<th>Humanitarian SCS with example papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralisation</td>
<td>Centralized pre-positioning (Listou, 2008); centralized fleet hubs (Pedraza-Martinez et al. 2011)</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Coordination (van Wassenhove, 2006); supplier relations (Kóvacs and Tatham, 2009); commercial-humanitarian cooperation (Majewski et al. 2010); collaborative procurement (Wild and Zhou, 2011); civil-military coordination (Heaslip et al. 2012); adaptability (Dubey and Gunasekaran, 2016)</td>
</tr>
<tr>
<td>Flexible supply base</td>
<td>Multiple suppliers (Ertem et al. 2010); asset transfer mechanism (Bhattacharya et al. 2013); dual sourcing (Iakovou et al., 2013); flexible sourcing (Day, 2014); buttressing supply chains (Sodhi and Tang, 2014); adaptive entity capacity (Day, 2014)</td>
</tr>
<tr>
<td>Flexible supply contracts</td>
<td>Flexible order quantities (Lodree, 2011); framework agreements (Balcik and Ak, 2013); option contract (Wang et al. 2015)</td>
</tr>
<tr>
<td>Flexible transportation</td>
<td>Operational mix for fleet (Besiou et al. 2014)</td>
</tr>
<tr>
<td>Information sharing</td>
<td>Demand signal visibility (Day et al. 2012); alignment (Dubey and Gunasekaran, 2016)</td>
</tr>
<tr>
<td>Make-and-buy</td>
<td>Logistics outsourcing (Majewski et al. 2010)</td>
</tr>
<tr>
<td>Postponement</td>
<td>Non-earmarking of items (Jahre and Heigh, 2008); rosters (Kóvacs and Tatham, 2009); non-earmarked funding (Besiou et al. 2014); standardisation (Jahre and Fabbe-Costes, 2015)</td>
</tr>
<tr>
<td>Speculation</td>
<td>Full speculation (Listou, 2008); Decentralised prepositioning (Jahre and Heigh, 2008); unsolicited goods ((Holguín-Veras and Van Wassenhove, 2014)</td>
</tr>
<tr>
<td>Strategic stock</td>
<td>Secure location (Hale and Moberg, 2005); pooling resources (Kóvacs and Tatham, 2009); vendor managed inventory (Van Wassenhove and Pedraza-Martinez, 2012); prepositioning (Kunz et al. 2015); temporary fleet hubs (Stauffer et al. 2015); distribution warehouses (Hong et al. 2015)</td>
</tr>
</tbody>
</table>

We did not identify any paper providing an overview or framework for possible strategies, nor did many papers provide much depth of each strategy. Specific strategies from SCRM not identified include revenue management, economic supply incentives, dynamic assortment planning, silent product rollover, and flexible manufacturing processes.

### 3.3. Framework for humanitarian risk mitigation strategies

Including the different types of risk and operationalized humanitarian RMS, Figure 3.1 depicts the resulting framework.
While extant literature discuss the strategies, many papers are of conceptual or theoretical nature, providing little more than anecdotal evidence. A review of published case studies can provide more understanding of what strategies humanitarian organisations use to improve their logistics preparedness, and can also provide an overview of research methodologies and focus in the studies.

### 4. ANALYSIS AND DISCUSSION

Table 4.1 presents the analysis. We found a total of 24 papers reporting case studies, with the first published in 2008. In terms of organizations, the focus is on big international ones.

#### Table 4.1 Risks mitigation strategies practiced by organizations

<table>
<thead>
<tr>
<th>Reference</th>
<th>Case study</th>
<th>Risk mitigation strategy</th>
<th>Exemplified by</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
<td><strong>Authors</strong></td>
<td><strong>Organization</strong></td>
<td><strong>Disaster/ Area</strong></td>
</tr>
<tr>
<td>2008</td>
<td>Jahre &amp; Heigh</td>
<td>IFRC</td>
<td>Global</td>
</tr>
<tr>
<td>2009</td>
<td>Mc</td>
<td>Mennonite</td>
<td>70 countries</td>
</tr>
<tr>
<td>2008</td>
<td>Listou</td>
<td>Norwegian Defence</td>
<td>Operation Atalanta, Medical supplies to Nordic Battle Group</td>
</tr>
</tbody>
</table>

Figure 3.1 Humanitarian Risk Mitigation Strategies (risk factors adapted from Ho et al. 2015)
<table>
<thead>
<tr>
<th>Reference</th>
<th>Case study</th>
<th>Risk mitigation strategy</th>
<th>Exemplified by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Authors</td>
<td>Organization</td>
<td>Disaster/ Area</td>
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<td></td>
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<tr>
<td>2010</td>
<td>Lachlin et al.</td>
<td>Central Committee</td>
<td>Global</td>
</tr>
<tr>
<td></td>
<td>IFC, UNHRD (UN Humanitarian Response Depots)</td>
<td>Global</td>
<td>Regionalised item prepositioning</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Charles</td>
<td>IFRC, UNHRD (UN Humanitarian Response Depots)</td>
<td>Flexible transportation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rwandan Refugee Crisis, 1994-1996</td>
<td>Strategic Stock</td>
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<td></td>
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<td>Postponement</td>
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<td></td>
<td></td>
<td></td>
<td>Collaboration</td>
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<tr>
<td>2010</td>
<td>Choi et al.</td>
<td>N.A</td>
<td>Yogyakarta Earthquake, 2006</td>
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<td>Postponement</td>
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<td></td>
<td>Collaboration</td>
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<tr>
<td>2010</td>
<td>Gatignon et al.</td>
<td>IFRC</td>
<td>Global</td>
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<td>Collaboration</td>
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<tr>
<td>2010</td>
<td>Jahre &amp; Jensen</td>
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<td>Collaboration</td>
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<td>Strategic stock</td>
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<tr>
<td>2010</td>
<td>Oloruntoba</td>
<td>N.A</td>
<td>Cyclone Larry</td>
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<tr>
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<td></td>
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<tr>
<td>2011</td>
<td>Duran et al.</td>
<td>CARE (Christian Action Research and Education)</td>
<td>Global</td>
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<tr>
<td>2011</td>
<td>McCoy &amp; Brandeu</td>
<td>UNHCR</td>
<td>Darfur Crisis, 2004/2005</td>
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<td></td>
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<tr>
<td>2011</td>
<td>Pedraza-Martinez et al.</td>
<td>IFRC, ICRC (International Committee of the Red Cross), WFP (World Food Programme), WVI (World Vision)</td>
<td>Global</td>
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<tr>
<td>2012</td>
<td>Cozzolino et al.</td>
<td>WFP</td>
<td>Global</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Collaboration</td>
</tr>
<tr>
<td>2013</td>
<td>Pedraza-Martinez &amp; Van Wassenhove</td>
<td>ICRC, IFRC, WFP, WVI</td>
<td>Global</td>
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<tr>
<td>2014</td>
<td>Besiou et al.</td>
<td>ICRC</td>
<td>Zambezia Province, Tanzania</td>
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<td>Postponement</td>
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<td></td>
<td></td>
<td></td>
<td>Flexible transportation</td>
</tr>
<tr>
<td>Reference</td>
<td>Case study</td>
<td>Risk mitigation strategy</td>
<td>Exemplified by</td>
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</tr>
<tr>
<td>Year</td>
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<td>Organization</td>
<td>Disaster/ Area</td>
</tr>
<tr>
<td>2014</td>
<td>Buddas</td>
<td>Finnish Red Cross</td>
<td>Global</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emergency Response Unit</td>
<td>Strategic stock</td>
</tr>
<tr>
<td>2014</td>
<td>Eftekar et al.</td>
<td>ICRC</td>
<td>Sudan, Afghanistan, Ethiopia</td>
</tr>
<tr>
<td>2014</td>
<td>Ergun et al.</td>
<td>Salvation Army</td>
<td>Haiti earthquake, 2010</td>
</tr>
<tr>
<td>2014</td>
<td>Holguin-Veras et al.</td>
<td>Region, commercial companies</td>
<td>Japan earthquake, Tohuku, 2011</td>
</tr>
<tr>
<td>2014</td>
<td>Scholten et al.</td>
<td>VOAD (Voluntary Organizations Active in Disaster)</td>
<td>Hurricane Katrina, 2005</td>
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</tr>
<tr>
<td>2015</td>
<td>Jahre &amp; Fabbe-Costes</td>
<td>Norwegian Red Cross, IFRC</td>
<td>Global</td>
</tr>
<tr>
<td>2015</td>
<td>Kunz et al.</td>
<td>UNHCR (UN High Commissioner for Refugees)</td>
<td>Global</td>
</tr>
<tr>
<td>2015</td>
<td>Stauffer et al.</td>
<td>IFRC</td>
<td>Global</td>
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<tr>
<td>2016</td>
<td>L’Hermitte et al.</td>
<td>WFP</td>
<td>Global</td>
</tr>
<tr>
<td>2016</td>
<td>Jahre et al.</td>
<td>UNHCR</td>
<td>Global</td>
</tr>
</tbody>
</table>

Strategic stock is by far the strategy most commonly reported (63 percent) and include items and vehicles. Postponement (38 percent) include non-earmarked funding/goods, centralization of stocks, and pre-positioning of semi-finished goods. Collaboration (38 percent) include coordination, cooperation with suppliers, joint planning and information exchange. Flexible transportation (14 percent) include operational mix, alternative evacuation routes, and transport modes. Flexible supply base (10 percent) include decentralized decisions, alternative sources, and cooperation agreements.
In terms of methods used in extant research, strategic stock has been studied using both quantitative (e.g., Duran et al., 2011), and qualitative approaches (e.g., Gatignon et al., 2010). In particular, network design models (e.g. Charles, 2010) and inventory management (e.g. McCoy and Brandeu, 2011) have been applied. Two other strategies have been studied using quantitative approaches: flexible transportation with system dynamics (Besiou et al., 2014), and postponement/strategic stock with the dynamic hub location model (Stauffer et al., 2015). The remaining have used qualitative approaches. Apart from some quantitative studies, few papers provide evidence on how the strategies impact on performance.

5. CONCLUDING REMARKS AND FURTHER RESEARCH

This paper aims to increase understanding of the use of RMS for improving logistics preparedness in the humanitarian context. We conduct a review of HL, basing our research on RMS suggested in SCRM. We found that humanitarian actors do indeed use such strategies, in particular those related to strategic stocks, postponement, and collaboration. The paper suggests a revised framework, adapted specifically to the humanitarian context and reaches a number of conclusions.

Firstly, some strategies do not seem much used by the humanitarian organizations judging by the case studies. In particular, little research has reported on the sourcing strategies of humanitarian organizations, and how they work, or could work, with product and service suppliers to improve their supply chains. Accordingly, there is a need for more research on how organizations develop markets for the items and services of interest by making use of a flexible supply base, flexible supply contracts, and relationships with suppliers (outside of the contract). Secondly, further research is required in order to understand the drivers and risks mitigated by (and the content of) flexible supply contracts; in particular, the supply base, and flexible transportation.

This study identified that quantitative approaches are limited to a few of the possible strategies. Further research using for example optimization, and system dynamics to improve the understanding of other strategies, is encouraged. Similarly, qualitative approaches are limited and would benefit from more rigorous and in-depth, longitudinal, case studies than what this study identified. We also suggest to design and position empirical studies based on the ideas put forward in the conceptual studies and the revised framework. This study has made use of secondary data. We suggest to undertake research through new case studies with data collection instruments directly based on the framework. Further studies should also explore the generalizability of the findings, and make refinements to the framework. Surveys or case studies of other organizations, particularly smaller and medium-sized ones is also encouraged.

Understanding strategies in their context is another area. One aspect of interest is to understand the importance of how the RMS fit in with the overall strategy of the organization (Tang, 2006a). Another is to use longitudinal case study approaches to study how strategies change over time. Yet another is to understand when each strategy should be used. This could build on the work of Talluri et al. (2013), who draw on contingency theory, and suggest differentiating between redundancy and flexibility approaches. Micheli et al. (2014), Grötsch et al. (2013), and Simangunsong et al. (2012), are others who propose use of contingency theory.

Finally, tools and models that can aid in the evaluation of costs and benefits of strategy investments are needed (Listou, 2015). This is particularly important in the humanitarian context, since organizations need funding to make such changes, but find this difficult to achieve (Tang, 2006a). In the studies we reviewed, there was little explicit connection between
preparedness and strategies and how the strategies improve performance. Nooraie and Parast (2016) is one exception. They model the trade-off between increased investment in supply chain capabilities and reduced supply chain risks. Further research could build on their approach.

“Nobody gets credit for fixing problems that never happened.” (Repenning and Sterman, 2001, p.64)

REFERENCES


Appendix 1:

<table>
<thead>
<tr>
<th>Database</th>
<th>Business Source Complete</th>
<th>Emerald</th>
<th>Scisencedirect</th>
<th>Wiley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journals</td>
<td>OR, IJOPM, JPSM, SCF:II, JORS, JOM, TR, POM</td>
<td>IJLM, IJOPM, IJPDL, JHLSCM</td>
<td>EJOR, IJPE, JOM, JPSM, TR</td>
<td>JBL, JSM, POM</td>
</tr>
<tr>
<td>No. of SCRM articles identified</td>
<td>64</td>
<td>140</td>
<td>108</td>
<td>20</td>
</tr>
<tr>
<td>No. articles before/after screening</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Humanitarian Operations + strategy</td>
<td>7 (1)</td>
<td>77 (13)</td>
<td>15 (1)</td>
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<td>16 (0)</td>
<td>122 (10)</td>
<td>25 (1)</td>
<td>23 (1)</td>
</tr>
</tbody>
</table>

Note 1: Both ‘logistics’ and ‘operations’ were used as search terms as journals differ regards which term they normally use. This leads to overlap between the two groups.

Note 2: The search for case studies was complicated and different combinations of search terms in different types of content (abstract, all) were tested to capture as many as possible, while keeping the screening volume at a reasonable level. The searches were cross-referenced with the authors’ knowledge of case studies in humanitarian logistics and we found that some studies were not identified, partly because they have not yet been published. Accordingly, we complement the results from the systematic review with case studies identified previously.
TIER III REGULATIONS IN THE BALTIC AND NORTH SEA
– DIFFICULTIES WITH IMPLEMENTING REGULATIONS AND THE IMPACT ON THE VOLUME AND PRICE OF UREA

Anna Loiko*
Tor Erik Jensen**

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***) Norway Buskerud and Vestfold University College, Norway, E-mail: tor.e.jensen@hbv.no

ABSTRACT

Purpose
This study aims to examine the current air pollution regulations in the Baltic and North Sea; develop a model for regional usage based on the Norwegian NOx Fund model and discuss the effect of the regulations on the marine urea market.

Design/methodology/approach
All the background information and evidence were processed by means of a literature review. In-depth interviews were conducted with government representatives, executives of international maritime companies, technical managers and techno-distribution companies.

Findings
The future of the Baltic and North Sea Nitrous oxide Emission Control Area (NECA) is not clear, even though the regulation proposal already exists and required technology is available. We suggest a model for international regional usage based on three options of NOx regulation implementation practices: refund emission payment programs (REPs), a fund and the original regulation formulation. After the Tier III implementation, the demand for marine urea is expected to increase over time, depending on the implemented model. Notwithstanding the future fertilizer index, the price for marine urea production and distribution is expected to be lower, resulting in a lower total customer price.

Practical implications
The findings should be vital to maritime organisations on both national and international levels, technology producers, shipping companies and logistics providers.

Original/value
The regulation is still under review. There is little relevant research available regarding the potential use the Norwegian model of economic stimulation and the impact of Tier III regulations impact on technology, infrastructure and price available. We explain some challenges of Tier III implementation, suggest possible solutions and economical effect on technology producers and supply chain. For international applicability, modifications to the original tax/fee model were proposed.

Keywords: Nitrous Oxide Emission Control Area (NECA), air pollution, Nitrous oxide (NOx), implementation problems, environment protection, urea, NOx Fund
1. INTRODUCTION

Air emissions from ships are an increasing environmental concern (Stipa et al., 2007). International shipping now contributes to about 15% of the global NOx emissions (Rahm, 2015). The principle exhaust gases from maritime transport, sulphur oxides (SOx), nitrogen oxides (NOx), CO2, CO, hydrocarbons, and particulate matter, have increasingly affected the air quality (Blumberg et al., 2016), especially in the coastal areas (Volker et al., 2010). Poor regional air quality, connected to ship emissions, are a concern because of their public health impact and greenhouse gas emission. Exposure to air pollution is associated with a number of health risks including premature death, cancer, heart and respiratory diseases (Han, 2010).

A key issue has been the limitation of NOx emissions in Northern Europe. Lately, the main regulatory instrument when it comes to air pollution by seagoing transport, the MARPOL Annex VI convention, has been amended to include nitrogen emissions. The Annex enforces a party or a group of parties to apply for Nitrogen Oxide Emission Control Area (NECA). In practice it means an NOx reduction 75% in the area compared with the previous standard for vessels built after 2011 (Lindstad et al., 2015).

In this article we propose a model of the current implementation of NOx regulations in the Baltic and the North Sea. We explore the background of the regulations and different parties’ interests regarding NOx limitation from seagoing transport, the Norwegian NOx reduction system, which is one of the most efficient models, as well as the consequences for NOx eliminating products, such as marine urea. More specifically, we aim to answer the following research questions:

- R1: What is the status of the new NOx regulations in the Baltic and the North Sea?
- R2: What is the most efficient way of implementing NOx regulations in the Baltic and the North Sea?
- R3: How the new NOx regulation will affect marine urea price.

This contribution is structured as follows: First, we provide a literature overview about the background of the actual regulations status; how NOx reduction measures are implemented on a national level in Norway, and the state of urea market. The following section presents grounded theory as the methodology of our expert interview. Further, we analyse the findings from the interviews, in some cases supported by trade news, on the status of NOx regulations and propose a way of the implementing the regulations in the Baltic and the North Sea, and our expectations regarding marine urea price.

2. BACKGROUND

A number of studies were conducted to estimate the contribution of shipping to the Nitrogen oxide emissions in the North Europe and Baltic countries (Volker et al., 2010, Viana et al., 2014, Raudsepp et al., 2013). The studies show that about 9% of the total airborne Baltic Sea (Bartnicki et al., 2011) and 7% North Sea (Volker et al., 2010) nitrogen deposition comes from ships. Despite a relatively small fraction of ship nitrogen deposition, the shipping contribution rises up to 50% in some areas and seasons (Stipa et al., 2007). The share of marine-born nitrogen oxides emissions is proportional to shipping activity in the region and increased by 7% between 2006 and 2009 (Jalkanen et al., 2009).

In response to the growing regional and global NOx emission impact, the International Maritime Organization (IMO) is tightening the emissions limits for NOx. MARPOL Annex VI
presents three NOx emission limits – Tier I, Tier II and Tier III. Tier I and Tier II are global, while Tier III will affect only vessels sailing in a specified Nitrogen Oxide Emission Control Area (NECA). While operating in NECA, vessels with diesel engine of over 130 kW output power are required to meet the strictest Tier III NOx emission limits (IMO, 2016). The regulation applies only to newbuildings and was to be enforced from 1 January 2016.

The environmental issue and background of the NECA application could be summarized as follows. Firstly, an applying party should document on ships’ emissions and their impact regarding health and nature. Secondly, present the economic impact of NECA on the maritime sector. Thirdly, compare cost effectiveness of NECA with land-based control. Despite the research documenting all of the above and proving the efficiency of NOx reduction technology (Incentive Partners & Litehauz, 2012, Kalli et al., 2010, Hammingh et al., 2012), the date of regulations implementation was postponed.

2.1. Postponing the implementation of the regulations

Scandinavian countries have been seeking to establish the Baltic and North Sea NECA from the 1 January 2016, - an issue which has been so far opposed by Russia (Baltic Port Organization, 2014). At the 65th meeting of the Marine Environment Protection Committee (MEPC) in March 2013 the Russian Federation submitted a document “Comments on the report of the Correspondence Group on Assessment of Technological Developments to Implement the Tier III NOx Emission Standards under MARPOL Annex VI” (IMO, 2013) The document declares a lack of technological readiness and infrastructure for NOx Tier III implementation and explicitly calls for an extension on the implementation of Regulation 13 (IMO, 2013). Russia received support from Poland, Latvia, Estonia, Greece, Cyprus and Malta. One month later, the decision was taken to postpone the Baltic and North Sea NECA from 2016 to 2021 and future work on the NECA application.

2.2. National implementation and NOx Fund

Since NOx emissions do not respect national borders and constitute a mutual responsibility, international agreements are required to protect the environment. One particular issue with transboundary pollution is the variety of environment policies in different countries. Sub-optimization on a national level is leading to continued high levels of pollution, ignoring its effect in a global context. The solution has been to apply international agreements.

The Gothenburg protocol was ratified in 1999 and entered into force in 2005, and is a part of Convention on Long-range Transboundary Air Pollution. According to the protocol, Norway was committed to reduce its emissions of NOx to a level 30% below the emissions in the base year 1990, by the end of 2010 and to stay at this level (The United Nations Economic Commission for Europe (UNECE), 1999).

To be able to meet these requirements, a tax of NOK 17 per kg NOx was introduced in 2007. As a reaction to the tax, four years later, fourteen business organizations who represented undertakings emitting NOx, and the Ministry of Environment on behalf of the Norwegian Government have established a NOx Fund. Today, 891 companies (per 5 Jan16.), representing over 95 % of all emissions subject to NOx tax, are members of the Fund and therefore exempted from paying the NOx tax. All companies, members of the NOx Fund, are eligible for financial support. The degree of support for specific measures depends on the type of NOx reduction measure, implementation cost and quantity of NOx reduction (Martinsen and Torvanger, 2013). NOx Fund is a non-profit organization, established in order to support the enterprises to fulfil their obligations under the agreement. Members of the NOx Fund pay NOK 11 /kg NOx
emission to the firm if they are offshore petroleum industry, and NOK 4 /kg if they are from other sectors such as shipping, supply vessels, fishing and aviation, instead of paying A governmental tax of NOK 17 /kg, and NOK 21.17 /kg from 2015, NOx emission. In addition, a company can apply for up to 90% refund of NOx technology installation costs, depending on the technology reduction effect (Confederation of Norwegian Enterprise, 2015).

We have examined three possible scenarios:

A company not being a member of NOx Fund and its ship not using any NOx reduction or measurement technology will pay 70 kg x NOK 21.17 /kg = NOK 1481.9 for each ton of consumed fuel, where 70 kg is an estimated average of Nitrogen Oxide released from 1 ton of bunker fuel.

A NOx Fund Member company, using NOx measurement technology on its ship, will pay approx. 50 kg x NOK 4 /kg = NOK 200 for each ton consumed fuel, where 50 kg is a measured average of Nitrogen Oxide released from 1 ton of bunker fuel (as per personal communication with NOx Fund).

A NOx Fund member company, using a Selective Catalyst Reduction (SCR) technology for its ship, but not a measurement technology, shall pay approx. (3.5 kg x NOK 4 kg) + (NOK 3600 /cbm – NOK 2500 /cbm) x 0.1 = NOK 124 for each ton of consumed fuel. 3.5 kg is the amount of NOx released from 1 ton of consumed bunker fuel subject to SCR technology that reduces emission by 95%, NOK3600 /cbm is an average urea price and NOK 2500 /cbm is a subsidy from the Fund.

After introducing the NOx Fund, NOx emissions have decreased significantly. The NOx tax and NOx Fund led to an efficiency improvement and NOx abatement technology installations, thus reducing NOx emissions from the maritime industry. In 2014, 142 000 tonnes of total NOx were emitted, more than 7 per cent less than the previous year. The reduction means that Norway achieved the 2020 emission target for NOX in 2014 (Stastistics Norway, 2014).

As indicated in our examples above, a membership at the NOx Fund seems to be advantageous from an environmental perspective. However, our question is if the Norwegian model may be used on the European or international level.

2.3. Effect of Tier III implementation on the urea market

Stringent NOx regulations led to the development of new NOx abatement technologies. SCR has appeared to be the only exhaust post-treatment system technology that is able to bring a vessel’s NOx emission to a satisfactory level in relation to Tier III regulation. SCRs use the ammonia compound urea as a reducing agent. The marine urea reacts with the NOx in a catalyst that breaks down the harmful NOx and converts it to neutral N2 and water. Thus, the shipowners are required to pay for urea in addition to a number of other operational costs. Urea consumption depends on a number of factors, such as engine configuration. In addition, SCR technology enables the engine to return a lower fuel consumption and urea costs can often be offset with bunker saving (WorkBoats News, 2015).

Looking at urea infrastructure, land-based SCR systems use about 20 million tonnes annually. The total demand for urea from the maritime industry today is less than 1% of the total land-based use (Briggs, 2014). We expect that implementation of the new environmental regulation will affect the supply and demand sides. An effective enforcement of emission regulations requires a thorough knowledge of their effect on the environment and the most effective way of implementation (Marmer et al., 2009). This study emphasizes the implementation difficulties of Tier III NOx emission regulation in the Baltic and the North Sea. The study also looks at the
impact of the regulation on volume and price of urea and applicability of the Norwegian model for NOx reduction procedures on the international level.

3. MATERIALS AND METHODS

As information is scarce regarding postponing Tier III implementation in Baltic and North Sea, the Norwegian NOx Fund model emerges as a working example of how new environmental regulations could influence the marine urea market.

Emission control from shipping in Europe is a sensitive issue being under negotiation at present, making it difficult to access current and accurate information.

To provide the study with in-depth relevant information, face-to-face and telephone expert interviews with suitable samples of experts in the field of environmental regulations, NOx abatement and urea market were adopted.

This approach was considered appropriate, as expert interviews assume the respondent has a direct involvement in the topic being discussed (Bohnsack et al., 2006). It provides detailed insight into emission protection on both political and economic levels. Respondents, chosen for the interviews, are all qualified experts, people with acknowledged familiarity in the research area. See below Ch.3.2. Respondents.

After consideration, classic ground theory (CGT) method was chosen as the most appropriate method to investigate the implementation potentials of Tier III air emission regulation in the Baltic Sea and the North Sea, applicability of the Norwegian model for Nitrogen oxide (NOx) reduction procedures on international level, i.e. funding through a governmental NOx-Fund, including challenges of cost of arrangement. A study began with an idea about possible consequences if Baltic and North Sea NECA would be implemented, followed by a collection of qualitative data. After the data review, repeated statements, ideas and proposals become apparent. Such elements were coded, grouped into concepts and then into categories.

3.1. The interview guide

An interview guide comprised three basic questions about the organization the respondent represents (e.g. mission, market position and position to the respondent; two questions about the use of NOx abonnement technologies by Norwegian shipping companies in Norway and outside national borders; three questions about their position regarding postponing of the regulations’ implementation, six questions about NOx Fund work; and five questions about the future of the urea market. cf. interview guide, appendix 1.

The technique of McCracken’s (McCracken, 1988) long-interviewing was adopted. The questions are generally generic, non-directive and introspective, open-ended in nature and semi-structured in form. An open-ended nature maintains the flexibility and freedom of discussion and semi-structured form is intended to enable the respondents to narrow down their experience. The current article presents the findings from the questionnaire.

Similar questions have sometimes been asked in different forms to ensure consistency of the received information. Sub-questions, as a result of received experience from the earlier interviews, were also added to ensure better information. To comply with McCracken’s (McCracken, 1988) recommendations, a grand-tour technique was used. This type of questions contributes to a richer interpretation during the subsequent interview analysis process (Carlson and McCaslin, 2003). The questions require respondents to describe or reflect on their perceptions and experience.
The interviewer recorded all the information received from face-to-face interviews and noted all the information from the telephone interviews. First, the question was asked with possibility for the open answer. If the respondents were not specific enough by own wording, the interview then asked explicitly about that domain by the answer alternatives from the interview instructions. The interview instruction was developed in order to simplify the analysis of the answer.

Finally, the respondents were asked to share information they consider may be relevant for the research from their point of view. The objective of this question was to find out the objective opinion to the respondent what is important and whether the researcher should look closer into other aspect. To avoid misunderstanding, the interviewer shared the interpretation with the respondent for approval.

Each respondents’ answer was summarized. In order to get a better overview and support the findings, all highlights and expressive quotations from the respondents were recorded.

The interview guide was piloted with two technical managers from two different shipping companies. The questions were generally understood well and some non-significant corrections were done. One question has been divided in two in order to clarify and simplify analysis.

### 3.2. The respondents

All respondents can be easily considered as “experts” in their field. The group was composed of a technical manager with a degree in naval engineering and more than 10 years’ work experience in the technical department of one of the largest Norwegian offshore companies; two sales- and strategy department managers from urea producing companies with a degree in economy and chemistry and five to ten years’ experience; urea trader with degree in nautical science and more than ten years at sea and fifteen years in trading company; two technology engineers with an education in naval engineering, experience as a chief engineers and more than ten years of experience in the shipping companies; representative from state environmental organizations with education from economy faculty and over thirty years from different state organization, including construction of environment regulation model in Norway.

The respondents are from three countries bordering The North Sea and The Baltic Sea (i.e. Norway, Great Britain and Russia) and can be considered as a convenience sample since this represents countries supporting NECA initiative and Russia, experts from economic, technical and environmental field, as well as political representatives. All respondents have a higher education, six of the respondents have more than twenty years’ experience in the field, members of different environment organizations and are deeply involved in the research problem. The total sample consists of seven respondents, one from Great Britain, one from Russia and five from Norway.

Each respondent was contacted by telephone at a pre-arranged time. All face-to-face interviews were conducted at the respondent’s work place. Interviews were conducted in English, Norwegian and Russian. All interviews were individual.

Data was gathered in the period from November 2015 to February 2016. The average duration of an interview was 1-1.5 hrs.
4. RESULTS AND DISCUSSIONS

4.1. Use of NOx abatement technology by Norwegian shipping companies

The adoption of eco-friendly technological innovations is driven by three factors: regulatory push, technology push and market pull (Horbach et al., 2012). All respondents agree that for the shipping industry, regulations are crucial to operating in a more environmentally-friendly way.

The interviewed experts all agreed that ships intended to use an SCR system while operating in Norwegian territorial waters and to switch it off once entering non-regulated waters in order to reduce operational costs. However, there are a few exceptions:

France’s Technip is well known by our respondents for use of their eco-friendly technologies as a sales argument. Thanks to eco-friendliness, this contributed to securing the company a new contract in Africa. Thus demonstrating added value compared with other operators by introducing NOx reduction equipment.

Some cargo owners require the transporter to be eco-friendly. Those managing to fulfil this requirement will be prioritized as their contractual partner. Charter company Cargill announced that they will only hire “eco” ships (Vineyard, 2012). The company is mainly involved in the transport of food and agricultural products. Being environmentally friendly creates a great promotion for the company.

Some of our respondents consider that eco-friendly import and export may be the new trend. In this way, the producer shows to the consumers that the products they buy are transported with minimum harm to the environment.

This also affects the oil industry, knowingly being a significant source of pollution. Our respondents say it is important for the oil companies to maintain a positive reputation in order to ensure contracts. This statement is also confirmed by numerous trade news articles and is written down in companies’ policies. Exxon stated that the company will move towards green operations, reducing emissions and supporting research in the field of green energy (Rendon, 2015). The French company Total posts on its website that they work towards limiting the emissions from their oil and gas related activity (Total, 2016). As a part of company’s environment program, Total has chartered a vessel Viking Lady, driven by fuel cell technology, from Norwegian ship-owner Eidesvik. The vessel is one of the most eco-friendly offshore construction vessels (OCV) ever built. She is able to reduce sulphur oxide by 100%, nitrogen oxide by 85% and carbon dioxide by 20% (Ship Technology, 2009). According to Maersk Line, a world leader of ocean freight, the Triple-E container vessel they operate the most efficient ship in the world. It is able to move every container producing 50 per cent less carbon dioxide than industry average. In all, the company plans to purchase twenty of such ships (Reyes, 2013).

Our respondents comment on the statements and underline that economies of scale surely is an important argument of the investments, while environmental arguments come as a nice add-on. Both technical managers acknowledged that their companies did not respond to “green” values as the main driver to install the technology. Regulations were in fact the main reason economical support was received from NOx Fund. The understanding that the company participating in creating of greener shipping is then an additional gain.

Despite NOx emission in Norwegian territorial waters being regulated by Norwegian Government, and NOx Fund control the emissions from shipping, there are still some difficulties to address to ensure that all ships report the actual numbers of emissions. The system
is based on self-reporting environmental monitoring, where the shipping company should self-monitor and regularly report NOx emissions released from their ships. Some respondents have doubted on reliability and comprehensiveness of the data, even though the NOx Fond attempts to ensure that the self-reporting system captures actual emission.

### 4.2. Postponement of the implementation date

The decision to postpone the enforcement of regulations provoked a wave of complaints in the press. The industry has invested billions into developing the technology that will “heal and protect” the environment (Kettmann, 2013). The decision also raised concerns for the shipyard and ship-owners that had ships currently under construction. Their design aimed at providing space to fit Tier III compliant equipment as to originally regulations. Consequently, a challenge whether to install the NOx reduction technology or pay for re-design. Those already invested in the technology became completely disillusioned (Ships & Maritime Equipment Association, 2013).

Our experts agreed that the postponement of the enforcement of Tier III regulation from 2016 to 2021 has a negative impact on the environment, occupational health and endangering innovation. Some experts expressed a fear that any last-minute change of decision regarding implementation date may lead to questions about any future IMO decisions. One expert has been extremely critical to the decision and commented that from now on it will be difficult to trust the timeline for other regulations as well.

On the other hand, among the positive factors regarding postponing of regulations’ implementation, some respondents have mentioned avoiding additional costs for ship operators working in an already competitive business environment due to overcapacity and economic downturn. In addition, some of them say that IMO might learn from North American ECA, where the NOx regulations in the similar formulation as for Baltic and North Sea NECA, has more negative than positive effect on environment. The experts see at least two issues with the Annex VI regulation 13 saying that the regulations apply only to the ship’s keel laid after 2016. Firstly, the concerns regarding intensions from less environment-friendly ship-owners and operators to prioritize the vessels built before 2016 for the ECA trade after regulation implementation. The evidence is a significant newbuilding order activity at Chinese shipyards in 2015. This is also confirmed by a recent publication writing about the highest activity level in Chinese shipyards seen in the past seven years (Andersen, 2015). In order to meet the deadline and avoid additional expenses connected to NOx regulation, the new vessels’ orders should be placed before late October 2015, so shipyards can lay down keels before the end of the year. Considering the fact that the lifetime of a modern vessel is about 25-30 years (Bimco, 2012), some respondents do not believe in the value of such a regulation over next two decades. Secondly, the respondents mention so called “cynically” dodging or the exploitation of Tier III loophole by Asian shipbuilders. In addition to the large order book from shipping companies willing to avoid additional costs, shipbuilders in China and Japan have been busy with laying of about 200 keels for vessels ordered by yard’s integrated shipping companies. Ang and Corbet (2016) confirm the information presented by respondents and comment that these keels are clearly intended for resale to buyers willing to avoid Tier III regulations. It is a relatively small cost and effort for a yard to build a smaller keel and keep it for the period of time needed, and it is regarded as perfectly legal.

Some respondents argue that there should be at least a limitation regarding ship’s delivery date. Avoiding regulations in a legal way is not a new practice. Some shipyards acted in the same way, when the performance standard for protective coatings for oil tanks was implemented,
even the delivery period was limited. It will not protect against cheating, but curb it (Ang and Corbet, 2016).

Despite numerous studies (Azzara et al., 2014, United States Environmental Protection, 2009) on the feasibility of IMO Annex VI Tier III implementation using SCR system, proving to be an efficient technology, the opposition to the proposed 2016 timeframe is mainly based on an arbitrary rejection of this technology (Ships & Maritime Equipment Association, 2013). Our experts’ opinions regarding the postponing of the implementation date were divided. Some doubt that the technology has been tested to the extent that ship-owners can be sure they invest in the reliable NOx reduction instrument. They also believe that it is not the right time for shipping to undertake extra expenses and by this supporting The Russian Federation, thus postponing the regulations’ implementation. Other argue that the right time will never come and the document submitted by opposition is nothing else than political play and an attempt to avoid additional costs.

Although there is some disagreement regarding undertaken measures, most of the respondents believe that the NOx reduction regulations will be enforced in 2021. The respondents also believe that the formulation of the coming regulation will be similar to the North American ECA, despite all the concerns regarding its effectiveness in the short term.

4.3. The overall situation of urea market

Most of the experts agreed that there was no need to postpone the regulations as the technology has been through the necessary tests and the producers could provide evidence of its efficiency. This being opposed by the respondent from Russian shipping company, claiming the lack of technology readiness and infrastructure. Whether or not it is based upon a consensus among researchers, their view is also that since the shipping industry only generates a small percentage of NOx emissions in the Baltic Sea one should concentrate on other regulations.

One argument concerns the lack of infrastructure. However, according to our respondents’ view, the production of marine urea is manageable, in particular as it is a relatively small volume needed compared with other industries. Considering urea infrastructure, as per information from urea suppliers, shipping consumes not more than 1 % of the total land-based use. Typically, a small fishing vessel requires around 30 tonnes and up to 1000 tonnes for large cruise ships (Briggs, 2014). After the Tier III implementation, the demand for marine urea expected to increase slowly over time. Marine demand will continue to be a small part of the total urea consumption and production will easily manage to satisfy customer demands.

Distribution is not expected to create any significant problems, as vessels consume relatively small volumes. Urea is available worldwide and the number of ports to be served is expected to be limited. The producers are ready to expand the distribution system once demand is in place.

Another argument for postponing is that environmental bi-products such as ammonia slip and excess CO2 emissions will increase, but respondents state clearly that these are not generated in significant volumes if SCR systems work properly.

Looking at urea price index, we can spot the correlation between urea and gas/oil/coal price. However, the marine urea price does not correlate to generic urea prices. To simplify the calculation, we assume the price of marine urea consist of fertilizer price presented by urea index and extra cost due to low production (sales) volumes. Urea price statistic is indicative only for urea to be used as a fertiliser, which is a different grade to marine urea. As fertiliser is mass produced it enjoys a lower cost per unit, unlike marine urea that is produced in batches at
a higher cost. In addition, distribution constitutes a great part of the customers’ urea price. Our experts assume that after Tier III implementation the larger volumes of marine urea will be required. It will lower the cost per unit and improve distribution facilities, resulting in low urea price in total.

4.4. Norwegian NOx reduction system and NOx Fund

The introduction of NOx tax leads to a significant increase in operational costs for the majority of shipping companies and affects competitiveness of Norwegian companies, subjects to the tax. Due to presents of foreign businesses in various markets, Norwegian companies were not in the position to carry increased costs, such as the new environmental NOx tax. Thus, interest groups, especially cruise industry, protested against the introduction of the NOx tax (Axelsen, 2007).

The solution was found in the introduction of the NOx Fund. In accordance with the respondents, this Fund has been well accepted by the majority of tax-effected companies. It is a non-profit organization, so it neither creates income nor involves expenditures for the state. It attempts to solve the issue of competitiveness and encourage innovation. The Fund does not grant support to research and development, but create a favorable environment for marketing of eco-friendly solutions and supports ready for implementation technology.

The main concern regarding effectiveness of Norwegian NOx Fund is if results justify the costs. Some interviewed experts are critical of the fact that the Fund’s investment policy is biased and is promoting LNG more favourably than the SCR solution. LNG propulsion is seen as a green alternative, but not all are aware of the methane slip issue. Not controlled methane slip reduces environmental benefits of using natural gas and questions the eco-friendly status of the propulsion system.

Respondents have also mentioned that non-profit organizations, such as the NOx Fund, spend received money not in the same rational way as a profit company would do. It creates a situation where some environmental projects have been integrated without accurate pre-qualification.

Despite the respondents’ concerns, the Norwegian NOx Fund model has received a lot of positive feedback from international organizations, foreign environment politics and scientists. For the contribution to the lower NOx emission, the Fund has been presented with the Green Ship Technology award in 2011 (Skips-reyen, 2011). Respondents say that the Fund model may also be used as a model for CO2 reduction in future. The Fund attracted attention from foreign governments, such as the Dutch and Swedes. Nevertheless, the Fund is still unique for Norway.

All our respondents agree that the fund system leads to greener shipping because of support given for NOx reduction. However, the support given differs a lot and resources are not equally distributed.

The interviewed experts have discussed three alternatives of implementing of NOx regulations: a refund emission payment programs (REPs), a fund and the original regulations’ formulation. The latter being described in ch.2.

Refund emission payment programs (REPs) involve the return of generated tax revenues to companies based on their relative output levels (Fredriksson and Sterner, 2005). The program is implemented in Sweden as an emission control instrument. In short, this works by refunding the emission taxes to the tax-paying polluters in proportion to their share of polluting output. Although the abatement results are practically the same as for a tax of the same value, but taxpayers are more comfortable on the psychological level (Sterner and Turnheim, 2009). The respondents comment that the same argument can be applied to the Norwegian NOx Fund as
well. The fee payed by members to the Fund is lower than tax imposed on non-members. This fact comforts the polluters and creates less averse to the system. Some of the respondents believe that if the Fund had been established from the beginning, without introduction of tax initially, the taxpayers would protest against the Fund, as they did with the tax.

Most of the respondents (5 of 7) consider that it is not possible to influence the implementation method of NOx regulation in North and Baltic Sea, or if one does so, it will delay the enforcement. However, six out of seven experts agree that either Swedish REPs or Norwegian NOx Fund, or combination of two of them, are preferable alternatives.

4.5. Suggested implementation method

Based on the ideas from the experts, the authors propose a combination of the present implementation method and a Fund based on the Norwegian NOx Fund model as a solution:

- All vessels’ having their keel laid after 2021 and delivered before 2025 need to comply with Tier III standards and excluded from tax.
- All vessels equipped with NOx abatement technology are excluded from tax.
- Vessels having their keel laid before 2021 and not equipped with NOx abatement technology, will need to pay an amount NOK/kg for each ton of NOx emitted.

Today’s fee (NOK 4 per Kg NOx emitted, cf. introduction) is regarded as manageable for the operators and may be used as a subsidy to compensate only for cost related to retrofitting of ships built before 2021, not including the technology as such. Firstly, one may argue that there is a limited fund available, thus a need to prioritize. Secondly, as ships represent different cost structures, the ship-owner’s incentive to invest in relevant technology is distributed unevenly, leading to unfair competition amongst them. Thirdly given a situation where the Fund has available resources after the proposed prioritization, only then a subsidy of technology-research costs. Organized as suggested it will lead to a higher demand in the technology and thus stimulate equipment providers to invest in research and development.

Considering the economies of scale, we further suggest that vessels that are seldom operating in the NECA area and those having only a few years lifetime left cannot apply for support. For these vessels, the installation of NOx abatement technology simply will not justify the cost.

However, the issue may be to finance the investments. In Norway, the oil and gas industry pay a higher amount than shipping, 11 NOK/kg, compared with 4 NOK/kg., their share being the largest of the Fund’s total. Europe’s oil and gas industry outside Norway is smaller in comparison. Thus the balance between fees and subsidies is different. This financial gap may also be partly covered by resources received from older vessels and vessels not frequently operating in NECA.

The suggested model demands a thorough implementation procedure to be successfully implemented in the Baltic and North Sea. We suggest more research regarding the level of taxes and/or fees; if too low, it will not encourage technology investments; if too high, owners of older vessels may be forced out of business. The balance between the two being an acceptable level. In addition, one should develop a model for calculating NOx abatement efficiency for each type of vessel. It will facilitate the application process and provide easily accessible information for ship-owners about applying for subsidy for a particular vessel.

The applicability of the tax model to a ship’s keel laid after 2021 should also be estimated.
5. CONCLUSIONS

It is expected that the use of NOx reduction technologies will become mandatory for new ships while operating in The Baltic and The North Sea as from 2021. However, Tier III standards will apply only to ships whose keels were laid after the 1 January 2021. As a ship’s average estimated lifetime is about 25-30 years, Europe may experience a relatively high emission level during the first years after regulations come into force. Thus, it is essential to find an approach that will encourage the industry to invest in greener shipping.

In order to protect the environment and compromise with the industry, a model based on a combination of the present implementation method and a Fund, inspired by Norwegian NOx Fund, were proposed. Applying the model, all vessels having their keel laid after 2021 must comply with the Tier III regulation. Secondly, all vessels using SCR technology with urea are exempted from paying a fee. Thirdly, vessels having their keel laid before 2021 and not equipped with NOx abatement technology will need to pay an amount of NOK/kg for each ton of NOx emitted. Fourthly, the applicability of the tax model of ships whose keels were laid after 2021, not frequently operating in NECA and not equipped with NOx abatement technology, should also be estimated.

The collected fees may be turned to a subsidy and used primarily to compensate for retrofitting ships built before 2021. Available resources after the proposed prioritization may be utilized as an investment in technological research. Thus, the model represents a balance between environmental protection and industrial interests.

After the Tier III implementation, the demand for marine urea is expected to increase over time, depending on the implemented model. Disregarding the future fertilizer index, the costs of marine urea production and distribution are expected to be lower, resulting in lower total customer price.

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Appendix 1:

Our research questions were developed as follows:

1. Please tell about the organization you present, e.g. mission, market position and your position and years of experience in the company);

2. Use of NOx abatement technology
   - Describe your experience regarding use of NOx abatement technology in Norwegian territorial waters by Norwegian shipping companies.
   - Describe your experience regarding use of NOx abatement technology outside regulated areas by Norwegian shipping companies.

3. The postponement of the implication date
   - The regulations were supposed to come into force from 2016. How would you estimate the implementation from 2021, and not 2016? Please explain.
   - What do you consider to be the main reason for change of the implementation date?
   - What do you consider to be the biggest challenge for Tier III implementation in Baltic and North Sea?

4. The future of the urea market
   - Do you consider the availability of NOx abandonment technology as satisfactory?
   - Do you consider the urea infrastructure in North European countries as satisfactory?
   - How will the regulations influence the volume of required marine urea?
   - Do you think the marine urea suppliers will be able to meet customer expectations regarding regulations being implemented in 2021?
   - What do you think the pricing policy of marine urea suppliers will be?
   - Describe the marine urea market after regulations implementation.

5. Norwegian NOx reduction system and NOx Fund
   - Do you consider NOx Fund’s work to be effective?
   - How do you estimate the Norwegian model of NOx reduction?
   - Can it be used as an example for other countries?
   - Can it be used as an example for coming regulations?
   - Do you believe the Norwegian system is more effective than systems in other countries?
   - Explain your point of view on the coming regulations. What could be the most effective way of their implementation?
6. What do you consider to be strong features of the model for the implementation of the entire regulation?
7. Do you want to share some more information you believe can be useful for research?
RETAIL STORES’ PERSPECTIVE ON URBAN CONSOLIDATION CENTRES

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ABSTRACT

Purpose
Urban consolidation centres (UCC) are often conceived to improve services in retail stores, which can thus contribute to more financially viable UCC-based solutions. However, few studies have examined how retail stores perceive those services. The purpose of this study was thus to explore retail stores’ demand for different UCC services in order to guide the development and implementation of UCC solutions, all toward more economically feasible business models.

Design/methodology/approach
Structured interviews were conducted with employees at 72 retail stores in six city malls in Linköping and Norrköping, Sweden.

Findings
Although a UCC can provide several services requested by retail stores, it is crucial to consider which services UCC customers demand in particular. It is also important to increase retail store managers’ knowledge of cost allocation so that the store can benefit from economy of-scale services that UCCs can generate.

Research limitations/implications
Finding suggest that a UCC may actually not enhance customer service in retail stores, it is vital to consider changes that improve economies of scale, which can be achieved by performing value added services at a UCC.

Practical limitations/implications
This study contributes knowledge about services most requested by retail stores, which can guide the development of functional business models that consider economic feasibility, a prerequisite for the long-term sustainability of urban logistics initiatives.

Originality/value
This study answers the call for research addressing retailers’ perspectives in urban logistics. By pinpointing services requested by retail stores, it can furthermore guide financing such initiative, which has previously been lacking.

Keywords: City logistics, receivers’, customer service, urban distribution, business mode
1. INTRODUCTION

According to a recent report from the United Nations (United Nation, 2014), the bulk of the world’s population growth is expected to occur in cities. With the increased number of city-dwellers and thus urban expansion, demand for urban freight deliveries also increases, which though necessary affect cities in negative ways—for example, with air pollution, noise, and traffic congestion (Allen et al, 2015).

Numerous initiatives have appeared on cities’ agendas to decrease the impact of freight deliveries on urban environments. One of these initiatives is the increased use of urban consolidation centres (UCC) (Muñuzuri et al, 2005). According to Browne et al (2005), a UCC is a facility that connects long-haul transport with deliveries to stores and offices, among other destinations, located in urban areas. With UCCs, long-haul transport with large vehicles designed for regional transport never has to enter the urban area. Furthermore, the consolidation of goods at UCCs can decrease the quantity of transport in the urban area, as well as the use of vehicles more suitable for urban transport. Yet, even if a UCC benefits a city and its inhabitants ecologically and socially, it still requires financing.

A large number of UCCs have been implemented worldwide during the last two decades. In most cases, funding for these centres has been provided by public authorities, and when financial support from local authorities decreases, the initiatives are often terminated (Ville et al, 2013). As Quak et al (2014) have pointed out, funding from local authorities is also the reason for short-lived UCC trials, and when those subsidies end, the UCCs are shut down. According to Allen et al (2012), other stakeholders—for example retail stores, carriers, and other receivers—must contribute financially to UCCs. Since many retail stores are often served by a UCC, communication and negotiation regarding the design of services and funding can be challenging. It might thus be beneficial for retail stores to be organised so that a single part represents all stores. For example, in the Stadsleveransen initiative in the Swedish city of Goteborg, the local trade organisation that represents more than 300 receivers served by the UCC has been described as the most critical part of the business model (Björklund et al, Under review). As Allen et al (2012) have also pointed out UCCs that serve large sites with a single landlord benefit from the landlord’s capacity to require tenants to use the UCC and to pay for it. For these retailers, the initiatives are more easily achieved success. Accordingly, as a first step, in this study we focus on the potential of a series of other single-landlord sites served by UCCs groups of retail stores in city malls.

In short, if a UCC can increase its customers’ willingness to pay to use its services, then receivers can benefit. Among these benefits, Browne et al (2011) have identified more reliable delivery, value-added logistics services, and more diverse retail services, including improved return logistics, fewer deliveries, additional stockholding, better inventory control, preparation of products, and greater consignment (Browne et al, 2005; van Rooijen & Quak, 2010). In this paper, we refer to all potential services that implementing a UCC can provide as UCC services. With these services, receivers can focus on their core activity and potentially increase customer service in retail stores. However, even if UCC services can improve customer service, it remains unclear whether receivers—in our case, retail stores—have any interest in those UCC services. In response, the purpose of this paper is to explore retail stores’ demand for different UCC services in order to guide the development and implementation of UCC solutions, all toward more economically feasible business models.

This paper is structured as follows. After presenting a literature review that introduces the benefits and challenges of UCCs, a methodology section describes how empirical data were collected from retail stores and analysed. Next, the empirical findings are presented, followed
by an analysis and a discussion of the results. The paper ends with a summary of conclusions, limitations, and recommendations for further research on the topic.

2. LITERATURE REVIEW

Though numerous, the definitions and descriptions of UCCs are rather similar. With minor variations, a UCC is ‘a logistics facility that is situated in relatively proximity to the geographic area that it serves be that a city centre, an entire town or a specific site (e.g., shopping centre) from which consolidated deliveries are carried out within that area’ (Browne et al, 2005, pg. 4). Although Ville et al (2013) use the same definition, theirs adds public authorities as UCCs’ frequent financial providers. A similar definition is that UCCs ‘include all initiatives that use a facility, in which flows from outside the city are consolidated with the objective to bundle inner-city transport activities’ (van Rooijen & Quak, 2010, pg. 5968). Inspired by these definitions, we define a UCC as a logistics facility that serves a city, either in part or entirely, and whose inflows from outside the city are consolidated and rearranged in order to provide more efficient transport within the city.

2.1. Pros and cons of UCCs

The implementation of a UCC influences how goods are distributed within the city. When goods are consolidated at a UCC, there is a greater opportunity to achieve a high load factor with vehicles that enter the urban area, namely due to more effective loading (Browne et al., 2005). Due to increased fill rates, fewer transports in the urban area becomes possible (Browne et al, 2005; BESTUFS, 2007). A UCC can also facilitate changes in the transport modes applied. As both Browne et al (2005) and van Rooijen & Quak (2010) have posited, last-mile deliveries can be performed with either smaller or environmentally friendly vehicles—for example, electric vehicles in Göteborg’s Stadsleveransen initiative (Björklund et al., 2015) and smaller vehicles more suitable for transports in narrow streets, as in Lucca, Italy (Björklund & Abrahamsson, 2015).

According to Browne et al. (2005), a city can benefit in many ways, both environmental and social, by implementing a UCC. Among the most common advantages are reduced emissions, reduced noise, less traffic congestion, and fewer traffic accidents, all due to fewer freight vehicles in the area. With more ecofriendly vehicles, the environmental benefits could be even greater. Yet, a notable drawback, at least from social perspective, is the increased traffic near a UCC, due to increased inbound freight transport (Browne et al., 2005). In that sense, the localisation of a UCC is critical.

However, the economic advantages posed by a UCC are not as clear as the environmental and social ones, and several initiatives readily demonstrate economic disadvantages. For one, a UCC poses a start-up cost and, later on, operational costs for running the UCC (Browne et al, 2005). According to Marcucci & Danielis (2007), there is also a risk of increased administration and handling costs, which is consistent with the results of Browne et al (2005)—namely, that larger companies, which consolidate goods at their own distribution centres, might unnecessarily experience increased costs. Malhene et al (2012) have concluded that the chief obstacle of UCCs is their fragile business model, if not their complete lack of one, which seems to be a common theme in urban logistics initiatives. As Quak (2011) has posited, many urban logistics initiatives focus on technical, environmental, and operational feasibility (e.g., emission-free vehicles) while the consideration of economic feasibility often is weak, if not absent. As such, urban logistics solutions suffer from a failure to present viable business
opportunities (Aastrup et al, 2012), which are nevertheless necessary for securing financial feasibility in order to achieve long-term success. Moreover, UCCs are costly to set-up and operate. As examples worldwide have shown, when governments—either local or national—have to account for these expenses, most pilot UCCs have been shut down when financing ends (Quak et al, 2014).

2.2. What can receivers gain from UCCs?

Another aspect of financing UCCs is who should pay for them and why—that is, who can gain from UCCs and in what ways. Quak et al (2014) have argued that among possible stakeholders, the willingness to invest depends on the benefits that each actor can receive. For example, van Rooijen & Quak (2010) describe previous initiatives that have focused on carriers, who actually gain few benefits from using UCCs. Considerations to the carriers and their benefits is also considered in the initiatives in Lucca and the Stadsleveransen initiative in Göteborg, which are partly financed by carriers that distribute goods to those cities (Björklund et al, Under review).

In the Lucca case, financing came from fees levied to freight carriers that entered the city, which was a policy initiated by local authorities. In several other cases, local authorities have more directly financed UCCs (see e.g. Quak et al, 2014; Ville et al, 2013), though as previously mentioned, doing so might not be a sustainable alternative. In fact, considering their potential to receive UCC services designed to meet their specific needs, the stakeholder group that might gain most from the implementation of a UCC is receivers. For instance, the ECO2CITY (i.e., Binnenstadt) initiative in the Netherlands is to a large extent built on the idea that receivers should contribute to financing the UCC since they benefit from using many of the services that the UCC provides (Björklund & Abrahamsson, 2015; van Rooijen & Quak, 2010). As mentioned in the introduction, we use the term *UCC services* for all potential value-added retail and logistics services possible by implementing a UCC.

A change in delivery patterns can result in several benefits for receivers who participate in UCCs. In their review of documented UCCs around the world, Browne et al (2005) found that a UCC can provide receivers with more flexible deliveries and more reliable delivery times. More precisely, more flexible deliveries imply both more flexible delivery times, as well as fewer deliveries. Aastrup et al (2012) add that receivers—in their study, 272 retail stores in Copenhagen, Denmark—can influence delivery times when goods are distributed by UCCs. In effect, fewer deliveries and increased awareness of delivery times can improve planning of retail store staff and increase the possibility that all personnel focus on their core activities: to sell products, not manage logistics activities (Aastrup et al, 2012; Browne et al, 2005).

Furthermore, changes in delivery patterns can result in reduced costs for receivers. However, as both Marcucci & Danielis (2007) and Allen et al (2012) have indicated, it is critical that the cost of using a UCC is less than the potential reduction in cost that it might yield. Other examples of services that UCCs can offer include improved stockholding, pre-retail activities, better return logistics, home delivery, and ordering processes (Aastrup et al, 2012; Allen et al, 2012; Browne et al, 2005; van Rooijen & Quak, 2010). In that context, stockholding implies that the UCC has storage space that receivers can rent—for example, to reduce the storage space in the store and thereby increase the sales area (Aastrup et al, 2012). Furthermore, since the rent—that is, value of the property—is normally far greater in commercial areas than in industrial ones, where UCCs commonly are located, a great deal of money can be saved by relocating the storage space. Browne et al (2005) add that storage at UCCs can also act as a buffer during seasonal peaks. UCCs can moreover offer services related to pre-retail activities, including unpacking, price tagging (Browne et al, 2005), and attaching antitheft devices (Aastrup et al, 2012). Meanwhile, return logistics includes handling returns and recycling.
packaging materials, which is yet another example of a logistics-related service that UCCs can offer (Browne et al, 2005). In their investigation of potential receivers’ interest in value-added services, Aastrup et al (2012) found that the three most popular services were the attachment of antitheft devices, access to external storage, and the return of packaging materials. Interestingly, the benefit of being able to return packaging material was deemed twice as great as the other two combined.

By extension, several logistics activities that take place in retail stores can be executed in UCCs instead. Among such activities, Kotzab & Teller (2005) identified several activities that are performed in retail stores, e.g. delivery and reception, transport to shelves or temporary backroom storage, storage in the backroom itself, transports from backroom storage to shelves, handling and preparatory activities, reordering, and disposal and recycling. The extent of those activities is not to be underestimated. In their study of one of Sweden’s largest grocery retail supply chain, Saghir & Jönson (2001) found that 75% of all handling times in the retail chain occurred in the store. van Zelst et al (2009) further identified in-store handling costs to be the largest cost in the entire retail supply chain. Aastrup et al (2012) have argued that several of these in-store logistics activities, including storage, preparatory activities, and displays, should be considered for relocation to the UCC instead. They add that simpler activities such as price tagging and attaching antitheft devices are also suitable pre-retail activities.

Simply put, a retail store serviced by a UCC can focus on its core activity: to provide customer service at the store. In a review of related research, Dabholkar et al (1996) concluded that the delivery of high-quality service is a basic retailing strategy for creating a competitive edge and that customers’ perceptions of in-store service depend on their browsing activity, their interaction with staff, and how returns are handled. Customers’ in-store experiences with interactions with personnel and the accessibility of the store space were early identified as other important aspects to customers (cf. Westbrook, 1981) (19). In their analysis of a survey of customers in three large shopping malls, Hosseini et al (2014) detected a positive, significant relationship between the service, expressed as employee–customer interaction, for example, and customers’ perceptions of in-store services.

However, if retail stores are to contribute to financing a UCC, then they also need to place greater value in the services that they can receive. Aastrup et al (2012) have averred that one reason for the dismal success of urban logistics initiatives might be the disregard of receivers’ requests and expectations: ‘A characteristic of this literature is that it identifies certain activities possible to provide but does not address the users’ perspective’ (Aastrup et al, 2012, pg. 7). Indeed, some retail stores have already consolidated goods from distribution centres, for example, and those deliveries might be optimised from their perspective, but probably not from the perspective of the city. Therefore, a shift to a UCC could result in greater expenses for receivers (Browne et al, 2005; van Rooijen & Quak, 2010).

3. METHODOLOGY

In this study, empirical data were collected by conducting numerous structured interviews with retail store personnel. The overall design of the study was largely influenced by other studies on the topic (e.g. Aastrup et al., 2012; van Duin et al., 2010).

3.1. Sample selection

Browne et al. (2005) have argued that there is a greater possibility to introduce a UCC to supply a shopping mall than to supply a specific urban area. Accordingly, we chose to study retail
stores located in city malls and selected six such malls in the Swedish cities of Linköping and Norrköping. In retail stores in those malls, we conducted 72 interviews with store personnel.

To increase potential respondents’ willingness to participate, we first targeted spokespeople for the companies responsible for each mall and explained the benefits of our study and the importance of including retailers’ perspectives in urban logistics. All company representatives were positive to the study and informed their respective stores that in-store personnel would be interviewed. As a result, personnel were often willing to participate, as long as interviews did not interfere with their daily work. All interviews were conducted in the stores, usually at the service or checkout desk, and respondents had the option to interrupt the interview if necessary—for example, if a customer asked for help. If employees were occupied, then the interview was performed later, if possible. During interviews, one employee typically answered all of the questions, though multiple employees were occasionally involved, especially if they perceived a need for other employees to participate in the interview due to their different responsibilities and knowledge regarding the need for different retail services. There were always two interviewers present; one asked the questions, while the other took notes.

Not all stores in the six malls were included, for the focus of the study was to explore retail stores, whereas the malls typically housed other kinds of stores irrelevant to our study. Excluded stores include restaurants, cafés, and kiosks, which were irrelevant due to the lack of retail activities performed therein. There were of course other stores whose goods were not conducive to being supplied through a UCC due to their specific character—for example, expensive jewellery and watches. Plus, these stores have additional security during deliveries, and delivery times are undisclosed. Aside from stores excluded from our study, others did not want to participate, primarily due to lack of time, though some companies claimed to have a policy that prohibited answering the types of questions included in the interviews. However, at a certain point near the end of data collection, we note saturation in our answers and therefore not see any need to include more stores, as in line with Bryman (2011) guidance that when new data do not provide new information, then saturation has been reached. The percentage of respondents in malls in Norrköping was less than that in Linköping, probably due to one of two reasons, if not both. First, it was more difficult in Norrköping to access available personnel due to the larger number of shoppers. Second, during the interviews, we noticed that stores belonging to the same retail chain reported nearly identical answers, which suggested that we had also attained data saturation from this direction, and we thus disregarded several stores in Norrköping. It should be noted that interviews in Norrköping were conducted last.

3.2. Design of interview questions

Following arguments from the literature review, a series of questions were identified that needed to be addressed in order to fulfil the purpose of the study. First, UCCs’ potential to consolidate consignment, thereby resulting in fewer deliveries, generates fewer interruptions for store personnel (e.g., Browne et al., 2005; Aastrup et al., 2012). Since personnel can thereby focus their time on interacting with customers to increase customer service instead of performing logistics activities, such as taking care of goods upon their arrival, we articulated the first question: Do receivers find that the number of deliveries per day influences the store’s capacity to provide customer service? Second, since distribution via a UCC can allow retailers to determine delivery times to a larger extent, we asked: Do retail stores that do not receive goods when they want find that they are more hindered in providing customer service? Third, other than consolidation and changed delivery times, there is potential for a UCC to offer several value-added services, such as stockholding, price tagging, and pre-retail activities (Aastrup et al, 2012; Browne et al, 2005). By linking the business perspective to that effect—
and thus the potential to improve customer service in stores—we investigated if the retail stores that was hindered in providing customer service experience greater interest in value-added services.

Neither before nor during interviews were respondents informed of the context of the interview questions. For example, UCCs were never mentioned. This decision was made because the interviews investigated only how personnel worked and what problems they experienced, meaning that the link to UCCs was therefore irrelevant from their perspective. Furthermore, we did not want to spend valuable interview time explaining a concept likely unknown to them and thereby compel them to answer questions in light of how they saw the potential of their answers based on our explanations.

Interview questions were designed so that respondents could respond with short answers, though more extensive answers were of course permitted. For example, two questions (i.e., Does delivery reception negatively affect your ability to provide the quality of customer service that you would like? and Do receivers find that the number of deliveries per day influences their capacity to provide customer service?) could be answered with a simple yes or no, but respondents were also allowed to add commentary to each answer in order to explain themselves in greater detail. In the case of brief answers, however, we did not encourage alternative answers. For example, respondents could answer, ‘What time do you receive goods?’ with ‘Between 8–10 am’, ‘Around 10 o’clock’, or ‘Before opening’ (i.e., before 10 am, which was the opening time for all retail stores studied). For another example, the question, ‘How many deliveries are made each week?’ could be answered with ‘Two to four’ or ‘Seven’. One reason for allowing open answers was to allow us to identify patterns in the empirical data, since results from previous research have to some extent been divided concerning preferable delivery times; for instance, Aastrup et al (2012) have stated that stores prefer delivery times early in the day, whereas van Duin et al (2010) advocated not having personnel in the store before opening hours, thereby arguing for deliveries during opening hours instead. In order to investigate to what extent retail stores are hindered in providing customer service based on whether they receive goods when they want, we also asked ‘What time would you prefer to receive goods?’ In order to investigate whether retail stores hindered in providing customer service would be more interested in UCC services, we also asked with which logistic activities they would like assistance in order to provide enhanced customer service. We chose not to put forward all possible UCC services identified in the literature, since the preponderance of services would extend the time needed for interviews. Furthermore, we found value in their reflecting upon which activities they deemed time consuming, which allowed for new activities to be identified.

3.3. Data analysis

The first step of data analysis involved identifying congregated periods for current and preferred delivery times. Guided by van Duin et al (2010) advice that not receiving goods before opening hours was a boon, one category was ‘Before opening hours’. Since the remaining answers could be stated as either a time or time interval, we identified patterns of commonly stated times and intervals and manually identified clusters of current and preferable times for delivery. The delivery frequencies were also manually clustered to provide an overview of the empirical data. For respondents that had stated an interval (e.g., three to six deliveries per day), we used mean values. In the case of uneven mean values, the lower bound was always chosen to illuminate a less optimistic view of potential UCC services. For instance, Aastrup et al. (2012) found that receivers deemed fewer deliveries to be beneficial.
Our analysis aimed to establish retail stores’ demand for UCC services by first exploring whether they had experienced any problems with the daily work involving different logistic activities and if that work had affected the customer service provided. Second, we investigated their need for or interest in assistance with activities that could be provided by a UCC. In other words, our analysis, with support from the literature, was based on identifying gaps between current problems and the stores’ interest in and needs for resolving them.

To analyse whether retail stores that received goods at unpreferred times of day experienced a higher demand for UCC services or that in-store logistics activities influenced customer service in a negative way, independent sample t-tests were applied. Two groups of respondents were identified: those who stated the same time or interval for current and preferred delivery times, and respondents who preferred a time other than the current one. Independent sample t-tests were also applied to identify whether respondents with a greater delivery frequency experienced a higher demand for UCC services or that the in-store logistics activities influenced customer service in a more negative way. Concerning delivery frequency, respondents were divided into two groups: those with many deliveries per week and those with few. Analysis was conducted three times by applying different division values in each: more or fewer than three deliveries (i.e., excluding respondents with three deliveries), more or fewer than four deliveries (i.e., excluding respondents with four deliveries), and one to three deliveries compared to four or more deliveries.

4. EMPIRICAL FINDINGS

The number of respondents in each mall is shown in

Figure 4.1 shows the 72 stores’ current and preferred delivery times. For 30 stores, current delivery times were spread throughout the day. Respondents’ answers were likewise spread widely, and answers were congregated to facilitate a clearer overview of the results. Aside from the predetermined category ‘At opening’, we identified that all remaining answers could be classified in three time intervals: ‘Before opening’, ‘In the morning (i.e., 10–12 am)’, and ‘Throughout the day (i.e., from opening to closing)’. The most common current time interval for deliveries was ‘Throughout the day’ (n = 30), while the second most common was ‘In the morning’ (n = 25). The remaining 17 stores received deliveries before or upon opening. Most stores that had chosen delivery times themselves (e.g., when receiving deliveries from their own central warehouses) received deliveries before or upon opening.

Table 4.1. As described in the methodology section, the low number of interviews at malls in Norrköping can be explained by the observed saturation and the greater number of shoppers, which hindered the possibility of conducting interviews.

Figure 4.1 shows the 72 stores’ current and preferred delivery times. For 30 stores, current delivery times were spread throughout the day. Respondents’ answers were likewise spread widely, and answers were congregated to facilitate a clearer overview of the results. Aside from the predetermined category ‘At opening’, we identified that all remaining answers could be classified in three time intervals: ‘Before opening’, ‘In the morning (i.e., 10–12 am)’, and ‘Throughout the day (i.e., from opening to closing)’. The most common current time interval for deliveries was ‘Throughout the day’ (n = 30), while the second most common was ‘In the morning’ (n = 25). The remaining 17 stores received deliveries before or upon opening. Most

216
stores that had chosen delivery times themselves (e.g., when receiving deliveries from their own central warehouses) received deliveries before or upon opening.

Table 4.1 Number of respondents in each city mall

<table>
<thead>
<tr>
<th>Mall</th>
<th>Linköping</th>
<th>Norrköping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of interviews</td>
<td>Mall A</td>
<td>Mall B</td>
</tr>
<tr>
<td>Number of stores</td>
<td>15</td>
<td>11</td>
</tr>
</tbody>
</table>

| Number of stores | 22 | 12 | 35 | 38 | 19 | 17 |

When asked about preferred delivery times, only eleven stores stated that they did not have any preference, and no store preferred deliveries in the afternoon. All other stores preferred deliveries at any time in the morning \(n = 23\), upon opening \(n = 21\), or before opening \(n = 16\). Interestingly, the similarities among malls show, for example, that in all malls save one (Mall F), requests for deliveries before or upon opening increased when the current situation was compared to the preferred situation (i.e., no change between two malls). Another difference worth noting concerns Mall C, where six stores received deliveries before opening, which accounted for more than 50% of the stores receiving deliveries before opening.

However, independent sample \(t\)-tests revealed no significant relationships or even tendencies that retail stores with deliveries before or upon opening were less hindered in providing customer service or experienced less demand for potential UCC services \(p > .2\).

Figure 4.1 Number of stores that stated each delivery time for current and preferred delivery times

Figure 4.2 depicts the current delivery frequency per week for the stores. As shown, most stores had a delivery frequency of five deliveries per week or fewer, meaning one delivery per day at
most. We therefore set the intervals of one (or less than one), two, three, four, five, and more than five deliveries per week as the number of respondents in the >5 category, which was represented by only 17 stores. Three stores stated that they had 10–15 deliveries per week; another three stores had 10 deliveries per week, and the rest 5–10 deliveries per week. Notably, a great deal of respondents mentioned that deliveries were delivered only on weekdays, meaning that in the case of six or more deliveries per week, these stores received more than one delivery each day.

Unlike with delivery times, most stores did not state any preference regarding delivery frequency. Interestingly, however, several stores stated that they would like to increase the frequency of deliveries. In those cases, deliveries occurred weekly or once every other week (i.e., ‘One delivery per week’, Table 4.2).

Furthermore, statistical analysis (t-tests) did not result in either any statistically significant relationship showing any linkage between stores with higher and lower delivery frequencies and the demand for UCC services or the impact on the customer service experienced. Independent of the deviation value used in the three analyses conducted, not even any tendency of such a relationship was identified.

![Figure 4.2 Distribution of delivery frequencies per week at stores](image)

Twelve stores stated that the reception of goods negatively affected their ability to provide the highest-quality customer service possible. However, as both observed and stated by some stores, if personnel were busy when deliveries arrived, then the carrier would simply wait until reception could be made—sometimes up to 5 minutes. A few stores increased their workforce when they expected deliveries—for instance, stores with only one delivery per week. If personnel were busy at the time of delivery, then unpacking was postponed or, in some cases, unpacked goods were left in the sales area. A few stores even had specific warehouse personnel, meaning that in-store personnel were not involved in goods reception.

Regarding other in-store logistic activities, 22 stores stated that their ability to provide the best customer service possible was hindered. Of these stores, 12 cited examples of logistics activities that sometimes hindered their provision of customer service, such as attaching antitheft devices (n = 4), unpacking goods (n = 4), price tagging (n = 2), and handling packaging
material \((n = 2)\). Many stores stated having enough time to perform in-store logistic activities in between helping customers, and one store commented that even if personnel were ready to drop what they were doing to help a customer, the customer might perceive that the personnel were busy and not ask for help. At least two stores mentioned that reporting received goods in the computer system was a highly time-consuming activity.

Meanwhile, 42 stores expressed a need for additional storage space. Seven of those stores reported needing additional storage room during seasonal changes or peak seasons (e.g., Christmas). For clothing stores, those periods were characterised by major changes to product assortments, which added to a greater need for storage space also meant more time-consuming in-store logistics activities.

Since some stores stated more than one problem, there were 19 stores that neither perceived that the reception of goods or in-store logistics activities negatively affected their ability to provide customer service nor had a need for additional storage space. By adding the request for change of delivery time, 59 stores indicated that they could gain something if a UCC solution were implemented. Table 4.2 shows the number of stores that identified each alternative as a problem. That number could be even greater, since several stores did not express any interest in UCC services due to their potential cost, as they expressed during interviews. Notably, no stores in Mall C experienced any problems with their reception of goods, and they experienced the fewest problems with in-store logistics activities. One explanation might be that Mall C is located on the outskirts of the city, hence the number of shoppers might be less at earlier times in the day.

### Table 4.2 Number of stores with perceived problems possibly related to potential UCC services

<table>
<thead>
<tr>
<th>Reception of goods</th>
<th>In-store logistics activities</th>
<th>Insufficient storage</th>
<th>Delivery time</th>
<th>No identified problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mall A</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Mall B</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Mall C</td>
<td>0</td>
<td>3</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Mall D</td>
<td>2</td>
<td>5</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Mall E</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Mall F</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>22</td>
<td>42</td>
<td>27</td>
</tr>
</tbody>
</table>

## 5. ANALYSIS, DISCUSSION, AND RECOMMENDATIONS FOR FUTURE RESEARCH

Most stores investigated identified a need for the services that a UCC can provide. As many as 59 of the 72 stores showed some interest in the services potentially provided by a UCC. The two UCC services most requested were change of delivery time and external storage; 27 stores
requested change of delivery time, and 42 stores showed interest in external storage, as further discussed in Section 5.3.

To meet the stores’ expectations—that is, UCC customers’ expectations—it is important for UCCs to provide expected services at a reasonable price. If customers find value in UCC services and are willing to pay for them, then there is a greater possibility of generating revenue streams to UCCs, which in the long run might support a viable UCC. This finding is also in line with the results of Marcucci and Danielis (2007) and Allen et al. (2012), both of which state that the cost of using a UCC—in our study, the stores’ costs for purchasing UCC services—needs to be less than the cost reduction it may yield—which in our study means the costs for the logistics activities possibly absorbed by the UCC as well as potential cost reduction due to change of delivery time.

With support from the literature, we have identified at least two arguments as to why a retail store would be willing to participate in financing a UCC. First, the literature suggests that the use of UCC services might increase the stores’ capacity to improve their customer service. Second, it is possible that cost savings could be achieved. Whether empirical findings or our study supports these two arguments is further discussed in the two sections below.

5.1. UCCs and improved customer service

Several stores stated that their ability to provide the best customer service possible was obstructed by in-store logistics activities (n = 22) and the reception of goods (n = 12). Of the 72 stores, 12 provided examples of logistics activities that sometimes hinder their provision of customer service. However, mentioned four times, one of the more common obstructive activities was ‘Unpacking products’, an activity that cannot be shifted to a UCC since the product needs its packaging during the transport from the UCC to the store. The activity that four of the stores cited as having potential to be performed by some other actor was attaching antitheft devices. Furthermore, independent sample t-tests did not identify even the most minor tendencies that stores with higher delivery frequencies or unpreferred delivery times experienced as hindering their in-store provision of customer service. However, we interpret this result to indicate that the problem and the relationships that we investigated were very complex.

In examining respondents’ comments, we offer some explanations as to why several stores did not experience any problems in providing customer service, nor any need for potential UCC services: carriers had to wait if personnel were busy (sometimes up to 5 minutes), deliveries were left in boxes in the store if personnel had limited time to unpack them, and the workforce increased on the day of delivery. Another aspect raised by one store is the importance of considering how customers experience the store. Decreased accessibility due to goods placed in the store, for example, could influence customers’ willingness to shop there. As Westbrook (1981) pointed out early, accessibility to the storage space is an important aspect for customers, since they might perceive the personnel to be busy and thus not ask for help and even perhaps make the purchase at another store. It should be noted that retail stores were excluded from data collection when they did not have time to answer the interview questions. It is therefore likely that these stores have a greater demand for UCC services. To some degree, it is a paradox that the stores that ought to have the most to gain from implementing a UCC are the most difficult to include in this kind of study.

To more precisely determine whether an UCC can improve customer service, more probing studies are needed, especially those aimed at grasping the perspective of customers. It seems that retail stores have found strategies to be able to maintain the level of customer service that
they seek; however, it remains unclear how cost-effective those solutions actually are, which constitutes another question that needs to be addressed in future research.

5.2. UCCs might reduce costs

Numerous stores stated that they might be interested in UCC services, yet feared the cost of those services. To be able to elucidate the potential of cutting costs, future research needs to examine this aspect from a more holistic perspective than the respondents do. For instance, receivers do not perceive the costs of making carriers wait. Even though the stores were not bothered by carriers’ having to wait, it is important to scrutinise how that wait affects the bigger system. For one, carriers’ delivery route times will increase, especially if multiple stores make them wait. At the same time, carriers’ vehicles have to then be parked, perhaps on a public square or narrow shopping street; even if the freight vehicle is parked at a loading dock, that may cause queues for other vehicles at the dock. Moreover, some actor has to pay for the wait—namely, the transport purchasing company. Thus, either directly or indirectly (e.g., increased prices for products purchased), retail stores indeed pay the cost of making carriers wait. Despite the sometimes inconvenient delivery of goods, these stores have found solutions to be able to focus on delivering a high level of customer service; however, they might not see the actual cost of those solutions. When increasing the workforce to cope with deliveries and in-store activities, for example, or always having two personnel present at the store to cope with both in-store activities and customer service, stores are already paying the cost, even if they do not recognise it. It is quite plausible that outsourcing some activities to a UCC might thus benefit the stores, which also underscores an important area for future research: to investigate the actual cost of in-store logistics activities and compare them with cost of purchasing those services from a UCC. Due to large-scale advantages with UCCs, the costs ought to decrease if performed within UCCs. In line with the reasoning of both Marcucci & Danielis (2007) and Allen et al (2012), it is thus crucial that the cost of using a UCC is less than the potential reduction in cost that it might yield.

However, receivers might not be the only actors who should finance UCCs. When identifying potential revenue streams for UCCs, it is important to identify all customers. For example, the city and its inhabitants can gain plenty from the implementation of a UCC—for example, via the decreased number of vehicles in the city and the reduced environmental impact. It is therefore arguably that city inhabitants should contribute to financing UCCs—for instance, with a tax.

5.3. UCC services (not) requested by Swedish retail stores

Several potential UCC services cited in the literature as being of interest to retail stores have been investigated. In this subchapter, the focus is foremost on services perceived in a way other than expected, at least according to the literature reviewed.

Storage. Contrary to other UCC services, most stores (n = 42) requested external storage. Interestingly, only seven of these stores would use storage during seasonal peaks, meaning that the remaining 35 stores were interested in using that storage permanently. The two malls that distinguished themselves by having more than 65% of their stores request additional storage were Malls B and D. Even if the numbers are incomparable, Aastrup et al. (2012) also found storage to be one of the most requested UCC services.

Time of delivery. Stores investigated preferred that deliveries arrived either around the time of opening or in the morning. Earlier deliveries might enable the stores to perform most of the retail logistics activities during the morning, when the number of customers is not as great and
the personnel have more time for customers when they do arrive. Of the 72 stores, 37 requested deliveries to arrive upon opening, if not before, which contradicts the finding of van Duin et al (2010), who state that not receiving goods before opening hours is a benefit due to the time saved on personnel costs. However, those researchers neglected to mention that the time prior to opening can be used for value-creating activities (e.g., in-store activities). Our study thus not only contributes knowledge regarding current and preferred delivery times, but by including questions that allowed open answers, it also identified one of the most desirable delivery times: upon opening. Yet, even if that time is one of the most preferred, it is not possible for logistic service providers to deliver to all stores simultaneously. It would therefore be interesting to study whether these respondents as a second alternative would have selected before opening or in the morning. Also notable is that no respondent mentioned the need for more reliable delivery times, as Browne et al. (2005) and Aastrup et al. (2012) have. One explanation for this could be that if it is a problem, then it is primarily handled by the personnel planner. On that point, the interviews in this study have been limited to in-store personnel, which stresses the importance of more thorough investigations and the inclusion of all forms of personnel that represent receivers, such as actors responsible for the often centralised purchase of transport services, personnel planners, in-store personnel, and managers at different levels.

Decrease of delivery frequencies. In the literature (e.g., Aastrup et al., 2012), the decrease of delivery frequencies is described as a value created by the UCC due to more consolidated shipments. There is thus potential for receivers to be less disturbed in their daily activities. However, our respondents did not perceive high delivery frequencies to pose a problem. On the contrary, some stores with very few deliveries per week would appreciate more deliveries. In line with the suggestion that future research examine receivers’ views on delivery times, we also acknowledge a need to more profoundly investigate the aspect of delivery frequencies that target different managers and other actors responsible for different areas.

Reporting in the computer system. This task was also identified as a potential UCC service that we could not find in the literature. Two stores mentioned that reporting received goods in the computer system was a highly time-consuming activity. This work could also be a type of low-skilled activity, as Aastrup et al. (2012) put it, suitable to perform at a UCC. However, in reality, it could be difficult to operationalize the task, since stores use different systems. Because that activity is identified as time consuming, further investigation of it is also needed.

Return handling. This UCC service was identified as one of the most requested by Aastrup et al (2012). However, only two of our respondents indicated that the packaging material, packages, or load units, among other things, were problems. It could be that they neglected this aspect, since we did not offer any examples of potential problems or benefits along those lines in our interviews. However, if this service was as large a problem as in the Danish study, then it would have most likely been mentioned. Explanations for the contradictory findings might be that the studies have been conducted in different countries, yet also—and perhaps even more likely—our stores were located in a city mall. City malls often have more systematic ways of handling the return of packaging material with containers for used material located in the building or nearby. In any case, this aspect ought to also be addressed in greater detail in future research.

6. CONCLUSIONS

With the increasing population in cities worldwide, the need and demand for freight transport will continue to increase as well. Though necessary, the effects of transport are quite negative
for cities and their inhabitants and include noise, traffic congestion, and carbon emissions. There is thus a need to decrease the impact of freight transport on cities, and one possible solution is implementing UCCs. With UCCs, goods are consolidated at the centre, which increases load factors, which in turn leads to fewer freight vehicles in urban areas. However, despite the many benefits of UCCs for city populations and the environment, examples of viable UCCs remain scarce, primarily due to their lack of economic viability. In this study, we have taken a point of departure by seeking to identify potential arguments for providing revenue streams in retail stores via the value propositions of potential UCCs. The purpose of this study was to explore retail stores’ demand for UCC services in order to guide the development and implementation of UCC solutions with more economically feasible business models.

Our findings indicate that the potential to further improve customer service at retail stores might not be possible with the implementation of a UCC and thus that the potential for increased income might not be the strongest argument for retail stores to pay for potential UCC services. Though a UCC has the potential to enhance in-store customer service, its remains unclear whether that is actually the case. In short, findings thus far have contradicted one other. As an alternative, we have identified that the stores investigated, more or less consciously, expend a great deal of resources on logistics activities that could be covered by UCCs. However, retailers do not perceive these extra activities to pose a cost since their personnel are already in place. There is therefore a need to underscore the economic value of these activities in order to advocate the potentials of outsourcing these activities at a lower cost to UCCs. The results of our study contribute to further research as it underscore the importance of a cost-oriented mindset—namely, that of store managers, who need to be aware of cost allocation and the benefits in terms of cost savings.

Our empirical findings show that additional storage and changes in delivery times are the most requested UCC services, though there was also some interest in other UCC services. It is therefore crucial for a UCC to offer the services requested by its customers in order to reach financial viability. That 82% of the retail stores had at least one problem that a UCC could improve points to the potential of UCCs in city malls, at least in Sweden. In addition, we contribute to the UCC-literature through identifying a new potential UCC service: computerised reporting. In other words, this shows the potential to identify and innovate new services that can further strengthen the financial viability of UCCs.

Our study also shows the importance of investigating the need for different UCC services in the planning phase of UCCs. The need differs widely depending on the store’s present situation. Not only does our study identify needs, or the lack thereof, that contradict what has been cited by other studies, but we also see somewhat different needs in the stores that we investigated due to their locations in different cities—that is, in or on the edge of the city—as exemplified by times that are more or less suitable for deliveries.

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REFERENCES


ABSTRACT

Purpose
The purpose of this research is to investigate the impact of logistics value-adding services and perceived service quality on brand equity among b2b customers of a brewery company.

Design/methodology/approach
A theoretical model is developed and tested using survey data from 173 hotel, restaurant and catering industry customers of a brewery company in Finland.

Findings
Value-adding services play an important role in building the brewery company’s brand equity through perceived service quality. Besides a direct impact on overall service quality, an indirect impact is detected through the operational dimension of service quality in logistics.

Research limitations/implications
A broader data set would be needed to generalize the findings also beyond the brewery business and the hotel, restaurant and catering industry customers in Finland.

Practical implications
To increase brand equity, value adding services like logistics can play an important role for b2b customers. This study is important for practitioners as well as academics since there has been little quantitative research available regarding value adding services in the context of service quality and brand equity research.

Original/value
This paper combines logistics as value adding service to customers’ willingness to pay extra profits in order to cooperate with service producer.

Keywords: value adding service, service levels, corporate brand equity, structural equation modelling and brewing industry
1. INTRODUCTION

In brewing industry, consumers of the beverages and soft drinks are the final customers and their judgements concerning brewery’s products are the most important matter. However, obviously availability and brand of the brewery and products influence how high consumers rank different breweries and their products and consequently how keenly they choose and use some beverage brand. Hence, it is very important for breweries to closely cooperate with their customers and distribution channel to obtain visibility and availability among the consumers of the beverages. In other words, in brewing business, role of the distribution channels is very important, because they are also “brand advocates” of the breweries, which do not have direct connection to their customers but still products are usually sold with breweries brand. In practise, it is quite common that breweries offer their beer taps and freezers for restaurants to use. Value adding services in brewing business are thus usually related to physical distribution of beverages. Hence, logistics services as adding services are very important in brewing business. In this study, we have collect data from the hotels, restaurants and catering (HORECA) firms who are customers of the Finnish brewery called Olvi.

During the last decades, the connection between service performance and customer loyalty has been a widely held topic in marketing and service management research in business-to-consumer business-to-business service contexts (Olsen, 2002; Chumpitaz and Paparoidamis, 2007; Juga et al, 2010.). According to Christopher (2005), axiom in marketing is that “customers don’t buy products, they buy benefits”, which relate not to specific product features but rather to such intangible things as image or service. Hence, to handle these intangible things concepts used in this study are also nebulous and impossible to observe directly and thus we have used latent variables. However, we have recycled concepts used in previous studies with validated measures in six latent variables and developed one latent variable for purposes of this study, logistics as a value adding service - with very good statistical construct reliability.

Recognizing the importance of service quality for business relationships, this study investigates the impact of perceived service quality with value adding services on loyalty and brand equity in brewing business. Our assumption is that in the brewing business, value adding services are one important way how breweries can promote their brand among sellers and improve their profitability.

The purpose of this research is to investigate the impact of logistics value-adding services and perceived service quality on loyalty and finally on brand equity among b2b customers of a brewery company and hence provide a source of competitive advantage. Based on earlier literature, critical service dimensions are identified and their impact with value adding services on loyalty and brand equity is examined empirically with structural equation modelling (SEM) using the LISREL software package. The importance of this study comes from the fact, that we have measured brand equity with items relating to, for instance, customers’ willingness to pay more to cooperate with Olvi. In other words, we have studied whether logistics as value adding services as independent latent variable may influence finally to dependent latent variable brand equity which includes also fiscal measure. After introduction, theoretical underpinnings are presented with tentative model. A tentative model is tested and final model is produced in the methodology chapter using SEM and model generating SEM. The last chapter is conclusions, which includes theoretical and managerial proposals with limitations and further research suggestions.
2. THEORETICAL UNDERPINNINGS

2.1. Theory and hypotheses

Langley and Holcomb (1992) raise competitive service levels to other important dimension, in addition to cost reduction, of value created by logistics and considerable attention is focused on how to provide the customer with value creating service prior to, during, and after the product itself is delivered. According to Mentzer et al. (2001), a process is needed to measure customers’ perception of the value created for them by logistics services, because it is the customers’ perspective of service quality that determines their satisfaction level. Thus, our first hypotheses are that

\( H_1 \): value adding services effect to all other service dimensions and in addition, it influences total experienced service level.

Service quality and its implications on business relationships has been many decades popular topics in the academic research of marketing and service management (Seth & Deshmukh, 2005). Foremost research streams and theories investigate the attributes or dimensions of service quality (e.g. Grönroos, 1984; Haywood-Farmer, 1988), distinctions between expectations and performance along service quality dimensions (e.g. Parasuraman et al., 1985; Bolton & Drew, 1991), connections between service performance and loyalty (e.g. Oliver, 1980; Cronin & Taylor, 1992; Sweeney et al., 1997), etc. Conceptual and empirical studies of logistics service quality contain, for example, definitions of logistics service quality and its dimensions (e.g. Mentzer et al. 1999; Rafaele, 2004) as well as analyses of the impacts of logistics service performance on loyalty and market share (e.g. Stank et al., 2003; Juga et al, 2010; Davis & Mentzer, 2006), and impact of the service quality on satisfaction, loyalty and brand equity (Grant et al, 2014). Following on Juga et al. (2010) we hypothesize that

\( H_2 \): experienced service can be measured by operational service, personnel service and technical service levels.

Empirical studies often face problems with measurement of behavior, leading researchers to exclude recording actual behavior and in most cases to focus on intentions, operating on the assumption that intentions strongly affect behavior (Cahill 2007). In addition, there is no general agreement on which aspects should be included in the concept of loyalty, although researchers have studied it widely in empirical contexts (Cahill et al. 2010). We adopted the loyalty intentions measures of Vogel et al (2008) and hence, instead of actual behavior, in fact we too have measured loyalty intentions. Previous studies have shown that experienced quality influence to loyalty intentions via satisfaction, however, according to Oliver (1999), while satisfaction is a necessary step in loyalty formation, it becomes less significant once loyalty starts to become fixed through another mechanism, such as personal determinism and social bonding at the institutional and personal level. Further, Rao et al. (2011) found quality to have a direct impact on a customer’s purchase intention in the context of the electronic logistics service quality. Thus, while satisfaction could be listed as mediating factor between the service quality and loyalty, we decided to exclude it and hypothesize that

\( H_3 \): experienced service quality explains loyalty intentions.

Davis et al. (2008) argue that brand equity is the relevant dependent variable in the context of B2B services. Traditionally, the marketing literature has studied loyalty as a component of brand equity (Aaker, 1991). However, researchers have also argued that loyalty is an outcome of brand equity (E.g. Van Riel et al., 2005) and thus a strong brand may result in increased customer loyalty. Nevertheless, the impact of loyalty on corporate brand equity has been
observed in the SMC literature, for instance, by Wagner et al. (2011) and Grant et al. (2014) and thus we adopt Aaker’s (1991) view and hypothesise that

**H4: loyalty intentions increase brand equity.**

When combining previous hypotheses, we can present our tentative model in Figure 2.1.

![Figure 2.1 Tentative model](image)

### 2.2. Concepts and measures

This study builds on the traditional satisfaction-loyalty paradigm in service management research (e.g., Parasuraman et al. 1985; Oliver, 1980). The operational and personal service dimensions are mostly similar to those advised in the Stank et al. (2003) and Juga et al. (2010) models, while the addition of the technical dimension can be justified by the Juga et al. (2010). Loyalty is measured using Vogel et al. (2008) measures and brand equity using Davis et al. (2008) measures. Value adding services are measured by customers’ experiences concerning devices and device maintenance, transportations and logistics. Devices for beverage distribution in the customers’ premises, like for example beer taps, are context related value adding services. Transportations relates to short term oriented and logistics relates to long term oriented value adding services (e.g., Soinio et al. 2012). A survey questionnaire was designed to study the attitudes of HORECA customers of Olvi brewery. The questions were measured on a 7-point scale, including Likert-scale statements (fully disagree … fully agree) as well as quality grades (poor … excellent). The concepts and their operational statements used in the questionnaire are presented in Table 2.1.
### Table 2.1 Concepts and operational measures

<table>
<thead>
<tr>
<th>Latent variable</th>
<th>Operational measures in the questionnaire</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational service</td>
<td>Based on recent experiences with OLVI, evaluate the service in terms of (1 = poor … 7 = excellent): [Altered from Juga et al. 2010]</td>
<td>OSERV</td>
</tr>
<tr>
<td></td>
<td>• ability to keep schedules</td>
<td>OS1</td>
</tr>
<tr>
<td></td>
<td>• ability to offer products promptly</td>
<td>OS2</td>
</tr>
<tr>
<td></td>
<td>• ability to provide sufficient capacity</td>
<td>OS3</td>
</tr>
<tr>
<td>Personal service</td>
<td>Based on recent experiences with OLVI, evaluate the service in terms of (1 = poor … 7 = excellent): [Altered from Juga et al. 2010]</td>
<td>PSERV</td>
</tr>
<tr>
<td></td>
<td>• service-mindedness of personnel</td>
<td>PS1</td>
</tr>
<tr>
<td></td>
<td>• accessibility of personnel</td>
<td>PS2</td>
</tr>
<tr>
<td></td>
<td>• expertise of personnel</td>
<td>PS3</td>
</tr>
<tr>
<td>Technical service</td>
<td>Based on recent experiences with OLVI, evaluate the service in terms of (1 = poor … 7 = excellent): [Altered from Juga et al. 2010]</td>
<td>TSERV</td>
</tr>
<tr>
<td></td>
<td>• technical level of information systems</td>
<td>TS1</td>
</tr>
<tr>
<td></td>
<td>• technical quality of information systems</td>
<td>TS2</td>
</tr>
<tr>
<td></td>
<td>• problem-free electronic communication</td>
<td>TS3</td>
</tr>
<tr>
<td>Value adding service</td>
<td>Based on recent experiences with OLVI, evaluate the service in terms of (1 = poor … 7 = excellent):</td>
<td>VALUEADD</td>
</tr>
<tr>
<td></td>
<td>• devices and device maintenance</td>
<td>VA1</td>
</tr>
<tr>
<td></td>
<td>• logistics</td>
<td>VA2</td>
</tr>
<tr>
<td></td>
<td>• transportations</td>
<td>VA3</td>
</tr>
<tr>
<td>Loyalty</td>
<td>Indicate your intentions regarding relationship continuity (1 = fully disagree … 7 = fully agree): [Altered from Vogel et al. 2008]</td>
<td>LOYAL</td>
</tr>
<tr>
<td></td>
<td>• We are likely to recommend OLVI to our business partners</td>
<td>L1</td>
</tr>
<tr>
<td></td>
<td>• With high probability we will continue the relationship with OLVI as long as possible.</td>
<td>L2</td>
</tr>
<tr>
<td>Brand equity</td>
<td>Refers to equity of the corporate brand (1 = poor … 7 = excellent): [Altered from Davis et al. 2008 and Grant et al, 2014]</td>
<td>BRANDEQ</td>
</tr>
<tr>
<td></td>
<td>• We are willing to pay more in order to do business with Olvi</td>
<td>BE1</td>
</tr>
<tr>
<td></td>
<td>• This company’s brand is different from other breweries</td>
<td>BE2</td>
</tr>
<tr>
<td></td>
<td>• The name of Olvi gives them an advantage over other breweries</td>
<td>BE3</td>
</tr>
</tbody>
</table>

To conclude, the tentative model (or structural model) in this study is a second-order measurement model consisting of the three quality-related factors as dimensions of the overall service perception and logistics as value adding service which is influencing to different service dimensions and overall experienced service quality. Overall experienced service level explains the customers’ loyalty and Olvi’s brand equity. The questions and statements listed in Table 2.1 are the observed variables measuring the latent constructs of the model.
3. METHODOLOGY

3.1. Data description and estimation method

The target group of this research consisted of Olvi plc’s restaurant customers, who are part of the larger HoReCa sector. The survey was e-mailed to 645 customers, approximately half of Olvi’s registered domestic restaurant customers. Authors sent two separate e-mails and set a response time of one week in each case. They received a total of 173 answers (26.8%), which may be considered as satisfactory (e.g., Larson, 2005). Response interest was higher in the first round, which produced 114 answers (65.9% of the total), and the second round added 59 responses (34.1%). The response waves were compared using ANOVA and there were no statistically significant differences between the groups. Hence, there is no reason to doubt that non-response bias would be a problem in this study (Armstrong and Overton, 1977). We analyzed our data using SPSS and Lisrel software’s. SEM estimations were made using maximum likelihood method.

3.2. Empirical results

We first run confirmatory SEM analysis to test our tentative model. However, p-values showed statistically insignificant relationships and thus we moved on to model generating SEM (Jöreskog, 1993). In model generating SEM, idea is to find statistically significant model which is also theoretically valid. We removed statistically insignificant relationships and found statistically acceptable SEM (please, see Figure 3.1). Hence, on practice, we did not add new relationships in the model but just rejected first hypothesis partially and thus all remaining relationships are also theoretically valid.

![The empirical model](image)

Figure 3.1 The empirical model

The fit indices and test values of the latent variables are summarized in Table 3.1.
### Table 3.1 Test statistics of the empirical model

<table>
<thead>
<tr>
<th>Test</th>
<th>Final model</th>
<th>Latent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>P-value</td>
</tr>
<tr>
<td>Chi-square (df)</td>
<td>218.33 (111)</td>
<td>0.000</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.075</td>
<td></td>
</tr>
<tr>
<td>CFI</td>
<td>0.979</td>
<td></td>
</tr>
<tr>
<td>TLI (NNFI)</td>
<td>0.975</td>
<td></td>
</tr>
<tr>
<td>SRMR</td>
<td>0.068</td>
<td></td>
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<tr>
<td></td>
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</tbody>
</table>

According to Browne and Cudeck (1993) RMSEA value below 0.8 stands for reasonable error of approximation. Hu and Bentler (1999) argue that a cut off value close to 0.95 for TLI (NNFI) and CFI are needed before we can conclude that there is a relatively good fit between the hypothesized model and observed data. SRMR should be below 0.8 for relatively good fit (Hu and Bentler, 1999). Further, CR, AVE and Cronbach’s alpha values provide statistical significance also to each factor. Hence we can judge model generated SEM statistically significant. As a result, we can accept hypotheses H1b, H1c, H2a, H2b, H2c, H3 and H4. However, we reject hypotheses H1a and H1d.

### 4. DISCUSSION AND CONCLUSIONS

Our results reveals that logistics as value adding service is not a dimension of the experienced service quality. Further, it does not explain technical service quality. However, logistics as value adding service has a strong positive influence on operational service level and weak positive influence on personal service level. In addition, experienced service quality explains customers’ loyalty and Olvi’s brand equity.

From theoretical point of view our results are that logistics as value adding service is not one service dimension but it needs a special focus. It influences to experienced service quality, but requires operational and personal service levels for mediators. This means that importance of logistics as value adding service depends on the mediating service levels and thus logistics as value adding service is futile if operational service and personal service are at low levels. Further, when usually operational service performance has been important dimension of the service quality, in this study we found that operational service quality has the lowest statistical loading on service quality. We find this fascinating result as logistics as value adding service is very important for service quality, we can maybe say that logistics as a value adding service has replaced importance of operational service quality. This is totally understandable because operational service quality relates heavily to logistics and if logistics is outsourced using value adding services, the importance of operational service quality diminishes. This is also supported by value adding service’s strong influence toward operational service quality.

Even if these theoretical founding are important also from managerial point of view, more important issue is the fact that one measure of the brand equity is customers’ willingness to pay.
more to cooperate with Olvi. Obviously this points out that logistics as value adding service can improve profitability. However, we have to always remember that there are several mediators which depends how strong positive improvements can be achieved with logistics as value adding service. Further, as it seems that logistics as a value adding service may be a substitute for operational service quality, logistics as value adding service may be more strategical tool relating to customers’ outsourcing decisions, than just simple value adding service.

Limitation of this research is, that data consists only one company of one country, which means that higher statistical generalizability should be in the focus of the forthcoming studies. Further, also larger model which includes for example cost perspective and maybe some other important factors relating to loyalty and brand equity should be taking account. However, if researchers include cost factor in our model, probably they also have to take customers’ heterogeneity in the account (E.g. Juntunen et al 2015). Also the role of the logistics as value adding service calls further research, is it only a simple service which adds value for customers or is it a strong strategic tool to penetrate customers’ supply chain.

REFERENCES


ABSTRACT

Purpose
The study investigates whether and how public procurement drives innovation, extending the notion of innovation to the supply chain and to the cascading of innovation throughout the supply chain.

Design/methodology/approach
For this embedded case study, relevant legislation was reviewed and data were collected using semi-structured interviews with key informants from the selected sectors.

Findings
In this work, factors affecting public procurement for innovation in two sectors in Finland, healthcare and energy, are identified. Using this information, supply chain management principles and information from revised EU directives on public procurement, insights into how innovation can be cascaded in a supply network are provided.

Research limitations/implications
The findings are based on the initial part of an ongoing longitudinal study, but limited since not all data points identified through the snowballing sampling were yet interviewed.

Practical implications
Identification of factors can aid policy-makers, procurers and suppliers in understanding the link between public procurement and innovation.

Social implications
The study raises awareness of the interlinkages in health and energy sectors between procurement processes and supply chains, and what actions organisations can take to promote innovative solutions, supporting smart, sustainable and inclusive growth.

Original/value
The study provides practitioners, policy-makers and researchers with insights on the issue of combining innovation and procurement.

Keywords: Public procurement, innovation, supply chain, public contracts regulation
1. BACKGROUND

Organisations involved with public procurement are subject to rules and regulations they are expected to adhere to (TEM, 2016). In April 2016, European Union (EU) member states are expected to have adopted the reformed public procurement legislation. The new legislation (European Commission, 2016), while taking into account changing economic circumstances and budget limitations, is aimed at simplifying and making more efficient the public procurement process for both suppliers and procurers. Under the reformed legislation, special attention has been paid to small- to medium-sized enterprises; total life cycle costs, competitive dialogue, innovation partnerships and cross-border joint procurement. Public authorities in Finland spend about 22.5 billion euro annually, about 15% of GDP on procuring public goods, services and works (Hankinnat.fi, 2016). Considering the size of the public purse, the EU identified public procurement for innovation (PPI) as an instrument that is a policy objective in itself and that can also be used to meet other policy objectives such as security of supply, sustainability, competitiveness and job creation.

According to Ellram and Cooper (1990), in SCM the supply network is a single body, not a set of separate elements, each of which performs its own function. Therefore, it can be concluded that actions in the first tier supplier-procurer relationship can affect activities in, or “cascade” to, other organisations in the supply chain. Organisations that are interconnected can affect the performance of each other’s activities, e.g. in sales and research (Johnsen, Wynstra, Zheng, Harland, & Lamming, 2000). Forrester (1958, p. 37) in writing on what is now thought of as supply chain management (SCM), identified how organisational success was dependent on “interactions between flows of information, materials, money, manpower and capital equipment”. Forrester went further to argue that there was an advantage for organisations that realised the “interrelationships between separate company functions and between the company and its markets, its industry and the national economy”.

In this paper, we take the position that to successfully and effectively cascade innovation in a supply network, it is necessary for the linked organisations to apply some common principles. In the literature on supply chain management (SCM), favourable outcomes for a supply network have been attributed to reciprocal sharing of information (Ellram & Cooper, 1990; Spekman, Kamauff Jr, & Myhr, 1998; Tyndall, Gopal, Partsch, & Kamauff, 1998); sharing of risks and rewards (Cooper, Ellram, Gardner, & Hanks, 1997; Cooper, Lambert, & Pagh, 1997); supply network cooperation (Ellram & Cooper, 1990; Tyndall et al., 1998); process harmonisation (Cooper et al., 1997; Tyndall et al., 1998); incorporation of suppliers and customers in the supply network (Frohlich & Westbrook, 2001); long term relationships between supply network members (Spekman et al., 1998); and lastly having the unified aim of serving the customer or end-user (Beamon, 1999).

The SCM literature is short on information dealing with public procurement for innovation and cascading innovation in a supply network1. What literature exists is on adoption of innovative technologies by individual firms, see e.g. (Grawe, 2009; Patterson, Grimm, & Corsi, 2004; Sheffi, 2004). Therefore, the authors looked at literature from other, sometimes related, disciplines that we consider will generalise to cascading innovation in a supply network through PPI.

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1 In this paper, the authors consider the supply chain to be a supply network and use the terms interchangeably. Supply chain implies a linear relationship while supply network illustrates the connections and relationships of myriad interacting entities, see e.g. (Cox, Sanderson, & Watson, 2001)
1.1. Public procurement

Public procurement refers to the process by which public authorities, e.g. government departments or local authorities, purchase goods, services or public works from companies (TEM, 2016). This purchasing of goods and services funded by the tax payer has led to public procurement being more regulated, for example when compared to private procurement (Henriksen & Mahnke, 2005). Furthermore, Leenders and Fearon (2008) state that public procurement has historically placed emphasis on price and quality of the procured goods and services as well as on the rigor of the procurement process itself. The way a supply network functions can be influenced by policy, legislation or regulation (Franks, 2000). In Europe, public procurement is regulated at the national and EU levels. The EU’s “classic directive” (2004/18/EC) and “sector directive” (2004/17/EC on public procurement in the utilities (i.e. water, energy, transport and postal services)), have been incorporated into Finnish legislation. The legislation outlines different procedures such as the open procedure where contracting authorities publish a contract notice and all interested suppliers may submit a tender; the restricted procedure where suppliers must request, and be invited, to participate; and the negotiated procedure where any supplier may request participation and the contracting authority then negotiates the terms of the contract with the selected supplier.

In April 2016, member states are expected to adopt reformed EU public procurement directives (2014/24/EU and 2014/25/EU) which specifically speak to the ways in which public procurement can maintain its high standard and still enable innovation. The new EU directives contain adjustments to the previous procurement legislation in terms of i.a. documentation required and existing procedures, but they also introduce new practices, such as innovation partnerships, aiming to develop an innovative product, service or works and to allow the authority to subsequently purchase the resulting supplies, services or works. Lastly, the new directives no longer specifically mention lowest price as a contract award criterion. The European Commission (2016) asserts that the revised regulations are to encourage flexibility and competition, at the same time boosting innovation and value for money in procured goods, services and works.

1.2. Why innovate?

According to Pasmore (1994), Hamel and Välikangas (2003) and Franks (2000), being innovative or employing innovative processes are some of the ways organisations can prepare for change or bring about change. Organisations also adopt innovations in order to achieve higher service levels (Prahalad & Mashelkar, 2010). However, the act of adopting innovation is on its own insufficient, it is more effective when it is used and also adds value to partner firms in a supply network (Kim, 2000).

For the purposes of this paper, innovation is seen as the “implementation of a new or significantly improved product, service or process, including but not limited to production, building or construction processes, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations” (Art. 2 (22) in 2014/24/EU, and Art. 2 (18) in 2014/25/EU).

Public procurement for innovation, PPI, can be characterised as "buying goods and services in a way that stimulates the supply chain to invest in developing better and more innovative solutions to meet the unmet needs of an organisation" (Hérnandez Garvayo, 2013). PPI can drive economic growth, better public service performance, adapt to the changing needs of public service users, minimise public spending and boost service efficiency (Tekes, 2016). Other reasons put forward in support of PPI include that authorities can act as lead markets for
new technologies (Czarnitzki, Ebersberger, & Fier, 2007). In addition, the economies of scale in public sector procurement of a single procurer or through bundling can be the stimulus required for manufacturers or providers to innovate as there is a ready market (Edler & Georgiou, 2007). Barriers to adoption of innovation include the risk aversion present in public sector procurement (Edler et al., 2005).

Additionally, some authors on PPI, see e.g. (Borrás & Edquist, 2013; Edler & Georgiou, 2007; Edquist, Hommen, & Tsipouri, 2000; Erridge & Greer, 2002; Tödtling & Tripl, 2005), have documented that innovation can be stimulated from both the demand and supply side: on the supply side, a core tool is funding for R&D and training as well as tax incentives for corporations, while on the demand side, stimulation for innovation can come from policy, regulation or public procurement. As pointed out earlier, organisations in a supply network have interdependencies; it follows that public procurement triggering innovation in one supplier organisation can precipitate or cascade innovation in other organisations not directly connected to the procurer (Kaafarani & Stevenson, 2011; Vonortas & Spivack, 2006).

1.3. Purpose

In this paper we aim to develop an understanding of whether and how public procurement drives innovation, extending the notion of innovation to the supply network and to the cascading, i.e. domino effects, of innovation in the supply chain. Using information from key informants, coupled with SCM principles and revised EU public procurement regulations, we seek to answer:

a) What are the factors within which public procurement processes should function to comply with public procurement legislation while fostering innovation in the supply chain?

b) How can procurement processes lead to cascading innovation?

This is the first study in Finland that deliberately targets particular sectors, health care and energy, and investigates the factors for fostering cascading innovation through public procurement. This work deals with propagating innovation in a supply network. The subject of how organisations innovate, while connected, is beyond the scope of this paper. The interested reader is directed to e.g. (O’Brien & Smith, 1995; Webster, 2004), for work on how organisations innovate.

The rest of this paper is laid out as follows: we describe the sample set and outline the methods used in gathering and analysing data. This is followed by an illustration, based on respondents’ descriptions of supply chains in the case sectors; there after we present finding from interview data highlighting factors that affect PPI. We then contrast the current PPI situation with how it can be made more effective and end with conclusions, limitations and suggestions for future work.

2. METHOD

According to Kirk and Miller (1986, p. 9), qualitative research can be described as “a particular tradition in social science that fundamentally depends on watching people in their own territory and interacting with them in their own language, on their own terms”. Marshall (1996) goes on to say that a goal of qualitative enquiry is to “provide illumination and understanding of complex psychosocial issues and are most useful for answering humanistic why? or how? questions”.

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This study was carried out using an embedded case study approach. The embedded case study method allows for the inclusion and comparison of more than one unit of analysis, and is particularly suitable for complex and contextualised objects of research (Scholz and Tietje, 2002).

An embedded case study involves multiple subunits of analysis (Yin, 2003). In this research the unit of analysis was the activity of public procurement, with the healthcare and energy sectors in Finland as subunits of analysis, i.e. the case is defined as the procurement activity in the public context, being informed by regulation and practices, while the sectors are subunits of analysis in which the activity takes place, but is also influenced by sector-specific factors. This study is further concerned with how innovation can be cascaded in a supply network, where the network is made up of multiple organisations. Marshall (1996) advised that the research question should guide the choice of research method. For data gathering, the units of observation were the organisations within the sector. Data were collected from the units of observation through the use of semi-structured interviews with key informants from the organisations forming the sectors included in the study. The key informants were arrived at through snowball sampling; the starting point of the “snowball” was a Finland's National Emergency Supply Agency (NESA) professional with expertise in each of the sectors of interest. Each interview subject was then asked to suggest who they thought would be able to provide information based on the topic under investigation.

From healthcare, key informants were procurement professionals, medical doctors, infectious disease specialists, sales persons, pharmacists, engineers (medical devices), quality assurance managers, product specialists and lawyers. In energy, key informants also had varied roles; analysts, procurers, logistics managers, sales persons, construction managers, lawyers, risk officers, scientists, business continuity managers, project advisors, strategists and technology managers. Importantly, each key informant had knowledge or was involved in public procurement, innovation and law, all of which are components of this study. Furthermore, through the roles the key informants had in their organisations, they interacted with key informants from the other organisations in the study at different points in the supply network. Table 2.1 shows a breakdown of the type of organisation, by sector, sampled for this study.

With the permission of the interviewees, the interviews were recorded. Apart from the interviews being recorded, the interviewers also took notes and made observations. The interviews included in the study took place between May 2015 and February 2016. The authors listened to the audio recording of each interview several times and in some cases did the transcription from speech to text. The transcripts were also read several times. Research validity was achieved by reaching consensus among the coders on the interpretation of the text. After reaching agreement, the data were coded, manually to start with, into themes and subthemes. The themes and sub-themes were formed from patterns in the data identified by the authors. The themes and sub-themes were then transferred to NVivo, the qualitative analysis software tool. Other information used in the coding came from the field notes taken and observations made during interviews.
Table 2.1 Descriptive characteristics for each sector and its key informants

<table>
<thead>
<tr>
<th>Sector</th>
<th># of interviews</th>
<th>Description of organisations in case sectors</th>
<th>Description of key informant roles in organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>Twenty-two</td>
<td>Industry federation, government departments, quasi-government departments, supplier organisations (device and pharmaceuticals), hospitals</td>
<td>Procurement professionals, medical doctors, infectious disease specialists, sales persons, pharmacists, engineers (medical devices), quality assurance managers, product specialists and lawyers</td>
</tr>
<tr>
<td>Energy</td>
<td>Fourteen</td>
<td>Industry federation, government departments, quasi-government departments, producers, supplier organisations</td>
<td>Analysts, procurers, logistics managers, sales persons, construction managers lawyers, risk officers, scientists, business continuity managers, project advisors, strategists and technology officers</td>
</tr>
</tbody>
</table>

In the analysis of Sandelowski (1995) and Patton (1995), all sampling in qualitative research falls under the broad umbrella of purposeful sampling. Morse (1991, p. 129) however, describes purposeful sampling as one of four types and is used when “the researcher selects a participant according to the needs of the study”. A shared principle in all three bodies of work, is that the cases are purposefully selected to suit the study. Morse (1991) goes on to state that researchers employing purposeful sampling elect to “interview informants with a broad general knowledge of the topic or those who have undergone the experience.”

The sectors in this study were purposefully sampled, in consultation with experts from NESA and the HUMLOG Institute from the HANKEN School of Economics. NESA (2016) maintains a list of sectors that it considers critical and which should function even when there is a crisis. Energy and healthcare are two sectors NESA considers critical in relation to security of supply, and the organisations within these sectors represent different echelons of the supply network in these sectors. NESA continually reviews the preparedness of its critical sectors and this study is part of that review. A characteristics considered in sector selection was that the sectors should be crucial to the wellbeing of Finnish society. In the same vein, healthcare and energy were identified as having higher risks of potential disruption. Lastly, another consideration was that innovation in a sector’s supply chain was likely to have an impact on other sectors, e.g. innovation in the energy sector can have an impact on the agro-tech sector by way of biofuels.

3. SUPPLY CHAINS IN THE HEALTH AND ENERGY SECTORS IN FINLAND

Based on information from interviewees, in this section we chart the primary supply network members in the healthcare and energy sectors in Finland (Figure 3.1).

Data in the healthcare sector were centred on the supply of physical goods such as pharmaceuticals, vaccines, medical equipment and medical devices. The public procurer unit was typically the hospital district warehouse or pharmacy, supplying end-users (i.e. doctors and nurses) in hospitals and health clinics within the district. Information from respondents
illustrates that the distribution of pharmaceuticals in Finland is dominated by two large wholesalers, while the medical devices and equipment distribution seems more fragmented. The manufacturers of both pharmaceuticals and devices/equipment are mainly multinational or global players, who often have a local representative (e.g. subsidiary or importer) in Finland, but otherwise the production and allocation-decisions of pharmaceuticals and medical devices are taking place outside of Finland (such supply chain members are illustrated in Figure 3.1 with boxes with dotted borders). On the pharmaceutical side, it is to be the local representative who submits tenders in a public procurement procedure.

In the energy sector, the aspect discussed by most interviewees in relation to PPI was electricity and electrical power, infrastructure and means of consumption. Compared to the health care sector, the first thing to note is that the supply of power is represented as two streams; the electrical power and the means by which it is accessed. Furthermore, it is noticeable that the electrical power over the network is in itself the same, although it might stem from different production methods. The supply of electricity is dependent on the infrastructure, and a buyer cannot procure supply of power without also procuring the transmission and distribution over the power network. There are however different actors involved in both streams; this is an artefact of the deregulation of the European electricity markets a few years ago. In contrast to the health care sector, the electrical power production does take place inside and outside Finland.

Although not illustrated in Figure 3.1, decisions taken by authorities and legislators or policy makers on the national and extranational arena have an impact on the supply chains depicted here. In addition, the health and energy sector supply chains are supported by logistics and information and communication technology that link together the primary supply chain members.
4. FACTORS AFFECTING PUBLIC PROCUREMENT FOR INNOVATION

In this section, we detail some of the factors that emerged from analysis of the interview data as affecting public procurement for innovation. It is worth mentioning that the concept of innovation was not predefined by the interviewers; instead interviewees were asked their views on innovation, public procurement and any linkages between the two. Factors affecting PPI can be broadly categorised into policy and regulation, incentives, proof of concept and trials, risk appetite, cost, tender process requirements, information exchange and market characteristics. Each of these is discussed in more detail in the remainder of this section.

4.1. Policy and regulations

Policy and regulation, relating to public contracts in particular and the two sectors in general, seem to affect how innovation finds its way into and can be fostered by the public procurement process. In the Finnish energy sector, informants pointed to policy and regulation as a factor spurring innovation. Some regulations, such as those pushing for increased use of clean energy, came about as a result of other policy objectives related to climate change. Policy makers would like to utilise public procurement in identifying and using innovative solutions that contribute to the reduction of carbon emissions. This is similar to instances documented in the literature where public procurement for innovation can also be used as an instrument to achieve other policy objectives (McCrudden, 2004).

In the health sector on the other hand, policy and regulation seems to have an inhibiting effect on innovation. Due to concerns about patient safety and thus strict requirements on clinical trials and approval procedures, new product development timelines grow long. In addition, when it comes to pharmaceuticals and vaccines, Finland’s practice of securing supply by imposing on suppliers and wholesalers to keep several months’ worth of safety stocks, based on past consumption, makes up a large part of the pharmaceutical procurer’s portfolio. In addition, this practice of securing supply also has implications for cash flow and business models in healthcare. The general principles of public procurement were also mentioned by informants in the health sector as a hindrance to introducing new things; the commonly used open procedure is supposed to guide procurers in setting requirements that would enable more than one supplier to give a tender for the searched solution, but at the same time innovations, e.g. new equipment or vaccines, may be offered by only one company.

4.2. Incentives

Numerous interviewees asserted that policy alone is insufficient to promote public procurement for innovation in the supply chain. In order for organisations to not only innovate but also propose innovative solutions, they must appreciate that there are other benefits for them, especially financial.

According to some of the informants, in the energy sector the carrot has proved mightier than the stick in the last few decades. The financial incentives for renewable energies have increased the share of wind and solar energy production in Europe, bringing in new solutions and products for energy production. The incentives for production have driven the innovations on the supplier side to create a greener market offering.

Additionally, the soon to be adopted EU directives make special mention of updating the public procurement process to facilitate the participation of small- to medium-sized enterprises. Informants in the energy sector noted how SMEs may have innovative ideas but find that
entering into tenders for public procurement requires what is to them large amounts of time and money. These are precious resources for many SMEs. However, offering incentives such as piloting, partnering and retention of intellectual property rights (IPR) encourages SMEs to take part in public tendering. For many Finnish SMEs, IPR can be used as a part of other solutions which can then be sold in other markets.

4.3. Proof of concept and product trials

A point that emerged in some interviews in the energy sector is what they referred to as the Finnish mind-set that leaned towards perfection and unease with failure. Informants reported that innovators in Finland wanted to bring to the public a “perfect” product; this means that if innovators deem their product not ready, they were unlikely to propose it as a solution.

This is where procurer-supplier piloting or proof of concept comes in. Piloting deployment of a new solution, perhaps with a cost sharing arrangement, allows for out of lab testing and improvements, demonstration of new solutions to other potential customers and the suitability of a solution to an articulated need. Further to this is that innovators need to understand that not all innovative solutions will be a success.

Product trials are allowed, and important for innovation, in the health care sector also, but the trials and test of new products are separate from the procurement procedure, since the products put in as tender must be mature. The product trials do not guarantee a future contract for the supplier, but information about the market offering may go into the public procurement process via the feedback loop between the end-user and the procurer.

4.4. Risk appetite

Separate but still connected to the previous point is the energy sector's ability to mitigate risk by having trial solutions in the real world. Piloting a solution requires cooperation between the procurer and the supplier. Public authorities can act as lead or example markets for innovative solutions. This has several advantages; risk and cost sharing between procurer and supplier, a demonstration of new products or services for other potential customers, a learning opportunity for users and the chance to test and improve the solution in the real world. In fact, Finland has established practice in public procurers and consumers being lead users for innovative products that were later diffused to the wider market (Czarnitzki et al., 2007).

Informants in the energy sector stated how their likelihood of proposing and using innovative solutions is affected by their having to fulfil conflicting demands. Interviewees reported that while they were urged to be more innovative, they were also bound by existing service level agreements related to security of supply. This contributed to their risk aversion in trying out new solutions. However, energy sector organisations pointed out that societal attitudes have in the past and can in the future influence innovation and adoption of new products, services and processes; for instance, sufficient demand from end users. This means that for the market to achieve critical mass there should be enough customer demand, which also means that a location would need to have enough like-minded potential customers. Interacting with customers in new ways is likely to bring about the use of innovative business models. The critical mass could be sparked by public procurement hence mitigating some of the risk.

Another issue mentioned in health care was related to the contract side of the process. Public procurement processes can be lengthy, but when the contract is awarded, suppliers need to be ready to meet contract requirements within a very short time. In order to avoid penalties, suppliers might need to build up a local storage although they are not yet guaranteed the contract. This adds risk on the supplier side and might inhibit them from submitting a tender.
New contract models that would enable the supplier to build up storages after the awarding of the contract, or to secure availability of goods in the first months of the contract period in more flexible ways, could better balance the risks of the provider and the procurer.

4.5. Information exchange

The new EU directives aim to simplify the competitive dialogue procedure, as well as enable innovation partnerships between the demand and supply sides. This level of dialogue acts as a route for information exchange. Both energy and health sector informants asserted that being better informed about public authority long range plans meant that they could also plan better for the inclusion of innovation in their strategy as some innovations had long lead times and high costs. For procurers, dialogue with suppliers served to inform them of what solutions were available and at what stage of development.

Informants in both sectors admitted that innovation, or the knowledge of new solutions, was affected by organisational structures and siloes. They added that more dialogue and therefore understanding between subject matter experts and procurement experts would help to lessen the risk aversion many times associated with the public procurement process. Specialist knowledge in specific areas of actual innovation and in the area of procurement is fragmented within an organisation. Coordination between different departments can at best foster innovation by making explicit the needs of the functional area and coding them into requirements for solution by the procurement expert.

While the upcoming legislation was hoped to bring about more innovative partnering, some informants said that while officially a new tool is added to the public procurement tool box, the possibilities for similar dialogue have existed before. According to this view barriers to adopting these existing approaches have been insecurity and risk averseness. For many informants “the market court” is something they would rather avoid. For example, the current legislation does not, as interpreted by the informants in this study, forbid the procuring entity to engaging in dialogue with potential suppliers prior to setting out a tender, even if after the tender is out, they are bound by law not to discuss with potential suppliers. In the health care sector however, open and restricted procedures were the ones described by informants when asked to describe their procurement process. Hence while the new legislation might promote competitive dialogue and information exchange across silos, the existence of the tool might not necessarily break the cycle of caution.

4.6. Cost

Cost is an aspect that affects public procurement at different points in the procurement process. To start, both procurers and suppliers are affected by prevailing economic conditions and budgetary constraints (Caldwell et al., 2005).

For procurers, budget limits influence how much they can spend on purchasing goods and services which may lead to their selecting what appears to be the cheaper solution. However, considered over a longer period, such a solution may end up having a higher total life cycle cost. The new directives advise procurers to take into account long-term financial benefits in evaluating tenders.

Supplier informants asserted that cost is likely to trigger innovation in more than one area. On the supplier side, financing the development of innovation had a bearing on their investment in

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2 The Market Court is a special court hearing market law, competition law, public procurement and civil IPR cases in Finland
innovation. This is especially relevant if there does not seem to be a guaranteed market for an innovative product or service. Some form of cost or risk sharing, e.g. piloting a solution, was proposed as a resolution that could spur innovation.

### 4.7. Requirements setting and awarding of contracts

Procurement has become more professionalised in recent years in terms of operationalising needs and standardising procedure. This has however also increased the length and rigidity of the procurement process. In the health care sector, several informants pointed out that the public procurement legislation adopted in Finland is stricter than when compared to other countries. This discouraged suppliers from suggesting innovative solutions to problems. Collaboration, information sharing and dialogue were named as factors in overcoming this. Collaboration in the form of partnering among many organisations to deliver one contract was also claimed to be one path in which innovative solutions could be brought to market.

### 4.8. Market characteristics

Finally, the size and structure of the market seem to have an impact on the fostering of innovation through public procurement processes. For the health care sector, the Finnish market is small compared to other markets, and companies providing pharmaceuticals and medical devices are often global players. They might not be motivated to innovate for the Finnish market specifically since it has only 5.5 million potential beneficiaries.

Both the health and energy sectors are dominated in some echelons of the supply chain by a few actors. The informants communicated that there seems to be an ongoing trend to consolidate and create larger buyer organisations with more bargaining power in order to lower the price. This might however make it more difficult to distinguish individual needs.

### 5. CASCADING INNOVATION IN THE SUPPLY CHAIN

In the preceding section, we identified factors currently affecting public procurement for innovation. In this section, we will first present examples of the current paths for adopting innovation through public procurement in the health and energy sectors. Then, using the factors presented in section 4, supply chain management principles discussed earlier and the revised EU directives on public procurement, we analyse how innovation can be cascaded in a supply network.

#### 5.1. Current paths for public procurement for innovation in the health and energy sectors in Finland

With information from interviewees and from legislation, in figures 5.1 and 5.2 we show the possible paths for cascading innovation through public procurement in the health and energy sectors respectively. These paths have been depicted as a process culminating into a market offering for goods, services or works that can be used by the public. Both figures show simplified versions of the current public procurement procedure as described by key informants in both sectors.
Figure 5.1 Interaction between public procurement and the development of a market offering in the health care sector in Finland

From Figure 5.1, the health care public procurement process starts with the identification of needs, which then leads to a decision to tender, followed by market research, setting of requirements, announcement of the tendering process, receipt and comparison of tenders, formulation of a contract, ordering and finally use of what has been ordered. Running parallel to this process is development of innovative solution or product of the potential supplier that starts with need identification, a decision to develop a solution, solution or product development, clinical testing, market approval and market offering. The market offering goes into the procurement process as a tender, if it fulfils the requirements.

Before setting the requirements, the procurer may carry out market research to learn about available products on the market, and even products in development. The procurer often also speaks with end-users, i.e. doctors and nurses, who are subject matter experts. Besides the goods that come to the end users through public contracts, other new market offerings may be tried out in the hospitals in small volumes. In addition, hospitals can cooperate with manufacturers in the clinical testing phase of the product development process, which is illustrated in Figure 5.1 as clinical trials at the hospital. The end-users experiences from these alternative products (i.e. not procured on the basis of public contracts) might later transfer to the requirement setting stage of the procurement through information exchange between procurer and end-user.

Figure 5.2 Interaction between public procurement and the development of a market offering in the energy sector in Finland

Figure 5.2 shows that in the energy sector also the starting point for the procurement process is needs identification that results in a decision to tender, followed by market research, setting of requirements, announcement of a tendering process, receipt and comparison of tenders, and finally the contract. Meanwhile, solution development for energy providers also starts with needs identification, followed by the development of a market offering, which might have to go through a market approval process, before there is a market offering that can be submitted.
to the tendering process. The awarded supplier then enters into a contract with the public procurer, after which electricity is distributed and used.

5.2. Cascading innovation in a supply network

In this section, we analyse how innovation can be cascaded in a supply network, using the factors presented in section 4, supply chain management principles discussed earlier and the revised EU directives on public procurement. The reader should note that as stated earlier, organisations in a supply network are linked. Therefore innovation in one organisation can lead to innovation in organisations in the same supply network but that do not interface directly with the (public) procurer. This is how innovation can be cascaded in the supply chain via public procurement.

There are some differences between the two sectors. In the energy sector, the primary “product”, electrical energy, remains unchanged. This is especially so from the end-users’ perspective. This is in contrast to the health sector where interviewees talked about development of a range of different products and solutions that reached the end-user. In the energy sector discussions of innovative solutions related more to processes (e.g. smart grids) and infrastructure (e.g. localised energy production) than to the “product” provided. For the end-user, the use of alternative forms of electricity may not be as complex as for product trials and clinical testing in the healthcare sector. Nonetheless, the energy sector also has points at which the procurement and adoption of innovation can be affected, which then leads to cascading innovation in the supply network. These points have to do with the sources (e.g. renewable energy), distribution (e.g. smart grids) and to a lesser extent consumption (e.g. smart buildings or devices) of energy. Key informants asserted that integration of non-controllable sources of energy, e.g. solar and wind, into the existing grid would require changes to the grid. While such changes would require large investments, this also requires innovation in production and distribution of electrical power thereby cascading innovation in the supply network. Innovation in generation would cascade to the rest of the supply network in distribution and even metering.

Related to this, public authorities have other policy objectives, e.g. emissions reductions, where PPI can be part of the solution. The new EU directives no longer specifically state lowest price as a contract award criterion, and public authorities may therefore, to a larger extent than before, award a contract to a higher priced bid that fulfils requirements and helps them meet other policy objectives. Additionally, initial investment and production costs for renewable energy from solar and wind could be offset by use of innovative partnerships with cost sharing of risk and rewards between supplier and procurer.

From the parallel processes outlined in the previous chapter, there are various points at which PPI can influence cascading of innovation in the supply network. One point is during need identification and before setting of requirements. At this point the procurer can conduct market research to learn about products available on the market and products in development. This may lead to procurers asking for more information from potential suppliers. Knowledge exchange between procurer and supplier may lead to better understanding of needs leading to development of innovative solutions that can later be tendered. Key informants pointed to long-term relationships, a SCM principle, as enabling better information exchange between parties involved. Also, knowing that there is a ready market for innovative solutions can act as an incentive for first tier suppliers and their suppliers to invest in innovative solutions (Kim, 2000).

Procurers in both sectors reported that possible triggers for procurement activities were contract end-of-life or perceived needs from end-users. This means that procurers interact with end-users, e.g. doctors and nurses in healthcare, who are also subject matter experts. Using
**competitive dialogue**, procurers can act as middlemen between end-users and suppliers; the procurer’s role can be in getting end-user needs directly to the supplier and also in using their expertise to translate end-user needs into requirements suitable for tender. This is another point at which public procurement can act to spur innovation at different levels of the supply network. Incorporating customers involves going beyond the first tier supplier and procurer interface and is a way cascading innovation in the supply network.

Some informants claimed that support from political leadership could act as encouragement for public procurers interested in seeking and adopting innovative solutions. A visible display of political will for innovation also sends a signal to the wider supply chain, beyond the procurer and supplier, thereby helping to cascade innovation in the supply chain. In addition to shaping supply, the regulations can also specify what and how public entities should procure, shaping the demand from the public side. This way the demand from the public sector gives inventions a market to become innovations, or even drives for completely new solutions.

In both sectors, in addition to the development of market offerings, key informants spoke of some innovations not be directly linked with the public procurement process, i.e. solutions not procured by the public authority. For example wholesalers in the health care sector mentioned that they focus on developing services for both the preceding and subsequent tiers in the supply chain. Another example is that both energy and health care organisations in the public sector engage in development projects together with industry, but that is outside the public procurement process. However, such collaboration contributes to strengthening the supplier-procurer relationship for the longer-term which may be used to advantage in the formal public procurement process. When the new EU directives are incorporated, such collaboration can be formalised and undertaken in the form of innovative partnerships, and the outcome of the partnership directly procured by the public organisation.

### 6. CONCLUSIONS

New rules in on public procurement are expected to change the landscape of public procurement in general, and for innovation in particular, in the European Union. In this work, we have identified factors which affect public procurement for innovation in two sectors in Finland; healthcare and energy. Using this information, practice from supply chain management and information from revised EU directives on public procurement, we provided insights into how innovation can be cascaded in a supply network.

The upcoming legislation change and the discussion it has raised on public procurement for innovation makes this study timely. The study raises awareness of the interlinkages in of the public procurement processes and the supply chains in the health care and energy sectors. The study points to what actions organisations can take to increase adoption of innovative solutions in line with the aims of the new EU directives, of helping to solve societal challenges or to support the Europe 2020 strategy for smart, sustainable and inclusive growth.

Innovation, broadly defined, may happen at any tier in the supply chain, but there are limited formal entry points for a new market offering into the public procurement process. In the Finnish context, there is an awareness of the need for innovation and its associated benefits and yet informants contend that more could be done to use public procurement as an instrument to foster innovation and cascade it in the supply network.

Innovation cuts across numerous subject areas, involves many organisations and is governed by authorities and rules at various levels. Public procurement for innovation needs to be dealt
with in an overlapping space that has a combination of know-how, policy and political will. Different public authorities may have differing primary policy goals to meet. Alignment, to some extent, of some of these policies, including that of innovation may aid in cascading innovation of the supply chain. With this approach, it is possible to effectively utilise public procurement for innovation as a policy goal in itself, as well as to meet other policy objectives such as increased competitiveness and job creation. Public procurement authorities have the possibility to harness the economies of scale possible through public demand and public participation in fostering innovation.

This study contributed to the literature on innovation in supply chains through linking the legislative aspects with the supply chain perspective. This led to the identification of eight factors in the health care and energy sectors in Finland that affect PPI. These factors are interlinked, and also help to highlight how public procurement can happen in order to both comply with legislation and to foster innovation. The study also resulted in the mapping of the connection between procurement and innovation in the case sectors.

6.1. Limitations and future research

This paper presented results from the initial part of an ongoing, longitudinal study about public procurement for innovation. The study is limited by the fact that not all data points identified through the snowballing sampling method have been interviewed. Later parts of the study will gather more data from the sectors included in this paper, and will also expand the study to a third, yet to be identified, sector. Detailed mapping and contrasting of public procurement for innovation of the three sectors will then be carried out.

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THE VOLUNTARY DEFENSE ORGANIZATIONS CONTRIBUTION TO PREPAREDNESS NETWORKS

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ABSTRACT

Purpose
The study analyzes the contribution of the voluntary defense sector to emergency preparedness networks and ongoing crises in developed countries. By analyzing the Swedish system, the study shows how the voluntary defense organization contributes in terms of providing physical resources, capabilities and physical work in crisis.

Design/methodology/ approach
This is a qualitative research study built on primary information from personal interviews and secondary information from relevant documentation. It is based on a literature review from emergency preparedness, the voluntary sector, network and relationships.

Findings
The study provides three main findings. First, the voluntary defense actors, resources and activities are part of a wider structure i.e. military and civilian. Second, although the military and civilian actors are part of the same network the system is not very flexible and different parts follow different logics. Third, the current type of risks and threats justifies the need to combine the civil and the military resources in an overall purpose including the voluntary sector.

Research limitations/implications
The research embodies an empirical study and provides the basis for future research not only on the contribution of the voluntary defense, but on the voluntary sector in general. Further development of the network in connection to the voluntary structures, can provide a research agenda for academics and applicability in the emergency preparedness field.

Practical implications
This study offers guidance to legislators, military commanders and managers to overcome existing challenges, encouraging voluntary organizations to integrate in networks and adapt their relationships in ongoing crises.

Original/value
The study brings new insights into the preparedness by studying voluntary organizations in developed countries. The use of the network can bring understanding for developing the relationships of actors, resources and activities in diverse situations.

Keywords: Emergency preparedness, Voluntary sector, Network and relationships

Paper type: Research paper
1. INTRODUCTION

The voluntary sector is commonly analyzed as a source of wealth in most developed countries including Sweden (Lundström and Svedberg, 2003). The voluntary organizations are frequently analyzed in terms of membership, participation and volunteering in democratic structures (Sivesind, Lorentzen, Selle and Wollebæk, 2002; Wijkström and Einarsson, 2006). The sector often acts not only as NGOs, foundations and religious communities but also more collectively through stable networks and in temporary settings (Sweden Statistics, 2015, p. 11). It is also one of the fastest growing segments of the economy (Kendall, 2003). In Sweden, there were a total of 92,500 voluntary organizations registered in 2013. The number of organizations in the sector regardless of activity amounted to 232,000 (Sweden Statistics, 2015, p. 89). These large numbers of organizations make it more difficult to model and grasp relationships (Axelsson and Easton, 1992).

Empirically, there is a need of development inside as well as outside organizations in terms of developing and managing their performance (Wijkström and Einarsson, 2006). Thus, focus is on the network and the relationships in emergency preparedness. The emergency preparedness network covers all involved actors in the preparedness and ongoing crisis (Kaneberg, Hertz and Jensen, 2016). In preparedness actors are involved in planning, training and exercising, followed by the acquisition of equipment and services to support emergency response (Perry and Lindell, 2003). In ongoing crises, actors are involved in mobilisation, registration, evacuation, sheltering, emergency medical care and after care (Boin and McConnell, 2007).

The voluntary defense forms part of the total voluntary sector and is separated from the state, the market and the household (Lundström and Svedberg, 2003). Organizations are acting in common interests but are challenged due to different ambitions of collaboration in the civil and military sphere (Heaslip and Barber, 2014). Considering the theoretical attention given to different ambitions and the military resources use in crisis it is not surprising that emergency preparedness research continues to produce mixed findings (Kisangani and Pickring, 2007). This has been apparent in several disaster responses in Sweden e.g., the Västmanland forest fire in 2014, and Storm Gudrun 2015 (Strömberg, 2015). Addressing challenges, Tatham and Pettit (2010); Hertz (2001), are delimiting the networks to improve the efficiency and effectiveness. However, crisis response networks are still challenged concerning their efficiency and effectiveness in developed countries (Boing, Hart, Stern and Sundelius, 2005).

The voluntary defense organizations (FFO)1 are designed and organized to be related to the responsible authorities for the total defense purposes (Körlof, Lagerblad, Lundgren and Wahlberg, 2014). In total, there are 18 organizations (Regulation 1994:524). The voluntary defense organizations cooperate within the framework for voluntary defense organizations cooperation (FOS) and have today about 400,000 members together (SOU 2014:73). The FFO organizations have resources to perform defense education, recruitment and training activities (Körlof et al., 2014). They are aligned in the structures of the armed forces and the emergency preparedness (Cross, 2012; Heaslip, Sharif and Althonayan, 2012). A major question is whether traditional academic views can explain how defense voluntary actors not only become involved in the preparedness networks, but how they can adapt in relationships responding to ongoing crisis (Jahre, Jensen and Listou, 2009). From the many challenges, existing networks are demanding different types of voluntary contribution (Rotolo and Berg, 2010).

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1 FFO is the recognized acronym for the voluntary defense organizations in Swedish. “Frivilliga försvarsorganisationer” governed by Regulation (1994:524) on voluntary defense (according to KKrV 2014)
might entail providing physical resources, planning capabilities or physical work during responses. Additional research in emergency preparedness is thus wanted in order to consider the particularity of dealing with networks based on different operational views, the military and the civil (Jahre et al., 2009). Integrating empirical insights from the voluntary defense sector and the theoretical field of emergency preparedness and network will contribute to both.

**Purpose**

The study analyzes the contribution of the voluntary defense sector to the emergency preparedness networks and ongoing crises in developed countries.

**RQ:** How do the voluntary defense organizations relates in networks to contribute to the preparedness and ongoing crises in terms of resources and activities?

The paper is organized into six sections. Section two is dedicated to a literature review within the emergency preparedness in which the voluntary defense sector is related to networks and relationships. Section three provides a description of the methodology in use. Section four provides a review on the empirical findings, about the voluntary sector combining different networks and different planning structures. Section five provides an analysis. Sixth section presents the final conclusions and future research.

2. **THEORETICAL APPROACH**

Within research on the emergency preparedness of developed nations, this study analyzes the voluntary sector as a part in preparedness networks and the relationships in ongoing crises. The FFO are actors in the Swedish system, who deliver resources and activities crucial to preparedness (Wijkström, 2000). The network view is employed to understand the essential relations in preparedness and ongoing crisis (McConnell and Drennan, 2006). In the network, actors, resources and activities (ARA) are framed in physical and organizational types (Gadde, Håkansson, Jahre and Persson, 2002). Areas to be considered are therefore: the emergency preparedness (Van Wassenhove, 2006; Boin and Lagadec, 2000); the voluntary sector (Nugroho, 2011) and defense voluntary sector (Samuelsson, 2005); and the network and relationships (Tatham and Pettit, 2010; Hertz, 2001; Axelsson and Easton, 1992).

2.1. **The emergency preparedness**

Emergency refers to predictable faults and failures with large impacts on large populations. Preparedness deals with national readiness combining; flexibility, improvisation, skills, networks and relationships (Boin and Lagadec, 2000). Networks in this context support three kinds of flows- material, information and financial- and requires careful and close coordination (Van Wassenhove, 2006). In emergency preparedness, planning and managing crisis is a vital part of institutional and policy toolkits. Converting this ideal into practice however, has proved to be difficult as planning for crisis requires integration and cooperation across multiple networks (McConnell and Drennan, 2006). One trend evident in developed nations, including Sweden (Lundström and Svedberg, 2003) is the emphasis on preparedness related to terrorism, chemical, nuclear, and technological threats (Lindell, Perry and Kathleen, 2001). According McConnell and Drennan (2006), these threats place great demands on available resources. A key premise dealing with planning (Alexander, 2005), is that each individual organization grows important links with other actors in its environment (Håkansson, 1988). In Boin and Lagadec (2000), preparation for dealing with current threats is more than just planning demanding a combination of civil and military resources. This issue set focus on a new way of
thinking and training to cope with effective responses, embracing strategies for organizational flexibility (Boin and Lagadec, 2000). A key question in understanding the difficulty for preparedness is why policy makers generally fail to see crisis. A core claim in Boin, Hart, Stern and Sundelius (2005), consists of two major points; first, it is nearly impossible to predict with any accuracy when and where a crisis will strike; and second, it is impossible to grasp the dynamics of a crisis once it becomes obvious. Due to that, policy makers are easily trapped between conflicting duties of highly unclear and dynamic situations and their ability to produce and revise adequate calculations.

2.2. The voluntary sector and the voluntary defense organizations

The voluntary sector according to Nugroho (2011), is also known as the third, non-profit sector, which has increasingly gained attention in research, and has become essential in social, as well as economic and political dynamics, in developed economies. The voluntary sector arrival and effective integration in public policy, is one of the fastest growing segments of economy (Kendall, 2003). According to Salamon and Helmut (1992) the voluntary sector is taking on an increased role in developed countries e.g., the United States, Japan, the United Kingdom, Europe and Australia, for purposes of bringing efficiency to their welfare. Thus, the need for volunteers contributing to preparedness is unlikely to decline given rising concentrations of people vulnerable to emergencies (Perrow, 2007). Building on Wijkström (2000) the Swedish voluntary sector engages 90-95 percent of the population as members in at least one association. Sweden differs from other countries in terms of resources in fields regarding, culture, education, recreation, religious, labor, defense and business associations (Wijkström, 2000, p. 161). Since it has a very large voluntary sector Sweden can act as an interesting comparison for other countries where the sector is growing (Lundström and Svedberg, 2003).

There are three separate sections of law regulating the voluntary resources. In Swedish Act (1992:1403) on total defense and increased readiness, "activities necessary to prepare Sweden for war" total defense consists of military activities (military defense) and civil activities (civil defense). The Swedish voluntary defense organizations (FFO) are regulated by regulation (1994:524) to promote activities, recruits and trains volunteers in for tasks of the total defense. An organization that conducts voluntary defense is in accordance to this regulation voluntary defense. Thus, the voluntary defense organizations are considered in this study according to the regulation. There are 18 voluntary defence organizations, not only promoting the Swedish total defense, but according to Körlof et al. (2014), the voluntary defense actors has special status in the emergency preparedness. As they are contributing to bringing resilience into emergency operations as a condition that still arises out of military supply chains (Graham, Heaslip and Barber, 2014, p. 65). A vital actor in Sweden agreeing with Samuelsson (2005) is the Armed Forces. The Swedish Armed Forces (SAF) are regulated to provide support to government agencies, municipalities, county councils and individual in Swedish law (2002:375), in connection with major extraordinary emergencies. An example of this corresponds the SAF support to the police law (2006:343). This law contains provisions on the Armed Forces’ support to the Police Authority and to the Security Service at terrorism in activities that may involve use of force against individuals. Other support regards tracing of missing persons and disposal of ammunition, and support in larger crises e.g., in big events such as Storm Gudrun in January 2005, high water in Småland in July 2004, and oil recovery in Skåne, June 2003. According to

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3 Act (1992:1403) on total defense and preparedness. In total defense "activities necessary to prepare Sweden for war

4 Regulation (1994: 524) on the voluntary defense
Samuelsson (2005), the military activities in support to civil society is vital ground for the voluntary defense sector. The Swedish Home Guard is part of the Armed Forces, with clear territorial focus and vital duties when the SAF provide support to civil society in emergencies. The home guard is vital for the FFO as they are delivering resources and knowledge to their battalions (Samuelsson, 2005). In the view of Grant (2010), FFO are important resources in the civil defense and often challenged by new threats impacting their goals of remaining competitive and attractive in the recruitment of volunteers (Rotolo and Berg, 2010).

2.3. Networks and relationships

The network view is based on relationships between actors, resources and activities (Håkansson and Snehota, 2006; Håkansson & Johanson, 2002). The network is delimited in dimensions such as social, technological, legal and administrative (Tatham and Pettit, 2010; Hertz, 2001, p. 239). It is often related for purposes of efficiency based on economic motives of exchange (Christopher, 2011; Van Wassenhove and Tomasini, 2009). However, in the view of Axelsson and Easton (1992) exchange does not have to involve an economic component, as there are other dimensions in which exchange may take place. Research on networks has for example focused on effective responsiveness (Van Wassenhove, 2006).

![Diagram of the ARA model](image)

Figure 2.1 The ARA-model: Source: (Håkansson, 1987, p. 17)

Thus, networks has been seen as a set of effective interconnected relationships whereby one relationship is dependent upon exchange in another (Cui and Hertz, 2011; Jahre and Jensen, 2010; Hertz, 2006). Networks consist on relationships that implies adaptation between connected organizations. Networks can be structured in permanent relations between the permanent and temporary networks created once a crisis occurs (Jahre, et al., 2009). Though, relationships need to be adapted in the network in order for the emergency system to function (Fenton, Passey and Hems, 1999). Two concepts seem particularly promising in terms of describing a network; first is the view of Håkansson and Snehota (2006) arguing that the relationships in the network must be properly understood; second is the view of Axelsson and Easton (1992), concerning the network relationships need to gradually evolve over time. These concepts involve actors, resources that are embedded in the activities of the other actors, and
which are considered as elements, in which organization are actors that use diverse resources to perform its activities, according to Håkansson (1987).

The outlined network in Figure 2.1, is called the ARA-model, in terms of Actors, having Resources related to each other in a network of Activities (2006; 1995; 1988). In it, resources and activities are considered completely intertwined, because according to Gadde et al., (2002), resources are necessary for the expected activities and have no value unless they are activated. Those are divided into physical and organizational types. Crucial for the network are facilities, products, business units and business relationships. In terms of strategic importance, relationships in collaborative purposes should be of special concern to managers (Smith and Laage-Hellman, 1992). Thus, the link between strategy and network frequently represents a major implication as strategic action is not limited to the focal firm but involves the network as a whole and assumes a mixture of cooperation and competition characterizing all firms’ relationships.

2.4. Summary

Within the boundaries of emergency preparedness, dealing with current risks and threats, those often demands a combination of resources (Boin and Lagadec, 2000). The network can be used to understand the FFO relationships in the Swedish preparedness system to aid civil society (Grant, 2010). In order to bring a better description about relationships, the network is providing structure for analyzing the relationships of actors, resources and activities (Håkansson and Johanson, 2002). This view can be applied to the preparedness and in ongoing crisis (Jahre, et al., 2009).

3. METHODOLOGY

Using a qualitative approach, this study focuses on the voluntary defense sector contribution to the emergency preparedness and to ongoing crisis. Yin (2002) argues that documentary information is the basis of evidence in research as long as the documents are correct and not biased. However, this view represents a difficulty if the articles used have not been written for the same purpose in the study or aim to reach different audience (L’Hermitte, Bowles, Tatham and Brooks, 2015). This is the case when understanding the voluntary sector in Sweden. This study builds on previous secondary materials from different sources such as; the FFO, the SAF, MSB, and other relevant actors engaged in the Swedish system. A smaller part of data pertains to the military and regulations or policy documents but are still necessary for building our overall understanding. An extensive use of secondary information is considered appropriate by Yin (2002), as it supports the study’s validity and trustworthiness. Thus, secondary data is based on a wide portion of articles, journals, magazines, homepages reports, regulations, statistics, and newspapers, aiming to confirm important assumptions and to create deeper understanding of the topic, such as; FFOs own specialized newspaper, home pages and articles in the specific fields.

In terms of quality, following Yin (2003), the study strengths have been the relatively easy access to organizations. Further, FMV, MSB, FM, SHV have contribute with valuable information about respondents and contact information. The selection of the FFO was considered appropriate as they represent a significant share of the total voluntary sector in Sweden and help to delimit the amount of information.

Concerning reliability and validity, Golafshani (2003) targets those concepts which for the study are reflected in combination of ways of establishing truth, i.e., academic studies,
secondary materials and personal interviews. Regarding the interview process there were twenty-five personal interviews conducted with representatives from FFO and other related organizations to FFO. The views of the actors, were gathered based on an interview guide and questions in three main areas: (1) general backgrounds and information about the organizations involvement in the networks of the system, (2) organizations resources and capabilities and their specific contribution to the emergency system, and (3) type of activities and collaboration with other actors activities, current and future challenges in the networks of both preparedness and ongoing crisis. The actors selected for the interviews correspond to; FFO organizations and other involved organizations with important approach in the relationships of the Swedish system (Table 3.1).

Anonymity was indispensable to guarantee the quality of the information. Following Bower and Gasparis (1978), respondents will tell a truer story and act with less reserve if they believe that what they say or do will be held in strict confidence. Thus, to protect respondents’ views in citations, their names were replaced by a given reference number in according to structure in appendix 1. Respondents’ views will not change the structure per se, but instead are vital for the development of the existing relationships.

Table 3.1 Study selected organizations and relationships

<table>
<thead>
<tr>
<th>Organizations name in Swedish</th>
<th>Acronyms</th>
<th>Association</th>
<th>Relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frivilliga Automobilräkens Riksförbund</td>
<td>FAK</td>
<td>Voluntary defense</td>
<td>FFO</td>
</tr>
<tr>
<td>Frivilliga Flygkåren</td>
<td>FFK</td>
<td>Voluntary defense</td>
<td>Related in relations to FFO</td>
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<tr>
<td>Frivilligas Samarbetskommitté</td>
<td>FOS</td>
<td>Voluntary defense</td>
<td></td>
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<tr>
<td>Frivilliga Radioorganisationen</td>
<td>FRO</td>
<td>Voluntary defense</td>
<td></td>
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<tr>
<td>Flygvapenfrivilligas Riksförbund</td>
<td>FVRF</td>
<td>Voluntary defense</td>
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<tr>
<td>Försvarets Personaltjänstförbund</td>
<td>FPF</td>
<td>Voluntary defense</td>
<td></td>
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<tr>
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<td>Voluntary defense</td>
<td></td>
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<tr>
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<td>SVK RF</td>
<td>Voluntary defense</td>
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<td>SBK</td>
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<td>Svenska Fallskärmsförbundet</td>
<td>SFF</td>
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<td>Voluntary defense civil NGO</td>
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<td>Försvarsmakten</td>
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<td>FMV</td>
<td>Civil authority</td>
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</table>

4. EMPIRICAL FINDINGS

This study is designed to bring understanding into the field of emergency preparedness based on the network of actors, resources and activities. Building on collected secondary materials and interviews with key actors in the system, the research question can be addressed.
4.1. The actors: civil and military

Current risks and threats are often demanding a combination of civil and military resources in an overall response. The network view can provide a basis for understanding the structure of actors in civil and military arrangements. In the view of respondents, several actors are connected in networks and are challenged not only due to unclear direction, management, planning, financing and control, but their ability to perform activities efficiently responding to current threats and crisis. In this regard, the FFO have described their involvement in several networks and challenges in their relations with other related actors:

The Voluntary Resource Group (FRG) is a network at the municipal level. The group is available to the municipality when the ordinary resources need to be reinforced. Voluntary resources are requested by municipal management when something extraordinary happened e.g., to help with evacuations, information, administrative and other practical activities. Even charitable assistance to victims is a task for FRG members. FRGs involves various NGOs, with experience, education and resources to cope with emergency tasks. There are today about 125 organized groups in 110 municipalities, but the overall goal is to have at least one group in each municipality: “FRG is a very important network for the FFO, while they are central figures in exercises and training, there have been little exercises together... We try to have the FRG in exercises and more often in training programs e.g., management exercises, table top exercises where FRG do not really have a role...we have still not involved them directly into leadership areas” (reference no.10 and 11 of 1 Dec. 2015).

The Swedish Contingencies Agency (MSB) has not only been assigned to collaborate with involved actors and to assist them in developing forms of work structures, but to build the emergency preparedness system. The Swedish government has set up areas of cooperation and coordination under the “Ordinance (2006:942)”. MSB supports and manages the FFO and coordinates their functions in specific activities. However, there were significant shortfalls and skills gaps across the sector, described as anticipating shortages in their management: “as voluntary organizations develop new services and projects they apply for finance and new proposals. However, our skills may not be required and we may be required to change. Though, due to rigid management, MSB responsible for the coordination of emergency preparedness, is completely missing the point and hinder the expected development of voluntary defense skills e.g., by endless documentation processes, inadequate system and high number of supervisors with little knowledge on voluntary defense sector conditions” (reference no.23 of 21 Dec. 2015).

The Swedish Armed Forces (SAF) has been assigned as responsible for considering the FFO in the total defense planning. While they are emphasizing means for the provision of resources and activities, their unique capabilities are required in the system. “The SAF stated that the FFO have several important resources and stressed in particular the strategic importance of their activities including the recruitment of young people as key resources. The FFO provide a broad set of knowledge and competence to the system. We provide a cost effective contribution to the military and the civil preparedness as our main task” (reference no.5 of 24 Nov. 2015).

The Home Guard (SHV) is a very important group that guarantees the FFO’s existence. “The Home Guard engages today 22 000 forces, thereof 5 500 positions consist of FFO” (reference no.2 of 17 Nov. 2015). The Home Guard with the national security forces is part of the SAF’s mission-based organization. The Home Guard operates over the entire conflict scale, during great strains in peacetime to armed combat in times of war. “Our units in the Home Guard have a response capability that is measured in hours. The personnel is made up of locally recruited volunteers and consists largely of experienced soldiers and officers with a background in
mission-based units” (reference no.22 of 18 Dec. 2015). The Home Guard units often support the police and Rescue Services in forest fires, flooding or searches for missing persons. “Our personnel includes those who have completed their basic military training, and includes a large amount of specialists, for example, paramedics, motorcycle and dog trainers, who are recruited and trained by the FFOs” (reference no.19 of 9 Dec. 2015).

The Swedish Defense Materiel Administration (FMV) is responsible for the logistics of the SAF and provides facilities, products, business units and business relationships. FMV is included in a wide network within the industry in order to provide the SAF with military goods and services. While the FFO is in need to develop their relations with the FMV for the benefit of both, collaboration with FFO differs not only in its overall volume, but also in its distribution across activity fields. If the ruling constitution, which is now 25 years old, is actualized, it ought to result in increased collaboration not only between FMV and the FFO but with SAF and MSB. Respondents considered that increase relations are a challenge due to lack of overall structure. “New areas of activity can be more effective through an extensive collaboration in the coming years e.g., planning the voluntary defense activities together with the preparedness planners” (reference no.16 of 4 Dec. and no.18 of 4 Dec. 2015).

4.2. The resources

Here the focus is on resources in terms of physical and organizational such as; facilities, products, business units and business relationships. The general view is that resources have no value unless they are motivated in the overall planning and also are considered in strategic dependence. In relationships across actors, actors facilitate access to and use of resources and are seen as an effective alternative. Unfortunately, the ability to quickly establish the presence of resource networks in an ongoing crisis is based on uncompleted governmental direction and policies. This represents implications for managers in the Swedish system, since directions to authorities build on two different ideals: the civil and the military. Considering respondents’ views, there is a great need to adapt directions and policies to current threats leading to increased relations with civilians and other voluntary groups. “The picture of civil-military collaboration as integral part in the broader concept of total defense, needs to be reinforced by a higher degree of direction and policy. There are gaps in the response to complex situations e.g., as in the latest migrations crisis” (reference no.3 of 19 Nov.).

In Sweden, the voluntary sector represents a major economic force. However the relationships do not always have to involve an economic component, since there are other dimensions in which exchange can take place. In order to consider whether an exchange is economic or not, respondents observed a need for conditions and preliminary calculations on how well the voluntary sector is performing in relation to these conditions as “there is need for further analysis considering uncertainty on some of the resources and the activities that have dominated the running of the voluntary organizations in recent years. At the very least, it seems that such issues apply only in certain situations, for certain organizations and even then, only to some of the mechanisms of the complex set of organizations” (reference no.15 of 4 Dec. 2015).

The FFO in Sweden include a large number of competent organizations that deliver resources and activities, ranging from search and rescue and voluntary fire brigade to sports clubs. While some of them may not always focus on crisis management, their personal resources can still be used on an ad hoc basis, as an aid in temporary activities during crisis. Given respondents: “Organizations that are unfamiliar to each other and have different roles, often struggle to relate. This becomes even more problematic in spontaneous setups. Reasons for problems in relations are accounted to organizations’ insufficient confidence in each other and their related
competition on the available resources e.g., financial resources” (reference no.3 of 23 Nov; no.13 of 3 Dec and no.24 of 21 Dec. 2015). The implication is if resources are associated with strategies or as resources to authorities, suppliers, customers or other voluntary actors.

While emergency preparedness planning and managing are vital parts of institutional policy, this ideal has shown to be difficult in practice. In economic terms resources become more valuable by integrating other resources across networks. It concerns new knowledge which often appears in the wider network, and new thinking that is generated in interaction to parties, increasing the chances to be accepted in the network. Considering the number of FFO and their relations with public, private and non-profit actors, respondents revealed complications related to their unclear role, and their vague responsibility, follow-on unclear management of the resources available: “One problem with many organizations and unclear roles and responsibilities, can be that some organizations are controlling and dominating the sector. A reason is if responsibility is required and organizations therefore turn responsibility over at each other, or if responsibility is being required and many actors feel they can claim it. The latter leads to competition between the actors, as a result of conflicts in relationships” (reference no.14 of 3 Dec. and no.20 of 9 Dec. 2015).

4.3. The activities

Activities can be seen in different ways and particularly related to business relations. One fundamental way is the cooperation activity of an organization. This cooperation, is rooted in the exchange of products and services and is concerned with flows of goods and information with the aim to generate and solve particular skills. Another way is the technical collaboration, and to gain strategy advantages in coordinated activities. The FFO argued that challenges to growth and advance technologically, organizationally, and socially need to be put in new perspective to meet a different crisis management in order to remain competitive. Thus, a developed defense policy may strengthen the FFO commitment to provide training related to their individual military profession. The FFO are already contributing with personnel, training and contribute to the Home Guard with resources and activities in the national security forces. This task however needs to develop: “as long as activities match a military task the difficulty stands only for the FFO-civil to include their activities in the military planning. For example, during the latest migration crisis and the requested assistance from the migration office, it became clear that the Swedish system did not have a structure for involving the FFO resources and activities in short periods of time, on either side. Current methods and policies in the Swedish system make it very difficult for organizations to mobilize, recruit, and ensure voluntary resources and activities quickly” (Reference no. 6 of 25 Nov. 2015).

Connecting to FFO as part of an ongoing crisis, they provide primary support to the total defense, which is divided into military activities and civil activities. In it, the activities of an organization can develop the activities of the different actors in the system. In this regard, respondents admitted challenges in the effective managing of the FFO activities in connection to the preparedness system as “a general difficulty regards the administrative role and guidance of voluntary actors in general. The voluntary resources are often used to release regular activities during emergencies. As it is under crisis, the ordinary activities and extreme work load in terms of both human and material resources are required with large ranges of resources. It means that additional resources are required to handle the activities that appear on the outside. It can be about almost anything that relieves the regular permanent staff” (reference no.7 of 26 Nov. and no.9 of 27 of Nov. 2015). Regarding the recruitment of volunteers, according to respondents, it sets again focus on management structures and budgets allocation for joint projects developing civil and military ambitions: “there is need to give the
FFO a stronger role in the system, as our resources and activities contributes to the long-term purposes of planning. The FFO aim to expand activities with youth people to contribute the defense, but we are in need to generate opportunities learning crisis management which can offer future employments and duty positions” (reference no. 22 of 16 Nov. 2015).

5. ANALYSIS

The case of the FFO presented above, shows how the networks of actors, resources, and activities are developed in the emergency preparedness of Sweden. In particular, there are two basic networks- the civil and the military- in place to take part in the response to a crisis. The use of the network view gives a base for understanding the relationships in which actors, resources and activities can adapt their relationships to diverse situations (Håkansson and Snehota, 2006; Håkansson and Johansson, 2002). There seems to be lack of a comprehensive description of the overall picture of the preparedness system and poor understanding of the network and the reasons for relationships to evolve in ongoing crises. One trend evident in Sweden (Lundström and Svedberg, 2003), is the increased focus on preparedness related to terrorism, chemical, nuclear, and technological threats (Lindell et al., 2001). Above that, dealing with new threats, networks can be considered for developing two general types of vital resources; physical resources and organizational resources which have no value unless they are activated in the planning (Gadde et al., 2002). According to respondents resources are often mobilized ad hoc in absence of a comprehensive plan behind.

Emergency preparedness networks are suitable to support flows- material, information and financial- that require careful and close coordination (Heaslip, et al., 2012; Van Wassenhove, 2006). In this flows, adapting resources within two parallel networks means great challenges for the responsible managers. Explicitly, they can be missing the mutual benefit of relevant skills and the non-profitable use of resources that the FFO comprises, and limiting their cooperation with other actors. Thus, to increase FFO relations with other actors and efficiently strengthen military and civil ambitions, FFO resources need to be organized in the same way as the resources of other actors across the networks.

Focusing on the actors in the network and the classification of the resources and activities, Håkansson and Snehota (2006) claim that networks can be used for dealing with exchange. Our analysis concerns the governing of the Swedish preparedness dealing with two different networks and two separate strategies. A challenge is however, coordinating the material, information and financial flows within two parallel and different networks. Nevertheless, critics are blaming the preparedness system for not being efficient. Policy deficiencies are hindering managers providing a basis for efficient leadership. In this regard, clarity problems were observed at different areas, e.g., management, strategies, ambitions and structures. One consequence of this is in particular, a missed economic effect in terms of the use of FFO resources and lack of connection with other resources in the networks. An inconsistency as relating to efficiency, it is often grounded on economic motives of exchange. Dealing with relationships in both permanent and temporary networks. Networks and relationships are suitable for developing a responsive model (Heaslip and Barber, 2014). The ongoing crisis management in Sweden however, follows civil and military views.
The two views put pressure on managers, as each follows their own ambitions and directions often resulting in an inflexible system. To cope with current risks and threats in Sweden, the view of Boin and Lagadec (2000), link us further to the urgent preparation, which is demanding a combination of civil and military resources in an overall network. Considering these demands, Figure 5.1, exemplifies preparedness networks in which the FFO are related part. The figure shows that actors, resources and activities are divided in two different networks - the military and the civil. In preparedness phase those may not completely match the expectations in ongoing crisis. This difficulty is grounded on that policy makers generally fail to see crisis management in a whole. From secondary data and interviews, policy makers are easily trapped between conflicting duties of highly unclear and dynamic situations and ability to produce and revise adequate calculations. In the absence of a common perspective two separated structures and incomplete responses will be developed.

6. CONCLUSION AND FUTURE RESEARCH

The study analyzes the contribution of the voluntary defense sector to emergency preparedness networks and ongoing crises in developed countries. We argue that the network view represents a basis for understanding the relationships and the question of responsibility in emergency preparedness and ongoing crisis. Discussing networks, it includes government agencies, county administrative boards and municipalities. All with their responsibilities based on the laws and regulations that need to be followed. The FFO are part of a wider network and generate resources and activities for response in crises. The study showed that FFO are challenged in their goals by inadequate strategy and management, as they have to plan and respond in two different network with no clear structure. From a theoretical perspective, relationships in the
lack of structure will continue to develop in informal ways and are generally used in emergent situations.

In answering the question, i.e. how do the voluntary defense organizations relate in networks to contribute to the preparedness and ongoing crises in terms of resources and activities? Considering the FFO contribution to the system, their adaptation in the networks represents challenges. The analysis of the FFO as actors in the system, provide the study with a view that goes beyond operational capability. The FFO have ability to effectively adapt resources such as services, products, systems and relationships, if they are part of an overall strategy and if they are considered in interdependent cooperation with the other actors in the network. FFO resources and activities are critical as strategy action is not often limited to an organization but implies the whole network. Thus, dealing with relationships in the preparedness, we found that there is a need of an overall strategy that involves the common interests of the civil and the military ambitions. The analysis showed that the problem remains in the overall structures of the preparedness, as planning is considered from two different networks—the civil and the military. Combining actors, resources and activities from those two different grounds, have no common strategy, each is following their own directions and ambitions, have shown to generate a great degree of inflexibility.

This study confirmed three major challenges. The first relates to actors in an incomplete response to ongoing crisis due to the unclear overall direction and the different ambitions in the planning. We found that the FFO are part of a wider network but are currently only existing in permanent agreement under voluntary regulation with the Armed Forces and various civil authorities. A problem is that the purposes for FFO are blurred as regulations do not show in what ways they should contribute. That is in part due to deficiencies among managers in understanding and communicating the FFO importance in the wider picture and the significance impact of their resources in the efficiency of the overall planning. Consequently, FFO are missing key relations with significant groups and are hindered to effectively adapt in essential networks. The second refers to the provision of vital resources separately to the military system and the civil preparedness. Management of resources and activities are in need of a change. This is due to the lack of a broader network that matches the purposes of total defense. The third challenge concerns activities being linked to current types of risks and threats, more often justifying the use of combined civil and military activities. This new situation i.e. changed and complex threats, demands that the FFO rapidly adapt resources to the activities in the networks. Looking closer at the FFO's conditions to adapt in network, they consist of several distinct organizations in which network is a prerequisite adding possibilities for other networks to complement resources and to develop. Thus, through planning, training and adequate management the FFO could represent an effective contribution with essential elements adding value to the system. Do not forget to

One major contribution of this study corresponds to the picture of the voluntary defense actors in the current emergency preparedness networks. This exemplification shows that the success of the response to ongoing crisis is considered in the early strategic tools and in common policies adopted by the system actors to manage the complexity of the actual need. With a more develop network structure the system would increase capability to include and manage a higher volume of resources and activities for diverse purposes. Emergency preparedness networks need to coordinate the voluntary contribution to military and civil planning under mandate of SAF.

This study provides a basis for understanding the networks in the field of emergency preparedness adapted to the voluntary sector. Significant on several accounts. First, there is the need to increase understanding of the voluntary actors in general, their resources and activities
as essential part of the social, economic and political structures of developed countries. Second, there is a need to adapt the current policies to enable the voluntary actors in the preparedness network of Sweden i.e. FFO. Third, managerial implications corresponds the voluntary actors are forced to take on a heavy administration burden from authorities, despite their limited resources e.g. reports, plans and forms in the searching for funds. Hence, further research ought to provide deeper understanding associated not only on the voluntary sector in general, but on structures to further improve the preparedness system in Sweden. The voluntary sector brings attention to its flexibility and capability to effectively adapt, likewise the preparedness system can benefit from flexibility and ultimately effective networks. Finally, the study support managers and leaders to understand the necessity of combining networks for effectively shifting special skilled actors to deliver common resources to the preparedness system and ongoing crises.

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Appendix 1: Interview respondents
<table>
<thead>
<tr>
<th>Reference number</th>
<th>Interview date</th>
<th>Type of interview</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16-nov 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>2</td>
<td>17-nov 2015</td>
<td>Personal interview</td>
<td>1 hours</td>
</tr>
<tr>
<td>3</td>
<td>19-nov 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>4</td>
<td>23-nov 2015</td>
<td>Personal interview</td>
<td>1 ½ hours</td>
</tr>
<tr>
<td>5</td>
<td>24-nov 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>6</td>
<td>25-nov 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>7</td>
<td>26-nov 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>8</td>
<td>27-nov 2015</td>
<td>Telephone interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>9</td>
<td>27-nov 2015</td>
<td>Personal interview</td>
<td>2 ½ hours</td>
</tr>
<tr>
<td>10</td>
<td>01-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>11</td>
<td>01-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>12</td>
<td>02-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>13</td>
<td>03-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>14</td>
<td>03-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>15</td>
<td>04-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>16</td>
<td>04-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>17</td>
<td>08-dec 2015</td>
<td>Personal interview</td>
<td>2 ½ hours</td>
</tr>
<tr>
<td>18</td>
<td>08-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>19</td>
<td>09-dec 2015</td>
<td>Personal interview</td>
<td>1 hours</td>
</tr>
<tr>
<td>20</td>
<td>09-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>21</td>
<td>09-dec 2015</td>
<td>Personal interview</td>
<td>2 hours</td>
</tr>
<tr>
<td>22</td>
<td>18-dec 2015</td>
<td>Personal interview</td>
<td>1 hours</td>
</tr>
<tr>
<td>23</td>
<td>21-dec 2015</td>
<td>Personal interview</td>
<td>2 ½ hours</td>
</tr>
<tr>
<td>24</td>
<td>12-jan 2016</td>
<td>Telephone interview</td>
<td>1 hour</td>
</tr>
<tr>
<td>25</td>
<td>14-jan 2016</td>
<td>Online interview</td>
<td>1 hour</td>
</tr>
</tbody>
</table>
ABSTRACT

Purpose
We investigate how modern network video technology in surveillance cameras can be used to improve different warehouse types and operations, and how barriers may prevent implementation.

Design/methodology/approach
An exploratory multiple-case study with nine case companies was conducted including on-site visits, interviews, questionnaires and a workshop.

Findings
We identified twelve video applications that could improve warehouse operations by making them safer, faster, more transparent, and more reliable. We found that video applications complement existing information technology and offer a new dimension with real time analysis of different activities in warehouse operations. The main barriers to implementing video technology include uncertain return on investment, staff integrity and union restrictions, and integration with other systems.

Research implications
The study shows that different applications are perceived as useful for different warehouse types and operations. Based on the findings, we present a typology suggesting which application can suit which warehouse type and operation.

Practical implications
Video technology provides an opportunity to improve efficiency and cut costs in warehouse operations which contributes to increasing the competitiveness of the company and the supply chain.

Social implications
The identified video applications can help to increase safety, sustainability and traceability in warehouse operations and across the supply chain.
Originality/value
This research is in the frontline to explore the potential of introducing video applications to increase efficiency and effectiveness in various warehouse types and operations.

Keywords: Warehousing, Operations management, Video, Technology, Barrier, ERP, WMS, RFID, barcode

1. INTRODUCTION

Warehouse operations are often highlighted as critical for supply chain management, making it possible for customers to receive the right product, at the right time and price (Faber et al., 2013). Due to increased emphasis on shorter lead times, constant changes in customer demand, and wider product ranges, the importance and pressure on warehouse operations has increased, for example in terms of storing multiple articles and ability to assemble customer orders (Rouwenhorst et al., 2000; Baker and Canessa, 2009). Even so, warehouse operations are often regarded as a burden due to the involved capital and operating expenses (Bartholdi and Hackman, 2010). According to Baker and Canessa (2009) and De Koster et al. (2007) warehouse operations represent approximately a quarter of the total logistics cost in a supply chain. Companies therefore continuously strive to cut costs and improve efficiency in warehouse operations, for example by reducing inventory and increasing turnover of stock (De Koster et al., 2007). Another aim is to resolve issues that might cause late or inaccurate deliveries in order to improve customer service (Huertas et al., 2007).

An opportunity for improving the efficiency of warehouse operations is the development of new information technology. Particularly, the implementation of enterprise resource planning (ERP) systems and warehouse management systems (WMS) has made it possible to store and track information in order to handle and coordinate operations faster with fewer resources (Nee, 2009). Another technological advancement is the introduction of radio frequency identification (RFID) and barcodes, which has made it possible to automatically identify products and storage locations throughout the warehouse, resulting in cost savings through shorter handling times (Karagiannaki et al., 2011). Despite these advancements, companies still struggle with improving the efficiency of warehouse operations and therefore seek new opportunities to improve their warehouse operations (Gu et al., 2007; Karagiannaki et al., 2011).

This paper explores intelligent video analysis in surveillance cameras, a relatively new technology that could be useful to complement other information technologies to further improve warehouse operations. Surveillance cameras are going through a shift from analogue to digital technology and have been used in other areas such as retail stores, airports and banks to, for example, count and detect objects. However, considering that the technology is new to warehouse operations, there is limited knowledge of what the potential benefits are and what factors need to be considered for implementing the technology in warehouses. The purpose of this paper is therefore to investigate the potential of introducing video technology in warehouse operations. To address this purpose, we seek to answer two research questions:

i) How can video technology be used to improve different warehouse types and operations?

ii) What barriers could prevent implementation of high technological surveillance cameras in warehouse operations?

We collaborate with a world leading company in the field of high technology cameras in order to understand more about the potential of using video technology in warehouse operations. We
conduct a multiple-case study by applying theoretical sampling to include various types of warehouses located in Northern Europe representing different characteristics such as different size and number of stock keeping units (SKU), diverse turnover and varying degree of automation. The study highlights beneficial video applications that can be used to improve the performance in various warehouse operations. We also describe barriers and discuss a way forward to enable implementation of video technology in warehouse operations. The structure of the paper is as follows. First, the paper includes literature on warehouse operations and relevant information technologies including ERP, WMS, RFID, and barcode. The literature also provides an understanding of existing video technologies. Thereafter, we describe the methodology including case selection and description as well as data collection and analysis. In the results section, findings from the nine cases are presented followed by an analysis and discussion of implications for managers and researchers.

2. LITERATURE REVIEW

2.1. Warehouse types and operations

Warehouses can, according to Bartholdi and Hackman (2010, p. 3), be described as “the points in the supply chain where product pauses, however briefly, and is touched.” Warehouses have an important intermediate role within the supply chain, affecting both costs and service (Faber et al., 2013). Reasons for having warehouses are, for example, to (i) better match supply with customer demand, (ii) consolidate a range of products to reduce transportation costs and to manage distribution processes more efficiently, and (iii) enable postponement of product differentiation by configuring generic products close to the customer (Bartholdi and Hackman, 2010; Faber et al., 2013).

Warehouses can be categorized based on the customers they serve and the operations which are carried out within the warehouse. Research is scattered and has suggested between two and seven categories (see e.g. Rouwenhorst et al., 2000; Frazelle, 2002; Bartholdi and Hackman, 2010). For the purpose of this paper, we build on the categorization presented by Berg and Zijm (1999) which includes contracted, distribution and production warehouses. This classification provides a clear division between the different types of warehouses and reduces the risk of ambiguity. Compared with other classifications, Berg and Zijm (1999) also consider the issue of liability, which is an important aspect for warehouse operations that often are part of supply chains with multiple legal entities.

The characteristic of a contracted or third party logistics provider’s warehouse is that an external partner manages and is liable for some or all warehouse activities. Distribution warehouses are used to collect, consolidate and/or assemble a wide range of products from different suppliers and deliver them to downstream customers. Typically, the product range is large for distribution warehouses while quantities per order may be small, making picking more time consuming (Rouwenhorst et al., 2000). Production warehouses are mainly used to store material through the production process. The storage includes raw material, semi-finished products and finished products and may require storage of large quantities during long time periods (ibid). Each of the three warehouse types involves various operations, as described in Table 2.1. In general, all warehouses have operations for receiving, put-away and storing, picking and shipping (cf. Berg and Zijm, 1999; Frazelle, 2002; Petersen and Aase, 2004; Gu et al., 2007; Bartholdi and Hackman, 2010). Contracted and distribution warehouses may have cross-docking flows which means that certain items are not stored, but instead shipped directly after receiving. Lately, coupled with the advancement of e-tailing and omni-channel distribution, there has been a
massive increase in return flow of goods from consumers (Jayaraman et al., 2008). Jayaraman and Luo (2007) concluded that returns can be as high as 15% for mass merchandise and 35% for catalogue and e-commerce retailers.

### Table 2.1 Warehouse operations and related activities.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving</td>
<td>Unload goods; inspect quality and quantity; and prepack for easier handling.</td>
</tr>
<tr>
<td>Put-Away and Storing</td>
<td>Determine where to store the item; and transport product to its storage location.</td>
</tr>
<tr>
<td>Picking and Sorting</td>
<td>Remove item from storage and sort items according to individual orders.</td>
</tr>
<tr>
<td>Packing and Shipping</td>
<td>Inspect completed customer orders; pack each order for shipping; prepare shipping documents; and load the products.</td>
</tr>
<tr>
<td>Returns</td>
<td>Receive and inspect returned products.</td>
</tr>
</tbody>
</table>

### 2.2. Information technologies in warehouse operations

There are multiple information technologies that can be used to support warehouse operations. Four of the most important technologies mentioned in literature include ERP, WMS, RFID and barcode. The ERP system is a technology infrastructure that integrates processes and data connected to inventory management, production planning, human resources and finances (Berg and Zijm, 1999). It serves as a common information platform that allows a company to share information both between internal units and to external partners with the goal to increase on-time deliveries, lower operating costs, and reduce inventory levels (Olhager and Selldin, 2003). ERP systems have a planning horizon of several weeks and cover every function within the organization. In comparison, the WMS focuses on short-term planning and shop floor control for the various warehouse operations only (Faber et al., 2002). The WMS is used to register incoming and outgoing goods. By using a system to track goods throughout the warehouse, it is possible to attain a better overview of completed and upcoming tasks. It can reduce searching activities in the warehouse and minimize inventory deviations as well as reduce inventories, improve space utilization and increase service levels (Faber et al., 2002; Nee, 2009; Bartholdi and Hackman, 2010). However, the WMS is incapable of providing real-time data which, due to human errors, can result in information inaccuracy (Poon et al., 2009).

To synchronize material and information flow, the WMS can be integrated with a real-time and automatic data retrieval system such as RFID (Poon et al., 2009; Wang et al., 2010). RFID technology uses radio frequency signals and space coupling to achieve automatic identification of static or moving targets through non-contact transmission of data (Zhang and Lian, 2008). The RFID system consists of a passive or active tag, an antenna and a reader. The tag contains radio frequency coupling components and chips where each tag has got a unique code. The antenna emits radio frequency waves and receives signals sent by a tag which enables wireless communication between reader and tag. The reader can then read or write tag information by decoding the radio frequency signals (Delen et al., 2007; Ngai et al., 2008; Hou, 2011). In warehouse operations, tags can be attached to each item. The RFID reader automatically decodes the tag information throughout the warehouse and transfers it to the WMS. RFID
technology is useful for, for example, confirming correct product and quantity and for deciding where to place goods which can increase space utilization (Hou, 2011). Other benefits include efficient packing and loading of goods and the ability to track product source of the material flow for inbound and outbound processes (Zhang and Lian, 2008). Together with a WMS, the RFID can thus enable faster receiving and shipping operations and improve the order fulfillment rate (Ross et al., 2009).

Another way of transferring data into a WMS is to use barcode technology. The barcode, which can be attached to an item or package, can be either linear one-dimensional or non-linear two-dimensional where the two-dimensional code can include up to hundred times more data. A barcode can identify, for example, manufacturer, product class and stock-keeping unit, but not the unique item (Musa et al., 2013). The barcode is an optical technology which means that the reader must be in direct line of sight. A barcode reader can thus only register one code at the time in comparison with the RFID which is able to read multiple tags simultaneously (Delen et al., 2007). The barcode is much cheaper than RFID tags and have no performance loss when used on or around water or metal (Musa et al., 2013;), although the barcode is more sensitive to heat, dirt and solvents, and can only be used once before being discarded (Delen et al., 2007).

2.3. Network video technology

A recently developed information technology that may be useful to further improve warehouse operations is network video technology. Considering the novelty of video surveillance technology and its application in warehouse operations, there is little research available. Many of the applications are currently being developed and there is a lack of documented benefits. Instead, current knowledge builds on information from the companies that develop and provide the technology. Network video technology enables recording of events for monitoring and real time analysis of video streams inside the cameras. The system includes cameras for recording the events, a network infrastructure for enabling communication between units, and software for managing the system and analyzing recorded material. The software is commonly referred to as video management system and facilitates integration with other technology such as ERP, WMS, RFID and barcodes (GuardRFID, 2012).

Several video applications that have been developed for other areas such as retail stores, airports and banks could potentially be useful in warehouse operations (cf. Table 2.2). One example is visual goods tracking which could be used to track a product’s way through a building such as a warehouse. By entering a product’s unique code, all relevant images for that product are displayed on the screen (Divis, 2015). Another in-camera application is barcode scanning which can be used instead of traditional laser-based scanners. It allows for faster barcode reading than laser scanners and makes it possible to identify barcodes on any surface and in any possible orientation. Cameras can also read through plastic film and identify partly damaged barcodes (Cognex, 2013). A third application is heat map visualization which tracks and displays movement over a given time period by matching increased movement by an intense color scheme of a particular area (Cisco, 2015). Other, available applications that could potentially be useful for warehouse operations include counting of products, dwell times estimations, queue management, tripwire analytics, face recognition, object identification and measuring volume (e.g. SICK, 2013; Ferreira et al., 2014; Axis, 2014; Clearview, 2015).
Table 2.2 Existing network video technology used in, for example, retail stores, airport and banks.

<table>
<thead>
<tr>
<th>Video application</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual goods tracking</td>
<td>Track goods’ movement through a building.</td>
</tr>
<tr>
<td>Barcode scanning</td>
<td>Read barcodes simultaneously, of different types and through plastic film.</td>
</tr>
<tr>
<td>Heat map</td>
<td>Identify crowded areas by analyzing movement.</td>
</tr>
<tr>
<td>Dwell time</td>
<td>Estimate the time an object has been standing at a place.</td>
</tr>
<tr>
<td>Counting objects</td>
<td>Count the number of objects passing the camera’s view.</td>
</tr>
<tr>
<td>Queue management</td>
<td>Estimate length of queue.</td>
</tr>
<tr>
<td>Trip wire</td>
<td>Notice if an object crosses an area.</td>
</tr>
<tr>
<td>Face recognition</td>
<td>Identify a person by comparing with images in a database.</td>
</tr>
<tr>
<td>Left/removed object</td>
<td>Notice if an object has been left or removed.</td>
</tr>
<tr>
<td>Object identification</td>
<td>Identify what kind of object the camera is viewing.</td>
</tr>
<tr>
<td>Volume measurement</td>
<td>Estimate dimensions of a good.</td>
</tr>
</tbody>
</table>

2.4. Barriers to implementing information technology in warehouse operations

Barriers to implementing information technology has been widely discussed in previous research on general logistics and SCM topics. However, there is limited research on the implementation of information technology in warehouse operations (Marchet et al., 2015) and, to the best of our knowledge, none focusing directly on implementing video technology in warehouse operations. In this literature review we therefore focus on literature discussing barriers to implementing general information technology in warehouse operations.

Information technology barriers can be divided into three categories: behavioral and cultural barriers, technical barriers and business and supply chain related barriers (Harland et al., 2007; Krmac, 2012). Behavioral and cultural barriers include, for example, an unwillingness to change and adopt new technology (Krmac, 2012). Staff may prefer carrying out the work the way that it has always been done. Another issue is that employees may perceive new technology as a threat to their job security (Lim et al., 2013). Technical barriers include the complexity of integration with existing systems such as the WMS (Krmac, 2012) and the lack of standardized technology (Ross et al., 2009). Lim et al. (2013) note that the lack of global standards used to be an issue for adopting RFID in operations, but as the technology matured a range of ISO standards have been developed to enable successful implementation. A related barrier is the lack of system reliability (Baker and Halim, 2007). Research has for example shown that RFID does not provide 100% reliability in the product identification process due to the location of tags and signal distortions caused by reader setup, warehouse characteristics like metal and moving objects, and the type of handled products (Lim et al., 2013). Another potential barrier concerns technical problems and debugging in the implementation phase which increases the risk of interrupting warehouse operations (Marchet et al., 2015). Business and supply chain related barriers primarily relate to unsure return on investment coupled with high investment costs and lack of documented benefits (Baker and Halim, 2007; Harland et al., 2007; Ross et
al., 2009; Marchet et al., 2015). There could also be a concern of privacy and the risk of industrial espionage through unauthorized access to stored information (Lim et al., 2013).

3. METHODOLOGY

To investigate the potential use of network video technology in warehouse operations we conducted an exploratory, multi-site case study following theory-building principles (Eisenhardt, 1989; McCutcheon and Meredith, 1993; Miles and Huberman, 1994). Multi-site case studies allow for in-depth investigation of the phenomenon (Yin, 2014) while extending generalizability beyond the isolated case (Meredith, 1998), and are thus considered suitable for building new theory in the field of operations management (Voss et al., 2002).

3.1. Case selection and description

We applied theoretical sampling (Eisenhardt, 1989) to select nine case companies representing three types of warehouses, namely contracted, distribution, and production (cf. Berg and Zijm, 1999). Criteria for selecting the cases were identified through a literature review and scoping study conducted within the collaborating partner’s own distribution warehouse. The scoping study included on-site visits to the warehouse and interviews with senior warehouse staff. We also used the scoping study to test and further develop the interview guides and the questionnaire used for data collection.

Based on the scoping study, we identified one technical and one financial criterion for selecting cases. First, the technical criterion builds on the insight that implementing video technology in a warehouse requires a certain level of technological maturity including the application of, for example, a WMS or ERP module with similar functionality to manage warehouse operations. A WMS or similar ERP module is also a critical element in order to optimize warehousing operations within the supply chain (Min and Zhou, 2002). Second, the financial criterion relates to the total volume and value of outgoing goods per year. Companies with either a high accumulated volume shipped per year or high product value indicate higher saving potential from new change initiatives. Also companies representing high volume and/or value of goods are more likely to have the capital required for investing in video technology. We therefore consider the categorization by the European Commission (2003) and only include large companies with a yearly turnover exceeding 50 million euros (approximately 0.5 billion SEK). To further increase generalizability of the findings, we also applied stratified sampling (Meredith, 1998; Patton 2002). Within each of the three types of warehouses we included companies with different characteristics such as different size and number of SKUs, diverse turnover and varying degree of automation, see Table 3.1. Anonymity is ensured by using fictitious company names.
Table 3.1 Overview of characteristics of case companies.

<table>
<thead>
<tr>
<th>Case company type of products</th>
<th>Contracted warehouses</th>
<th>Distribution warehouses</th>
<th>Production warehouses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
<td>C3</td>
</tr>
<tr>
<td>Industry/type of products</td>
<td>Electronics</td>
<td>Footwear, food, body lotion, etc.</td>
<td>FMCG, electronics, etc.</td>
</tr>
<tr>
<td>Global turnover (bnSEK)</td>
<td>182</td>
<td>39</td>
<td>62</td>
</tr>
<tr>
<td>Warehouse size (m²)</td>
<td>22,500</td>
<td>107,000</td>
<td>110,800</td>
</tr>
<tr>
<td># W/H employees</td>
<td>70</td>
<td>190</td>
<td>100</td>
</tr>
<tr>
<td>Automated operations</td>
<td>Limited</td>
<td>Sortation</td>
<td>Limited</td>
</tr>
<tr>
<td># Storage locations</td>
<td>25,000</td>
<td>11,000</td>
<td>91,000</td>
</tr>
<tr>
<td># SKUs</td>
<td>35,000</td>
<td>300,000</td>
<td>10,000</td>
</tr>
<tr>
<td># Order-lines picked per day</td>
<td>6,000-7,000</td>
<td>22,000</td>
<td>18,000</td>
</tr>
</tbody>
</table>

3.2. Data collection and analysis

To avoid bias imposed by the camera company, the data collection and analysis were conducted by the researchers without any involvement from the collaborating partner. However, throughout the project, we regularly discussed with the collaborating partner in order to understand more about the technology and feasibility of developing and implementing the various applications highlighted by the case companies.

Data collection was carried out in three steps. In the first step, we conducted a full day, on site visit to each of the case companies. The visits started off with a guided warehouse tour in order to gain an understanding of the operations. Thereafter, we conducted semi-structured interviews with selected staff (see Appendix). Interviewees were selected based on that they (i) have multiple years of experience from working with logistics and warehouse operations, (ii) have thorough insights to their own company’s warehouse operations, and (iii) are involved in strategic decision making regarding future investments in the company’s warehouse operations. The collected information was transcribed and summarized, and thereafter sent back to the case companies with the purpose to confirm accuracy. The output from the first sessions were a complete mapping of the case companies and their warehouse operations, as well as the case companies’ views on network video technology and its potential for improving warehouse operations. We compiled a list of the suggested video applications (e.g. human detection and quality inspection) and added to the list of already existing applications (cf. Table 2.2).

In the second step, we included all applications in a questionnaire with a five-step Likert scale and sent it to the case companies addressed to the same interviewees who were involved in the first step. We visited or called each of the interviewees and guided them through the questionnaire. The interviewees were asked to grade and describe their interest for each of the identified video applications. We also requested the respondents to elaborate on barriers to the implementation of video technology in warehouse operations. Each interviewee listed and ranked barriers, and also provided their view as to how the barriers could be overcome. In the
final step, we invited the case companies to a half-day workshop where we presented our findings and discussed the implications of our study for future warehouse operations. In the workshop, the participants were asked to elaborate on (i) the video applications with highest potential in warehouse operations, (ii) financial, technological and union related barriers, and how they could be resolved, (iii) in what way video applications could substitute or complement other information technology used in warehouse operations, and (iv) the future of network cameras in warehouse operations.

4. FINDINGS AND ANALYSIS

4.1. Applications

The empirical study highlights twelve video applications that are considered more or less beneficial for improving warehouse operations. In Table 4.1, from left to right, each application is listed with a definition. Thereafter, the table details for which processes the interviewees perceive the application to be useful. Finally, average scores are listed for the three groups of warehouses (contracted, distribution, production) as well as for all nine case companies together. The case companies’ perception of the potential benefit of each application was graded between 1 and 5 where 1 = very low; 2 = low; 3 = moderate; 4 = high; 5 = very high.

Two video applications are perceived to have high potential benefit for warehouse operations, namely human detection; and measure volume. Human detection is considered vital to further improve safety in warehouse operations. In Sweden alone, an average of 800 accidents occurs with fork lifts per year (Arbetsmiljöverket, 2013). By applying cameras that can identify humans nearby a forklift and alarm or decelerate the forklift, it is possible to reduce the number of accidents. The warehouse manager at P1 elaborates: “It would be valuable to use the application when reversing a forklift. We have around 50 groups visiting the warehouse per year and several staff on the floor to manage the operation. The drivers don’t always pay attention to what is going on behind the forklift, so it would be useful if there could be a zone around the forklift that the cameras scan, and when a human is within that zone the forklift stops. It is important that the cameras can understand if it is for example a pallet or a human that is close. We don’t want the forklift to make full stop every time there is a container or pallet.”

The measure volume application is considered useful to quickly receive information on good’s dimensions, measured from several angles. Compared to manual methods and laser beams, which are currently used by the case companies, video technology could make the process faster and more precise. The store operation manager at D2 describes their receiving operation further: “When we receive products to the warehouse, some of the items’ measures are already entered into the systems, but the rest are measured by using a yardstick and thereafter manually entered into the system. There is always a risk that there is an error in this process, for example by typing the wrong digits or missing a comma.” The product dimensions can be displayed on a screen or directly added to that SKU in the WMS to identify appropriate storage location. Precise measures could also be useful to calculate and book the right volume on trucks to avoid being overcharged or, in the case of the contracted warehouses, avoid undercharging customers for transportation. The operations manager at D1 underlines the potential benefits in the shipping process: “We would save a lot of time in the measuring process and it would also help us to pack in the most optimal way possible.”
Table 4.1 Video applications that could be used in warehouse operations.

<table>
<thead>
<tr>
<th>Video application</th>
<th>Description of video application and potential benefits</th>
<th>Receiving</th>
<th>Storing</th>
<th>Picking</th>
<th>Shipping</th>
<th>Returns</th>
<th>Contracted WH (average)</th>
<th>Distribution WH (average)</th>
<th>Production WH (average)</th>
<th>Average for all case companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human detection</td>
<td>Detects when a person is alarmingly close to a forklift; can be used to increase work safety.</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>3.7</td>
<td>3.7</td>
<td>4.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Measure volume</td>
<td>Automatically reads goods’ dimensions; can reduce costly and time consuming manual work.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>4.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Barcode scanning</td>
<td>Enables reading, for example, (i) of damaged barcodes (ii) through plastic films; can increase picking/packing efficiency by eliminating manual scanning.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>3.3</td>
<td>3.7</td>
<td>3.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Heat map</td>
<td>Identifies frequently visited location and bottlenecks; can provide input for layout decisions, placement of SKUs, and re-scheduling of activities.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>3.7</td>
<td>3.7</td>
<td>2.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Visual goods tracking and counting</td>
<td>Enables video documentation and facilitates handling of complaints; can also be used to identify potential improvements in warehouse operations.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.0</td>
<td>3.7</td>
<td>3.0</td>
<td>3.2</td>
</tr>
<tr>
<td>Object identification and counting</td>
<td>Controls if the correct item in the right quantity has been picked; can help to reduce pick errors and increase picking/packing efficiency.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.7</td>
<td>3.3</td>
<td>3.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Quality inspection of pallets</td>
<td>Inspects pallet quality at receiving by comparing with a reference object; can be used to determine if a pallet is broken and enables more efficient quality inspections.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.0</td>
<td>3.0</td>
<td>3.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Inventory control</td>
<td>Controls inventory levels at various storage locations; can be used to alert when a shelf is empty and a SKU needs to be restocked.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.0</td>
<td>3.3</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Counting loaded pallets</td>
<td>Counts the amount of loaded pallets on a truck; can help to reduce shipping errors.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.0</td>
<td>1.7</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Conveyor belt dwell time</td>
<td>Identifies and visualizes bottlenecks in automated conveyor belts; can provide input for improving the layout of conveyor belts.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>2.7</td>
<td>2.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Truck turnover time</td>
<td>Counts the time a truck has been standing at a bay; can be used to improve utilization of fleet of forklifts.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>1.7</td>
<td>1.3</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Queue management</td>
<td>Identifies the number of packages on the conveyor belt and sends an event to handle the queue making the process more efficient.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
<td>2.3</td>
<td>1.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

* Numbers are means of answers ranking from 1 to 5.

Another four applications received a total average of 3.0 or higher. These include barcode scanning, heat map, visual goods tracking, and object identification and counting. First, the barcode scanning application is perceived as useful to substitute the traditional laser-based scanners. The case companies appreciate that cameras enable faster barcode reading than laser scanners and makes it possible to identify multiple barcodes at the same time in any orientation and on all surfaces. The store operations manager at D2 explains the issue in traditional barcode reading: “We have to use labels that are not wrinkled or torn, and there cannot be anything written on top of the label. In those cases, the reader is unable to interpret the information and
we lose a lot of time.” Video cameras can read through plastic film and read partly damaged barcodes, which could save a significant amount of manual work in the receiving operation. The logistics business developer at C1 elaborates on the potential benefit in the receiving operation: “Today our receiving staff spend much time on scanning each product, printing the label and putting it on the parcel. It would save a lot of time to automatically scan and print multiple labels at the same time. By fixing a camera in front of the scanning area, the staff also don’t have to use a manual scanner.”

Second, the heat map application visualizes real time data of goods’ flow and could be used to identify frequently visited location and bottlenecks in receiving, picking and shipping areas. The interviewee at C1 underlines this aspect: “The heat map application can definitely be useful in a warehouse operation by visualizing how many picks that are generated from a certain location, and we could then move products that are frequently ordered to convenient locations. We could use the video application on a regular basis to quickly control whether a more detailed ABC-analysis needs to be done. Thereby it would be possible to avoid unnecessary manual work to analyze large amounts of WMS-data. I have carried out manual ABC-analysis and heat maps in Excel where we map the entire warehouse. It takes a lot of time! With the video application maybe it would be possible to focus the efforts more efficiently.” Considering these aspects, the heat map application can, according to the interviewees, provide input for decision making in regard of (i) changing the warehouse layout, (ii) re-placing SKUs in picking aisles to reduce travel times, and (iii) re-scheduling various activities to resolve congestion in, for example, restocking and picking operations. The last point is underlined by the logistics managers at C2: “We use simulation tools to estimate flows in the warehouse, but they are never precise enough. It would be interesting to use heat maps to identify congestions for pickers and trucks.”

Third, by installing cameras around the warehouse, the visual goods tracking application makes it possible to record product flows through the warehouse facility. With the help of a WMS, a time stamp is created when a tag or barcode is scanned. Then, upon entering a package’s ID, all video sequences associated to that ID are displayed on the screen. This functionality could, according to the case companies, be very useful for handling customer complaints in return operations. The director of logistics at D3 shares the case company’s experience of using the application: “We already use visual goods tracking today in our warehouse operation and are extremely pleased. Now we can show our customers a video sequence to prove that we did not cause the damage or delivered an incorrect order. Legally, we can build a much better case when handling customer complaints. In some cases, the customer tries to cheat you and avoid paying for the products, but that is not possible anymore.” The application makes it possible to analyze when and how products have been damaged in relation to the transfer of liability between companies. As discussed by the logistics business developer at C1, the application also reduces the manual labor required to handle this process: “Today, we take pictures of damaged products that are returned to our warehouse. Identifying the damage, getting the digital camera set up, filling in the required documentation; that process for dealing with just one complaint takes about half an hour.” In addition to handling complaints, the case companies also suggest that the application can be used to identify potential areas for improvement throughout the warehouse.

Finally, the object identification and counting application could, similar to existing pick-to-light systems, help to ensure that the right product has been picked in the right quantity. By installing cameras above pick-and-pack stations it would be possible to automatically confirm a correct pick or alert the picker in case of a mistake. Such an application could decrease the risk of sending out an incorrect order, and could also lead to that companies may reduce the
following quality controls for checking that the right products have been picked in the right quantities. The interviewee at C1 adds: “We work continuously to improve the picking process and reduce the number of errors. It would therefore be valuable to implement an application that can make the picking process more efficient with higher accuracy. It represents an additional point of confirmation that the order is correct.”

An important insight from this study is that different applications are useful for different operations. Most applications are recognized to be useful in one or two of the warehouse operations. Measure volume, as one example, is perceived to be beneficial in the receiving operation and in the shipping operation whereas the object identification and counting application could be useful in the picking and packing operation. Two of the applications can, however, be beneficial to use in all processes. The human detection application can increase safety for the staff throughout the entire warehouse whereas the barcode scanning application can improve and increase the speed of scanning in all warehouse operations. Related, this study indicates that different applications are interesting for different types of warehouses. For example, the inventory control application is scored much higher by distribution warehouses (average 3.3) compared to contracted and production warehouses (average 2.0). Similarly, the application counting loaded pallets is rated considerably higher by contracted warehouses (average 3.0) in comparison with distribution and production warehouses (average 1.7 and 2.3). The varying interest can partly be explained by the fact that different types of warehouses emphasize different operations depending on where they perceive major issues and costs to arise from (cf. Rouvenhorst et al., 2000). Contracted warehouses handle the goods of multiple clients and thus handle SKUs with very different characteristics. One of the case companies, for example, handles anything from running shoes to engine parts of motorbikes. The contracted warehouses included in this study also deliver directly to end consumers, which implies large number of small orders as well as high return flows. In this context, contracted warehouses experience picking, shipping and handling of returns as the most challenging and time consuming operations. The video applications that are most interesting to them therefore include (i) heat map and (ii) measure goods’ volume. In comparison, the distribution warehouses included in the study have a large number of SKUs with large throughputs and intense picking operations. These warehouses therefore expressed an interest in applications that can help to improve space utilization in order to be able to store more SKUs, and applications that can reduce travelling in the warehouse and make picking more efficient as well as reduce picking errors and customer complaints. Such applications include, for example, (i) heat map, (ii) barcode scanning, (iii) object identification and counting, and (iv) visual goods tracking. Meanwhile, the production warehouses emphasize warehouse operations that have an impact on the production process. These operations mainly include receiving and shipping of raw material, work-in-progress and finished goods between the warehouse and the production lines. To minimize downtime in production, the interviewees expressed an interest in the application that control truck turnover times to ensure that material is received on time, as well as the quality inspection application which helps to minimize quality issues with incoming pallets.

To summarize the findings and analysis section, we use the qualitative and quantitative input to create a typology outlining which application can suit which warehouse type and operation, see Table 4.2.

Table 4.2 Typology suggesting which application can suit which warehouse type and operation.

<table>
<thead>
<tr>
<th>Type of Warehouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>281</td>
</tr>
</tbody>
</table>
### 4.2. Barriers to implementing video technology in warehouse operations

The barriers identified in the empirical study are presented according to the three categories presented in the literature review: behavioral and cultural barriers; technical barriers; business and supply chain related barriers. The behavioral and cultural barriers primarily relate to employee integrity and the fact that video monitoring is negatively perceived by personnel working in the warehouses. The interviewee at C1 elaborates: “There are really two perspectives on using video applications. On the one hand, you want to get as much information as possible about the warehouse operation. On the other hand, it is not possible to compromise the integrity of the staff, you cannot use video to monitor staff in any way you want.” Based on previous experience of installing cameras, employees at the case companies question the cameras’ features and purpose, and also fear that video material is used to observe and penalize individual performance rather than to improve the operations. Hence, applications that focus on goods movements rather than movement of personnel may be more acceptable to staff and the union. To overcome this barrier, the interviewees confirm that involving the staff and the labor union early is critical to show how the applications work and highlight the potential benefits of video technology. To secure integrity of staff, it would also be important to blur faces in the video material.

Technical barriers are perceived as the most challenging to overcome. Many of the applications are not stand-alone products, but require integration with other system such as the WMS. The manager at C1 describes further: “The systems must be able to communicate with each other so that our WMS or the automated system works together with the cameras. This integration is not impossible but presents a tough challenge. In our case, we own our systems used in the warehouse operations so we could basically do whatever we want with it. However, it may take some time to get everything working together.” The WMS market is fragmented and each case company apply different WMS software in their warehouses. The case companies also view technology that supplies the WMS with information (e.g. barcode scanners) easier to implement than applications that work with the WMS (i.e. simultaneous sharing and receiving information from the WMS). The interviewees shared experiences of complex implementations of new features in existing WMS and other systems. IT departments were often seen as unwilling to integrate systems due to the risk for system failure, particularly in automated warehouses with several connected systems in place. Implementation time could also be extensive and debugging

<table>
<thead>
<tr>
<th>W/H operation</th>
<th>All</th>
<th>Contracted</th>
<th>Distribution</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Receiving</strong></td>
<td></td>
<td></td>
<td>Measure volume</td>
<td>Truck turnover time, Quality inspection of pallets</td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>Human detection and barcode scanning</td>
<td></td>
<td>Inventory control</td>
<td></td>
</tr>
<tr>
<td><strong>Picking</strong></td>
<td>Heat map, Object identification and counting</td>
<td>Heat map, Object Identification and counting</td>
<td>Object identification and counting</td>
<td></td>
</tr>
<tr>
<td><strong>Shipping</strong></td>
<td>Measure volume, Counting loaded pallets</td>
<td>Measure volume</td>
<td>Measure volume, Truck turnover time</td>
<td></td>
</tr>
<tr>
<td><strong>Returns</strong></td>
<td>Visual goods tracking</td>
<td>Visual goods tracking</td>
<td>Visual goods tracking</td>
<td></td>
</tr>
</tbody>
</table>
time consuming. Overall, to overcome this barrier, much effort must be put on making sure that the video applications can be easily integrated with a wide range of systems including variations of WMS and ERP systems.

Lastly, business and supply chain related barriers primarily relate to unknown return on investment. There is a lack of information regarding how much the technology will cost and, more importantly, what the concrete benefits and savings will be in a warehouse operation. The warehouse manager at P1 comments: “Many of the applications have great potential for improving our warehouse operation, but in the end I need to argue for the investment and for that I need a solid business case.” Considering that video applications is a new technology in warehouse operations, it is important that benefits of video applications are documented with best-practice examples to show potential savings and the return on investment. Otherwise it can be difficult for warehouse managers to apply for funding and motivate implementation, particularly considering that implementations are complex and require many man-hours to work properly. A related issue is that warehouse operations are sensitive to breakdowns, especially if they are highly automated. The case companies therefore avoid being early adopters of new technology and instead prefer to invest in robust solutions.

5. CONCLUDING DISCUSSION AND FUTURE RESEARCH

We conducted a multiple-case study with nine case companies to explore the potential of introducing video technology in warehouse operations. Our findings suggest that several video applications have high potential to improve the efficiency of different warehouse types and operations. Below, we discuss the main implications.

First, compared with existing technology including ERP, WMS, RFID and barcode (cf. section 2.2), video applications offer a new dimension with real time analysis of activities in the warehouse. Applications such as the heat map and measure volume can be used instead of manual labor and takes a fraction of the time to complete the tasks. Video technology can thus help to lower costs and increase speed in warehouse operations, which contributes to making the entire supply chain more competitive. Second, video technology can be used to complement and improve the efficacy of existing information technologies. As one example, the barcode scanning application may reduce some of the weaknesses of using barcodes (cf. Delen et al., 2007). The video application makes the handheld scanner redundant and enables scanning of multiple labels at the same time. It can also interpret damaged or wrinkled labels correctly. Hence, it makes the scanning process much faster and improves the competitiveness of using barcodes for tracking products through the warehouse and supply chain. Another example is the visual goods tracking applications which improves the tracking possibilities when using RFID tags or barcode labels. The application makes it possible to connect the tag or label identification number with recorded video sequences to visually track a product’s way through the warehouse. A third implication of our study is that video technology presents an opportunity to mitigate the human factor. One example is the ability to improve accuracy in picking operations. This improvement is important for reducing picking errors and the resulting costly return flows from customers, particularly considering that warehouses more often cater directly to end consumers and experience a growing number of customer orders. Another example is the human detection application which improves safety in future warehouse operations. Warehouse operations represent the majority of injuries in supply chains, hence reducing fork lift accidents is high on every warehouse manager’s agenda.
An important finding of this research study is that different applications are perceived as useful for different warehouse types and operations. This finding implies that video technology needs to be carefully tailored to the particular warehouse context. We presented a typology (cf. Table 4.2) which could serve as a useful starting point for future research investigating implementation of video technology in warehouse operations. It would be worthwhile for future research to investigate best-practice examples and successful cases where video applications have been implemented in warehouse operations. By conducting such case studies, it will be possible to understand what the actual gains and cost savings are for different warehouse types and operations. Another research opportunity is to investigate critical success factors for resolving the various barriers to video technology. Particularly, the issue with staff integrity is, in the warehouse environment, unique for video surveillance and worthwhile to look further into. Another interesting avenue for research is to investigate further how video technology could contribute to improving traceability, visibility and sustainability as well as competitiveness of future supply chains.

REFERENCES


Appendix 1: Overview of data collection.

<table>
<thead>
<tr>
<th>Warehouse type</th>
<th>Company</th>
<th>Interviewees</th>
<th>Experience, case company (years)</th>
<th>Experience, logistics (years)</th>
<th>Interview 1 (3 hours)</th>
<th>Questionnaire + Interview 2 (45 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot study</td>
<td>Pilot company</td>
<td>Warehouse manager</td>
<td>12</td>
<td>12</td>
<td>3/12, 2015</td>
<td>25/3, 2015</td>
</tr>
<tr>
<td>Contract</td>
<td>C1</td>
<td>Business developer, logistics</td>
<td>4</td>
<td>4</td>
<td>12/2, 2015</td>
<td>30/3, 2015</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>Head of logistics development</td>
<td>2</td>
<td>6</td>
<td>6/3, 2015</td>
<td>1/4, 2015</td>
</tr>
<tr>
<td>Distribution</td>
<td>D1</td>
<td>Operations manager</td>
<td>7</td>
<td>7</td>
<td>24/2, 2015</td>
<td>26/3, 2015</td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>Store operations manager</td>
<td>7</td>
<td>24</td>
<td>3/3, 2015</td>
<td>31/3, 2015</td>
</tr>
<tr>
<td></td>
<td>D3</td>
<td>Director of Logistics</td>
<td>15</td>
<td>15</td>
<td>19/3, 2015</td>
<td>1/4, 2015</td>
</tr>
<tr>
<td>Production</td>
<td>P1</td>
<td>Warehouse manager</td>
<td>10</td>
<td>28</td>
<td>25/2, 2015</td>
<td>10/4, 2015</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>Warehouse and transport manager</td>
<td>8</td>
<td>8</td>
<td>13/3, 2015</td>
<td>27/3, 2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project engineer</td>
<td>16</td>
<td>16</td>
<td>24/3, 2015</td>
<td>2/4, 2015</td>
</tr>
</tbody>
</table>

Appendix 2: Interview questions, Round 1.

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>Can you describe the operations in your warehouse? Which ones are the most challenging and time consuming?</td>
</tr>
<tr>
<td>Question 2</td>
<td>How could existing network video technology (cf. Table 2.2) be used to improve any (or all) of your warehouse operations?</td>
</tr>
<tr>
<td>Question 3</td>
<td>Which applications would be most beneficial to use in your warehouse operations?</td>
</tr>
<tr>
<td>Question 4</td>
<td>Can you think of any other video application (in addition to the ones mentioned in Table 2.2) that could be used to improve your warehouse operations?</td>
</tr>
</tbody>
</table>

Appendix 3: Questionnaire and interview questions, Round 2.

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire</td>
<td>Estimate your interest for the video applications (cf. Table 4.1, column 1 and 2); the interest should be based on the scale between 1-5 (as detailed in 4.1 on page 8)</td>
</tr>
<tr>
<td>Question 1</td>
<td>More specifically, what is the underlying reason to the extent of your interest for each of these applications?</td>
</tr>
<tr>
<td>Question 2</td>
<td>What would increase your interest in investing in any of these applications?</td>
</tr>
<tr>
<td>Question 3</td>
<td>Can you think of any other video application (in addition to the ones listed in Table 4.1) that could be used to improve your warehouse operations?</td>
</tr>
<tr>
<td>Question 4</td>
<td>What are the major barriers you see for implementing video technology in your warehouse?</td>
</tr>
<tr>
<td>Question 5</td>
<td>What are the underlying reasons for considering them as barriers and how could the barriers be resolved?</td>
</tr>
</tbody>
</table>
FREIGHT DEMAND MODELLING FOR SOUTHERN AFRICA

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EJ Lanz****
Stefaan Swarts*****

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ABSTRACT

Purpose
The Southern African Regional Freight Demand Model (RFDM) is the first attempt to generate a uniform way in which to translate economic and trade data into reliable freight flows for 17 countries in Sub-Saharan Africa and to initiate an understanding of trade flows in and between countries with a specific focus on corridors and ports.

Design/methodology/approach
Four iterations of the RFDM have been completed since 2012. The RFDM uses economic and trade data to generate volumetric supply and demand tables for each country for a base year, a six and 30-year forecast for 66 commodity groupings. The countries are then further divided into 63 districts and origin-destination pairs assigned to districts based on trade data, population distribution and industry and port locations. Volumes are flowed over a pre-defined network along the shortest path or by weighting routes.

Findings
The outputs of the model include volumetric flows in tonnes and tonne-kilometres for a base year, a six and 31 year forecast for 66 commodity groups in four flow typologies, namely domestic, import, export and intra-regional flows for each of the 17 Sub-Saharan African countries. Additional data on current and future corridor movements, port volumes and rail potential are also part of the outputs.

Research limitations/implications
The authors are in the process of developing a new methodology for creating origin and destination trade flows between countries. Due to inconsistencies and gaps in reporting of trade data a number of assumptions are made that reduces quality of outputs.
**Practical implications**
The understanding of trade volumes and flows in and between countries, could assist in the lobbying of appropriate logistics infrastructure investments for planning entities within governments.

**Original/value**
The RFDM is a first of its kind model for Southern Africa that provides a multiple year, macro overview of volumetric flows within and between countries.

*Keywords: Freight demand modelling, logistics infrastructure, Sub-Saharan Africa, volumetric flows.*

**1. INTRODUCTION**

The logistics infrastructure in Sub-Saharan Africa is generally inadequate and in a poor state, impeding development. This leads to costly, slow and unreliable cross-border corridor transport in most of Sub-Saharan Africa. These challenges are exacerbated for landlocked countries with export potential (De Bod, 2008). In order to enable appropriate logistics infrastructure investment planning, an understanding of the current and future demand for freight transport is critical. Freight flow analysis has, however, been historically lacking due to the general shortage of, and inconsistencies in, data available for African countries.

The Southern African Regional Freight Demand Model (RFDM) is the first attempt to generate a uniform way in which to translate economic and trade data into reliable freight flows for 17 countries in Sub-Saharan Africa and to initiate an understanding of trade flows in and between countries with a specific focus on corridors and ports.

**1.1. Background to study area**

The seventeen southernmost African countries where chosen to form part of the study area based on the proximity to South Africa and according to specifications from a project conducted for a commercial client in South Africa.

Table 1.1 gives selected socio-economic statistics for the 17 countries that form part of the RFDM study area (World Bank, 2015).
Table 1.1 Selected socio-economic statistics for the 17 countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Population (’000)</th>
<th>% of total</th>
<th>Land area (sq. km)</th>
<th>GDP (US$ millions)</th>
<th>Exports % of GDP</th>
<th>Imports % of GDP</th>
<th>Exchange rate Local to US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>22 137</td>
<td>43</td>
<td>1 246 700</td>
<td>131 400</td>
<td>59</td>
<td>42</td>
<td>98.30</td>
</tr>
<tr>
<td>Botswana</td>
<td>2 039</td>
<td>57</td>
<td>566 730</td>
<td>15 813</td>
<td>50</td>
<td>43</td>
<td>8.98</td>
</tr>
<tr>
<td>Burundi</td>
<td>10 483</td>
<td>12</td>
<td>25 680</td>
<td>3 094</td>
<td>8</td>
<td>34</td>
<td>1546.69</td>
</tr>
<tr>
<td>Congo</td>
<td>4 559</td>
<td>65</td>
<td>341 500</td>
<td>14 135</td>
<td>80</td>
<td>71</td>
<td>494.41</td>
</tr>
<tr>
<td>DRC</td>
<td>69 360</td>
<td>42</td>
<td>2 267 050</td>
<td>32 962</td>
<td>33</td>
<td>39</td>
<td>921.25</td>
</tr>
<tr>
<td>Kenya</td>
<td>45 546</td>
<td>25</td>
<td>569 140</td>
<td>60 937</td>
<td>16</td>
<td>34</td>
<td>87.92</td>
</tr>
<tr>
<td>Lesotho</td>
<td>2 098</td>
<td>27</td>
<td>30 360</td>
<td>2 088</td>
<td>50</td>
<td>110</td>
<td>10.85</td>
</tr>
<tr>
<td>Malawi</td>
<td>16 829</td>
<td>16</td>
<td>94 280</td>
<td>4 258</td>
<td>46</td>
<td>56</td>
<td>424.90</td>
</tr>
<tr>
<td>Mozambique</td>
<td>26 473</td>
<td>32</td>
<td>786 380</td>
<td>16 386</td>
<td>27</td>
<td>39</td>
<td>31.35</td>
</tr>
<tr>
<td>Namibia</td>
<td>2 348</td>
<td>46</td>
<td>823 290</td>
<td>13 430</td>
<td>40</td>
<td>63</td>
<td>10.85</td>
</tr>
<tr>
<td>Rwanda</td>
<td>12 100</td>
<td>28</td>
<td>24 670</td>
<td>7 890</td>
<td>15</td>
<td>31</td>
<td>681.86</td>
</tr>
<tr>
<td>South Africa</td>
<td>54 002</td>
<td>64</td>
<td>1 213 090</td>
<td>349 817</td>
<td>31</td>
<td>33</td>
<td>10.85</td>
</tr>
<tr>
<td>Swaziland</td>
<td>1 268</td>
<td>21</td>
<td>17 200</td>
<td>3 400</td>
<td>51</td>
<td>70</td>
<td>10.85</td>
</tr>
<tr>
<td>Tanzania</td>
<td>50 757</td>
<td>31</td>
<td>885 800</td>
<td>49 184</td>
<td>20</td>
<td>30</td>
<td>1654.00</td>
</tr>
<tr>
<td>Uganda</td>
<td>38 845</td>
<td>16</td>
<td>199 810</td>
<td>26 312</td>
<td>20</td>
<td>29</td>
<td>2599.79</td>
</tr>
<tr>
<td>Zambia</td>
<td>15 021</td>
<td>40</td>
<td>743 390</td>
<td>27 066</td>
<td>41</td>
<td>38</td>
<td>6.15</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>14 599</td>
<td>33</td>
<td>386 850</td>
<td>13 663</td>
<td>27</td>
<td>56</td>
<td>361.90</td>
</tr>
</tbody>
</table>

It is estimated that a total of 390 million people lived in the region in 2014 with a combined land area of 10 million square kilometres and a regional gross domestic product (GDP) of US$ 772 billion.

2. METHODOLOGY AND APPROACH

2.1. Similar research

This paper is the continuation of a previous paper (Havenga, 2012) where the initial methodology and approach followed where discussed and has now been improved and refined. Due to a lack of reliable data for most African countries a simplified approach to well-known European models such as the Strategic European Multi-Modal Modelling (STEMM) and TRANS-TOOLS (‘TOOLS for Transport Forecasting and Scenario Testing’) has been developed. The RFDM is based on methodology used to develop a similar model for South Africa (Havenga, 2007). The South African Freight Demand Model (FDM) has been developed and refined over the past 18 years. Its outputs include freight flows between 372 districts for 84 separate commodity groups for all land freight modes within the country borders. The first full-scale version of the FDM was released in 2006, and has been updated annually. The RFDM is not a simulation model but provides a static snapshot of flows between and within different countries for a specific time period.
The World Bank (2012) conducted a study on defining and developing an investment strategy for a core strategic transport network in Eastern and Southern Africa. Historic trade flows in the region where analysed and trade demand and trade flow projections were provided. This will be used to benchmark and validate the RFDM results later in the paper.

2.2. Economic forecasting process

The first step in the modelling process is to generate supply and demand tables for each of the 17 countries. To arrive at a solution a bottom-up approach is used where each country’s results are added together to obtain a view for the whole region. The advantage of using this methodology is that the distributions for the demand and supply in the various sectors flow directly from the country information which was used to build the regional economy. The forecasting process works on exactly the same methodology. There are three distinct components to the economic forecasting process, namely the compilation of a social accounting matrix (SAM) for each country. Secondly, the calculation of the volumes per commodity for the base year, and thirdly the forecasting thereof.

2.2.1. Social Accounting Matrices

Social accounting matrices (SAMs) were developed for each country by using published information on national accounts or where data was unavailable using estimates based on desktop research or the structure of previous SAMs or in a final instance a SAM of a country with a similar level of development was used as a proxy for expenditure patterns. The national accounts provide detailed components of an economy such as private consumption expenditure, government consumption expenditure, investment, exports and imports as well as the gross domestic product, which are then disaggregated into individual commodities in the SAM.

2.2.2. Calculating the base year

Due to the existence of a SAM for a country in monetary terms, the values now have to be converted to volumes (tonnages) if no actual volume figures exist. In the absence of commodity volumes a price per tonne for each country specific commodity is used to convert the monetary values into volumes. If country specific commodity prices do not exist, the South African price per tonne from the FDM were used as proxies. The outcome is detailed supply and demand tables per country on a commodity basis for the base year. Supply consists of production and imports and demand consists of consumption, exports, intermediate demand and investments. Table 2.1 shows an example of the supply and demand table output.

Table 2.1 Example of supply and demand table output

<table>
<thead>
<tr>
<th>Commodity (tonnes)</th>
<th>Angola</th>
<th>Botswana</th>
<th>Burundi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Sorghum</td>
<td>103 346</td>
<td>96 639</td>
<td>19 055</td>
</tr>
<tr>
<td>Maize</td>
<td>2 172 515</td>
<td>223 240</td>
<td>125 926</td>
</tr>
<tr>
<td>Sunflower Seed</td>
<td>28 373</td>
<td>660</td>
<td>0</td>
</tr>
<tr>
<td>Wheat</td>
<td>71 557</td>
<td>14 304</td>
<td>2 709</td>
</tr>
<tr>
<td>Rice</td>
<td>186 658</td>
<td>32 577</td>
<td>44 736</td>
</tr>
<tr>
<td>Vegetables</td>
<td>3 416 207</td>
<td>102 635</td>
<td>565 708</td>
</tr>
<tr>
<td>Potatoes</td>
<td>254 716</td>
<td>185 832</td>
<td>157 303</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.2.3. Forecasting

To forecast the demand of various commodities in an economy, it is generally necessary to have historic time series data. Where these do exist the time series’, in most cases, are not long enough to do regression analysis and provide statistically acceptable outcomes. To overcome this problem, specifically for imports and exports, a rational algorithm based on the principles of the Delphi technique has been developed whereby the growth of certain commodities in a specific commodity group is benchmarked higher or lower than the average growth rate for that specific group of commodities. For example, to what extent will wheat grow faster or slower than the average growth rate of field crops.

If time series data were not long enough to conduct a regression analysis secondary information was collected from various published sources to arrive at a conclusion over the potential of growth in certain commodities. A third method was to rationally derive certain conclusions about the potential growth of certain commodities. For example, looking at the production of certain agricultural commodities in countries where the climate is not conducive to the production of those commodities. Further, it had to do with the endowment of certain mineral resources in a country, e.g. although Angola is currently a big oil producer, reserves could run out in future.

2.2.4. Verification and validation of outputs

After the base year results and again after the forecasting results a process of verification and validation of the data outputs take place. The two ways in which this is done is by comparing the previous year’s results with the new outputs to achieve consistency in the year-on-year figures. Where there are significantly different figures a more in depth investigation is done to decide which of the figures are correct. A number of country specific sources are used to validate the modelled results and also include sources that cover all the countries, these are:

- International Trade Centre, [http://www.trademap.org/]
- South African Revenue Services (SARS), Detailed import/export data received and analysed

The key to verification and validation of the economic modelling process lies in the saying that “a person does not model what is known”, therefore any verifiable volume figures always replaces the modelled results.

2.3. Modelling the volumetric flows

The need arose to develop an alternative methodology to assign flows between countries and districts within countries as the gravity modelling process used for the South African FDM would not yield the desired results. Through analysis of know trade data, flows between countries and districts are modelled. Figure 3.1 shows a map of the 63 districts the countries are divided into.
2.3.1. Trade data analyses

Intra-regional trade data

Trade data between the 17 RFDM countries are extracted from the UN Comtrade database. The data are obtained on the Harmonized System 4 (HS-4) digit level. Datasets are processed at the HS-4 level and then classified into the 66 RFDM commodities. Of the approximately 78,000 data entries, 95% have both a US dollar (USD) value and a kilogram (kg) value. For each HS-4 commodity, the entries that have a USD and kg value are consolidated and used in order to obtain an average intra-RFDM USD per kg value. This value is then used to estimate the kg value for the remaining 5% of the data entries that only have a USD value.

For trade between countries, the latest year of reported data between the two countries are used (the earlier year of reported data was used as a sense check). If both countries have the same year of reported data, the maximum volume figure for each HS-4 level commodity is taken. Some major discrepancies are found between the corresponding data entries and the reason for taking the maximum value is that taking an average value distorts both entries and if the minimum value is taken some flows are reduced to very small volumes. Specific commodity research is also conducted to obtain the most correct figure if large discrepancies exist.

Country specific import & export data

Trade data between the 17 RFDM countries and the five continents (Rest of Africa, America, Asia, Europe and Oceania) are also extracted from the UN Comtrade database on a country level and then aggregated into the continental regions. The data are also obtained and processed on an HS-4 level and then classified into the 66 RFDM commodities. The trade data reported by the countries to each continent have both a USD value and quantity value. The data reported by consolidating the continents, with country partners, only have a USD value. For this data a
volume figure is calculated using a USD per ton conversion factor (per HS-4 level code) based on the data entries that have both USD value and tonnage value or the intra-regional USD per kg value obtained from the UN Comtrade data. The maximum reported figure for each HS-4 level commodity was taken as the volume between an international country and a RFDM country, similar to the intra-regional volumes.

Matching trade volumes with the supply and demand table outputs

A trade flow between two RFDM countries needs to be such that a country’s import or export of a commodity does not exceed the total import or export of that commodity from/to all regions. To prevent this from occurring, each flow is adjusted when necessary. This is done by dividing base supply and demand table imports and exports for a country’s total volume for a specific commodity by the trade data collected from UN Comtrade to obtain an adjustment percentage. The initial trade flow was then multiplied by the minimum of the two adjustment percentages. This prevents exceeding the total base volume for a country specific commodity when adding all individual flows together. For the forecasts, the growth percentage of each commodity per country is calculated. The assigned base intra-regional flow volume is increased by the minimum of the two growth percentages.

Distributing remaining flows to world regions

The volumes assigned to intra-regional trade is then subtracted from the original base table imports and exports to obtain remaining trade volumes. These volumes are also subtracted from the Africa trade volumes to obtain a rest of Africa volume estimate. The volumes of each continent (Africa-Rest, America, Asia, Europe and Oceania) are used to create a trade profile (percentage to each continent) of each commodity for each country for both imports and exports. The remaining import and export volumes are then assigned to the continents according to these trade profiles. For the forecast the remaining flow volumes are obtained in the same manner and use the same base trade profiles.

Dividing domestic flows per country district

The domestic volumes per commodity were split into districts based on rural and urban population percentages. For each commodity the South African FDM supply and demand split for rural and urban districts were calculated. Using this split the rural and urban population percentages of each RFDM country was weighted. The supply and demand volumes of each country were multiplied by weighted rural and urban population percentages of each district within the country to obtain district supply and demand volumes. For agriculture and mining commodities the supply and demand volumes were split into districts based on country specific production locations for the commodities when available.

2.3.2. Assigning volumetric flows to the network

For each district the import and export volumes were assigned to specific ports. The commodity assignments are correlated to known port volumes for the RFDM ports. It is possible for a commodity to be assigned to more than one port. In selected cases where a lack of data existed a commodity was assigned to the closest port. To create flows for imports, the port was selected as the origin of trade and for exports as the destination of trade. In each district a main city was selected to represent the origin or destination of commodity volumes for the district. The main city could also be a port city. The origin and destination points for the four flow types are represented in Table 2.2.
Table 2.2 Origin or destination per flow typology

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Origin</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td>Main City</td>
<td>Main City (within same country)</td>
</tr>
<tr>
<td>Intra</td>
<td>Main City</td>
<td>Main City (in different country)</td>
</tr>
<tr>
<td>Export</td>
<td>Main City</td>
<td>Assigned Port</td>
</tr>
<tr>
<td>Import</td>
<td>Assigned Port</td>
<td>Main City</td>
</tr>
</tbody>
</table>

An additional city may be used as the origin or destination based on verified research of a given commodity and to provide more granularity. The volumes between each unique origin-destination (OD) pair were flowed over a pre-defined road network using the Python script in QGIS, which assigns volumes along the shortest path or using different weights to force movements over certain corridors.

3. RESULTS AND OUTPUTS

3.1. Total volume and growth for the region

The total volumetric demand for the region is estimated at 1.494 billion tonnes for the 2014 calendar year. This is forecasted to grow to 1.884bn tonnes by the year and 4.874bn tonnes by 2045. In addition the estimated tonne-kilometres were 569bn for 2014 and forecasted at 717bn and 1,946bn for 2020 and 2045, respectively. The total regional tonnage volume is expected to grow at a CAGR of 3.9% between 2014 and 2020 and between 2020 and 2045. Tonne-km growth is forecasted at 3.9% for 2014 to 2020 and slightly higher at 4.1% between 2020 and 2045. Table 3.1 gives a breakdown of the volumes in tonne and tonne-km for each country for the base year 2014 and the forecasted years of 2020 and 2045. In addition the compounded annual growth rates (CAGR) between 2014 and 2020 and 2020 and 2045 are also given.

It is interesting to note that South Africa’s contribution to regional volumes are set to decline in future with its share of total tonnage reducing from 55% in 2014 to 41% by 2045. The share of tonne-km is set to decline even further, from 57% in 2014 to only 35% by 2045.
Table 3.1 Volumes and growth per country for 2014, 2020 and 2045 (tonnes and tonne-kms)

<table>
<thead>
<tr>
<th>Country</th>
<th>2014</th>
<th>CAGR</th>
<th>2020</th>
<th>CAGR</th>
<th>2045</th>
<th>2014</th>
<th>CAGR</th>
<th>2020</th>
<th>CAGR</th>
<th>2045</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>161.1</td>
<td>5.1%</td>
<td>217.0</td>
<td>4.0%</td>
<td>575.4</td>
<td>25.1</td>
<td>5.1%</td>
<td>33.8</td>
<td>4.9%</td>
<td>112.2</td>
</tr>
<tr>
<td>Botswana</td>
<td>20.1</td>
<td>5.5%</td>
<td>27.6</td>
<td>5.6%</td>
<td>106.7</td>
<td>11.5</td>
<td>5.4%</td>
<td>15.7</td>
<td>6.6%</td>
<td>78.6</td>
</tr>
<tr>
<td>Burundi</td>
<td>10.4</td>
<td>2.8%</td>
<td>12.2</td>
<td>3.4%</td>
<td>28.0</td>
<td>2.2</td>
<td>3.1%</td>
<td>2.6</td>
<td>3.7%</td>
<td>6.5</td>
</tr>
<tr>
<td>Congo</td>
<td>34.8</td>
<td>4.3%</td>
<td>44.7</td>
<td>3.8%</td>
<td>113.1</td>
<td>5.8</td>
<td>4.9%</td>
<td>7.8</td>
<td>4.3%</td>
<td>22.2</td>
</tr>
<tr>
<td>DRC</td>
<td>57.9</td>
<td>5.9%</td>
<td>81.8</td>
<td>5.2%</td>
<td>287.4</td>
<td>44.9</td>
<td>7.0%</td>
<td>67.6</td>
<td>5.7%</td>
<td>272.8</td>
</tr>
<tr>
<td>Kenya</td>
<td>64.7</td>
<td>3.2%</td>
<td>78.0</td>
<td>3.9%</td>
<td>201.7</td>
<td>24.1</td>
<td>3.0%</td>
<td>28.7</td>
<td>3.8%</td>
<td>73.0</td>
</tr>
<tr>
<td>Lesotho</td>
<td>4.9</td>
<td>4.5%</td>
<td>6.4</td>
<td>3.6%</td>
<td>15.4</td>
<td>1.6</td>
<td>4.0%</td>
<td>2.0</td>
<td>3.5%</td>
<td>4.8</td>
</tr>
<tr>
<td>Malawi</td>
<td>27.6</td>
<td>4.6%</td>
<td>36.1</td>
<td>4.7%</td>
<td>114.0</td>
<td>9.3</td>
<td>4.4%</td>
<td>12.0</td>
<td>4.3%</td>
<td>34.3</td>
</tr>
<tr>
<td>Mozambique</td>
<td>55.7</td>
<td>6.4%</td>
<td>80.9</td>
<td>6.2%</td>
<td>365.5</td>
<td>15.6</td>
<td>8.9%</td>
<td>26.0</td>
<td>6.2%</td>
<td>117.8</td>
</tr>
<tr>
<td>Namibia</td>
<td>14.1</td>
<td>4.8%</td>
<td>18.7</td>
<td>4.9%</td>
<td>62.0</td>
<td>9.3</td>
<td>4.3%</td>
<td>12.0</td>
<td>4.5%</td>
<td>36.0</td>
</tr>
<tr>
<td>Rwanda</td>
<td>19.4</td>
<td>5.7%</td>
<td>27.1</td>
<td>5.3%</td>
<td>98.7</td>
<td>3.6</td>
<td>5.6%</td>
<td>5.0</td>
<td>5.2%</td>
<td>17.9</td>
</tr>
<tr>
<td>South Africa</td>
<td>829.1</td>
<td>3.0%</td>
<td>992.7</td>
<td>2.9%</td>
<td>2 007.6</td>
<td>323.3</td>
<td>2.7%</td>
<td>378.4</td>
<td>2.4%</td>
<td>679.1</td>
</tr>
<tr>
<td>Swaziland</td>
<td>14.1</td>
<td>3.2%</td>
<td>17.0</td>
<td>3.3%</td>
<td>38.6</td>
<td>2.6</td>
<td>3.1%</td>
<td>3.1</td>
<td>3.6%</td>
<td>7.6</td>
</tr>
<tr>
<td>Tanzania</td>
<td>65.1</td>
<td>5.4%</td>
<td>89.1</td>
<td>5.5%</td>
<td>342.6</td>
<td>29.6</td>
<td>5.3%</td>
<td>40.4</td>
<td>5.7%</td>
<td>162.3</td>
</tr>
<tr>
<td>Uganda</td>
<td>51.4</td>
<td>5.8%</td>
<td>72.3</td>
<td>5.1%</td>
<td>249.8</td>
<td>18.5</td>
<td>6.2%</td>
<td>26.5</td>
<td>6.2%</td>
<td>119.1</td>
</tr>
<tr>
<td>Zambia</td>
<td>37.1</td>
<td>4.4%</td>
<td>48.1</td>
<td>4.5%</td>
<td>143.4</td>
<td>28.5</td>
<td>5.0%</td>
<td>38.2</td>
<td>5.2%</td>
<td>135.1</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>26.7</td>
<td>4.2%</td>
<td>34.1</td>
<td>5.3%</td>
<td>124.3</td>
<td>13.5</td>
<td>4.4%</td>
<td>17.5</td>
<td>5.5%</td>
<td>66.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1 494</strong></td>
<td><strong>3.9%</strong></td>
<td><strong>1 884</strong></td>
<td><strong>3.9%</strong></td>
<td><strong>4 874</strong></td>
<td><strong>569</strong></td>
<td><strong>3.9%</strong></td>
<td><strong>717</strong></td>
<td><strong>4.1%</strong></td>
<td><strong>1 946</strong></td>
</tr>
</tbody>
</table>

Table 3.2 gives a breakdown of the contribution of each flow typology to the overall volumes for the base and forecast years. It is expected that the split will remain relatively constant for tonnes and tonne-kms over the period. The contribution of exports will show a small reduction whilst the contribution of imports will increase slightly.

Table 3.2 Contribution of each typology per year for tonnes and tonne-kms

<table>
<thead>
<tr>
<th>Typology</th>
<th>Tonnes</th>
<th>Tonne-km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2014</td>
<td>2020</td>
</tr>
<tr>
<td>Domestic</td>
<td>68%</td>
<td>68%</td>
</tr>
<tr>
<td>Exports</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td>Imports</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>Intra</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>

3.2. Domestic volumes

Domestic tonnages contributes significantly to each country’s total volume profile, as expected. Figure 3.2 gives a visual representation of the growth in domestic tonnages per country between 2014 and 2045. The total domestic volume for the regions was estimated at 990 million tonnes for 2014 and is expected to reach 3 268m tonnes by 2045.

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The regional CAGR for domestic volumes between 2014 and 2045 equals 3.9% per year with Mozambique (5.7%), Tanzania (5.4%) and DRC (5.1%) expected to show the highest growth and Swaziland and Burundi the lowest at 2.9% and 3.2%, respectively.

3.3. Trade volumes

Total trade volumes for the region came to 475 million tonnes in 2014. Exports to the continents were 67% of the total with imports being 27%. Intra-regional trade between the 17 countries made up the other 6% of trade. Trade volumes are forecasted to increase to 1,529 million tonnes by 2045 with the exports, import and intra-regional split standing at 63%, 32% and 5%, respectively. Figure 3.3 gives a simplified visual representation of the region’s volumetric trade with the five major continental groups.

Asia is the biggest trading partner with 67% share of total volumetric trade, this is set to decline to 63% by 2045. Europe is in a distant second with 15% and will increase slightly to 17% by 2045. The Americas has a 10% share of the total and this will remain constant up to 2045. The Rest of Africa’s share is expected to increase from 6% to 7% by 2045. South Africa still dominates the trade profile of the region, but as mentioned previously this is set to drop over the forecast period with its influence becoming less prominent as other countries increase their export and import volumes. South Africa’s share of exports are set to decrease from 61% in 2014 to 38% by 2045 and its share of imports from 42% to 29%.

As can be expected mining commodities dominate the regional exports with 84% of the total exports originating in the mining sector. This is expected to decline to 74% by 2045, with the manufacturing sector increasing its share from 13% to 22% of the total. Agricultural exports will show a modest increase from 3% share in 2014 to 5% share of total by 2045. Manufactured goods represent 66% of the total imports into the region and this is set to increase to 73% by 2045. Mining imports were 23% for 2014 and are expected to decline to 17% by 2045. Agricultural imports will also decrease from 12% share in 2014 to 10% share of total in 2045.
Figure 3.2 Volumetric trade profile of the region (million tonnes)

Trade within the borders of the region (intra-regional trade) is dominated by manufactured products with a contribution of 67% to the total volume of 29.6 million tonnes. Mining represent 23% and agricultural products 11% of the total. The distribution is expected to change slightly in future with manufacturing, mining and agriculture contributing 70%, 19% and 10%, respectively to the total volume of 77 million tonnes.

3.4. Corridor Volumes

Figure 3.4 maps all the major corridors in the region. Most corridors were chosen according to their existing importance in the region whilst others are expected to become more important in future. Examples are the LAPSSET corridor connecting the port of LAMU in Kenya with the countries of Ethiopia and South Sudan in future and the Lobito-Benguela corridor that connect the port of Lobito in Angola with the copper mines in southern DRC and northern Zambia.

Table 3.3 gives a breakdown of the tonnes and tonne-kms per corridor for 2014, 2020 and 2045. The corridor that will handle the largest volume by 2045 is forecasted to be the East Africa North corridor with 156 million tonnes. It connects the port of Mombasa in Kenya with the countries of Uganda, Rwanda and Burundi. The three North-South corridors that run through Zambia, Zimbabwe, Botswana and South Africa are expected to handle a combined volume of 215 million tonnes by 2045.
Figure 3.3 Major corridors in the region

Table 3.3 Corridor volumes for 2014 and estimates for 2020 and 2045

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Tonnes ('000)</th>
<th>Tonne-kms (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2014</td>
<td>2020</td>
</tr>
<tr>
<td>Bas Congo</td>
<td>3 388</td>
<td>4 954</td>
</tr>
<tr>
<td>Beira</td>
<td>9 362</td>
<td>11 777</td>
</tr>
<tr>
<td>Congo</td>
<td>6 724</td>
<td>9 141</td>
</tr>
<tr>
<td>East Africa Central</td>
<td>14 379</td>
<td>19 777</td>
</tr>
<tr>
<td>East Africa North</td>
<td>40 052</td>
<td>50 215</td>
</tr>
<tr>
<td>Gauteng-Swaziland</td>
<td>1 285</td>
<td>1 473</td>
</tr>
<tr>
<td>Goba-Lebombo</td>
<td>1 644</td>
<td>2 147</td>
</tr>
<tr>
<td>Lesotho</td>
<td>1 816</td>
<td>2 312</td>
</tr>
<tr>
<td>Limpopo</td>
<td>2 811</td>
<td>3 547</td>
</tr>
<tr>
<td>Lobito-Benguela</td>
<td>2 594</td>
<td>3 475</td>
</tr>
<tr>
<td>Malanje</td>
<td>6 502</td>
<td>9 039</td>
</tr>
<tr>
<td>Manzini-Durban</td>
<td>1 403</td>
<td>1 734</td>
</tr>
<tr>
<td>Maputo</td>
<td>16 724</td>
<td>20 700</td>
</tr>
<tr>
<td>Nacala</td>
<td>2 432</td>
<td>8 377</td>
</tr>
<tr>
<td>Namibe</td>
<td>1 170</td>
<td>1 770</td>
</tr>
<tr>
<td>North-South BBR</td>
<td>22 690</td>
<td>30 379</td>
</tr>
<tr>
<td>North-South BR</td>
<td>13 765</td>
<td>18 806</td>
</tr>
<tr>
<td>North-South NRZ</td>
<td>10 119</td>
<td>12 608</td>
</tr>
</tbody>
</table>
### 3.5. Flow analysis

Figure 3.5 shows a representation of all surface trade flows in the region for the 2014 base year and the 2045 forecast (it therefore excludes domestic flows) mapped onto a simplified road network.

![Figure 3.4 All surface trade flows for 2014 and 2045](image)

### 3.6. Benchmarking and validation of results

#### 3.6.1. Comparison of the four RFDM iterations

As part of the verification and validation of the RFDM results it is important to compare outputs with each other. There have been four iterations and with each iteration the model is updated.
and refined further. It is therefore not always possible to draw comparisons on a detailed level, but the consistency of certain outputs can be tested. Over time and through each iteration it is expected that the model outputs will stabilise and become more consistent and comparable to the previous attempts. Figure 3.7 shows the total tonnage for each of the four models.

The base year and year 6 forecast has remained relatively constant through the four year period. There is a slight increase in the total tonnages between the 2013 and 2014 base and year 6 forecast. This is expected to happen as the model parameters stabilise and outputs become more consistent. The 31-year forecast still shows a reduction in total volumes. The major reason for this is a more reserved growth outlook for the region and especially for South Africa, which still dominates the volumetric output of the region.

![Figure 3.5 Comparison of base year and forecasted volumes for the four models](image)

Figure 3.5 Comparison of base year and forecasted volumes for the four models

Figure 10 compares the 31-year tonnage CAGR for the four models per typology. It is obvious that through the four iterations of the model the growth forecast has become much more reserved and is driven mainly by the outlook for mining commodities over the medium to long term.

![Figure 3.6 Comparison of 31-year tonnage CAGR per typology for all four models](image)

Figure 3.6 Comparison of 31-year tonnage CAGR per typology for all four models
3.6.2. Comparison of RFDM with World Bank study

As mentioned previously the World Bank conducted a study in 2012 to develop an investment strategy for a core strategic transport network for Eastern and Southern Africa that included a base year volume estimate and a seven and 22 year volumetric forecast for 14 countries also included in the RFDM. Table 3.4 and Table 8 shows the total export and import volumes per country, respectively. A comparison is drawn between the base year estimates of the World Bank in 2008, the World Bank forecast for 2015 and the average base year volumes for all four RFDM iterations (2010, 2012, 2013 and 2014). Logically the World Bank base of 2008 should be lower than the average RFDM volumes and the World Bank forecast for 2015 should be higher. On average this seems to be the case when looking at the tables, with green representing the low figure, yellow the middle figure and red the high figure for each separate country.

Table 3.4 Comparison of World Bank and RFDM export volumes

<table>
<thead>
<tr>
<th>Country</th>
<th>WB base 2008</th>
<th>WB 2015 forecast</th>
<th>RFDM base (4 year average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>51 380 000</td>
<td>101 512 000</td>
<td>88 619 705</td>
</tr>
<tr>
<td>Botswana</td>
<td>6 970 000</td>
<td>5 590 000</td>
<td>1 504 232</td>
</tr>
<tr>
<td>Burundi</td>
<td>32 000</td>
<td>135 000</td>
<td>96 720</td>
</tr>
<tr>
<td>DRC</td>
<td>1 331 000</td>
<td>4 118 000</td>
<td>3 774 982</td>
</tr>
<tr>
<td>Kenya</td>
<td>3 324 000</td>
<td>6 426 000</td>
<td>6 864 570</td>
</tr>
<tr>
<td>Malawi</td>
<td>1 478 000</td>
<td>5 178 000</td>
<td>1 155 268</td>
</tr>
<tr>
<td>Mozambique</td>
<td>3 184 000</td>
<td>8 002 000</td>
<td>8 486 766</td>
</tr>
<tr>
<td>Namibia</td>
<td>1 464 000</td>
<td>4 586 000</td>
<td>2 477 615</td>
</tr>
<tr>
<td>Rwanda</td>
<td>87 000</td>
<td>157 000</td>
<td>751 134</td>
</tr>
<tr>
<td>South Africa</td>
<td>81 161 000</td>
<td>128 469 000</td>
<td>189 927 737</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1 548 000</td>
<td>3 491 000</td>
<td>3 125 568</td>
</tr>
<tr>
<td>Uganda</td>
<td>1 883 000</td>
<td>5 732 000</td>
<td>3 180 614</td>
</tr>
<tr>
<td>Zambia</td>
<td>3 846 000</td>
<td>10 335 000</td>
<td>4 630 661</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>2 380 000</td>
<td>7 204 000</td>
<td>2 409 682</td>
</tr>
</tbody>
</table>

Selected outliers include much lower RFDM export estimates for Botswana and Malawi and much higher export estimates for Rwanda and South Africa. South Africa’s exports for only coal and iron ore in 2014 came to 153 million tonnes, which shows the World Bank figures are too low. Further investigation into the specific commodity mix is necessary to explain the other outliers.

Table 3.5 Comparison of World Bank and RFDM import volumes

<table>
<thead>
<tr>
<th>Country</th>
<th>WB base 2008</th>
<th>WB 2015 forecast</th>
<th>RFDM base (4 year average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>10 488 000</td>
<td>28 291 000</td>
<td>12 495 818</td>
</tr>
<tr>
<td>Botswana</td>
<td>4 316 000</td>
<td>6 153 000</td>
<td>4 524 752</td>
</tr>
<tr>
<td>Burundi</td>
<td>157 000</td>
<td>584 000</td>
<td>847 186</td>
</tr>
<tr>
<td>DRC</td>
<td>3 689 000</td>
<td>15 886 000</td>
<td>4 233 763</td>
</tr>
<tr>
<td>Kenya</td>
<td>7 885 000</td>
<td>20 344 000</td>
<td>13 074 244</td>
</tr>
<tr>
<td>Malawi</td>
<td>3 184 000</td>
<td>10 249 000</td>
<td>2 348 912</td>
</tr>
<tr>
<td>Mozambique</td>
<td>3 981 000</td>
<td>6 281 000</td>
<td>5 985 740</td>
</tr>
</tbody>
</table>
The RFDM imports for Burundi are much higher than both World Bank figures and Malawi, Namibia, Zambia and Zimbabwe’s RFDM imports are much lower. This will also require more specific investigation regarding the specific commodity mix.

Figure 3.7 gives a comparison between the World Bank and RFDM long-term export and import compounded annual growth rates (CAGR). The general trend shows that the World Bank growth rates are higher than the RFDM growth rates (see Table 3.4). The seven year difference in the base years can offer a partial explanation in that the slump in raw material commodity prices started in 2014 which had an effect on future volume forecasts for all countries that rely heavily on mining exports. A conservative approach was followed in the RFDM export forecasts, which has a direct effect on the import forecasts.

Table 3.6 Comparison of total CAGR for all 14 countries

<table>
<thead>
<tr>
<th>Trade type</th>
<th>CAGR WB 2008-2030</th>
<th>CAGR RFDM 2014-2045</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exports</td>
<td>6.6%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Imports</td>
<td>7.4%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

Figure 3.7 Comparison of World Bank and RFDM long-term growth rates
Only Botswana has a much higher RFDM export CAGR (10.2%) compared to the World Bank forecast of 1.1%. The discovery of higher coal reserves in Botswana than previously thought has opened possibilities of sustainable coal exports, which will increase volumetric exports from Botswana in future.

4. CONCLUSIONS

The RFDM as a first attempt to model freight demand and flows for 17 countries in Southern Africa has proven very successful in providing a macro-economic view and data. The complimentary effect of freight corridors in Sub Saharan Africa is also illustrated in this work. South Africa’s Freight Demand Model has been proven to be quite successful in guiding policy and investment (Havenga, 2013), but it can never be a stand-alone exercise.

The linkages, for instance, between the Mozambique, Zimbabwe and North-East South Africa region is a case in point. These are extremely dense corridors, but master planning on South Africa’s side alone negates the effect of possible available alternate routes that can be developed that supports the ideals of all three countries. Such a Sub-Saharan, regional or SADC masterplan will only be possible with a freight demand model for the total region.

The 5th iteration and update will be conducted later in 2016 and will bring further refinement and improvements that include a more robust method of assigning trade volumes between countries which will provide more reliable and correct trade flow volumes. Improving the assignment of volumes on the trade corridors and to specific ports also requires more basic research and an improvement in the methodology.

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CONTAINER REPOSITIONING:
THE LANDLOCKED HINTERLAND PERSPECTIVE

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ABSTRACT

Purpose
In this paper, we challenge real business implications of published research outcomes that apply mathematical analysis of container movements processes for specific geographical regions or argument hypothetically based on a set of assumptions which appear impossible to accomplish in most real business scenarios. Furthermore, we question whether repositioning is considered as a problem of equipment movement optimization or as one of collaboration and research the parties involved in its management – especially in the case of the mostly landlocked hinterland in Central and Eastern Europe (CEE).

Design/methodology/approach
Based on extensive and structured literature review of empty container repositioning research, we identify a lack of integration from a holistic point of view and related theoretical underpinnings such as economies of massed reserves and provide further empirical evidence about the present situation from an explorative field study in the Czech Republic.

Findings
Inland repositioning approaches by shipping lines or other container owners as well as related research projects apparently ignore landlocked hinterland markets such as CEE, its container turnover and importance for the key European seaport gateways. Accordingly, quality of hinterland transport market data from/to CEE countries is truly questionable/limited. Moreover, similar research studies focused on markets close to seaports such as the Netherlands or Germany by cargo sector or company lack empirical support, too. All in all, we come to the conclusion that most research projects or practical approaches by the companies all over Europe so far neglect actual container volumes and their importance.

Original/value
The paper addresses the topic of inland repositioning management with a linkage to the CEE countries that is not considered by geographically framed research studies mainly focused on contestable European hinterlands. Based on the discussion and questions we raise therein, shipping lines with substantial market shares in CEE hinterland should reassess their current strategies in regard to inland repositioning of empty containers towards a more collaborative approach.
Keywords: Container Repositioning, Intermodal Transport, Landlocked Hinterland

1. INTRODUCTION

Based on the development and expansion of container shipping since the 1960s, maritime transportation experienced technological changes leading to its organization, structure and connectivity progress. Once container standardization was applied, global liner shipping networks were soundly established consisting of specialized container terminals in the seaports and fully cellular container ships. Since its early development, the process of containerization was associated with international trade imbalances. Therefore, the majority of global maritime shipping trade lanes today come along with a surplus of either export or import of loaded containers (UNCTAD, 2015). The difference leads to an accumulation of empty containers at seaports or terminals and depots in the hinterland. In 2014, port-to-port shipments of empty containers were 24.1 % on average with 6.7 % of them being transshipped (Neylan, 2015).

Therefore, efficient repositioning management of empty containers between import and export hinterland areas is one of the key challenges by containers´ owners and lessors today in regard to the reduction of costs generated by trade imbalances (Rodrigue, 2013). For instance, costs of empty container repositioning accounted for USD 15 billion in 2005 (Song et al., 2005). In addition, global trade lanes such as Far East Asia-Europe route have become more imbalanced in recent years. Because of overall long-term increase of total operational costs in maritime shipping, there is continuous emphasis on container movement efficiency improvement. Empty containers movements burden handling operations at the seaports´ terminals. Moreover, they consume capacity of equipment designed for movements of full containers. At the same time, they cause an increase in volume of traffic within the seaports and neighbouring transport infrastructure (Boile, 2006). It is important to indicate that empty container repositioning management is generally perceived as the process carried out mostly by the shipping lines or by their owners in form of leasing companies. However, there is no direct monetary impact of the repositioning management efficiency proved on the cargo beneficiaries side (Wang et al., 2008).

With the emergence of globalization and its support by innovations in the area of information and communication technologies (ICT), the shipping line´s ability to offer not only port-to-port service, but door-to-door service (carrier haulage) to its customer located in (even landlocked) hinterland started to be essential for the shipping line´s long-term competitiveness (Vojdani et al., 2013). Therefore, it is necessary to widen the research scope of empty container repositioning geographically. Three basic categories are considered: empty container repositioning between seaports by container ships, empty container repositioning among inland terminals by inland transportation modes and empty container repositioning in intermodal transportation including both categories mentioned above.

The remainder of this paper is organized as follows. Section 2 provides a literature review matrix for the management of empty containers´ repositioning and its assessment. Section 3 elaborates our research methodology while stressing the holistic point of view that is considered for the research topic. Section 4 is focusing on the intermodal transport market of the Czech Republic, its characteristics and specifics as a topical example of a landlocked hinterland. Section 5 finally summarizes our research findings together with implications for academia and business sector.
2. LITERATURE REVIEW

There has been extensive set of research literature focusing on empty container repositioning management in recent years. Some of its authors focus on the perspective of maritime shipping (Dong et al., 2013, Notteboom and Rodrigue, 2008, Broeuer et al., 2010, Chao and Yu, 2012, Song and Dong, 2011). From the point of view of inland repositioning of empty containers, the research literature includes network analysis while focusing on a specific type of containers or inland mode of transport (Olivo et al., 2013, Islam and Olsen, 2013). The research approaches applied for door-to-door, i.e. global intermodal transportation of containers are dependent on formal mathematical optimization models or operational research (Crainic, 1993, Olivo et al., 2005, Vojdani, 2010) while supported by information technology. Furthermore, we can distinguish between an intra-organizational perspective of a single company (Chao and Yu, 2012, Dang et al., 2013, Chang et al., 2015) or inter-organizational one coming along with collaboration (i.e. companies specific to a port region or special type of containers (Brouer et al., 2010, Imai and Rivera, 2001, Konings, 2005, Shintani et al., 2010, Wu and Lin, 2015).

Another stream in the empty container repositioning literature focuses on empty equipment storage and stacking costs reduction and revolves around the technological innovation of foldable containers (Konings, 2005, Shintani et al., 2010, Bandara et al., 2015, Moon and Hong, 2016), container fleet management (Imai and Rivera, 2001, Wu and Lin, 2015) pooling or similar strategies (Vojdani et al., 2013, Sterzik et al., 2015) supported by the development of complex information and communication technologies (ICT) for container tracking and tracking (Kolarovszki and Dubravka, 2013). From a methodology point of view, these contributions focus either on the collection of informative and descriptive (qualitative) data or mathematical optimization (without empirical testing) including collaborative methodologies.

In other research publications (Song and Panayides, 2012, Karmelic et al., 2012, Rodrigue and Notteboom, 2015), the alleviation of the repositioning problem is grounded in the classification and possible interchangeability - given by different commodity characteristics - of cargo with a focus on cooperation by cargo beneficiaries and the shipping lines. Several authors focused on empirical studies and propose to resolve the empty containers repositioning problem based on a substitution of container types by using for instance dry cargo containers for bulk liquids and reefer containers for general cargo (Arduino et al., 2015).

Moreover, the present literature rarely considers the factor of container ownership as a major factor in empty repositioning management although the shipping lines and leasing companies define and seek different (and conflicting) objectives. In general, shipping lines consider their containers as equipment. Therefore, container decision making is focused on freight facilitation while reducing transportation and handling costs. By contrast, leasing companies define containers as their key assets (Theofanis and Boile, 2008), and they search constantly for those business partners that allow them to recover best their investment costs (Wang, 2014).

In addition, most of the reviewed literature lacks empirical data or validation by business sector. At the same time, its authors agree on the complexity of shipping of containers as an integrated part of global supply chains thus supporting the necessity to regard repositioning as a complex problem. The repositioning of containers within maritime shipping is pivotal for most published outcomes while focusing on collaborative network analysis. Those works that are concerned with inland repositioning focus on pricing policies by depots services providers or inland transport times using optimization models. Within inland repositioning, the collaborative approach is rarely applied. For a literature review matrix, see Table 2.1. Its pivotal value is based on the illustration of more than 40 well-cited and published articles by geographical scope and market approach criteria. Concerning the Central and Eastern Europe (CEE) landlocked
hinterland, there is a striking literature gap present with notable exception of a few published studies with limited scope and not specifically focused on repositioning issues (De Langen, 2007, Zanuy, 2009).

**Table 2.1 Repositioning literature review matrix**

<table>
<thead>
<tr>
<th>Repositioning domain / market approach</th>
<th>Maritime Repositioning</th>
<th>Inland Repositioning</th>
<th>Intermodal door-to-door repositioning</th>
</tr>
</thead>
</table>

### 3. METHODOLOGY

Our main hypothesis works on the assumption that the empty container repositioning lacks integration by a holistic point of view such as the economies of massed reserves (Mulligan, 1983). According to them, consolidation of all equipment movements, including the repositioning of empty container and full ones results in a lower degree of fluctuation in transport volume lowering the impact of containerized trade imbalances. In other words, efficient repositioning management of empty containers has to integrate the complexity of supply chain management and inland logistics. The more holistically the number of container movements is analysed, planned and scheduled, the more efficient the movements become. This results in significant costs reduction for shipping lines or other container owners such as leasing companies.
In addition, there is research missing in addressing empty container repositioning aspects of intermodal transport within a wider landlocked hinterland of CEE countries and in particular the Czech Republic. Logically, our research provides a broader perspective on inland logistics platforms focusing on the CEE region. It concerns the role of local market players’ branches in regard to repositioning management. While augmenting the matrix for repositioning by a geographical scope, our research is focused on regional and local aspects of empty containers repositioning management in CEE with the Czech Republic in particular (see Figure 3.1 for an illustration).

![Figure 3.1 Container repositioning strategies and research scope, adopted from Theofanis and Boile, 2008.](image)

4. LANDLOCKED CZECH REPUBLIC: MARKET AND EQUIPMENT

Since joining the EU in 2004, the Czech Republic is well integrated in the European intermodal transport system. Due to its geographical location, it acts as a one of the freight distribution gateways between markets of EU-15 member states and markets of the CEE region including EU countries such as Slovakia, Hungary, Romania and Bulgaria together with non-EU countries such as Ukraine or Moldova. Furthermore, Czech Republic facilitates a relatively well-developed and functioning transport network. Since 2004, the country has benefited from much higher export value and volumes, which resulted in increased demand for transport and logistics services. Since the EU enlargements in 2004, 2007 and 2013 (Croatia), there has been a continuing shift in manufacturing and distribution capabilities and channels from North-South flows to larger East-West flows (Notteboom, 2009) with the origin and destination in the CEE hinterland.
4.1. Market and its structure

The Czech Republic is a landlocked country. With the effort to reduce costs of distribution and with higher transport costs in land-locked countries in general, it is challenging for manufacturers, distributors, importers and exporters located in the Czech Republic to compete on a global market level. Development of efficient and reliable corridors moving both full and empty containers towards seaports and depots in neighbouring countries is thus of strategic importance.

Therefore, the majority of its international overseas trade depends on the efficiency of its rail and road links to nearby European ports such as Hamburg and Bremerhaven in the North Sea range as well as Koper in the Mediterranean range. The Port of Hamburg dominates with a 59% share (300,000 TEU), followed by Bremerhaven (21 %), Koper (14 %) and Rotterdam (3%), see Figure 4.1 (Industry discussion seminar and presentations, Association of Forwarding and Logistics of the Czech Republic, 6 May 2015). In 2009, COSCO started to operate a container terminal at Piraeus with a 35 years concession, which is expected to increase Chinese trade with the EU and partly trigger new routing options. There is also the potential inland alternative offered by the Trans-Asian Railway (TAR) including the links of New Eurasian Land Bridge (NELB) and Trans-Siberian Railway (TSR) that could be suitable for importers and distribution companies active in inland China with door-to-door services to the Czech Republic provided through Poland and Germany. However, it is not competitive yet for container exports (eastbound traffic) from the EU to China due to low exports rates offered by shipping lines for the maritime Royal Route (RR).

![Figure 4.1 Port shares for overseas containerized cargo for the Czech Republic 2014 (in %), Hafen Hamburg Marketing, e.V., 2015](image)

The country inland transportation costs appear competitive in regard to other landlocked countries such as Slovakia, Hungary, Austria or even sea-accessible Poland; in particular when comparing average of Twenty-foot-Equivalent Unit (TEU) export and import procedure costs (World Bank, 2014). Moreover, container transportation from/to overseas destinations is for Czech traders primarily a matter of slightly prolonged delivery times.
In spite of the Czech Republic is an overall export oriented economy with a foreign trade surplus, its container imports represent approximately 60% of the total containerized cargo being handled. But in recent years, export and import ratios became more and more balanced. Transportation in maritime (ISO) containers represents 97.1% of non-accompanied intermodal transport (in tons) including the maritime leg. In 2014, 500,000 TEUs were handled at Czech Republic with 74.2% of containers being full (Association of Forwarding and Logistics of the Czech Republic, Maritime Club seminar, November 2015). The remaining 25.8% represents empty containers repositioned to yards and depots mostly in Germany and Austria (Ministry of Transport of the Czech Republic, 2015). For 2014, there were an additional 900,000 TEUs in transit and transhipment through the country, namely for the Germany, Slovakia and Hungary trade (FLAVIA project publications, 2012). The project FLAVIA addressed issues within intermodal freight transport in Central/South-East Europe such as modal split for rail, inland waters, increasing road congestions, border crossings rail delays, terminal technique and psychological barriers of market players against intermodal transport and repositioning management. In the Czech Republic, inland waterways can only be navigated seasonally and are not used for container movements, unlike many regions in Europe, particularly the Rhine/Scheldt delta (Novakova, 2013). Carriers only use barges for bulk products such as coal, construction materials or grains.

Approximately 76% of all containerized cargo with destination or origin of Czech Republic is handled by rail (European Commission, 2012). Certainly, rail transport remains as the preferred mode for repositioning empty containers. For instance, full containers reaching Prague by rail or by road from Hamburg are coming back empty by rail to Germany or Austria where they are either re-loaded or repositioned to overseas destinations. This example of Czech Republic-Germany container flows can be similarly applied to other CEE countries such as Slovakia, Hungary or Romania, too.

In the Czech Republic, key rail operators in the intermodal market are METRANS, Rail Cargo Operator and CD Cargo, while several of them operate their own intermodal terminals (see Table 4.1). The Prague Uhrineves terminal operated by METRANS (stacking capacity 15,000 TEUs) is one of the biggest inland rail container terminal in the CEE region with annual lifts of about 300,000 TEUs originating or destined to the Czech Republic. Annually, the Terminal Ceska Trebova handles approximately 250,000 TEUs - mostly in transhipment. A significant share of transhipment for the Czech containerized cargo trade takes place at Dunajska Streda terminal in Slovakia, which is linked to the port of Koper in Slovenia. The latest activity by METRANS includes taking over the container terminal operations at Krems a.D. in Austria that may partly attract empty container volumes originally repositioned to Dunajska Streda terminal. In terms of the intermodal transport utilization, discrepancies can be easily observed. The Dunajska Streda terminal has the same capacity than the METRANS terminal at Prague, including the same equipment pool (such as terminal cranes and reach stackers). However, it transships only 40% of the TEU turnover of Prague. Some reasons lie in a lower rail capacity for consolidated container trains from Adriatic ports such as Koper so that shippers favour pick-ups or drop offs at Uhrineves or Ceska Trebova terminals.

Table 4.1 Key intermodal container terminals for the Czech Republic – terminal ownership by operators and location, Ministry of Transport of the Czech Republic, 2015

<table>
<thead>
<tr>
<th>Terminal Operators</th>
<th>Terminal Locations (City)</th>
</tr>
</thead>
<tbody>
<tr>
<td>METRANS</td>
<td>Ceska Trebova, Ostrava-Senov, Pilsen-Nyrany, Prague-Uhrineves, Zlin-Lipa, Dunajska Streda (SK), Krems a.D. (AT)</td>
</tr>
</tbody>
</table>
The location of the main intermodal (rail) terminals (see Figure 4.2) does not really reflect the needs and location of Czech national logistic activities and commercial interests, which results in high levels of domestic road haulage in cartage service. In addition, there is limited liberalization of the rail sector, implying a less competitive rail market (Mazac et al., 2010) with ongoing domination by METRANS followed by state controlled CD Cargo.

In 2015, there were 12 shipping lines with their branch or agent office in the Czech Republic. Nevertheless, a substantial share of containerized cargo is managed by parent offices located in Germany, Austria or Poland. The Czech container market is quite specific in terms of a high level of carrier haulage by the shipping lines with relatively low ratio of merchant haulage and freight forwarders as key intermediary for the inland transportation (Industry discussion seminar, Association of Forwarding and Logistics of the Czech Republic, 4 November, 2015).

This freight forwarders´ market is dominated by companies with their origin mostly in EU-15 countries, namely companies such as DHL, DB Schenker, Dachser, DAMCO or Kuehne&Nagel (K&N). Besides this, Blue Anchor Line and Austromar (a subsidiary of O.S.K. - Österreichisches Seefrachten Kontor) act as non-vessel operating common carriers (NVOCC).
4.2. Inland repositioning approaches by market players

At regional level, the shipping lines’ freight forwarders’ and multimodal transport operators’ (MTOs) branches within the CEE are clustered, leading to management responsibilities that are regionally oriented. Excluding Maersk Line with its high degree of container ownership (90%, country top equipment manager interview, November, 2015) and covering approximately 25% of the Czech Republic’s carrier haulage (accounting for 55% of the country exported and imported TEUs), the other shipping lines present in the country outsource necessary repositioning of empty container management to METRANS. In effect, this rail and inland depots operator is the only party except Maersk Line that collects the data and attempts to optimize empty container flows within the country, its depots and terminals in neighbouring countries operated by METRANS or its affiliated operators.

Based on feedback by several shipping lines’ management in the Czech Republic, CEE hinterland and its countries are not considered as sufficient TEUs market to insource inland repositioning management strategies in the region (Association of Forwarding and Logistics of the Czech Republic Maritime Club seminar, November 2015).
In recent years, the Czech Republic market has experienced changing dynamics in terms of export and import TEU volumes generated by the shippers. As a result, the shipping lines fail to respond effectively to increased demand for empty containers for exports while imports stagnate. Besides, special containers such as reefers or flat racks are regularly not at disposal to the shippers (SpeedCHAIN plenary session, November, 2015). In other words, the shipping lines overlook the possibility to participate actively in local or regional inland repositioning management and just included inland reposition of empty containers costs in their carrier haulage rates (Rodrigue, 2013). Since inland transportation as part of carrier haulage is relatively more profitable for the carrier compared to merchant haulage (Crainic, 1993), the shipping lines neglect the opportunity to attract more customers located in the landlocked hinterland struggling to stay price-competitive with freight forwarders in the market of FCL door-to-door shipments.

Based on empty containers repositioning strategies (Figure 3.1) and economies of massed reserves, more balanced flows and increasing volumes in exports should engage the shipping lines branches to act proactively. Yet, the potential to reduce inland transport costs is neglected. From a practical perspective, inland repositioning management (by the shipping lines) is missing despite CEE (landlocked) hinterland generates more than 25 % of all TEU exports and imports for Hamburg (Hafen Hamburg Marketing e.V., 2015) or 50 % of Koper (Luka Koper, 2015).

5. CONCLUSIONS

The containerization as a set of integrated processes supporting the increased and generalized use of the container is the driving force of intermodal transportation. Therefore, the turnover of both full and empty containers within CEE hinterland is likely to increase in coming years. Currently, the shipping lines active in that region are not ready to reassess their repositioning management strategies that only focus on maritime repositioning while neglecting the potential and importance of inland repositioning based on optimization or market collaboration with shippers. At this point, there is hardly any present evidence in research or business practice that this situation could change rapidly.

In the case of Czech Republic, inland repositioning is outsourced to inland depots operators. However, apart from METRANS and Maersk Line, shipping lines, leasing companies and/or MTOs have not implemented sufficient inland repositioning strategies so far. Moreover, the CEE region and the Czech Republic in particular go through trade a balancing period with stagnating TEU turnover westbound from Far East Asia and increasing demand for CEE container exports at the same time. This difficult to reverse business situation is likely to have negative consequences for the future development of inland transportation costs in the CEE with constantly increasing numbers of containers being moved both full and empty across the CEE region.

Moreover, a potentially fruitful dialogue between academia and relevant business parties with a focus on the role and opportunities of inland and intermodal door-to-door repositioning management in CEE is sought. In the Czech Republic, business parties such as shipping lines or MTOs branches have both quantitative and qualitative data to conduct empty repositioning optimization projects including collaborative approaches. Academia would be more than ready to provide resources to conduct related projects. However, practitioners do not apply relevant human resources and apparently perceive the university sector primarily as their source for operational job positions. Additionally, management and decision-making capacity in the
shipping lines’ local branch headquarters appear highly limited - both financially and autonomy-wise. Currently, this all prevents a cooperation on applied research within the empty container repositioning management in the Czech Republic from its business implementation.

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MACRO-SCALE INDICATORS BASED ANALYSIS OF
TEXTILE PRODUCT RECALLS IN THE EU

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ABSTRACT

Purpose
The purpose of this article is to study the relationship between macro-scale indicators (social, economic and governance) with textile product recalls in the EU. Here the main focus is given to a systemic approach to understand the problem from a holistic perspective, focusing on the interactions among components rather than focusing only on causes.

Design/methodology/approach
The EU’s recalled textile product data and macroscale indicators used in the study were obtained from multiple sources, namely RAPEX, Transparency International, Eurostat, and The World Bank. The data have been used for the years 2008-2013. Multiple linear regression analysis and p-value statistics were used to scale the impact and statistical significance respectively, of the indicators on the textile product recalls.

Findings
Findings from the study suggest that the textile recall is influenced by governance and social aspects of the EU member states while the economic aspect has negligible statistical significance. Results further suggest that better governance and higher social inequality lead to lesser textile product recalls.

Original/value
This study is first to quantitatively identify of the role of social, governance and economic aspects of the EU member states on their textile-product recalls. The previous qualitative research works have been focused on a particular brand or recall which limit the generalization of their conclusions. Whereas, this paper uses a systemic approach to understand the problem from a holistic perspective, focusing on the interactions among components rather than focusing only on causes.

Keywords: Textile product recalls, macro-scale indicators, governance, social, economic

1. INTRODUCTION

Nowadays, with strict government regulation and consumer interests, product recall has become prevalent. In spite of state-of-the-art operations, philosophies, tools and techniques, products
may still be flawed. Product cost has always been a competitive aspect therefore to optimize a product cost; manufacturers sometimes knowing/unknowingly use inferior or restricted materials, chemicals, or design. This poses direct threats to the consumers, and results in recall whenever identified (Ahsan and Gunawan, 2014; Etayankara and Bapuji, 2009; Kumar and Schmitz, 2011). In 2014, the European Commission’s rapid alert system for dangerous non-food products (RAPEX) reported unprecedented 2435 product recall notifications and only 14% of the total notified products were found to be originated from Europe (EU28 and EEA countries) whereas among remaining 86%, 79% were originated from non-European countries and 7% were unidentifiable. (European Rapid Alert System for Dangerous Non-Food Products: 2014 Complete Statistics, 2014). Further exploring the statistics, Textiles and clothing (hereafter called textile products), one the regular products used by all classes of the society, is one of the frequently recalled products accounting for more than 25% of the cases for the years 2010-2014 (European Rapid Alert System for Dangerous Non-Food Products: 2014 Complete Statistics, 2014).

Providing a safe product comes under the corporate social responsibility (CSR) for manufacturer, however, the government and society play an important role in the implementation of an effective CSR and sometimes act as watchdogs (Porter and Kramer, 2006). Studies have suggested that the product quality or standard set by a manufacturer is influenced not only by the place/country of manufacture, but also by the targeted destination or country-of-sale (Bastos and Silva, 2010; Fajgelbaum et al., 2009). Effect of country-of-sale is obvious because the product has to meet the expectations of the end user. Further, every government has its product safety regulations, and product not complying with such regulations has sale restriction. Product safety regulations and their implementation are often influenced by living standard, consumers’ safety awareness, and social and environmental concerns (Ene, 2012; Nadvi, 2008; Ponte and Gibbon, 2005). Studies have evaluated the impact of product recalls on brand equity/reputation (Eilert, 2013; Grunwald and Hempelmann, 2010; Korkofingas and Ang, 2011; Magno et al., 2010), financial losses (Davidson III and Worrell, 1992; Govindaraj et al., 2004; Zhao et al., 2013), firm’s competitiveness (Chen et al., 2009; Eilert, 2013; Korkofingas and Ang, 2011) and retails’ brand value (Ni et al., 2014), whereas the effects of social, economic and governance aspects of a country on its recalls have remained elusive. To the best of our knowledge, there is no published quantitative analysis correlating the occurrence of product recalls with a country-of-sale’s economic, social and governance aspects, even though, according to recent incidents and previous studies (such as, Ene, 2012; Luo, 2008; Magno, 2013), they incite or act as underlying reasons for the product recalls. In this context, this paper studies the effect of macroscale indicators including economic, social and governance aspects of various EU member states on their textile product recalls.

2. FRAME OF REFERENCE

Product recall is a reverse logistic activity of withdrawing a product from the customer and market due to noncompliance of product specifications or services with the government regulations. These products may harm the users directly or indirectly. According to Ahsan and Gunawan (2014), manufacturer-initiated recall is considered voluntary, and Hora et al. (2011) argued that these recalls are influenced by many factors, including the type of product defect, recall strategy and supply chain issues. Chen et al. (2009) showed that the ‘preventive recall’ or manufacturer-initiated recall strategy has higher negative impact on stock value as compared with that of ‘reactive recall’ or government-initiated recalls. Moreover, consumers may consider a manufacturer-initiated recall as confession of guilt and file lawsuits against the
company (Spier, 2011). Therefore, the manufacturer may want to avoid or delay to initiate a recall. Government-initiated recalls follow a series of investigation stages before notifying the manufacturer/supplier for the recalls. Luo (2008) argues that weak legislation, lax enforcement, lack of government supervision and rampant corruption play important roles in recalls, and stated that only poor management and weak organizational control of manufacturers resulting in a harmful product in the market cannot wear the whole blame.

Magno (2013) stated the complexity of products and markets, consumer protection activities, product safety legislation and intervention of government agencies as the major factors behind product recalls. Ene (2012) argued in the Bulgarian context that insufficient consumer protection was negatively correlated with the purchasing power of citizens. Therefore, beside government regulations, consumers’ social and economic aspects become underlying reasons for product recalls.

The government-initiated recalls of the EU member states are initiated by a single organization, RAPEX, and the criteria for determining the government regulation-wise non-complying product are same for all the EU member states. RAPEX notifications are notified in two categories to the enterprises/distributors regarding the product recalls i.e. obligatory or mandatory, and voluntary. In obligatory recall, member state authorities oblige the producer/distributor to take preventive or restrictive action to the recalled product, whereas in voluntary recall, the preventive measures adopted by the producer/distributor are independent from the intervention of the authorities of member state. Previous studies (for example (Korkofingas and Ang, 2011; Kumar and Schmitz, 2011; Tennert, 2014)) have attempted to understand recalls and their consequences from an organization or set of organizations or specific recall perspective, and the conclusions were generalized. Whereas, this paper attempts to understand the recalls from a holistic perspective, without going into the company or product details so that a generalized understanding can be made accounting all the recalls. Hence, in this study, recalled textile products were not differentiated based on recall type or involved company/organization or total recalled units, rather total unique textile related notifications by RAPEX were taken into account. Furthermore, the problem is attempted to understand from multiple aspects. Based upon the above analysis the following hypotheses are formulated for the present study,

- **H1**: Economic aspects of an EU member state have an impact on its textile product recalls.
- **H2**: Social aspects of an EU member state have an impact on its textile product recalls.
- **H3**: Governance aspects of an EU member state have an effect on its textile product recalls.

Social, economic and governance aspects of a country can be explained by a large number of indices, calculated by local as well as international, government, non-government and/or private organizations. Economic aspect is an important to understand the basic questions, such as does low consumer buying power implies more recalls? or is it simply that poorer countries import cheaper products that are more prone to errors? To calculate the economic cost of IPR infringement cost in ‘clothing, footwear and accessories sector’, various EU member states were analysed on social, economic and governance indices (“The Economic Cost of IPR Infringement in Clothing, Footwear and Accessories Sector”, 2015). Since the present study also analyses the EU member states in a similar way, therefore we chose some of descriptor variables from above-mentioned report, which were relevant to this study (shown inTable 2.1). Among all the selected variables, final consumption expenditure of household for clothing per capita (rCLE/C) and the percentage of household spending on clothing (HSC(\%)) were the variables directly related to textile products, whereas other indicators represent general social,
economic and governance aspects. Furthermore, aforementioned RAPEX recalled products were found to be majorly originated from outside the EU; hence, border customs can play a role in the preliminary filtering of the harmful/non-complying products. To account for the border customs role, ‘Logistics Performance Index’ (LPI) which is calculated by the World Bank, was included in this study. For short descriptions of variables see Table 2.1. These variables can be grouped into three categories, namely, economic, social and governance. As the name specifies, economic consists of variables related to the economic aspect, such as rCLE/C, GDI/C, nGDP/C, rGDP/C and PT. Whereas, social category consists of variables representing the social aspect, such as POP, POPuP, POPuP (%), II and HSC (%). Governance category comprises the variables or indicators which are influenced by local governance and politics. This includes CPI, RG, GE, V&A, PS&AV, RoL, CoC and LPI.
Table 2.1 Description of the selected independent variables

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Parameter</th>
<th>Acronym</th>
<th>Units</th>
<th>Description/definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total Population</td>
<td>POP</td>
<td>--</td>
<td>The number of persons having their usual residence in a country on 1st January of the respective year. Countries may report legal or registered resident</td>
</tr>
<tr>
<td>2.</td>
<td>Final consumption expenditure of household for clothing</td>
<td>rCLE/C</td>
<td>€</td>
<td>Final consumption expenditure of household income on clothing per capita.</td>
</tr>
<tr>
<td>3.</td>
<td>Gross disposable income per capita</td>
<td>GDI/C</td>
<td>€</td>
<td>Real gross disposable income per capita</td>
</tr>
<tr>
<td>4.</td>
<td>Percentage of household spending on clothing</td>
<td>HSC (%)</td>
<td>%</td>
<td>Percentage of total household spending on clothing</td>
</tr>
<tr>
<td>5.</td>
<td>Nominal gross domestic product</td>
<td>nGDP/C</td>
<td>€</td>
<td>Nominal gross domestic product per capita</td>
</tr>
<tr>
<td>6.</td>
<td>Real gross domestic product</td>
<td>rGDP/C</td>
<td>€</td>
<td>Real gross domestic product per capita</td>
</tr>
<tr>
<td>7.</td>
<td>Income Inequality</td>
<td>II</td>
<td>--</td>
<td>The ratio of total income received by the 20% of the population with the highest income (top quintile) to that received by the 20% of the population with the lowest income (lowest quintile). Income must be understood as equivalised disposable income. II also known as ‘social exclusion’.</td>
</tr>
<tr>
<td>8.</td>
<td>Poverty threshold</td>
<td>PT</td>
<td>€</td>
<td>Poverty threshold is the income level below which one is considered to be poor. Poverty threshold in general calculated as 60% of the national median income.</td>
</tr>
<tr>
<td>9.</td>
<td>Population under poverty</td>
<td>POPuP</td>
<td></td>
<td>Number of people in a country having income below poverty threshold.</td>
</tr>
<tr>
<td>10.</td>
<td>Percentage of total population under poverty</td>
<td>POPuP (%)</td>
<td>%</td>
<td>Percentage of the total population which have income below the selected poverty threshold</td>
</tr>
<tr>
<td>Sr.</td>
<td>Parameter</td>
<td>Acronym</td>
<td>Units</td>
<td>Description/definition</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------------</td>
<td>---------</td>
<td>-------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>11.</td>
<td>Corruption Perceptions Index</td>
<td>CPI</td>
<td>--</td>
<td>Corruption perception index measures the extend of corruption in a country perceived its public.</td>
</tr>
<tr>
<td>12.</td>
<td>Control of corruption</td>
<td>CoC</td>
<td>--</td>
<td>Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as &quot;capture&quot; of the state by elites and private interests.</td>
</tr>
<tr>
<td>13.</td>
<td>Rule of law</td>
<td>RoL</td>
<td>--</td>
<td>Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.</td>
</tr>
<tr>
<td>14.</td>
<td>Political stability and absence of violence</td>
<td>PS&amp;AV</td>
<td>--</td>
<td>Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.</td>
</tr>
<tr>
<td>15.</td>
<td>Voice and accountability</td>
<td>V&amp;A</td>
<td>--</td>
<td>Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.</td>
</tr>
<tr>
<td>16.</td>
<td>Government effectiveness</td>
<td>GE</td>
<td>--</td>
<td>Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.</td>
</tr>
<tr>
<td>17.</td>
<td>Regulatory quality</td>
<td>RG</td>
<td>--</td>
<td>Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.</td>
</tr>
<tr>
<td>18.</td>
<td>Logistic performance index</td>
<td>LPI</td>
<td>--</td>
<td>Logistics Performance Index overall score reflects perceptions of a country's logistics based on efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time.</td>
</tr>
</tbody>
</table>
3. RESEARCH DESIGN AND PROCEDURES

All data utilized in this paper are secondary and from publicly available statistics sources. The use of secondary data provides both high internal validity and a good opportunity to replicate the study (Rabinovich and Cheon, 2011). The research presented here uses a systemic approach to understand the problem from a holistic perspective, focusing on the interactions among components rather than focusing only on causes (Aastrup and Halldórsson, 2008).

3.1. Data Collection

The RAPEX notification database has been used for the textile product recall notifications made in EU for the years 2008-2013. RAPEX relies on the close cooperation between the European Commission and the participating national authorities of EU member states, Norway, Iceland, and Liechtenstein. We focused on the official EU member states in the years 2008-2013. Croatia has joined the EU as well as RAPEX in the year 2013 therefore it has been excluded from the present study and we focused on remaining EU member states (as shown in Table 3.1).

Each RAPEX participating nation has a national contact point which notifies the European Commission (EC) for any observed harmful or non-complying product or incident. Then the EC circulates this information to all other RAPEX members’ national contact points and simultaneously publishes a report on the notified products on the website on a weekly basis. Further, the national contact points communicate the notified dangerous products to responsible authorities to monitor and take appropriate measures in their respective countries. The RAPEX database shows the recalled products in total 30 categories. Textiles and clothing items are included in the category entitled ‘Textiles, clothing and fashion items’, which also includes non-textile fashion items such as belts, slippers, leather items, etc. Therefore, the non-textile item notifications were manually excluded by analysing the product description in the secondary data obtained from the RAPEX database.
Table 3.1 Country- and year-wise textile recalls notifications reported by RAPEX. * denotes the country participating in 10 countries having uppermost total notifications for the years 2008-2013.

<table>
<thead>
<tr>
<th>Country</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>Total</th>
</tr>
</thead>
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<td>AT</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bulgaria*</td>
<td>BG</td>
<td>36</td>
<td>86</td>
<td>154</td>
<td>118</td>
<td>202</td>
<td>121</td>
</tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td>717</td>
</tr>
<tr>
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<td>0</td>
<td>39</td>
<td>100</td>
<td>37</td>
<td>22</td>
<td>81</td>
</tr>
<tr>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
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<td>DK</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>21</td>
<td>14</td>
<td>42</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Finland*</td>
<td>FI</td>
<td>4</td>
<td>24</td>
<td>13</td>
<td>8</td>
<td>3</td>
<td>53</td>
</tr>
<tr>
<td>France</td>
<td>FR</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Germany*</td>
<td>DE</td>
<td>8</td>
<td>15</td>
<td>24</td>
<td>19</td>
<td>3</td>
<td>73</td>
</tr>
<tr>
<td>Greece*</td>
<td>EL</td>
<td>20</td>
<td>53</td>
<td>69</td>
<td>11</td>
<td>19</td>
<td>40</td>
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<tr>
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<td>HU</td>
<td>32</td>
<td>11</td>
<td>100</td>
<td>75</td>
<td>224</td>
<td>124</td>
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<td>Ireland</td>
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<td>0</td>
<td>1</td>
<td>3</td>
<td>7</td>
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<tr>
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<td>4</td>
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<td>1</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>20</td>
<td>1</td>
<td>21</td>
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<tr>
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<td>4</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td>25</td>
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<tr>
<td>Luxembourg</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Netherlands</td>
<td>NL</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Poland*</td>
<td>PL</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>18</td>
<td>8</td>
<td>39</td>
</tr>
<tr>
<td>Portugal</td>
<td>PT</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Romania</td>
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<td>0</td>
<td>1</td>
<td>10</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td>Slovakia</td>
<td>SK</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Slovenia</td>
<td>SI</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Spain*</td>
<td>ES</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>27</td>
<td>20</td>
<td>81</td>
</tr>
<tr>
<td>Sweden</td>
<td>SE</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>UK</td>
<td>8</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>125</td>
<td>266</td>
<td>534</td>
<td>381</td>
<td>565</td>
<td>428</td>
</tr>
</tbody>
</table>

The 18 independent variables (macro-scale indicators) selected were obtained from primarily three sources: Eurostat, Transparency International, and the World Bank. Each of the variables for all the countries was obtained strictly from only one source; therefore, the accuracy of every variable can be considered the same for all the countries. The list of all variables with a short description is given in Table 2.1. Eurostat is the official statistics department for the EU that maintains the official figures about the EU member states. In some cases, where data for a member state were not available for a particular year, the missing values were replaced with the immediate previous year’s data. GDI/C for Luxembourg and Malta were not reported by Eurostat for any of the years between 2008-2013, therefore the missing values were replaced by the mean manipulation method (Acuna and Rodriguez, 2004) of that particular year of the remaining countries. Similarly, data were interpolated for LPI values that were officially published in 2007, 2010, 2012 and 2014.
3.2. Research Method

![Distribution of total textile recall notifications reported by RAPEX for the EU 27 during the years 2008-2013.](image)

It has been observed from the RAPEX notification data that, 10 EU member states accounted for more than 90% of total recall notifications in the years 2008-2013 (as shown in Figure 3.1 Distribution of total textile recall notifications reported by RAPEX for the EU 27 during the years 2008-2013). Therefore, to analyse the effects of input variables and study the differences between all EU member states and top 10 EU member states (EU10), the analysis was done in two stages i.e. stage one: analysis of EU27; stage two: analysis of EU10.

Multiple linear regression analysis was used to study the interrelationship between various independent variables with the textile recalls, and the p-values were used to substantiate the statistical significance of the input variables. Pairwise correlations among the input variables were used to group the highly correlated variables, and one variable was selected from a group of variables that showed correlation magnitude 0.9 or higher (hereafter called ‘correlation threshold’) with other variables present in the same group. The linear regression model used for the analysis is as follows,

\[ y_{ij} = \alpha_0 + \sum_{k=1}^{n} \alpha_k x_{ijk} + \epsilon_{ij} \]  

where \( y_{ij} \) is the total textile recalls for \( i \)th country during \( j \)th year. \( n \) is the number of uncorrelated independent variables, \( \alpha_0 \) is the intercept, \( \alpha_1, \alpha_2, \ldots, \alpha_n \) are the coefficients to be estimated, \( x_{ijk} \) is the value of \( k \)th variable for \( i \)th country during \( j \)th year. \( \epsilon_{ij} \) is the residual or error term.

4. RESULTS

Table 4.1 shows an overview of independent variables. Between EU27 and EU10, major changes were observed for POP and POPuP (with an increase in the mean values for EU10 from EU27), which means that comparatively big countries by population participate in EU 10. The same is evident from the skewness value which changed for POP from 1.48 for EU27 to 0.85 EU 10. The same is true for POPuP where it changes from 1.23 to 0.85. Therefore, these
variables may be different impacts while studying in both of the cases separately. Some changes can be seen in the skewness values for the variables nGDP/C, rGDP/C and GE although major changes in their means or ranges were not observed.

*Table 4.1 Overview of variable distributions for EU 27 and EU 10.*

| Variable | EU 27 | | | EU 10 | | |
|----------|-------|------------------|-------|------------------|-------|
|          | Mean  | Skewness | Range     | Mean  | Skewness | Range     |
| POP\(^1\) | 18479954.27 | 1.48 | 407832 – 82217837 | 26540853.32 | 0.85 | 776333 – 82217837 |
| CLE\(^1\) | 528.40 | 0.16 | 100 – 1200 | 533.33 | -0.33 | 100 – 1000 |
| GDI/C\(^1\) | 17381.48 | -0.32 | 7153 – 25897 | 17473.77 | -0.54 | 7153 – 25897 |
| HSC (%)\(^1\) | 4.79 | -0.11 | 2.7 – 6.8 | 4.51 | 0.20 | 2.7 – 6.7 |
| nGDP/C\(^1\) | 24141.98 | 1.53 | 4600 – 83400 | 22118.33 | 0.19 | 4600 – 44400 |
| rGDP/C\(^1\) | 21408.64 | 1.01 | 3500 – 68700 | 19756.67 | 0.09 | 3500 – 39300 |
| II\(^1\) | 4.77 | 0.57 | 3.2 – 7.4 | 4.97 | 0.17 | 3.4 – 6.6 |
| PT\(^1\) | 5494.26 | 0.28 | 781 – 13320 | 5408.22 | 0.00 | 869 – 10759 |
| POPuP\(^1\) | 4395.35 | 1.23 | 72 – 18194 | 6684.67 | 0.54 | 181 – 18194 |
| POPuP(%)\(^1\) | 24.54 | 1.20 | 14 – 49.3 | 27.02 | 1.19 | 16 – 49.3 |
| CPI\(^2\) | 6.36 | 0.09 | 3.33 – 9.40 | 6.11 | 0.35 | 3.33 – 9.40 |
| CoC\(^3\) | 1.02 | 0.10 | -0.30 – 2.52 | 0.90 | 0.41 | -0.30 – 2.52 |
| RoL\(^3\) | 1.16 | -0.37 | -0.16 – 1.98 | 0.99 | 0.04 | -0.16 – 1.98 |
| PS&AV\(^3\) | 0.75 | -0.58 | -0.47 – 1.51 | 0.59 | -0.28 | -0.47 – 1.45 |
| V&A\(^3\) | 1.13 | -0.33 | 0.29 – 1.71 | 1.07 | 0.04 | 0.32 – 1.69 |
| GE\(^3\) | 1.15 | -0.32 | -0.36 – 2.26 | 1.06 | 0.38 | -0.05 – 2.26 |
| RO\(^3\) | 1.24 | 0.00 | 0.49 – 1.92 | 1.16 | 0.34 | 0.49 – 1.91 |
| LPI\(^3\) | 3.47 | -0.05 | 2.78 – 4.18 | 3.468 | -0.01 | 2.83 – 4.11 |

\(^1\)Source: Eurostat. \(^2\)Source: Transparency International. \(^3\)Source: The World bank.
Table 4.2 Pairwise correlation of input variables for EU 27 member states for the period 2008-2013. Highlighted numbers in bold show correlation magnitude $\geq 0.9$

<table>
<thead>
<tr>
<th></th>
<th>POP</th>
<th>CLE</th>
<th>GDI/C</th>
<th>HSC (%)</th>
<th>nGDP/C</th>
<th>rGDP/C</th>
<th>II</th>
<th>PT</th>
<th>POPuP (%)</th>
<th>POpuP (%)</th>
<th>CPI</th>
<th>CoC</th>
<th>RoL</th>
<th>PS&amp;AV</th>
<th>V&amp;A</th>
<th>GE</th>
<th>RQ</th>
<th>LPI</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CLE</td>
<td>0.23</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>GDI/C</td>
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<td>0.82</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSC (%)</td>
<td>0.08</td>
<td>0.51</td>
<td>0.37</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>nGDP/C</td>
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<td>0.84</td>
<td>0.65</td>
<td>0.18</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>rGDP/C</td>
<td>0.11</td>
<td>0.87</td>
<td>0.71</td>
<td>0.20</td>
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<tr>
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Table 4.3 Pairwise correlation of input variables for EU10 member states for the period 2008-2013. Highlighted numbers in bold show correlation magnitude $\geq 0.9$

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<th>HSC</th>
<th>nGDP/C</th>
<th>rGDP/C</th>
<th>II</th>
<th>PT</th>
<th>POPuP (%)</th>
<th>POPuP (%)</th>
<th>CPI</th>
<th>CoC</th>
<th>RoL</th>
<th>PS&amp;AV</th>
<th>V&amp;A</th>
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<th>RQ</th>
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As reported in
Table 4.2, nGDP/C, rGDP/C and CLE/C are highly correlated to each other. PT, which is a relative measure to median income, found to be correlated with nGDP/C, rGDP/C, CLE/C and GDI/C. However, the correlation between PT and GDI/C is below 0.9 therefore they cannot be considered the same as per selected correlation threshold. CPI and CoC represent the perception of general public towards corruption control but calculated by two different organizations. A very high correlation with each other (0.98 for EU27 and 0.99 for EU10) confirms their accuracy. Except PS&AV, all remaining governance indicators (i.e. CoC, RoL, V&A, GE, RQ) show high correlation with each other, while many of them show a good correlation with variables such as, nGDP/C, rGDP/C, PT and GDI/C. PS&AV does not show a high correlation with other governance indicators as it shows with II and POPuP (%). LPI for all EU 27 fall in the upper half quantile and show a good correlation with many of the economic indicators nGDP/C and rGDP/C, which is similar to the observation made by (Arvis et al., 2014). The similar observations for correlation among various indicators can be made with some changes in correlation magnitude for EU 10, as shown in Table 4.3.

Table 4.4 Grouping of highly correlated variables. Underlined variable represents the selected variable from the corresponding group.

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<th>Group</th>
<th>EU10</th>
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<td>Group 1</td>
<td>POP, POPuP</td>
</tr>
<tr>
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<td>GDI/C</td>
<td>Group 2</td>
<td>CLE</td>
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<td>Group 3</td>
<td>GDI/C</td>
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<td>Group 4</td>
<td>II</td>
<td>Group 4</td>
<td>HSC (%)</td>
</tr>
<tr>
<td>Group 5</td>
<td>PT, CLE, nGDP/C, rGDP/C</td>
<td>Group 5</td>
<td>nGDP/C, rGDP/C, PT</td>
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<td>Group 6</td>
<td>POPuP(%)</td>
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<td>PS&amp;AV</td>
<td>Group 8</td>
<td>PS&amp;AV</td>
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<tr>
<td>Group 9</td>
<td>LPI</td>
<td>Group 9</td>
<td>LPI</td>
</tr>
</tbody>
</table>

Table 4.4 shows the variable groups selected based upon the correlation, as discussed earlier. In each group one variable (indicated by underline in EU27 and EU10 columns) is selected which qualifies the selection criterion i.e. correlation threshold. In both cases (EU27 and EU10), there are 9 groups; however, the members of each group are not the same due to the differences in correlation for EU 27 and EU 10.

Table 4.5 and Table 4.6 show the statistics obtained by fitting the multiple linear regression for EU 27 and EU 10 respectively. For EU 27, II and POPuP (%) show p <0.001, while for PS&AV p = 0.023. For the remaining independent variables, p > 0.2, which indicates a comparatively a very small statistical significance as compared with II, POPuP (%) and PS&AV. II and PS&AV having negative sign with their regression coefficients indicate that increase in these quantities results in lower recalls. This may be attributed to the fact that the EU states with more stable political and peaceful status (indicated by high PS&AV) may result the authorities to regulate the product well and therefore result in better monitoring of the products before introducing in the markets. Whereas, increased II implies increased social gap or income difference between the richest and poorest classes. Therefore, negative sign of the II coefficient indicates that the
increased gap results in the lesser product recalls. POPuP (%) with a positive sign points to countries where a higher fraction population living under poverty are more susceptible to textile product recalls. This model could explain 44.2% of the total variance.

Table 4.5 Multiple linear regression model for EU27

<table>
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<th>SE</th>
<th>tStat</th>
<th>p Value</th>
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<td>POP</td>
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<td>1.35×10^{-7}</td>
<td>-1.05</td>
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<td>GDI/C</td>
<td>8.62×10^{-4}</td>
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<tr>
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<td>-4.63</td>
<td>&lt;&lt;0.01*</td>
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<tr>
<td>PT</td>
<td>6.45×10^{4}</td>
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</tr>
<tr>
<td>POPuP(%)</td>
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<td>6.36</td>
<td>&lt;&lt;0.01*</td>
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<td>0.56</td>
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<td>PS&amp;AV</td>
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<td>LPI</td>
<td>6.88</td>
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<td>0.54</td>
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</table>

Number of observations: 162, Error degrees of freedom: 152
Root Mean Squared Error: 26.4
R-squared: 0.44,
F-statistic vs. constant model: 13.4, p-value: <<0.001

*Significant at 95%, ** Significant at 99%
Table 4.6 Multiple linear regression model for EU10

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<td>18.31</td>
<td>-0.12</td>
<td>0.90</td>
</tr>
<tr>
<td>nGDP/C</td>
<td>2.26×10⁻³</td>
<td>2.62×10⁻³</td>
<td>0.86</td>
<td>0.39</td>
</tr>
<tr>
<td>II</td>
<td>-26.78</td>
<td>9.01</td>
<td>-2.97</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>PS&amp;AV</td>
<td>-12.71</td>
<td>17.32</td>
<td>-0.73</td>
<td>0.47</td>
</tr>
<tr>
<td>V&amp;A</td>
<td>-233.24</td>
<td>57.90</td>
<td>-4.03</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>LPI</td>
<td>73.12</td>
<td>30.28</td>
<td>2.41</td>
<td>0.02**</td>
</tr>
</tbody>
</table>

Number of observations: 60, Error degrees of freedom: 50
Root Mean Squared Error: 32.20
R-squared: 0.65,
F-statistic vs. constant model: 10.2, p-value: <<0.001

*Significant at 95%, ** Significant at 99%

For EU10, II and V&A have \( p <0.001 \), while POP and LPI have \( p = 0.02 \) and 0.03 respectively (as shown in Table 4.6). Although, RoL and V&A represent the groups having almost same indicators in EU27 and EU10, respectively (as shown in Table 4.4a and Table 4.4b), V&A shows a much higher significance in EU10 as compared with RoL in EU27. Similarly, PS&AV, which is common in both cases (EU27 and EU10), shows \( p = 0.46 \) for EU 10 as compared with \( p = 0.02 \) in EU 27. Therefore, it can be concluded that PS&AV is an important factor in general, however, when countries with the most recalls are concerned, these are the remaining governance indicators (i.e. CoC, RoL, V&A, GE, RQ) represented by RoL are more significance while PS&AV becomes insignificant. The negative sign with the regression coefficients of V&A, ROL and PS&AV points that the countries with better governance indicators (represented in terms of V&A, ROL and PS&AV and other correlated indicators) are likely to have lesser recall notifications. It is worth noting that, POP has a negative coefficient, which means that the country with higher population tends to have less recalls. The positive sign of the regression coefficient with LPI clearly indicates that higher LPI leads to higher recalls. Current model (EU10) explains ~65% of the total variance.

### 5. DISCUSSION

From the presented data (in Table 2.1) it is clear that some of the EU member states have high recalls as compared to other, for instance BG and HU accounted for more than 50% of the total recalls in the years 2008-2013. The underlying reasons could be the weak legislation, lax enforcement and/or lack of government supervision which let the harmful products to enter in the market. The same is verified by the negative regression sign with governance indicators
(PS&AV, RoL for EU 27 and PS&AV, V&A for EU10) in the multiple regression coefficients, which show that weaker governmental control will increase the number of recalls. This supports the argument made by Luo (2008) that the strict and transparent government legislation impacts the recalls negatively and forces the organizations to closely monitor their products for safety aspects. LPI is the measure of the border customs efficiency and efficient logistic distribution and in general, positively influenced by the better governance (Arvis et al., 2014). Inspite of having a positive correlation, there are different signs of regression coefficients with LPI and as that with other governance indicators (such as PS&AV, V&A and RoL). This means when good governance (indicated by higher value of governance indicators such as PS&AV, V&A and RoL) would result in lesser recall, better LPI, which is positively correlated with governance indicators, would lead to higher recalls. In reality, most of the textile products recalled in the EU were reported to made-in-China and other non-EU countries, therefore they must have confronted EU border customs in a legitimate trade transaction. Country with better customs performance (or LPI) indicates that its border customs can capture the non-complying products more efficiently and allows relatively safer textiles in the market. This, in turn, would generate less recalls. But LPI having a positive sign with the coefficients in both cases (EU10 and EU27) shows that higher LPI tends to increase textile recall notifications, in contrast to the expected outcome. Moreover, LPI is highly significant for EU10 \((p < 0.01)\), it cannot be neglected. Therefore, it clearly indicates that the textile recalls cannot be handled by mere good governance, but different indicators need to be considered separately. Further, it is worth noting that, none of the economic indicators \((nGDP/C, PT and GDI/C)\) shows good statistical significance, which confirms that the textile recall is not an issue related with economic aspects of a country, rather it is a social and governance issue as social indicators \((such as II, POPuP(%)\) and PS&AS for EU27 and V&A, LPI, II and POP for EU10) show a high statistical significance (as shown in Table 4.5 and Table 4.6). In a specific context to Bulgaria, Ene (2012) also made the similar conclusion that product recalls can be controlled by effective implementation of consumer protection policies where the government and society have a primary role.

Furthermore, following the above analysis and revisiting the formulated research hypotheses, H2 and H3 are supported because many social and governance indicators showed a high statistical significance \((p \leq 0.05)\) for both of the cases. However, all the economic indicators that showed a low statistical significance \((p \geq 0.45)\), therefore H1 stands false and confirms that the economic aspects of the EU member states do not affect the corresponding textile product recalls and this is true for both cases (EU10 and EU27). This clearly indicates that low consumer buying power and/or poorer countries (which may import cheaper products) have no relation with product recalls.

### 6. CONCLUSIONS

Product recall has recently become a very common phenomenon and an inevitable action for manufacturers. The present paper studied the impact of macro-scale indicators on textile product recalls in the EU. Textile product recalls pertaining to this study represent the unique recall notification made in the EU during the years 2008-2013, which were obtained from the RAPEX database, the EU’s official database for non-food dangerous products notified for recall by the European Commission. The analysis was done by formulating two cases. In the first case, all EU member states were studied and the impact of various indicators on the EU member states was scaled using multiple regression analysis. Whereas, in the second case, top 10 EU member states, which account for more than 90% recalls were studied using the same regression analysis technique. Both analyses revealed that textile product recall is influenced by social and
governance indicators, while economic indicators show little statistical significance. In general, with no surprise, better governance (specified by various governance indicators, except LPI) negatively correlated to the textile product recalls. However, there is an exception with LPI, which shows a positive regression coefficient. Better LPI indicates an efficient border customs, transportation, and other related parameters, which may help in preliminary filtering of the harmful products. Considering the contradicting results from the current study, the role of border customs may need further analysis. Further, a large difference in significance levels of some indicators was observed as a major difference in two cases. Particularly, POP and LPI show a high significance for EU10 as compared to EU 27. This certainly indicates that population and border customs forces play an important role for current high product recalling EU states, which may not be true when all EU states taken all together. Recalling is an issue pertaining to non-complying products in the market. Since, both cases reveal that importance of governance and social aspects on textile product recalls, handling of this issue can be done by facilitating the government and society with more information about the product. It is also important for the customers to be notified for recalled products. These both purposes are served by the traceability system, which identifies and trace the products by product attached traceability tags; hence, the recalled products can be located and identified efficiently. Externally attached RFIDs and barcodes are generally removed at the point-of-sale; as a result, it becomes difficult trace products afterwards. The expert group setup by EU for involuntary traceability recommends integrating tracking tag to the physical product so that it remains with the product (Research Support for an Informal Expert Group on Product Traceability, 2013). Therefore, future research can be focused on designing of traceability system with integrated tracking tags to textiles for better textile product traceability in the markets and their withdrawal during the recall crisis.

ACKNOWLEDGMENTS

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REFERENCES


A STUDY ON OPERATIONAL CHALLENGES IN PUBLIC CATERING

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ABSTRACT

Purpose
The aim of the paper is to illustrate how the procurement of local food is implemented in the public-sector catering. The paper describes procurement practices of institutional kitchens. The operational and logistics factors that constrict the use of local food suppliers are highlighted.

Design/methodology/approach
Qualitative methods were used in conducting the study. Seven in-depth interviews were done among institutional kitchens and a local food producer to examine the supply chain structure and procurement practices.

Findings
The study showed factors that have an impact on sourcing decisions in institutional kitchens. The main reasons for using local food are connected to economic factors as lower transportation costs, short delivery times and delivery flexibility. A deeper co-operation is needed between institutional kitchens and the local producers so that they can better respond to the changing demand of markets.

Research limitations/implications
The study is descriptive in nature and rest on cases implemented during 2014 in a limited region. It provides evidence from only one country and results may not apply in other contexts.

Practical implications
The results offer new information for local food producers as well as municipalities and development organizations about the factors affecting on the use of local food in institutional kitchens.

Social implications
The study may support the use of local food.

Original/value
The paper complements the current discussion on local food procurement. So far, there are a few studies illustrating the procurement and logistics practices in the public catering.

Key words: local supplier, food supply chain, public procurement, institutional kitchen, short supply chain

1. INTRODUCTION

The paper discusses the challenges of purchasing local food in the public catering sector. Local and organic food constitutes a strategic topic both the agricultural and food policies of the
The local food system is often seen as an alternative for global food systems. In response to the single globalizing model, many local food initiatives have emerged around the world since the 1970’s. Having evolved within a particular social, economic, and environmental context, these new food systems in many ways mirror those of traditional cultures. These are typically orientated toward local and regional consumption, with relatively short distances – or food miles – between the producer and consumer (Norberg-Hodge, 2002). There is no single definition of local food system in the scientific literature, but in most cases, spatial distances and personal relationships between the various stages of the food supply chain as well as restrictions to a geographic region are the relevant issues (Scönhart et al., 2008). One set of the definitions of local food is based on geography and looks to define local in terms of the distance between producers and customers though there is no clear agreement of a limiting distance. In Finland, the local food is defined as “food production and consumption that uses raw materials and production inputs from their own region to enhance local economy and employment” (MTK, 2008). Some examples are “Local Food Plus” in Canada, which uses provincial boundaries (Campbell and MacRae, 2013), and “Bondens egen marknad”, a farmers’ market in Sweden with a limit of 250 km. (Nordmark, 2015). In the UK, the National Association of Farmers’ Markets (NAFM) specifies local food in the terms of the radius from the market and the association suggests that 30 miles is ideal, 50 miles is nevertheless acceptable (Jones et al., 2004).

Food supply chains are increasingly asked to deliver sustainable products in a sustainable manner. Public procurement through its “power of purchase” is one of the most influential means through which the state can effect behavioural change in economy and society. Forcing sustainable improvements in its suppliers, public procurement can have a huge influence over the food system, but organizational innovation is needed in logistics and supply chain management (Pagliarino, 2015).

In the EU directives on public procurement, contract award criteria with respect to public services have been changed towards more sustainable values during the last 20 years. The new procurement directives were published 17 April 2014. Member States must transpose the Public Contract Directives into national law within 24 months of that date. Public procurement is a significant activity for governments because of its scale and, increasingly because of the broader roles it can perform (Harland et al., 2013). According to the OECD (2013) it accounts, on average for 12.8 per cent GDP, equivalent to 29 per cent of general government spending. The primary procurement aim across most justifications is achieving value for money. However, it has been increasingly recognized that public procurement can be used more strategically to achieve additional aims (OECD; 2013). It acts as a vehicle for achieving wider socio-economic goals (Erridge, 2007) such as sustainability (Walker and Preuss, 2008), supporting SMEs, encouraging innovation (OECD, 2013) and aiding minority owned businesses (Loader, 2015).

In prior research local food in public catering is approached from sustainability viewpoint (Galli et al., 2014; Morgan and Sonnino, 2007; Smith et al., 2016). Local food in Finnish public catering has been studied from following viewpoints: procurement and sustainability (Lehtinen, 2012; Tikkanen, 2014), professional identity (Mikkola, 2009), food policy (Wahlen et al., 2012; Risku-Norja and Løes, 2016) and food education (Roos and Mikkola, 2010; Tikkanen and Urho, 2011; Risku-Norja and Mikkola, 2014). However, the author did not find any earlier studies that focus on operational and purchasing practices in public catering. To fill this empirical gap, this paper highlights the purchasing practices of the public catering sector. Especially, the paper
aims to describe the factors that have an impact on sourcing decisions and the use of local suppliers. Supply chain structure, inventory policy, procurement practices are illustrated.

The paper is structured as follows. First, the paper discusses about the public catering in Finland and summarized the features of local supply chains. Next, we account for the methodology and key empirical findings concerning the public procurement practices follow with examples and observations about delivery and ordering practices. The main findings of the empirical study are summarized and finally conclusions are highlighted.

1.1. Public catering in Finland

In Finland public catering had its first expressions at the end of the 19th and at the beginning of 20th century, and during the institutionalization process, free school meals become statutory in 1948 (Tikkanen and Urho, 2011). Public catering has played an exceptionally important role in the Finnish food sector: Approx. 20% of catering services are maintained by municipalities and other public organizations. Institutional food service can be defined as entities that provide meals at institutions including schools, colleges and universities, and hospitals, as well as correctional facilities, public and private cafeterias, nursing homes, and day-care and senior centers (Connor, 2014). In 2011, the number of institutional kitchens was totally 9162 including both distribution kitchens (5046) and preparing ones (4116). Totally public catering provided 419 million meals during a year. (Taloustutkimus 2012).

Efficiency requirements have led to increasing centralization of public catering services. First the number preparing kitchens decreased e.g. 9.1 per cent between the years 2009-2011. Second, the municipalities have established joint procurement groups e.g. consortium that are responsible for purchasing decisions. According to study on Finnish municipalities (Muukka et al., 2008) nearly 70% of the municipalities belong to a procurement consortium. Third, the operations are more and more outsourced. Traditionally, municipalities have been “self-operated” in which the municipality organised all activities using its own capital, management and labour. Recently, municipalities have started outsource their catering services partly or wholly to a private catering service company inviting bids and choosing largely on price and then having a contractor organise all procurement and production activities.

The degree of domestic from the food used by public-sector kitchens is approximately 80 per cent. The share of one’s own province is highest with bakery products and 15-20 per cent of the procurement consists of local food. In terms of money, the largest product groups and producing entities are meat products, dairy products and fruit, vegetables and berries. The largest amounts of local food in terms of money are purchased from these product groups for use in public-sector kitchens. Finnish joint procurement group and procuring entities purchase about 15 per cent of food used in the public-sector kitchens from their own province. (Viitaharju et al., 2014)

By producing locally produced and refined ingredients and food, municipalities will be able to act in a more customer-oriented manner while increasing the appreciation of local food among consumers. Favouring local food also means investing in the economy and employment of the region and supporting sustainable development in the regions throughout the food production chain. (Viittamäki et al., 2014)

According to Connor (2014) there are several reasons why scholars and practitioners are interested in institutional food service and food system. First, they purchase food in fairly large and predictable quantities, unlike high-end restaurants or retailers, for example, whose demand fluctuates with economic cycles to a greater degree. Many institutions have educational missions, using food service operations to enhance food, agriculture, and nutrition lessons.
Finally, individual institutions, particularly schools, are not direct competitors; unlike supermarket retailers or restaurants, sharing information or best practices within another institution do not risk customers leaving to eat another location.

### 1.2. Local food chains

Food chains can cluster by supply chain type for three basic categories (King, 2010):

- A major grocery supply chain for a product category (mainstream chain)
- A supply chain for a local product that is marketed directly by producers to consumers (direct market chain)
- A supply chain for a local product that reaches consumers through one or more intermediaries (intermediated chain).

Mainstream supply chains rely on national and international networks to deliver products to consumers, but many supply chain functions in mainstream supply chains, such as retail distribution services, are performed locally and contribute to local economic activity. Seasonality also plays a role in the share of revenue retained locally; some mainstream supply chains obtain products from local growers during certain times of the year and from national and international growers in the off-seasons.

Fuel use of transportation is more closely related to supply chain structure and size than to the distance food products travel. Products in local supply chains travel fewer miles from farms to consumers, but fuel use per unit of product in local chains can be greater than in the corresponding mainstream chains. In these cases, greater fuel efficiency per unit of product is achieved with larger loads and logistical efficiencies that outweigh longer distances. Van Hauwermeiren et al. (2007, p. 45) concluded from their comparison of local versus mainstream food systems that “Local food systems can be much more sustainable by increasing their efficiency through optimizing their transport and storage by diminishing the transport distance and storage time for a strict minimum and by increasing the stored and traded quantities to a full storage room and a full loaded transport mode.”

Even though the demand and interest for local food products are growing, the mainstream or traditional food supply chain the local food producers are still often seen as supplementary suppliers. The small production volumes, inadequate resources, high price levels, challenges on creating and marketing appropriate products, challenges in creating close business relations, and the risks related to the reliability of deliveries and typical issues hindering the access to traditional mainstream food supply chains. (Forsman and Paananen, 2002)

The small-scale rural food manufacturers and distributors face a traditional logistical problem of a small or medium sized enterprise (SME): the logistics and distribution is expensive one own, and access to the major distribution system is difficult. The alternative supply chains consist of small companies within thin material flows under pressure of vast competitors, the major food retailing industry. The fact that goods are perishable and the handling is regulated which complicated national and EU-wide legal provisions give its own characteristics to the supply chain. (Martikainen et al., 2014)

Hughes (2003) describes the ideal supply chain as short, fast, transparent and seamless, with few links in the chain and close contact between company and customer. However, in practice the chain often appears to be the opposite: complex, price-driven, confrontational, disjointed and opaque. Vorst, Tromp and Zee (2009) point out that proper design of a food supply chain involves not only improved logistics, but also preservation of food quality and environmental
sustainability. In a supply chain, it is more important to cooperate in order to create the most competitive chain than to compete for individual company profits (Christopher, 1998).

In Table 1.1, Nordmark (2015) summarized values, constraints and possible solutions associated with local food supply chain. According to Nordmark the transparency of food produced nearby can be higher than that of food produced away, which can be advantageous for locally produced food. Today, small-scale producers deliver their produce directly to retailers and it may take almost a day to deliver small portions of produce. The question may then arise of finding the best and simplest delivery choice available to small-scale farmers. In order to reduce impact on the environment, transport can be made more efficient. Cooperation, integration and optimisation are useful when improving logistics and finding improvements in supply chains.

Table 1.1 Values, constraints and possible solutions associated with local food supply chain and solutions associated with the local food supply chain. (Nordmark, 2015)

<table>
<thead>
<tr>
<th>Perceived values in consumer demand</th>
<th>Constraints related to logistics for producers</th>
<th>Possible solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Promote employment</td>
<td>• High logistics costs, including management, billing and transport</td>
<td>• Develop new logistics system for local food supply</td>
</tr>
<tr>
<td>• Environment</td>
<td>• Seasonality/discontinuity in the marketing chain</td>
<td>• Integration within local food supply system</td>
</tr>
<tr>
<td>• Promote lifestyle in countryside</td>
<td>• Environmental impact</td>
<td>• Integration with large scale supply</td>
</tr>
<tr>
<td>• Promote animal welfare</td>
<td>• Insufficient baseline data and scientific analysis of local food</td>
<td>• Focus on reducing costs</td>
</tr>
<tr>
<td>• Food quality and security</td>
<td></td>
<td>• Focus on reducing environmental impact</td>
</tr>
<tr>
<td>• Tasty food</td>
<td></td>
<td>• Collect and analyse scientific data</td>
</tr>
<tr>
<td>• Organic food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Transparency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Promote regional food tradition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Tourist attraction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. METHODOLOGY

This study was implemented in the spring 2014 in order to investigate the logistical questions. The study was an independent part of the “Accessibility of local and organic food in Northern Ostrobothnia in Finland” project covered the period from 1. October 2012 to 30. September 2014. The project (Kotavaara et al., 2014) aimed to analyze local and organic food in geographic context and to develop their availability and access to markets at Northern Ostrobothnia. GIS based accessibility analyses and qualitative surveys were conducted interactively during the project with the aim to generate novel approaches for analyzing accessibility in the context of local and organic food markets and logistics. Questionnaires and supporting interviews covered agricultural producers, companies in processing and refining, institutional kitchens and public procurements and food circles.

In this study, qualitative interviews were the main source of research data. Seven in-depth interviews were implemented (see Table 2.1). The secondary data included a questionnaire for institutional kitchens that was conducted at an earlier stage of the project. 22 respondents from institutional kitchens answered the earlier questionnaire.
The study examines the supply chain structure, inventory policy and procurement practices among the institutional kitchens. The purpose of the study is mainly descriptive illustrating the current situation in Northern Ostrobothnia, which formed the case including sub-cases e.g. single interviews. The study answers for the following questions:

- What are the main features of the procurement among the institutional kitchens studied?
- What factors impact on the use of local food in the kitchens?

The case study method was used in conducting the study. According to Yin (2003), a case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. In general, the case study strategy is suitable, when “how” and “why” questions are posed, when the investigator has a little control over events, or when the focus is on contemporary phenomena with a real-life context (Yin, 2003). Yin mentions that case studies can be used for exploratory, descriptive, and explanatory purposes.

Selecting cases should be based on criteria that are consistent with the research problems and the theoretical framework (Ghauri, 2004:112). In the study, a qualitative sampling of was purposive rather than random. The interviewees were first selected among the respondents to the earlier questionnaire made among institutional kitchens in Northern Ostrobothnia (Kotavaara et al., 2014) so that interviewees presented diverse sizes of organizations. Second, the organization A was selected to expose the viewpoints of a local producer.

A list of respondents and length of interviews are listed in Table 2.1. The list of questions asked in interviews is presented in the appendix. The interviews were recorded and transcribed or careful notes were made (Interview G). The obtained information was then interpreted and analyzed, together with secondary findings from homepages, newspaper articles etc.

*Table 2.1 Respondents and length of each interviews*

<table>
<thead>
<tr>
<th>Organization</th>
<th>Role of respondents</th>
<th>Length of the interview</th>
</tr>
</thead>
</table>
| A: Local producer of peeled potatoes and salad components | 1) CEO  
2) Production manager | 1h 20 min |
| B: International catering service company | Local customer manager of school kitchens | 48 min |
| C: Purchasing consortium | Procurement specialist | 1 h 22 min |
| D: Municipality | Food service director | 1 h 14 min |
| E: Municipality | Food service director | 1 h 10 min |
| F: Municipality | Food service manager | e-mail questionnaire |
| G: The Oulu Region Joint Authority for Education | Manager in charge of food procurement | Phone interview |
3. EMPIRICAL STUDY

According to the earlier questionnaire carried out by the project, 60 pro cent of the kitchens purchased local food on a regular basis. Twelve of 20 respondents used large national wholesalers. Other channels were local intermediaries (9 answers) and direct from producers (9 answers). The low degree of processing and difficult availability considered the most important factors that have limited the acquisition of local and organic food in northern Ostrobothnia (Kotamäki, et al, 2014). In this chapter, procurement and delivery practices are illustrated. Two examples describing practices in a large purchasing consortium (C) and a small municipality (E) are presented.

3.1. Public procurement practices

Typically, the purchasing consortium of several municipalities is responsible for supplying food ingredients and materials for the institutional kitchens. For example, the purchasing consortium of Oulu region is responsible for the food acquisitions of 11 municipalities, the joint authority for education and hospitals. Whereas in the southern region of Northern Ostrobothnia, the municipalities (including municipality D and E) have been responsible for acquisitions independently. Furthermore, some of the service points of the municipality can be outsourced to a private actor (e.g. private company B) as in the town of Oulu. Because the economy of municipalities is tight, outsourcing of food services to private actors can be a growing trend in the future.

The municipal acquisition is based on the procurement law (The Act on Public Contracts 348/200/) and most of the food acquisitions exceed the national threshold value which requires a public procurement procedure, €30 000. The acquisitions which go under the threshold value can be made using a light procurement procedure. On the basis of the interviews the use of the light procurement procedure has been problematic: It was unclear for the responsible personnel how the purchase value is specified. Thus, they rather applied the public tendering process for all food purchases to be on the safe side.

Usually the suppliers are responsible for the transportation costs. In the invitation of tenders suppliers inform a dropping payment: it is the transportation cost to the dropping point. The dropping payment varies much between the suppliers: there are no rules how dropping payment should be calculated. It is more common that wholesalers or the local producers do not charge dropping payment at all. Alternatively, some of the interviewees also suspected that actual costs of the product are transferred to transportation costs so the actual price of the product is reduced lower enough.

Sourcing decisions are usually based on combined affordability including both price and quality criteria. In the acquisitions, a product range of suppliers plays an important role. The kitchens try as much as possible to purchase from “one place” which favours the wholesales, especially when small purchasing volumes are in question. The wholesales are also favoured because they offer a wider product range than by ordering directly from producers. The supplier is usually responsible for the transportation.

"We are not invited to tender products but suppliers and then we looked at the product range that the supplier can offer” (Respondent C)

The interviewees highlighted that the ordering from wholesalers is not necessarily the cheapest. Often local suppliers will be competitive when the purchasing volumes are high, for example such products as potato. It was estimated that the overhead costs of wholesale businesses were
considerably bigger than those of the small local companies. In Figure 3.1, basic steps of local food from farmers to institutional kitchens studied are described.

![Figure 3.1 Local food chains from farmers to institutional kitchens.](image)

3.1.1. Example: Purchasing consortium C

The purchasing consortium of Oulu region invited to tender vegetables, potatoes and other foods separately. The food service managers from different municipalities define the contents of the invitations to tenders together. Municipalities can decide themselves if they participate in the invitation to tenders process. For example, the previous contract period of the potato was for two years added with the option of two years. In the invitations to tenders the place of deliveries and lead times are specified. The supplier can offer only for some places of delivery (e.g. kitchens in some municipalities) or to the whole region. The logistics costs in the offers are presented separately as dropping payments. The primarily price has been used as a comparison criterion of offers, because the quality criteria are presented in the invitation for tenders; i.e. only those companies that fulfill the quality criteria can make an offer. For example, the lead time between potato peeling and delivery is defined in the invitation for tenders. The last contracts concerning potatoes were done with the four suppliers of which three operated in the local region. Each food service manager decides which of these suppliers are used in their kitchens.

"We have attempted to use as much as local food as much as law allows —, of course, I have tried that the local producers are added in. ….. It is cheaper to supply the potato and vegetables locally than to transport bags of carrots over 200 kilometers.” (Respondent C)

3.1.2. Example: Municipality E

The municipality E is located 126 km to the south from Oulu. In the municipality there are about 2700 inhabitants including 500 school pupils. Figure 3.2 presents the sources of raw materials used in the production kitchen of the municipality. Meals are prepared in a centre kitchen from which it is delivered to two satellite kitchens, a day nursery, a service center for elderly and home help service. Salaries form the most of the food service budget of the
municipality and the share of food materials is about a third. The internal delivery of the food accounts about six per cent.

In the last call for tenders, potatoes and the vegetables have been acquired separately through light procurement process, because the yearly value has stayed under the threshold value. The invitations for tenders were sent to local producers and informed in the local newspapers. Bread, meat, fish, dry and frozen foods are acquired by using a public tendering process. The criteria for supplier selection were following: price (80 %), quality (10 %), the reliability of delivery (5 %) and environmental matters (5 %).

The potatoes are delivered every morning directly by the producer as well as vegetables by a local intermediary. The bread, meat, fish, dried and frozen foods are supplied from national wholesalers. The milk is got through the wholesaler even earlier the deliveries came directly from the dairy company. All the materials from wholesalers are delivered with the same truck that delivers also material to local retailers. In this way, the transportation costs paid by the municipality are minimised.

3.2. Deliveries and ordering in the kitchens

In the invitations of tenders it is defined how much suppliers should deliver during the offering season. The interviewees pointed out that local producers have difficulties in delivering required quantities and follow the delivery rhythm required. Furthermore, the degree of processing is too low among local producers.

“There is not local supply and the degree of processing is low, as vegetables are not peeled and chopped. The quantities are small and sourcing causes extra work. There are no local intermediaries…” (Respondent F)

Because the storage space is very limited in the production kitchens, the size of orders must decide carefully. The small the order quantities are the higher are the transportation costs. Also preservability and the package of groceries have an impact on the delivery rhythm. For example, the potatoes packed in a vacuum preserved longer and can order further.

The lead time of deliveries varies: The ordering rhythm from wholesalers is generally 48 hours and the order is done two days beforehand. However, the lead time of deliveries for local producers is only 12-24 hours. The main feature of the local producers is that they are able to react quickly to customers’ changes and needs and have high flexibility in their production.

Earlier, groceries were ordered to the kitchens by telephone but today the order is done by electric order systems. The supplier offers a net based order system into the use of a customer so that each supplier have an own internet based system. In catering sectors there are also their own ERP systems including e.g. order configurations and automated menu creation. The order systems of large wholesale companies are usually compatible with the systems of large catering service companies. However, the local producers do not have developed ordering systems and thus, it is easier for busy catering personnel to use ordering system offered by national wholesalers.

“Of course it is a problem that when we change the supplier also the ordering system changes and we must learn to use a new system.” (Respondent D).
As earlier it was already mentioned, the product offered from the ordering system of a supplier is a significant factor when selecting a supplier. Available raw materials and groceries have an impact on the recopies and weekly menu in the kitchens. Typically national wholesalers and large food companies are able to offer a wider range of products and give support in developing new recipes. Local producers with limited product range seldom have this kind of support to their customers.

3.3. Findings from the empirical study

The interviews done in this study highlighted the problems concerning the procurement of local food in institutional kitchens. First, the demand for cost efficiency in public catering sector has an important impact on the procurement process. Most of the kitchens belong to the procurement consortium and they tend to concentrate on purchases to a limited number of suppliers. The product range of the supplier is an important factor in sourcing decision. The most favoured sourcing channels are local intermediaries and national wholesalers. To source directly from farmers is no longer a common practice.

Figure 3.3 summarized the main factors that impact on the use of local suppliers in studied kitchens.
To minimize the logistics costs e.g. dropping payments, the number of weekly deliveries is minimized. On the other hand, production kitchens have very limited storage base especially for frozen food and thus inventories are held by the suppliers. The local producers are competitive when they are specialized to deliver large quantities potatoes, bread etc. The high flexibility in delivery time is in an important factor for the success. When the lead time of orders is two days for wholesalers the time for local producers and intermediaries is 12-24 hours or less. The interviewees criticized the limited product range of local suppliers as well as the low degree of handling and processing of raw materials. The kitchens use more and more ready-made components when repairing meals and they are more tied up the product range of curtain suppliers than before. The co-operation between the institutional kitchens and local suppliers seemed to be limited. The local producers have not been able to respond to this changing demand of more value-added products. On the other hand, national wholesalers are offering their customers free ordering systems, the wide range of products and specific food components. These operational factors are often more important in sourcing decision than the price itself.

4. CONCLUSIONS

During last decade there have been many studies and developing projects concerning the local food. These have concerned how to promote the availability of local food among consumers and catering services (Risku-Norja and Løes, 2016). Many of the studies have focus on the sustainability issues and there seem to be a mutual understanding that local food has positive social and environmental impacts. The public catering sector in an important market for locally produced food, especially in Finland institutional kitchens have been an extremely important customer for local producers. This study confirms that institutional kitchens prefer to use local food and the favoured sourcing channel is through local intermediaries or the national wholesalers. The main reasons for using local food are connected with supporting local economy, economic issues as lower transportation costs, short delivery times and delivery
flexibility. However, sustainability factors as such are not important factors when sourcing decisions are made by the public catering.

Based on the empirical study, the municipalities adhered well to the Act of Public Contract. Because of the bureaucratic tendering procedures, small food producers have had difficulty in taking part into this competitive bidding put out by the purchasing consortiums. In the near future within the new Public Contracts law the process of bidding in public contracts should be quicker, less costly, and less bureaucratic, enabling small companies to compete more effectively.

The study showed up factors that have had a great impact on sourcing decision. First, the institutional kitchens liked to concentrate on their purchases so that the number of deliveries per week is optimized. Thus, the product range offered by the supplier is an important factor which so far has favored national wholesalers. Second, institutional kitchens are using more and more preprocessed components when preparing meals, which limits the direct purchases from farms or local producers. Also the developed ordering and production control systems used in kitchens may hinder the acquisition from local producers. As Forsman and Paananen, (2002) argued, the small production volumes, inadequate resources, challenges on creating and marketing appropriate products and risks related to the reliability of deliveries hinder local suppliers to deliver mainstream food chains as well as institutional kitchens.

In the future, deeper co-operation is needed between institutional kitchens and the local producers so that they can better respond to the changing demand for the markets. Especially, it is important to develop together more customized groceries and food components as well as logistics solutions. As presented by Nordmark (2015, see Table 1.1) focal food supply chains should integrate more with the large scale supply channels e.g. mainstream chains or develop new logistics systems for joint deliveries including light processing and distribution hubs etc. Also it is important to collect and analyze data about the costs of local supply, especially concerning the logistics costs used in tenders.

The achieved results in the study represent mainly the viewpoint of the institutional kitchens in Northern Ostrobothnia instead of providing different viewpoints about public catering in the whole country. However, the earlier studies (e.g. Viitamäki et al., 2014; Tikkanen, 2014) support the fact that the cases describe the situation in Finland in well. The results offer new information to local food producers as well as municipalities and development organizations about the factors affecting on the use of local food in the institutional kitchen. It may help to identify constrains and problems in current local food systems.

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Appendix 1: Discussions themes of the interviews

The deliveries to the kitchen
   How many production and satellite kitchens do you have in the municipality?
   How is the transportation organized?
   How many times do you have deliveries to the kitchens?
   Are the deliveries combined e.g. joint transportation?
   Do you think that you have too many deliveries during the week?
   How about your own storage base: do you have storages for frozen food?
   Have you increased or decreased your storages?
   Do you have an internet based ordering system?
   What is lead time for deliveries (24 h or 48 hour or something else)?

The use of local food
   How the suppliers are defined in the contracts?
   Do you use single or dual sourcing – e.g. you have more than one supplier per produce and how the volume is divided?
   From where do you supply your local products? How is the transportation organized?
   What is the main obstacle that constrains the use of local producers?

The use of national wholesalers
   How do you know the origin of the food supplied? Is wholesaler offering you’re the information?
   In what form the food materials (e.g. salads, carrots etc.) are delivered?
   What way the food materials are coming to your kitchen e.g. direct from the food company, from local distribution center etc.?

The cooperation with the suppliers
   How much do you have cooperation with your suppliers (e.g. meetings, visits)?
   Have you developed recipes together with your suppliers?
DEFENCE MAINTENANCE
– ASSESSMENT OF SAVINGS MEANS AND POTENTIAL

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ABSTRACT

Purpose
This paper attempts to assess the areas of potential savings in Finnish Defence Forces (FDF) maintenance operations and evaluate the means for achieving those savings.

Design/methodology/approach
The overall volume of defence maintenance operations is estimated from public documents. Twelve senior-level experts in the FDF and defence industry were asked to utilise Analytical Hierarchy Process (AHP) to rate the relative potential savings between different systems categories, maintenance functions, and strategic alternatives in defence maintenance operations.

Findings
Nordic maintenance cooperation was not perceived as a strong potential cost-savings solution compared to outsourcing or internal efficiency measures. The respondents ranked the potential savings of the C4ISR and land systems above air and maritime systems.

Research limitations/implications
Because defence maintenance costs cannot be found form publicly available sources, a relative instead of absolute assessment using AHP was used. The high inconsistency of assessments by the experts indicate uncertainty in potential, especially in C4ISR systems.

Practical implications
The assessment of potential savings and the means to achieve them provide advice to the FDF maintenance decision makers and may have applications in other defence forces.

Social implications
The relative importance of strategic actions in maintenance cost savings provides information for political decision makers as well as the division of work between the FDF and defence industry.

Original/value
Although the literature addresses different approaches to increase maintenance efficiency, it does not evaluate the relative potential of these approaches, especially in the defence context. Such an assessment benefits the decision makers in defence maintenance.

Keywords: Maintenance, Logistics, Defence
1. INTRODUCTION

Since the end of the Cold War, European defence budgets have been in decline, and the recent era of austerity has not altered this trend. Compared to the formidable economic power of Europe, the military sphere is viewed as an underperformer, especially compared to the United States. According to the European Commission (2015), the fragmentation of European defence markets leads to the unnecessary duplication of capabilities, organisations, and expenditures, and, as a result, the industry lacks the necessary economies of scale.

International cooperation is often suggested as a way to reduce duplication and increase economies of scale. According to Lorell and Lowell (1995), there are three types of objectives for international collaboration in weapons acquisition: economic, political and operative—such as logistical efficiency and wartime support capabilities through the promotion of standardisation and interoperability of military equipment. The Nordic Defence Cooperation (NORDEFCO) was established in 2009 between the Nordic countries. According to Saxi (2011), the main driver behind this intensified Nordic cooperation was economic: shrinking budgets, rising costs, and increased international missions. Cohn (2013, p. 57) observes that even within NORDEFCO's current structure, several projects could deliver efficiency gains, such as harmonising the requirements for cooperating in acquisition and common maintenance. However, his overall conclusion concerning international cooperation for Sweden is that even though significant results and savings have been achieved, these accomplishments are and will remain marginal relative to the basic problem of the gap between the tasks and capabilities of the Swedish Defence Forces (Cohn, 2013, p. 71).

In addition to international cooperation, another direction could be outsourcing to private operators. Public entities are not necessarily perceived as operating as efficiently as the private sector. In defence, this outsourcing would take the form of public-private partnerships (PPP), a term that the European Commission (2004, p. 3) defines as “forms of cooperation between public authorities and the world of business which aim to ensure the funding, construction, renovation, management or maintenance of an infrastructure or the provision of a service”. However, according to Khanom’s (2010) literature review, few people agree on what a PPP is and how it should be defined. While the United States allows up to 50% of its maintenance volume to be outsourced (US 10 §2466), the European average in 2013 was 7.3% (EDA 2015a), which appears to leave room for more outsourcing. On the other hand, Hurt (2011) claims that several European countries have already outsourced their maintenance in order to achieve cost reductions. The boldest example was in the U.K., which even asked for bids to outsource the entire acquisition life cycle to a government-owned, contractor-operated entity (although the U.K. did not implement these plans) (BBC 2013). As Wise and Baumgartner (1999) point out, many equipment manufacturers may find opportunities in moving downstream in the value chain because even though equipment sales may not grow, the maintenance and service needs of the existing industrial bases can still grow. The authors also note that manufacturers have the advantage of knowing their equipment. For the customer, this means that cooperation in maintenance services, or even outsourcing to the equipment manufacturer, could be a viable opportunity.

A partnership strategy by the Finnish Ministry of Defence (FMoD, 2011) defines such outsourcing or partnership with the private sector as a strategic partnership that serves the core functions of the FDF and includes contingency plans for crisis time, thereby differentiating it from other partnerships with private sector. Furthermore, as there are only a few possible service providers and because of crisis time requirements, a strategic partnership is a long-term one. As integration, maintenance, and damage repair capabilities are critical for the Finnish
military's security of supply by the FMoD (2012), it is clear that maintenance, if outsourced, must become a strategic partnership.

International cooperation and outsourcing are not the only ways to achieve more efficient maintenance. Internal efficiency measures, such as lean initiatives, are an obvious alternative. In fact, the Danish Ministry of Defence (2012) lists efficiency measures in equipment maintenance including consolidating the main depot structure, utilising workshop capacity more efficiently by consolidating the maintenance structure, in addition to opportunities for outsourcing activities. In Sweden, the area of stocks, services, and depots reports five examples of increased internal efficiency, such as reducing the number of air systems depots from three to two and closing down eight warehouses (FMV, 2015, p. 32) while international cooperation is also recognised by FMV as a potential way to increase efficiency. According to the GAO (2003), when requirements are set for a weapons system, operating and support costs do not receive the same attention as other performance characteristics even though they are the largest factors in a weapons system’s total ownership cost.

The overall objective of this paper is to assess potential savings and evaluate the means to achieve those savings in the FDF's defence maintenance operations. This objective will be achieved by answering the following three questions:

- What is the approximate FDF maintenance budget, and how substantial are the potential savings?
- Where in the maintenance budget are the potential savings?
- Which of the strategic alternatives in defence maintenance (Nordic maintenance cooperation, internal efficiency measures, or outsourcing) offers the greatest potential cost savings?

As to the last question, the Danish Defence Agreement (DMoD, 2012) mentions all three alternatives when it states it will internally consolidate the maintenance structure and utilise capacity better, outsource parts of activities, and assess the potential for bilateral and multinational cooperation in the acquisition, operation, and maintenance of equipment.

2. DEFENCE ACQUISITION LIFE CYCLE

The concept of military capability is used when talking about how to achieve a particular operational effect in time and space (ADoD, 2006). Military capability is a systemic concept that, in Australia for example (ADoD, 2006), consists of organisation, personnel, collective training, major systems, supplies, facilities, support, command, and management. From the life cycle perspective, logistics is the bridge between the deployed forces and the industrial base that produces the weapons and materiel that the forces need (NATO 2012, p. 20). Defence acquisition (which is called acquisition logistics in NATO (2012)) is concerned with acquiring major systems, i.e. the materiel aspect of military capability (ADoD, 2006). Figure 2.1 shows a generic defence acquisition life cycle model that includes all the phases, from need development to materiel disposal (Rendon and Snider, 2008). There are different life cycle models in different countries, and within one country, the models change every now and then. For example, NATO (2007) has six system life cycle phases following ISO/IEC 15288 standards, while the current model in Finland (adopted in 2015) has six somewhat different life cycle phases (Pääesikunta, 2015).
The last phase of the life cycle model in Figure 2.1 contains production, deployment, operations, support, and disposal (although other life cycle models may treat some of these as separate phases). While deployment often refers to troop movements, in this context it refers to having the all the parts of military capability, including materiel, ready to be used. Operations (i.e. usage) require support, which includes maintenance.

EDA reports divide military expenditures into classes of personnel, operations and maintenance (O&M), investment, and other expenditures (EDA 2015b). Furthermore, the EDA defines O&M costs to include “(spare parts and supplies) of major equipment, other equipment and supplies, and costs related to maintaining utilities and infrastructure” (EDA, 2015b). According to the EDA (2015b), these O&M costs accounted for 25.1% of total military spending. The single largest cost item in the EDA’s 2013 defence data, however, was personnel (49.3%), which includes “all personnel-related expenditures for military and civilian personnel”. These definitions do not make it entirely clear where O&M personnel expenses are reported when O&M tasks are done by personnel. In contrast, the U.S. definition of O&M costs is clear, as the Defense Acquisition Guidebook (2013) states that O&M “includes the costs (organic and contractor) of manpower, equipment, supplies, software, and services associated with operating, modifying, maintaining, supplying, training, and supporting a system in the DoD inventory”. As this paper focuses only on maintenance costs (while the cost of operating a system, including personnel operating costs and other operating costs such as fuel are excluded), the public documents are not likely to provide a firm basis for assessing maintenance costs even if system-level cost data were available.

Table 2.1 Cost Ratios by Weapon System Type (Jones et al., 2014)

<table>
<thead>
<tr>
<th>System Type</th>
<th>R&amp;D</th>
<th>Investment</th>
<th>O&amp;S/Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-Wing Aircraft</td>
<td>20%</td>
<td>39%</td>
<td>41%</td>
</tr>
<tr>
<td>Rotary-Wing Aircraft</td>
<td>15%</td>
<td>52%</td>
<td>33%</td>
</tr>
<tr>
<td>Missiles</td>
<td>27%</td>
<td>33%</td>
<td>39%</td>
</tr>
<tr>
<td>Ships</td>
<td>1%</td>
<td>31%</td>
<td>68%</td>
</tr>
<tr>
<td>Surface Vehicles</td>
<td>9%</td>
<td>37%</td>
<td>54%</td>
</tr>
</tbody>
</table>

There is a widespread rule about life cycle cost assessments known as ’30/70’, i.e. investment represents only 30% of life cycle costs, while deployment, operations, and support make up 70% of the costs. Jones et al. (2014), however, found an average cost ratio of 55/45 with many
weapons systems deviating significantly from the average (Table 2.1 shows cost data by weapon type). Jones et al. (2014) also caution that the figures are just a point estimate without a range or other statistics. In addition, the estimates are likely to include personnel operating costs in the operations, support, and disposal phases. Given the long life cycles for major military systems, the validity of the data in Table 2.1 (or other similar retrospective cost data) can be questioned when making key acquisition life cycle decisions in the investment phase because any data is, by definition, from the previous generation and represents outdated technology.

Comparing Table 2.1 with Figure 2.1 reveals a conceptual difference: Figure 2.1 shows the capability life cycle and Table 2.1 shows cost ratios by system. Military capability was defined as a systemic concept including not only systems but also other parts like personnel, so costs that can be allocated to weapons systems are less if a causal relationship between cost and the costing object is followed.

Military readiness is usually expressed as the percentage of total units available and capable of performing a mission at any given time. If a weapons system is not ready when it is needed, its performance characteristics are of no use. In general, readiness can be achieved either by building highly reliable weapons systems or, if the systems are not highly reliable, supporting them with an extensive logistics system that can ensure spare parts and other support items are available when needed. (GAO, 2003)

A special feature of military systems is that in peacetime they are used for training. The peacetime training needs may differ considerably from the wartime scenarios. A key issue is the intensive use in wartime versus lighter use in peacetime training. This contrast translates into a need to expand maintenance capacity in wartime and prepare for that need in peacetime. For a country maintaining a reserve force, the armaments and materiel necessary for mobilisation need to be stored in peacetime because only a fraction of the units are required for training. The results of Suomala et al. (2005) in their study of the life cycle costs of a towed artillery piece highlight these issues. Their result was that the per unit life cycle costs of the artillery piece averaged EUR 8.2 million; the majority of the costs were attributed to ammunition and included significant uncertainty. Excluding ammunition, the life cycle costs were EUR 1.2 million, slightly over half of which was acquisition price.

3. SAVINGS IN MAINTENANCE: A LITERATURE REVIEW

NATO (2012, p. 20) defines logistics as “the science of planning and carrying out the movement and maintenance of forces”. Among the core functions conducted by NATO are supply, maintenance, movement and transportation, petroleum support, infrastructure, and medical support (NATO 2012). The FDF (Pääesikunta, 2008) defines logistics in a similar fashion. Maintenance is, by definition, one part of logistics.

Maintenance can focus on any part, component, device, subsystem, functional unit, equipment, or system that can be considered individually (PSK, 2011). Military systems are structured as “systems”, which include their “subsystems” and “components” (DoD, 2011). Therefore, military systems maintenance is focused on these three categories. Maintenance operations can be classified by maintenance levels. In Finland, a two-level system is used. The U.S. DoD uses a three-level system (DoD, 2015): organisational (O) maintenance that is normally performed by an operating unit on a day-to-day basis to support operations; intermediate (I) or shop-type maintenance that includes limited repair of commodity items; and depot-level (D) maintenance for major repairs or complete rebuilding. By definition, maintenance activities performed by
the organisation cannot be centralised without centralising the operative units and, therefore, do not present an opportunity for savings through either international cooperation or centralisation.

Maintenance costs may be divided into internal maintenance, maintenance by production personnel, external maintenance services, materials, maintenance management and planning, maintenance administration, training costs, data systems and documentation, and rental charges (PSK, 2011).

Internal maintenance can be rationalised to achieve cost savings. According to Moubray (1997), usually 40-70% of cyclical maintenance can be eliminated through Reliability Centered Maintenance (RCM) methods. RCM is a process to ensure that systems continue to do what their users require in their present operating context. It is generally used to achieve improvements in fields such as the establishment of safe minimum levels of maintenance (Moubray, 1997). In external maintenance, maintenance contracts can be developed, and performance-based logistics contracts have increased systems availability and brought savings (Vitasek et al., 2006; GAO, 2008).

Systems operators can greatly affect systems maintenance costs and availability. The main emphasis in Total Productive Maintenance (TPM) is to persuade the operators to carry out regular daily maintenance and the maintenance crew to carry out specialised maintenance. Wireman (2004) estimates that 10-40% of routine maintenance tasks can be transferred to systems operators. For work costs, the savings achieved through learning, which could be estimated from learning curves, are important. Learning effects of 10% efficiency increase with doubling the cumulative production volume are reported. Such general figures may or may not be accurate in the maintenance context, where a considerable amount of time may be spent diagnosing the problem.

Economies of scale is one source of efficiency gains. A report by McKinsey notes that in recent years, many efforts by various MODs have shown that centralising some maintenance tasks increases “wrench time” and lowers the cost of spare parts inventories (Staples, 2013). Spare parts costs can be subdivided into purchase price, ordering costs, and inventory carrying costs. International cooperation, in principle, should decrease purchase prices and reduce ordering costs per part as larger volume orders are made. Inventory carrying costs would be reduced, too. Purchase price savings are, in the end, a matter of agreement between the buyer and seller. A producer’s savings depend on the manufacturing process of spare part. While the savings for make-to-stock items can be minimal, the savings for made-to-order spare parts can be considerable, depending on the ratio of fixed to variable costs. However, different weapons systems behave differently in this respect, and particulars (e.g. export rules) may lead to the fact that theoretical savings cannot be achieved in practice. Consider, for example, spare parts for U.S. equipment. In theory, pooling Nordic volumes would lead to increased negotiation power and a lower unit price. In practice, however, the U.S. government charges foreign users of U.S.-made military equipment the same price as U.S. users, so no actual savings from pooling Nordic volumes can be realised in the unit purchase price.

4. ASSESSING MAINTENANCE SPENDING

Table 4.1 shows the O&M expenditures for the Nordic countries and Australia and the O&M’s share of the total defence budget. The figures are taken from the 2015 national budgets, except Finland’s O&M figures, which are from the EDA (2015a). The Australian figures are included
in Tables Table 4.1 and 3 because it is one of the few countries with comparable, accessible
data. The O&M share varies, but for these figures, it is around 20%, except for Finland.

Table 4.1 2015 O&M expenditure and its share in Nordic countries and Australia. Figures
are in national currencies. Sources: Försvarsmakten (2015,) Forsvaret (2015),
Finansministeriet (2015), ADoD (2014), and EDA (2013)

<table>
<thead>
<tr>
<th>Budgeted Cost</th>
<th>Sweden</th>
<th>Norway</th>
<th>Denmark</th>
<th>Australia</th>
<th>Finland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defence Total</td>
<td>39 585</td>
<td>37 042</td>
<td>19 287</td>
<td>34 219</td>
<td>2 383</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>6 568</td>
<td>8 209</td>
<td>3 475</td>
<td>6 843</td>
<td>761</td>
</tr>
<tr>
<td>O&amp;M Share</td>
<td>17%</td>
<td>22%</td>
<td>18%</td>
<td>20%</td>
<td>26.6%</td>
</tr>
</tbody>
</table>

The problem with Table 4.1 as a source for assessing the maintenance costs as defined in this
paper is that defence forces do not report the full maintenance costs. Firstly, O&M costs are
reported together, which means that consumables such as fuel are reported together with
maintenance. NATO (2016, p. 12) includes both fuel and ammunition in O&M costs, as well
as spare parts, supplies, and rents; the EDA follows a similar definition. Secondly, because
personnel costs are reported as one item by NATO (2016, p.12) and the EDA, the labour costs
for maintenance operations carried out by defence personnel are not reported as O&M costs.
On the other hand, when maintenance is outsourced, the service fees (including labour costs
and maintenance service purchases) are likely reported as O&M. Thirdly, it is unclear whether
equipment upgrades are included under O&M or acquisition. As the Australian House of
Representatives (2012, p. 60) notes, “It is when potential major upgrades are required that a
decision would be made about implementing a major new project or undertaking minor
upgrades through sustainment. This decision is dependent on the assessed extent of the
upgrade.”

Apart from the data in Table 4.1, there are sporadic statements that add some information
regarding maintenance expenditures. Norwegian Forsvarets Årsrapport (2015) mentions that
the O&M costs for submarines as 65% maintenance and 35% operating costs. In Finland,
Millog Oy is "the FDF’s strategic partner, providing life cycle support services for material
under the responsibility of the Army and the Navy, in both normal and crises time. Such services
include the maintenance of wheeled and tracked vehicles, weapon and electronic systems, naval
vessels and systems, as well as the materiel services and life cycle services including
modifications and installations” (Patria, 2015, p 14). At the beginning of 2015, the Army's
garrison depots and the Navy's central warehouse and depot were outsourced to Millog Oy
(FDF, 2015). This change included outsourcing 317 people from FDF to Millog Oy. The annual
fixed cost of this outsourcing is EUR 99.5 million (Patria, 2015). According to Millog Oy's
(2015) annual report, its 2014 turnover was EUR 121.8 million and consisted solely of the
domestic defence sector. However, it is not entirely clear after this move whether all Army and
Navy maintenance (excluding O-level) is carried out by Millog Oy.

Table 4.2 shows O&M expenditures for each service branch in Australia, Sweden, and Norway
(comparable data from Finland and Denmark are not publicly available). Assuming that Millog
Oy's turnover of EUR 121.8 million plus the 2015 outsourcing deal of EUR 99.5 million
represents the FDF's Army and Navy maintenance costs, then multiplying Millog Oy's
estimated 2015 turnover of EUR 221.3 million by the average share of O&M costs by the Army
and Navy in Table 4.2 (42%) results in an estimate of EUR 527 million for FDF maintenance costs.

Table 4.2 The share of O&M expenditures for each service branch in 2015 Försvarsmakten (2015,) Forsvaret (2015), and ADoD (2014). Figures are rounded.

<table>
<thead>
<tr>
<th>Branch</th>
<th>SWE</th>
<th>NOR</th>
<th>AUS</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army</td>
<td>14%</td>
<td>22%</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>Navy</td>
<td>12%</td>
<td>28%</td>
<td>29%</td>
<td>23%</td>
</tr>
<tr>
<td>Air Force</td>
<td>43%</td>
<td>35%</td>
<td>27%</td>
<td>35%</td>
</tr>
<tr>
<td>Other</td>
<td>30%</td>
<td>15%</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td>Sum</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

The estimate of EUR 527 million has many caveats: is the outsourcing deal of 2015 fully new turnover or does it include some of the previous turnover?; is Millog Oy responsible for all Army and Navy maintenance?; does Millog Oy provide services other than maintenance for the Army and Navy?; and finally, how much bias does the method estimating the figures for the Air Force and other maintenance based on average O&M share bring? As the 2015 defence acquisition budget was EUR 447 million (MoF, 2016), maintenance costs are a significant part of the defence budget.

5. METHODOLOGY OF EXPERT INTERVIEWS

The purpose of the interviews was to assess where to find potential savings in the FDF maintenance budget and evaluate which of the strategic alternatives offered the highest potential for maintenance cost savings. The participants were twelve director-level experts of the FDF and Finnish defence industry, six from FDF's logistics command and six from Patria PLC. The participants were chosen based on their position in the organisational hierarchy as well as their responsibilities for maintenance in the FDF and defence industry. Four belonged to top management, and eight were managers of land, maritime, air, and C4ISR systems, so every potential participant within the selection criteria was interviewed. Participants only evaluated their own area of responsibility. The top management group (n = 4) compared the relative potential savings of the systems categories and determined whether the savings were found in the FDF or the defence industry. The system manager group (n = 8) compared only within the one systems category area in the FDF or defence industry that was their responsibility. All the invited respondents agreed to be interviewed, which highlights the importance of seeking new procedures for cost efficiency and savings in the field of defence maintenance by the respondents.

The interviews used the Analytic Hierarchy Process (AHP) to compare the alternatives and determine their relative priorities. AHP is a multicriteria decision-making approach introduced by Saaty (1977). AHP is applied through pairwise comparisons and relies on the judgements of experts to derive priority scales (Saaty, 2008a). AHP has attracted the interest of many researchers mainly due to the mathematical properties of the method and the fact that the required input data are easy to obtain. It uses a multilevel hierarchical structure of objectives, criteria, subcriteria, and alternatives (Triantaphyllou & Mann, 1995). In comparing the
alternatives, the interest is not on the exact measurement of some quantities but the proportions between them (Brunelli, 2015). The mathematical model behind AHP is presented by Saaty (2008b).

As the FDF has four systems categories, the first criteria presented was—which systems category has the greatest potential savings? Organisational responsibilities for maintenance are divided between the FDF and defence industry, so the first subcriteria presented was—are there larger potential savings in the FDF or defence industry concerning the evaluated systems category? The second subcriteria concerned the nine maintenance cost factors— which cost factor has the largest potential savings? Finally, all the cost factors were evaluated—what are the best means to achieve the assumed potential savings?

Table 5.1 Hierarchy of AHP

<table>
<thead>
<tr>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where can potential savings be found and what are the best means to achieve them?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria (systems category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>land systems; maritime systems, air systems, C4ISR systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subcriteria 1 (organisation responsible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDF, Defence Industry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subcriteria 2 (maintenance cost factor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>internal maintenance, maintenance by production personnel, external maintenance services, materials, maintenance management and planning, maintenance administration, training costs, data systems and documentation, rental charges</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternatives (saving solutions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic maintenance cooperation, internal efficiency measures, outsourcing</td>
</tr>
</tbody>
</table>

The interview protocol started with a presentation of principles, including definitions of the terms used and basis for AHP methodology. In the data collection phase, the respondent was asked to rank the relative importance of a number of pairwise comparisons using Expert Choice software. After filling in the pairwise comparisons, the respondent named potential savings opportunities; 175 opportunities were suggested. Each interview was conducted individually between the interviewer and respondent. The interview length varied from one to four hours. The interviews were conducted from January to February 2016 at Finnish Logistics Command.

The reliability of AHP estimates is customarily expressed as a consistency ratio (CR), that is, the consistency of pairwise comparisons divided by the consistency of random comparisons, so that a lower CR indicates higher consistency and reliability. For the top management group evaluating the systems categories, the CR varied from 6.7% to 20.7%, while the systems managers’ evaluations varied from 14.3% to 39.2%. The most internally inconsistent responses were for the C4ISR systems. Saaty (2008b) suggests that the CR should not exceed 10%. Comparator (2016), on the other hand, stresses the importance of accuracy over consistency and maintains that in particular circumstances values as high as 20% or 30% are acceptable. High CRs can be explained by clerical errors, model structure, inappropriate use of 'extreme'
judgements, and lack of information (Comparion, 2016). When an evaluator has little or no information about the factors being compared, then judgements will appear more random and will result in a higher CR. Even though many of the evaluations had higher CRs than Saaty recommends, the results regarding the alternatives are still valuable. In addition, the results also highlight the lack of information among the decision makers. The highest CR was among the C4ISR systems evaluations.

6. RESULTS

6.1. Relative potential savings inside systems categories, maintenance cost factors, and strategic alternatives

The full AHP results are reproduced in the appendix. The results quantify the relative potential savings in each part of the maintenance costs. Likewise, the relative potential savings between different systems categories is presented as well as the most potentially strategic choices between Nordic maintenance cooperation, internal efficiency measures, and outsourcing. Each systems category was divided into potential savings in the FDF and defence industry.

Table 6.1 Potential savings of systems categories (numbers rounded).

<table>
<thead>
<tr>
<th>Systems category</th>
<th>FDF</th>
<th>Industry</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land systems</td>
<td>15.3%</td>
<td>15.1%</td>
<td>30.5%</td>
</tr>
<tr>
<td>Maritime systems</td>
<td>3.3%</td>
<td>2.7%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Air systems</td>
<td>9.6%</td>
<td>7.7%</td>
<td>17.3%</td>
</tr>
<tr>
<td>C4ISR systems</td>
<td>21.5%</td>
<td>24.7%</td>
<td>46.2%</td>
</tr>
</tbody>
</table>

The respondents rated the potential savings between the FDF (49.8%) and defence industry (50.2%) as almost equal (Table 6.1). The greatest potential savings (76.7%) were considered to be in the C4ISR (46.2%) and land systems (30.5%), while air systems (17.3%) and maritime systems (6.0%) were considered to have the least potential savings.

Table 6.2 shows the AHP results concerning the potential savings from the various maintenance cost factors. Materials (18.7%), external maintenance services (18.3%), internal maintenance (17.4%), and maintenance management and planning (13.3%) were ranked as the most promising, holding 67.7% of potential savings. The greater potential savings in internal maintenance done by the defence industry can be explained by the scale of outsourcing these operations from the FDF to the defence industry. The difference in the potential savings in materials reflects responsibilities left in the FDF, which are not outsourced to the defence industry on a large scale.

Table 6.2 Potential savings of maintenance cost factors

<table>
<thead>
<tr>
<th>Maintenance cost factor</th>
<th>FDF</th>
<th>Industry</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal maintenance</td>
<td>6.1%</td>
<td>11.3%</td>
<td>17.4%</td>
</tr>
</tbody>
</table>
The results of comparing the strategic alternatives in Table 6.3 are presented in two different ways: percentages of potential savings according to AHP (AHP results) and percentages reflecting how many times this solution was chosen as the most favourable way to achieve savings (most favourable). According to the AHP results, the respondents ranked the relative importance of achieving cost savings through internal efficiency measures (44.1%), outsourcing (34.4%), and Nordic maintenance cooperation (21.4%). According to the most favourable savings solution, internal efficiency measures were selected most often (62.5%), then outsourcing (30.6%), and Nordic maintenance cooperation (6.9%).

Table 6.3 Potential savings of strategic alternatives

<table>
<thead>
<tr>
<th>Strategic alternative</th>
<th>AHP results</th>
<th>Most favourable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal efficiency measures</td>
<td>44.1%</td>
<td>62.5%</td>
</tr>
<tr>
<td>Outsourcing</td>
<td>34.4%</td>
<td>30.6%</td>
</tr>
<tr>
<td>Nordic maintenance cooperation</td>
<td>21.4%</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

The results show that the majority of potential savings could be achieved by developing internal efficiency measures and outsourcing carefully selected maintenance cost factors. Nordic maintenance cooperation is ranked as the least likely strategy to produce potential savings.

6.2. Savings solutions from the interviews

In the open-ended interviews, 175 savings solutions were suggested. Of these, 106 were from FDF respondents and 69 from defence industry respondents. Each of the savings solutions was classified using the life-cycle phases of Table 2.1: R&D, investment, operations and support, and unspecified life cycle management. The results are shown in Table 6.4. It is notable that 110 of these solutions could not be directly attributed to the operations and support phase of a systems life cycle. Unspecified (94), R&D (1), and investment (15) included solutions that are not included in defence maintenance responsibilities.

Table 6.4 Classification of savings solutions

<table>
<thead>
<tr>
<th>Life cycle phase</th>
<th>FDF</th>
<th>Industry</th>
<th>Total</th>
</tr>
</thead>
</table>
More detailed results of the identified savings solutions are not presented in this article but will be used in developing activities for the FDF and defence industry.

7. CONCLUSION

There are few scientific publications about the field of defence maintenance and its potential savings. Public documents do not allow defence maintenance costs to be assessed (even approximately) because personnel expenses are excluded, and operating expenses such as fuel and ammunition are included in publicly available O&M expense figures. This paper arrived at an estimated FDF maintenance expense of EUR 527 million, but that remains only an informed guess.

The respondents felt that the C4IRS and land systems offered the greatest potential savings; air and maritime systems had less potential savings. This result is understandable because the Navy is smallest of the three service branches, and the Army is the largest. The AHP assessment of the C4IRS systems had the largest CR so while these systems were perceived to offer substantial potential savings they were difficult to estimate, which indicates a lack of knowledge. The cost factors of materials, internal maintenance, and outsourced maintenance were seen as the top sources for potential maintenance savings.

Alternatives to developing external maintenance services (saving potential 18.3%, see Appendix) varied. Nordic cooperation was seen as the best possibility for maritime systems. The potential savings from internal maintenance (17.4%) can be rationalised using the RCM method, which can eliminate 40-70% of cyclic maintenance work. Regarding cost savings in materials (18.7%) and rents (6.1%), in these areas outsourcing and Nordic cooperation were seen as more promising strategic alternatives than internal measures according to AHP results. With the TPM method, approximately 10-40% of routine maintenance tasks can be transferred to systems operators, which could explain views concerning savings in maintenance by production personnel (7.0%).

Of the strategic alternatives, the greatest savings can be achieved by developing internal efficiency and outsourcing carefully selected maintenance cost factors. Nordic maintenance cooperation is not currently perceived as a potential cost-savings solution. As potential cost savings are larger with commonality in equipment, Nordic cooperation's smaller potential savings reflects the fact that generally only land systems share the same military equipment (Lehtonen and Isojärvi, 2015) (Finland, for example, is the only Nordic user of F/A-18 fighter aircraft.) Försvaret (2015) has assessed the motivation behind 69 current NORDEFCO projects in Sweden and found that in 50 of them (72%) cost savings was not the motive. From a national security viewpoint, internal efficiency measures are the safest and, unlike cooperation, do not carry the risk of losing national maintenance capabilities. Outsourcing maintenance also has national security issues, as crisis time contingency planning necessitates a special kind of strategic partnership.

| Unspecified | 62 | 32 | 94 |
| R&D         | 1  | 0  | 1  |
| Investment  | 6  | 9  | 15 |
| O&S/Disposal| 37 | 28 | 65 |
During the interviews, the respondents made many suggestions for maintenance cost savings actions. The majority of the suggestions could not, however, be classified into the O&M stage of the capability life cycle; decisions affecting maintenance costs are not limited to this stage. Therefore, maintenance costs need to be viewed in the context of the entire life cycle.

The inherent confidentiality issues in research regarding defence forces limited access to data and the choice of methodology; only a relative assessment by AHP was possible. The external validity (e.g. to other than the FDF) suffers because not all aspects of the FDF environment may be made public. The relatively high consistency indices of some respondents’ AHP evaluations reduced the internal validity of the AHP findings, especially regarding cost factors.

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Pääesikunta (2015), Suorituskyvyn rakentaminen ja ylläpito (capability construction and sustainment), HK 666, PVOHJEK, Puolustusvoimat.
Saxi, H. L. (2011), Nordic Defence Cooperation After the Cold War, Norwegian Institute For Defence Studies (IFS), Oslo.
### Appendix 1: Full AHP results

<table>
<thead>
<tr>
<th>System category/Function</th>
<th>Land (30,5 %)</th>
<th>Maritime (6,0 %)</th>
<th>Air (17,3 %)</th>
<th>C4ISR (46,2 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FDF</td>
<td>IND</td>
<td>FDF</td>
<td>IND</td>
</tr>
<tr>
<td>1. int. maintenance</td>
<td>1.1 %</td>
<td>3.3 %</td>
<td>0.4 %</td>
<td>0.5 %</td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>27.0 %</td>
<td>12.5 %</td>
<td>30.9 %</td>
<td>26.9 %</td>
</tr>
<tr>
<td>internal measures</td>
<td>38.0 %</td>
<td>73.2 %</td>
<td>64.2 %</td>
<td>50.0 %</td>
</tr>
<tr>
<td>outsourcing</td>
<td>35.1 %</td>
<td>14.3 %</td>
<td>5.0 %</td>
<td>23.1 %</td>
</tr>
<tr>
<td>2. maintenance by</td>
<td>1.0 %</td>
<td>0.4 %</td>
<td>0.4 %</td>
<td>0.1 %</td>
</tr>
<tr>
<td>production personnel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>30.1 %</td>
<td>6.2 %</td>
<td>9.1 %</td>
<td>33.3 %</td>
</tr>
<tr>
<td>internal measures</td>
<td>39.6 %</td>
<td>80.8 %</td>
<td>81.8 %</td>
<td>53.8 %</td>
</tr>
<tr>
<td>outsourcing</td>
<td>30.3 %</td>
<td>13.0 %</td>
<td>9.1 %</td>
<td>13.0 %</td>
</tr>
<tr>
<td>3. external services</td>
<td>1.6 %</td>
<td>3.0 %</td>
<td>1.1 %</td>
<td>0.6 %</td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>30.2 %</td>
<td>39.6 %</td>
<td>62.5 %</td>
<td>39.1 %</td>
</tr>
<tr>
<td>internal measures</td>
<td>37.4 %</td>
<td>49.9 %</td>
<td>15.6 %</td>
<td>35.3 %</td>
</tr>
<tr>
<td>outsourcing</td>
<td>32.3 %</td>
<td>10.5 %</td>
<td>21.9 %</td>
<td>25.6 %</td>
</tr>
<tr>
<td>4. materials</td>
<td>3.9 %</td>
<td>1.3 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>31.1 %</td>
<td>22.9 %</td>
<td>18.4 %</td>
<td>54.8 %</td>
</tr>
<tr>
<td>internal measures</td>
<td>36.1 %</td>
<td>69.6 %</td>
<td>71.8 %</td>
<td>29.1 %</td>
</tr>
<tr>
<td>outsourcing</td>
<td>32.8 %</td>
<td>7.5 %</td>
<td>9.8 %</td>
<td>16.2 %</td>
</tr>
<tr>
<td>5. maintenance mgmt and</td>
<td>4.0 %</td>
<td>2.8 %</td>
<td>0.4 %</td>
<td>0.4 %</td>
</tr>
<tr>
<td>planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>9.1 %</td>
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</tr>
<tr>
<td>internal measures</td>
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<td>77.7 %</td>
<td>81.8 %</td>
<td>70.2 %</td>
</tr>
<tr>
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<td>31.0 %</td>
<td>7.0 %</td>
<td>9.1 %</td>
<td>11.0 %</td>
</tr>
<tr>
<td>6. maintenance administration</td>
<td>0.9 %</td>
<td>0.8 %</td>
<td>0.1 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>26.5 %</td>
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<td>21.8 %</td>
<td>18.9 %</td>
</tr>
<tr>
<td>internal measures</td>
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<td>80.8 %</td>
<td>67.7 %</td>
<td>60.1 %</td>
</tr>
<tr>
<td>outsourcing</td>
<td>35.7 %</td>
<td>6.2 %</td>
<td>10.5 %</td>
<td>21.0 %</td>
</tr>
<tr>
<td>7. training costs</td>
<td>0.4 %</td>
<td>0.6 %</td>
<td>0.1 %</td>
<td>0.1 %</td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>32.4 %</td>
<td>17.4 %</td>
<td>40.6 %</td>
<td>37.9 %</td>
</tr>
<tr>
<td>internal measures</td>
<td>35.6 %</td>
<td>63.4 %</td>
<td>49.1 %</td>
<td>21.9 %</td>
</tr>
<tr>
<td>outsourcing</td>
<td>32.0 %</td>
<td>19.2 %</td>
<td>10.3 %</td>
<td>40.2 %</td>
</tr>
<tr>
<td>8. data systems and</td>
<td>1.9 %</td>
<td>1.2 %</td>
<td>0.1 %</td>
<td>0.6 %</td>
</tr>
<tr>
<td>documentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>28.6 %</td>
<td>7.2 %</td>
<td>18.0 %</td>
<td>20.5 %</td>
</tr>
<tr>
<td>internal measures</td>
<td>33.1 %</td>
<td>81.4 %</td>
<td>65.4 %</td>
<td>38.8 %</td>
</tr>
<tr>
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<td>38.3 %</td>
<td>11.4 %</td>
<td>16.6 %</td>
<td>40.7 %</td>
</tr>
<tr>
<td>9. rental charges</td>
<td>0.4 %</td>
<td>1.5 %</td>
<td>0.5 %</td>
<td>0.1 %</td>
</tr>
<tr>
<td>Nordic cooperation</td>
<td>33.6 %</td>
<td>6.3 %</td>
<td>44.8 %</td>
<td>18.3 %</td>
</tr>
<tr>
<td>internal measures</td>
<td>32.2 %</td>
<td>67.2 %</td>
<td>42.7 %</td>
<td>31.7 %</td>
</tr>
<tr>
<td>outsourcing</td>
<td>34.2 %</td>
<td>26.5 %</td>
<td>12.5 %</td>
<td>50.0 %</td>
</tr>
<tr>
<td>Total</td>
<td>15.3 %</td>
<td>15.1 %</td>
<td>3.3 %</td>
<td>2.7 %</td>
</tr>
</tbody>
</table>

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SUPPLY CHAIN FLEXIBILITY DECISION MAKING: AN ORGANIZATIONAL PERSPECTIVE

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ABSTRACT

Purpose
In this paper we investigate flexibility decision making within a supply chain context. Empirical studies about supply chain flexibility are often based on a manager’s perspective on flexibility decision making in his/her own organization and its role in the supply chain, but research shows flexibility depends on all employees involved. Until now little is known about how the choices of managers and employees within an organization are made and contribute to flexibility in a supply chain context.

Design/methodology/approach
For our study we collected and analysed in-depth case study data from a multinational manufacturing organization. Using systems theory combined with strategic choice theory we examine the individual level factors that influence the decision making process regarding supply chain flexibility issues.

Findings
We found that flexibility is a key issue within all organizational processes that are geared towards fulfilling customer demand. The way in which management and employees handle flexibility is affected by their situation and their strategy or goal. However, there are more factors that influence the flexibility decision making process, such as available information and resources. Management and employees struggle to balance these factors in making the optimal supply chain flexibility decisions.

Originality/value
Previous flexibility research is undertaken from the perspective of the manager. Our study includes the choices of managers and employees to understand the flexibility decision making within an organization in its supply chain.

Keywords: Supply chain flexibility, dimensions, employees, organization, strategy, goals

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1. INTRODUCTION

In today’s business environment organizations face a complex, continuously changing environment characterised by trends and changes in the area of globalization, technological changes and innovations, changes in the customer’s needs and expectations and disruptions (Duclos et al., 2003; Marley et al., 2014). Where “manufacturing flexibility” is relatively well documented, the definition, role and measurement of flexibility in the supply chain is less reported. Where increasingly more research focusses on supply chain flexibility, still many supply chain flexibility studies only investigate the viewpoint of the manufacturing system, as a single entity in the supply chain in order to develop a flexibility model. Such models are typically tested using survey or simulation studies (Manders, 2014). The concept of flexible supply chains extends the principle of flexible production systems to the whole supply chain (Björk and Carlsson, 2007). Therefore, this concept covers all procurement, product development, manufacturing, logistics, marketing/sales and information/strategy processes, to achieve supply chain flexibility. Yet, supply chain flexibility is supposed to lead to supply chains being flexible as a whole (Duclos et al., 2003; Stevenson and Spring, 2009). However, being flexible as an entire supply chain begins from our point of view with the focus on flexibility, the flexibility goals and the way supply chain flexibility is handled within an organization as part of the supply chain. What most of the studies still overlook is that for flexibility it will not suffice to investigate only the viewpoint of the (manufacturing) manager. Although the manager probably determines the overall strategy regarding flexibility, the employees as well make decisions regarding the role of flexibility in the organization’s processes. As Upton (1995) argued, the degree of flexibility in the context of a firm depends more on the people/employees involved than on the technical resources. It is necessary to study the actions and reasoning of all managers and employees simultaneously to cover how an organization handles flexibility and especially if and how it contributes to supply chain flexibility. Exploratory research regarding the viewpoints of the entire organization instead of focus from the manufacturing point of view is needed to understand how organizations handle (supply chain) flexibility in a supply chain.

This research does not only present the experiences of managers, but also the experiences of the key employees involved in these processes, which range from - receiving the order, purchasing goods or raw materials from their suppliers, through manufacturing and delivering the goods to their customer - in order to achieve supply chain flexibility. With this organizational perspective we aim to explore which factors are associated with the development of supply chain flexibility, while investigating the importance of each flexibility dimension as well. Following systems theory, we include an integrated view of the organization in its supply chain and focus on the influence employees have on flexibility decision making by using the strategic choice theory. Specifically, this study attempts to answer the following research questions:

- RQ 1: How do the managers and employees within an organization experience flexibility and supply chain flexibility?
- RQ 2: Why do these managers and employees choose or prioritize a certain flexibility dimension?
- RQ 3: How do these managers and employees make their flexibility decisions?

This article is organised as follows. First, we introduce our definition of supply chain flexibility, systems and strategic choice theory and a description of the flexibility dimensions (section 2). The methodology is described in part 3, which is followed by the results in part 4. Relevant
issues and opportunities for further investigation are presented in part 5, followed by conclusions in the final part.

2. LITERATURE REVIEW

2.1. Supply chain flexibility

The evolution of flexibility concept can be traced back to the economics literature by Stigler in the 1930’s, as part of the economic decision making in the context of a firm’s ability to accommodate to greater variations in the demand output (De Toni and Tonchia, 2005). Information technology developments in the 1980’s boosted the number of studies on flexibility (Wadhwa and Rao, 2003) and introduced the organizational perspective making use of terms like labour flexibility. Studies in the late 1980s and 1990s mainly focused on flexibility from a manufacturing perspective and led to the development of conceptual frameworks, models and measures for manufacturing flexibility (Wadhwa and Rao, 2003; Stevenson and Spring, 2007). Gerwin (1993) first mentioned that most studies at that time are inward looking and need to look further, beyond the internal organization network. Point of view should not be confined to the places where the value creation takes place. In the past few years, the focus shifted to the flexibility of organizations within supply chains or the so called value chains (Duclos et al., 2003; Wadhwa and Rao, 2003; Stevenson and Spring, 2007). Supply chain thinking and value chain thinking, differ in their starting points. Supply chains focus on the chain of supply, which was expanded later to include all efforts involved in producing and delivering a final product or service in an efficient way. Hence supply chain thinking covers the goods flow from supplier to the customer. Value chains focus on the customers’ requirements and the value creating processes, thus the activities needed to fulfil the end customers’ demand. Value is an experience and starts with the customer. Only those activities that add value and contribute to the customers’ needs are taken into account. What supply chain thinking and value chain thinking have in common is the view of a chain, including the same organization’s which enable the flows of products and services in one direction and the flow of value (demand and cash) in the opposite direction. Furthermore, supply chains increasingly incorporate the end customer demand, including processes which are often covered with the term demand management. This holistic approach can also be seen in the development of value chains. Due to increasing competition and globalization, the value chain focus is shifted to core activities as well as including the development of strategies to remain competitive and efficient. Based on these developments the concepts of value chain and supply chain are interchangeable in our opinion. This interchangeability can also be seen in the supply- and value chain flexibility definitions:

- The customer focus is presented in the definition of supply chain flexibility by Gunasekaran et al. (2001) and Yi et al. (2011): supply chain flexibility is the flexibility to meet particular customer needs in the supply chain.
- Das and Abdel-Malek (2003) define supply chain flexibility from the focus on the existing supply chain structure and the existing durable relationships as the “elasticity” of the buyer-supplier relationship under changing supply chain circumstances.
- Swafford et al. (2006) mention that value chain flexibility can be derived from a combination of managing the operational processes and the intra organizational relationships regarding supply-procurement, manufacturing and logistical flexibilities within the network.

Our definition of supply chain flexibility covers this process- and customer perspective and closely follows Upton (1995) and Zhang et al. (2002): Supply chain flexibility is the ability of
all members within the supply chain “to change or react to environmental uncertainty and meet the increasing variety of customer expectations without excessive costs, time and organizational disruptions or performance losses”.

2.2. Systems theory, strategic choice theory, and supply chain flexibility

A system is an analytical framework composed of elements, components, which together form an integrated whole to achieve goal(s) (Bowersox et al., 2007). Systems are not visible and do not exist as some entity in the real world (Skyttner, 1996; Caddy and Helou, 2007). Systems are only perceptible if you observe situations with a certain overarching perspective, by using a helicopter perspective. This means that by using systems theory you step back from the actual situation and try to see the whole, by focussing on connections and relations rather than things or seeing patterns rather than taking a static picture (Senge, 1990; Lindskog, 2012). Hedge a system is a concept with a subjective nature that is formed in the mind of the observer structuring and linking his/her observations and thoughts (Skyttner, 1996; Caddy and Helou, 2007).

Supply chains are systems (Mentzer, 2001), composed of components, striving for a certain goal often focussing on the customer (Bowersox et al., 2007; Caddy and Helou, 2007), such as flexibility. The starting point of our research is the logistics flow, which covers the company’s processes and activities in a supply chain context. The processes include the goods-, information- and money flows with components such as organizations, people, information infrastructure, as well as intangible and tangible resources. The operation of each component is interdependent. The manner in which it interacts within the system (of the supply chain) has an effect on how the system operates as a whole (Ackhoff, 1981). Systems can be broken down into subsystems by defining boundaries (Caddy and Helou, 2007).

Furthermore, the systems theory point of view is not only focused on the internal perspective (Ackoff, 1981). Systems interact and are influenced by their environment (Ackoff, 1981; Mentzer, 2001). According to Skjøtt-Larsen (2000): “In the end, it is the employees and not the systems and processes that will ensure solutions for the logistics tasks and provide the company with the necessary competitiveness. Therefore, it is crucial not to underestimate the human and cultural aspects in the implementation of projects of change in the company” (Skjøtt-Larsen, 2000, pp. 386). As Knemeyer and Naylor (2011) argued “supply chain systems are networks of interacting human decision makers” (pp. 296).

Exploring and expressing how actions in the name of organizations are driven by individuals, by their motivations, and by their connections within their organization and with their external environment, is researching supply chain decision making from a strategic choice perspective (Child, 1997). Strategic choice theory suggests that the decisions that managers and employees make for their firms have significant implications for the firms’ outcomes -success or failure- and are a key performance determinant (Child, 1972; Ketchen and Hult, 2007). Firms can enact and actively change (aspects of) their environment to ensure alignment with their strategy to achieve predetermined goals as flexibility (Hsu et al., 2007; Ketchen and Hult 2007).

This research focusses on the organizational perspective as part of the supply chain system to incorporate a process- as well as a customer perspective. Systems theory is chosen to cover a “holistic” viewpoint, being able to see the “bigger picture” (Lindskog, 2012), by focussing on the internal and external components the organization and the employees within its supply chain have to deal with regarding flexibility. We combine this overall systems theory point of view with strategic choice theory to cover the decision making within this organization to achieve
the defined goals (Child, 1972; Bowersox et al., 2007) and include the human aspects by focussing on the managers and employees, as human decision makers, to determine how they contribute to flexibility of the organization and the supply chain as described by Skjøtt-Larsen (2000).

2.3. Flexibility dimensions

(Supply Chain) Flexibility is a complex, multidimensional concept. Many dimensions of flexibility have been identified in the supply chain flexibility literature. The importance of these dimensions differs depending on the specific environment, processes, in which they are used. The dimensions are not necessarily correlated. In other words, being flexible in one dimension does not automatically mean that the organization is also flexible in the other dimensions (Stevenson and Spring, 2007). Sethi and and Sethi (1990) reported 50 dimensions found in the manufacturing literature. We identified 95 flexibility dimensions in a systematic literature review of supply chain flexibility literature (Manders et al., 2014). It is however important to note that these dimensions are not standardized or widely accepted. There is an overlap between these flexibility dimensions. Different names are used for the same dimensions. For eliminating overlapping flexibility dimensions we used the following procedure. We categorized the 95 dimensions into seven business areas: product development, procurement, manufacturing, logistics, marketing, (financial) information and organization. For each business area we mapped the flexibility definitions on the processes and characteristics of the supply chain and value chain (Fantazy et al., 2009), covering the goods and service, information/demand and money flows. In this way we identified overlapping flexibility dimensions. Furthermore, we could discern the definitions, and hence the dimensions, that were broadly adopted in literature. This whole procedure was verified by two experts. Based on this compilation of seven mappings, the thirty most used and mentioned dimensions that cover the topic of flexibility within the supply chain were identified (see Table 2.1).

Table 2.1 Measured flexibility dimensions

<table>
<thead>
<tr>
<th>Business area</th>
<th>Flexibility dimension</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product development</td>
<td>Product development</td>
<td>The ability to respond to changing customer needs with new products and modifications to existing products</td>
<td>Zhang et al. 2002</td>
</tr>
<tr>
<td></td>
<td>flexibility</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>New product</td>
<td>The ability to design and introduce new products into the system</td>
<td>Stevenson &amp; Spring 2007</td>
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<tr>
<td></td>
<td>design flexibility</td>
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<td></td>
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<tr>
<td></td>
<td>Product modification</td>
<td>The ability to customize (standard) products to meet customer specifications</td>
<td>Lummus et al. 2003; Vickery 1999</td>
</tr>
<tr>
<td></td>
<td>flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement</td>
<td>Procurement</td>
<td>The ability to respond to changing requirements regarding the sourcing, purchasing and supply of goods</td>
<td>Manders¹</td>
</tr>
<tr>
<td></td>
<td>flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sourcing</td>
<td>The ability to find more suppliers for each specific material, component or service</td>
<td>Sanchez &amp; Perez Perez 2005</td>
</tr>
<tr>
<td></td>
<td>flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply</td>
<td>The ability to respond to changing requirements in terms of location and/or delivery date</td>
<td>Based on Tachizawa &amp; Thomson 2007</td>
</tr>
<tr>
<td></td>
<td>flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Category Definition</td>
<td>Source(s)</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Purchasing flexibility</td>
<td>The ability to respond to changing needs in the ordering, delivery and receipt of supplied goods</td>
<td>Manders¹</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>The ability to manage production resources to meet customer requests</td>
<td>Nair 2005</td>
<td></td>
</tr>
<tr>
<td>Volume flexibility</td>
<td>The ability to adjust (increase or decrease) capacity, batch sizes, output levels and/or quantities in response to customer demand</td>
<td>Based on Sanchez &amp; Perez Perez 2005; Lummus e.a. 2003; Beamon 1999</td>
<td></td>
</tr>
<tr>
<td>Mix flexibility</td>
<td>The ability to change the variety or combination of produced or delivered products and/or performed activities</td>
<td>Based on Beamon 1999; Zhang et al. 2003</td>
<td></td>
</tr>
<tr>
<td>Operations flexibility</td>
<td>The ability in which an activity can be done in different ways using alternative process plans, processes and available assets</td>
<td>Based on Sethi &amp; Sethi 1990; Vokurka &amp; O’Leary Kelly 2000</td>
<td></td>
</tr>
<tr>
<td>Process flexibility</td>
<td>The ability to produce a range of different (types of) products or fulfill different activities in a certain fixed situation</td>
<td>Based on Stevenson &amp; Spring 2007; Hopp et al. 2010; Sanchez-Perez Perez 2005</td>
<td></td>
</tr>
<tr>
<td>Expansion flexibility</td>
<td>The ability to easy add capacity to the system</td>
<td>Stevenson &amp; Spring 2007</td>
<td></td>
</tr>
<tr>
<td>Logistics</td>
<td>The ability to align, adapt and adjust the process of the goods flow including the inbound and outbound activities and the storage of the goods to the changing customers’ needs</td>
<td>Swafford et al. 2000; Soon &amp; Udin 2010, Nair 2005</td>
<td></td>
</tr>
<tr>
<td>Inbound logistics</td>
<td>The ability to transport and produce products by different paths throughout the processing centers of the system</td>
<td>Based on Stevenson &amp; Spring 2007</td>
<td></td>
</tr>
<tr>
<td>Routing flexibility</td>
<td>The ability to have a number of alternative paths a part or product can take through the system in order to be completed</td>
<td>Vokurka &amp; O’Leary-Kelly 2000; Stevenson and Spring 2007</td>
<td></td>
</tr>
<tr>
<td>Material handling</td>
<td>The ability to move the different products between processing centers throughout the system using multiple paths</td>
<td>Koste &amp; Malhotra 1999; Stevenson &amp; Spring 2007</td>
<td></td>
</tr>
<tr>
<td>Physical distribution</td>
<td>The ability to adjust inventory and transport to provide a widespread access to products and meet customers’ needs</td>
<td>Based on Zhang et al. 2005; Lummus et al. 2003; Singh et al. 2011</td>
<td></td>
</tr>
<tr>
<td>Delivery flexibility</td>
<td>The ability to respond to changes in the delivery requests regarding location and/or delivery date</td>
<td>Based on Stevensson &amp; Spring 2007; Skintzi 2007</td>
<td></td>
</tr>
<tr>
<td>Storage flexibility</td>
<td>The ability to adjust the storage capacity and/or move the stock between locations to transfer the goods/products in time</td>
<td>Based on Schütz &amp; Thomasgard 2012; Sanchez &amp; Perez Perez 2005</td>
<td></td>
</tr>
<tr>
<td>Marketing flexibility</td>
<td>The ability to adapt to changes in the market environment and/or in customer needs by customization and</td>
<td>Based on Stevenson &amp; Spring 2007; Lummus</td>
<td></td>
</tr>
</tbody>
</table>
There was no clear subdivision between the flexibility dimensions found on procurement, sourcing, supply and purchasing. The definitions mentioned for procurement and purchasing flexibility are created looking to definition of the flexibility dimensions found and based on procurement and purchasing literature.

<table>
<thead>
<tr>
<th>Flexibility Type</th>
<th>Definition</th>
<th>Source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch flexibility</td>
<td>The ability to rapidly introduce new products and/or product varieties to the market</td>
<td>Vickery 1999; Sanchez &amp; Perez Perez 2005</td>
</tr>
<tr>
<td>Responsive flexibility</td>
<td>The ability to respond to target market needs</td>
<td>Lummus et al. 2003</td>
</tr>
<tr>
<td>Organization flexibility</td>
<td>The ability to respond to changing circumstances by managing the organizations relationships, structures and controlling its capacity</td>
<td>Based on Yi et al. 2011</td>
</tr>
<tr>
<td>Network flexibility</td>
<td>The ability to align the organization management and labor force to meet customer demand/service requirements</td>
<td>Lummus et al. 2005</td>
</tr>
<tr>
<td>Labor flexibility</td>
<td>The ability to change the number of workers</td>
<td>Based on Gong 2008</td>
</tr>
<tr>
<td>Worker flexibility</td>
<td>The ability of a worker to perform a number of different tasks with different responsibilities</td>
<td>Based on Stevenson &amp; Spring 2007</td>
</tr>
<tr>
<td>Inter-organizational relationship flexibility</td>
<td>The ability to build and maintain collaborative relationships up and/or downstream to adapt to changing circumstances</td>
<td>Based on Stevenson &amp; Spring 2007</td>
</tr>
<tr>
<td>(Financial) Information systems flexibility</td>
<td>The ability to align the information system architectures and systems with the changing information needs of the organization as it responds to changing customer demand</td>
<td>Lummus et al. 2005</td>
</tr>
<tr>
<td>Spanning flexibility</td>
<td>The ability of the organizations to collect, store and disseminate information in horizontal information connections across the supply chain to increase value to customers</td>
<td>Zhang et al. 2002; Nair 2005</td>
</tr>
</tbody>
</table>

1 There was no clear subdivision between the flexibility dimensions found on procurement, sourcing, supply and purchasing. The definitions mentioned for procurement and purchasing flexibility are created looking to definition of the flexibility dimensions found and based on procurement and purchasing literature.

3. METHODOLOGY

Case study research within logistics and supply chain management has been discussed by Aastrup and Halderson (2008) and Dinwoodie and Xu (2008) and grouped into six categories. Given the scarce empirical evidence on this topic, our single case study is allocated to the exploratory, theory extension and theory refinement category (Eisenhardt, 1989; Dinwoodie and Xu, 2008; Yin, 2009) to pave the way to more detailed insights in this field (Dubois and Gadde, 2014). The overall aim of this study is to learn how employees make flexibility decisions and contribute to flexibility within their company and the supply chain.
3.1. Sampling
We started with a list of Dutch manufacturing companies with one hundred or more employees. We used theoretical sampling and selected and contacted several organizations checking the information exchange between the focal organization and the supply chain and the importance of mutual benefits, while we assume that there has to be some form of integration to support supply chain flexibility decision making. We proceeded with the company that could fulfill our requirements with respect to providing access to supply chain members and the information and planning requirements.

3.2. Data collection and analysis
We used interviews, observations and collected contextual information from the organization and the processes involved, including documents and presentations (Dubois and Gadde 2014). The interviewees were chosen using purposive sampling. In interaction with the company we decided which people should be interviewed to get a complete and detailed overview of flexibility decisions within the processes and the contacts with the suppliers, logistic service provider and retailer. We took a multi actor perspective and used a key informant method to select our interviewees, recommended by McCracken (1988). The participants in the seven interviews were the (factory outbound) logistics manager (participant 1), the market logistics director, the supply inbound manager, the OPTS (purchaser operations), the supervisor production planning and the production planner, the scheduler (manufacturing) and the outbound planner (participant 7). Face to face interviews of approximately 90 minutes were carried out. The interviews were voice recorded. The audio-taped interviews were transcribed by the researcher, also using written notes and pictures made of the cards with the flexibility dimensions selected and discussed, during the interviews. Coding was used to structure and analyse the collected data (Miles and Huberman, 1994). We based the codes on our research questions and the semi structured interview protocol (available upon request). In addition to the case characteristics, this includes for every employee:

1. The definitions used and the experiences regarding flexibility
2. The definitions used and the experiences regarding supply chain flexibility
3. The reasons why they choose for or prioritize certain flexibility dimensions

Appendix 1 presents the coding scheme. The transcripts and coding files, as well as the original recordings, were stored in the case study database together with all information gathered. We used observation data to understand and map the processes the employees executed, the relationships within their context and the choices made within these processes that determine the use of certain flexibility dimensions. Furthermore, also other data sources are used, such as presentations and forms provided by the participants and secondary data on the company website and in company publications. After the coding, we applied pattern matching, ordening and mapping techniques to analyze our data (Miles and Huberman, 1994). In this way we compared the information from the participants (1) processes, activities and relationships (2) their (supply chain) flexibility experiences within this supply chain and (3) their prioritized supply chain flexibility dimensions.
Table 3.1 Validity and reliability in case studies (based on Eisenhardt 1989, Yin, 2003, Gibbert et al. 2008)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Methods used in the cases regarding this criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal validity</td>
<td>Theory triangulation:</td>
</tr>
<tr>
<td></td>
<td>• SLR results used to set up the research framework</td>
</tr>
<tr>
<td></td>
<td>• Different theoretical lenses are used to cover the processes and organizational perspective on flexibility in this research including the flexibility dimensions chosen and the interpretation of the findings made.</td>
</tr>
<tr>
<td>Construct validity</td>
<td>Data triangulation:</td>
</tr>
<tr>
<td></td>
<td>• Interviews</td>
</tr>
<tr>
<td></td>
<td>• Company documents</td>
</tr>
<tr>
<td></td>
<td>• Observation</td>
</tr>
<tr>
<td></td>
<td>• Public available sources like websites, company publications</td>
</tr>
<tr>
<td></td>
<td>Clear chain of evidence:</td>
</tr>
<tr>
<td></td>
<td>• Description of the data collection circumstances</td>
</tr>
<tr>
<td></td>
<td>• Check for circumstances of data collection vs. actual procedure</td>
</tr>
<tr>
<td></td>
<td>• Reflection of how actual course of research affected data collection process</td>
</tr>
<tr>
<td></td>
<td>• Explanation of data analysis</td>
</tr>
<tr>
<td>External validity</td>
<td>A detailed description of the process and activities done by the different participants</td>
</tr>
<tr>
<td></td>
<td>Nested approach to compare the experiences of the participants within the processes from receiving the order, purchasing goods or raw materials from their suppliers, manufacturing, to delivery of the goods to their customer in their strive for supply chain flexibility</td>
</tr>
<tr>
<td></td>
<td>Theoretical sampling for case study selection to meet the selection criteria</td>
</tr>
<tr>
<td></td>
<td>Explanation of the cast study context</td>
</tr>
<tr>
<td>Reliability</td>
<td>Development of an interview protocol</td>
</tr>
<tr>
<td></td>
<td>“Talk the walk” approach, describing the case study research</td>
</tr>
<tr>
<td></td>
<td>Store all research data in a case study database</td>
</tr>
</tbody>
</table>

We processed information in an iterative way, as we discussed our initial observations and findings with the employees involved and shared the final findings in the form of fact-sheets. Case studies are considered to be an adequate research strategy for in-depth and exploratory research. To assess rigor, our chain of evidence covering internal validity, construct validity, external validity and reliability is presented in Table 3.1 (Eisenhardt, 1989; Gibbert et al., 2008; Yin, 2009).

### 3.3. Research framework

The aim of this study is to investigate the flexibility decision making of managers and employees within an organization in its supply chain context. In the interviews we gathered information about the organizations, the processes and activities, and the position of the
interviewee, the interviewees’ perspective on flexibility and supply chain flexibility, their experiences with flexibility and supply chain flexibility, the flexibility dimensions important for them (and their organization) and the reasons why they choose to focus a certain dimensions. By analyzing this information using systems and strategic choice theory we created an overview of the organization processes within the supply chain and an overview of the flexibility decision making process. Our research framework is presented in Figure 3.1.

![Research framework](image)

**Figure 3.1 Research framework**

### 4. FINDINGS

#### 4.1. Supply chain overview

The organization in this research is a worldwide multinational company in the fast moving consumer goods (FMCG) industry which has a factory (operations) and market organization in the Netherlands. It operates on a 24/7 basis. Using systems theory, the supply chain structure and the processes of this company including the goods and information flow (dotted lines) are presented in Figure 4.1. The grey images within this figure cover the important external relationships that influence the company’s processes and decision making. First, the logistics activities such as warehousing, inventory and transport in the Netherlands are outsourced to a logistics service provider (LSP) nearby. Then, the (inter)national transport activities are executed by different transport- or logistics companies. Finally, we model the relationships with its suppliers where the goods used in the company’s processes are purchased and the customers such as retailers and foreign market organizations ordering products. All processes, relationships and information flows coordinated by this organization are presented in Figure 4.1 covering the supply chain.
Overall, flexibility is a key issue within this focal company. Especially in the last decade, due to developments such as the decrease of inventory levels within their supply chain and the existence of comprehensive product ranges to fulfil customer demand. All departments and employees within these departments are aware of the importance of flexibility. The participants used nearly the same definition to describe what flexibility means for them: “flexibility is a way to adapt or respond to the needs of the customer”.

The answers regarding supply chain flexibility lack this consistency. Some of the participants (3 out of 7) argue that there is supply chain flexibility, others deny or do not experience the existence of this kind of overall flexibility. The participants who recognize the presence of supply chain flexibility often put forth the kind of relationship between the customer, market organization, operations or supplier they have experienced themselves. The supply chain flexibility discussion in these interviews indicates that the employees within this organization are mostly focused on the previous or next step in the chain. For the Logistics Manager the focus is more internal on the relationship between the market organization – operations, while for the Market Logistics Director the focus lies more on the link between the external customer (retailer) – market organization. The inbound manager brings forward the operations – supplier linkage. The focus is dyadic.

The expectations regarding the possibilities of supply chain flexibility in the near future is often a positive one. In the opinion of the participants supply chain flexibility can lead to a more stable chain through developments such as sharing information in a timely manner, developing a kind of “mirror” system where you can compare forecast/expectations and the real situation and communicating these performances, but also daily operation issues to gain a mutual understanding within the company and the supply chain to learn from these experiences.

Discussing flexibility in this context also presents a more critical view of flexibility. This critical viewpoint is focused on the discussion whether we, as employees, do not go too far with flexibility. More flexibility is not always better and do we really need to be that flexible? Although these opposite views presented in our interviews, both answers show the quest for a more stable situation. As a manager addressed: “Flexibility is a continuous deviation from processes, leading probably to a kind of complexity”. “To be flexible in that case is an advantage, maybe the strength of the organization, but also a weakness”. “A weakness visible in those moments when fewer daily hiccups or disruptions occur and employees see how hectic it normally is; how many people are involved delivering flexibility or controlling processes, because of the continuous changes” as a planner explained.
4.3. **Flexibility decision making**

Using strategic choice theory (Child, 1972) to analyse our current findings we discovered the factors that influence the flexibility decision making of the managers and employees within an organization in its supply chain. The decision making process is affected by (1) the current situation of the manager or employee. Followed by the (2) strategy and goals chosen. We discovered three more factors that are of influence: organization management-, information and resource factors (3). The actual performance and experiences of the organization within its supply chain are then the input for the next round of decision making (4) when it will start all over again. Based on the analysis we developed an overview called the flexibility decision making framework as presented in Figure 4.2.

**Figure 4.2 Flexibility decision making framework**

**Situation**

The current situation covers the focal organization, its environment and the relationships in between. We used systems theory to focus on the organization’s processes purchasing, planning, scheduling, manufacturing and sales and the connections within its supply chain environment which incorporates suppliers, logistics service provider, transport companies and retailers.

The company starts with forecasts and orders generated by the market organization. There is a long-term “rolling” forecast from 24 till 3 months and a sales and operations planning (SNOP) for the last 3 months. The operations receive the SNOP in their ERP system using a system interface with the system the market organizations uses. The material requirements planning and outbound planning activities are directly executed within this ERP system. The production planning and scheduling uses a different “homemade” mainframe in which they make a twelve-week production plan and a detailed week plan. This detailed week plan can still be adjusted and fine-tuned on a daily basis. Changes are based on the real daily sales orders and stock levels. 80% is produced on forecast, the other 20% is produced to order. With the input from the production planning regarding the number of products that need to be produced and the available information about the labour shifts, the scheduler plans the different production lines. Important is not only the tonnage of the total production lines planned, but also the distribution over the different packaging options.

Based on the schedulers’ plan, the inbound part of the organization arranges the availability of raw- and packaging materials. Regarding packaging material, a 5-7 weeks consignment stock is stored at the logistics service provider’s nearby. Packaging material must always be available for at least a two week period. The packaging material suppliers are located all over Europe and manage the consignment stocks. A multiple sourcing policy is used regarding the raw materials.
A large number of the raw material suppliers are located in the Benelux and some are located in other Western European countries. The raw material suppliers deliver directly to the plant on an hourly till daily basis. Some raw materials are purchased globally and stored at the logistics service provider as well.

The outbound department organizes the storage and transport that is outsourced to the logistics service provider and multiple transport companies. Input for their activities is the shared production planning and scheduling data. Based on these data the ERP system generates recommended shipments. These are checked by the outbound logistics team and if correct, orders are sent to the logistics service provider and the selected transport companies or carriers. Using tendering, the transportation volumes per country are linked to one or several transport companies or carriers. As well as the production planning the outbound planning has to deal with daily changes based on the actual sales orders, but also on the available time slots at the dock, customs activities, etc. Finally, the outbound logistics department analyses the end product stock levels stored at the logistics service provider. They focus especially on the items that did not move within a four week period, because of the best before dates.

The developments within the current situation that influence flexibility decision making are:

First, we see that suppliers are no longer settled nearby the factory location. The reason is that suppliers moved their locations to different countries. Furthermore our focal company changed its procurement policy from focussing on local orientated purchasing to purchasing activities in countries all around Europe and even worldwide.

Second, the customer, and the retailer, have become more powerful. The customer can buy its products around the world through developments in the area of globalisation and internet technology. Hence, the customer can choose from a large assortment of products to meet his demand. Therefore, the retailer wants to deliver a product for a lower price or add certain features to convince the customer to buy his product instead of somebody else’s. In the last decade, due to bankruptcy of competitors and take overs, the size and market position of the retailers in the Dutch market has increased. Retailers now have more power as a manager from our focal company gives an example: “A retailer demands a smaller sized product to make his product a bit cheaper in comparison to its competitors. This product only differs some grams compared with the normal standard product”. Another example is that “a retailer asks for different packaging or different packaging sizes to stack and present the products directly at the shelves in their stores”. The assortment of the focal manufacturing company grows substantially by these requests and the customer has even more to choose from. This means for the focal company that, besides the uncertainty whether the customer chooses for his product, another uncertainty arises, namely that of which of the products from the focal company’s assortment the customer will buy at a certain moment.

Third, due to the economic and market developments the companies decreased their stock levels. For economic reasons our focal company downsized their stock positions, but also the market developments on the retailers’ side have its influence. The retailers prefer to have the products stored directly on the shelves in their shops. There is no room for further inventory holding within the shops any more. The amount of products stored in the retailers warehouses and distribution centres are diminished as well. The reason is that although the retailers market increased in the last decade, the amount and size of the warehouses and distribution centres was not. The warehouse and distribution centres got a different function by focussing on cross docking activities.
Strategy and goals

The focal organizations strategy is to sell products to meet the customers demand. Meeting the customers’ demand means delivering the right product and quantity – despite daily hiccups – at a certain requested location on time. It simply “has to be there” as the Market Logistics Director, Inbound Manager and Purchaser said. An important KPI in that sense is the percentage of orders that can be delivered directly from stock. Saying no at a request, appears not to be an option as mentioned within nearly every interview. Due to the developments within the organization and environment, these strategies incorporate the necessity to be flexible.

Flexibility is a key issue within this organization, but not one that is subject of regular discussion or review. Employees are told to be as flexible as necessary to fulfil the customer demand. Hence it is difficult for an employee to get a complete overview regarding the effect of his/her decision taken and to determine what is necessary in a certain situation. A planner explained “Every day we receive demand changes from our customers. We then have to decide if we can make it and meet the changed demand or not. Most of the times we can arrange it. Although it often costs quite a lot of time and effort. Sometimes, we come to the conclusion that considering the planned or on-going production/distribution activities it is not feasible to accept the changes. This often means we have to interfere with on-going activities within and even beyond our scope or it negatively influences other customers’ demands. This decision is not always acceptable for the customer. The customer will then use his other contacts within the firm to change the decision in its favour. Based on for instance the long term customer relation and the chosen strategy, overruling then takes place”. Especially this overruling, often by the management, will influence the further decision making of the employee. As an employee explained: “if overruled a couple of times, the next time you will agree and be flexible right away”. So within the firm a less critical attitude regarding flexibility is developed.

Analysing the chosen flexibility dimensions by ranking the participants in the order of the logistic flow (purchasing, inbound, production planning and scheduling, logistics, outbound planning and market), show that only volume and spanning flexibility are chosen by all participants (Table 4.1).

Nearly all participants selected besides spanning flexibility, information system flexibility as well. These flexibility dimensions are necessary to provide the information flow, which triggers the goods flow to the customer. Looking further into the processes, we see that the purchaser and inbound manager chose flexibilities which could be expected regarding the process they have to fulfil. They have to take care of the availability of the raw materials, semi-finished goods, packaging materials as well as the organizational or inter-organizational flexibilities regarding their internal and external relationships. They select: procurement-, sourcing-, supply-, and purchasing flexibility, as well as the inbound logistics-, volume-, storage-, and delivery flexibility regarding their logistics tasks. The production planner and schedulers are of course focused on manufacturing, volume, mix, operations and worker flexibility, sometimes combined with labour flexibility. The outbound planner focuses on the physical distribution part. This means having contact with the logistics service provider and the transport companies to arrange the transport of products, from production to the customer. The selected dimensions can be divided in those important regarding the products which have to be handled in transport, the activities that have to be planned and the resources and capacity needs that have to be managed. The dimensions selected regarding the product handling are product development, new products, product modification and volume flexibility. Regarding the activities which have to be planned, they choose for logistics-, physical distribution-, storage-, and delivery flexibility. For the resources and capacity needed they focus on procurement-, supply-, labour-, worker-, and expansion flexibility. The logistics manager has a broad perspective regarding
the organization, the inter-organizational relationships, the market and the processes within his managerial scope. His flexibility perspective includes procurement, sourcing, supply and purchasing flexibility followed by production including volume, mix, operation flexibility, and naturally, the flexibility regarding the logistics activities concerning physical distribution, as well as storage and delivery flexibility. The market logistics director is focused on the products the customers requires. This incorporates the products that have to be produced with the focus on manufacturing, volume and mix flexibility, but also the flexibilities necessary to be responsive including the launch of product developments and/or product modifications.

Table 4.1 Summary of the case study results on flexibility dimensions in process order

<table>
<thead>
<tr>
<th>Flexibility dimensions</th>
<th>Participant 4</th>
<th>Participant 3</th>
<th>Participant 5</th>
<th>Participant 6</th>
<th>Participant 7</th>
<th>Participant 1</th>
<th>Participant 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product development flexibility</td>
<td>X</td>
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<tr>
<td>New product design flexibility</td>
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<td>X</td>
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<tr>
<td>Procurement flexibility</td>
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<td>X</td>
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<tr>
<td>Sourcing flexibility</td>
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<td>X</td>
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<tr>
<td>Supply flexibility</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>Purchasing flexibility</td>
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<tr>
<td>Manufacturing flexibility</td>
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<tr>
<td>Volume flexibility</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Mix flexibility</td>
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<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Operations flexibility</td>
<td>X</td>
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<td>Process flexibility</td>
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<td>Expansion flexibility</td>
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<td>Logistics flexibility</td>
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<td>Inbound logistics flexibility</td>
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<td>Material handling flexibility</td>
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<tr>
<td>Routing flexibility</td>
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<tr>
<td>Physical distribution flexibility</td>
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<td>Storage flexibility</td>
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<td>Delivery flexibility</td>
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<td>Marketing flexibility</td>
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<td>Launch flexibility</td>
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<td>Responsive flexibility</td>
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<td>Network flexibility</td>
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<tr>
<td>Organizational flexibility</td>
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<tr>
<td>Labor flexibility</td>
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<td>X</td>
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<tr>
<td>Worker flexibility</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td>Interorganizational relationship flexibility</td>
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<td>X</td>
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<td>Information systems flexibility</td>
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<tr>
<td>Spanning flexibility</td>
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</table>

The influence of organization management-, information- and resource factors

Overall, we see a different focus on flexibility and coherent with that a selection of different flexibility dimensions. The current situation together with the chosen strategy and goals only partial declares the flexibility decision made. Matching the data provided by the company and the information we gathered through the interviews and the observations -of the processes and choices made from a systems perspective- we found some other important factors influencing supply chain flexibility decision making. These factors include the organization management, the information and the resource context:

I. Organization management factors
   - Lack of management information history
First of all, it is difficult to learn from the past, while it is often not possible to get an overview of the plans and expectations in advance combined with how the real situation turns out later. Many changes are made, but not all information is stored. “The changed information almost always overwrites the earlier plans and expectations” as an employee explained. The lack of historical data makes it hard to learn from former choices and improve the flexibility decision making process.

- **Management Key Performance Indicators are not in line with overall company goals**
  Second, opposing Key Performance Indicators (KPI’s) influence the choices made by the employees within the different departments. These Key Performance Indicators conflict with performance indicators of other departments and these all together are not maximal contributing to the overall company goals, not to mention the supply chain goals.

II. Information factors
- **A lack of accurate and timely information**
  In addition to the former point regarding systems data being overwritten, the technological information infrastructure influences the flexibility decision making in even more areas. Within this organization different information systems are used, some of them have interfaces, but not all the available information can be shared in a timely manner. This means that sometimes the information is available, somewhere within the organization, but the employees cannot access the necessary information. Reasons for this can be found in the moment data systems or interfaces communicate with each other or do a run with new data. If information is not available, employees tend to work with the historical data there is. This is often data they stored or collected themselves, “for instance in Excel files” as an employee explained.

- **Information overload**
  Nevertheless, sometimes the information is available, but cannot be found in the information system or it is just too much information to handle. Furthermore people still make their own interpretation of the shared data. Flexibility decisions are made based on this incomplete and sometimes coloured information shared.

III. Resource factors
- **The arrangements employees can make regarding resources is limited**
  Flexibility decisions are influenced by the available resources. Being flexible, in this case, striving for that perfect flow, costs money. Looking at the employees involved in flexibility decision making within this company, they make the decisions necessary to their processes, to adapt to the changing circumstance. They arrange extra resources themselves, but only within their decision range. This incorporates for instance decisions regarding the transfer of products within the storage capacity, a different utilization of the available production capacity by changing the composition of customer orders, or the usage of some extra transportation. Hence, flexibility decision making will also be influenced by decisions regarding the amount of resources that is out of the employee’s scope. These decisions often have to deal with financial resources and investments. A manager gives an example “Ideas as upgrading the storage or production capacity involves bigger and often long term investments”. These decisions are subject of a thorough decision making process within the higher levels of the organization. The available resources and the space the employees have within their job to arrange the deployment of these resources, influences the flexibility options they have, i.e. their level of flexibility.
Knowledge sharing can be improved
Beyond these tangible resources like equipment and financial resources, knowledge is also an important intangible resource in flexibility decision making. Meetings are planned at different organization levels, often focussed on their own processes as part of the organization and supply chain. Knowledge is also shared within the different departments the employees belong to. However, it is not always visible or shared with the rest of the organization. A better understanding of each other’s processes, decisions and the circumstances that influences these separate flexibility choices can increase the level of knowledge and understanding within the logistics flow. Discussion and reflection on flexibility decisions taken, creates besides new experiences, some new learning points. This new knowledge can then be used as input for the next decision making process to make the flexibility decisions even more in line with the overall company and supply chain goals.

Performance
Our results show that the focus of flexibility decisions lies on fulfilling the demands and requirements of each customer. It is hard to tell whether this way of making flexibility decisions is beneficial to all the supply chain goals, however it contributes to organization and logistic customer service strategy of this supply chain. In order to achieve these goals, we conclude that although there may be an organizational view on flexibility, the actual flexibility decisions are made by employees in their day to day activities. There is no procedure to compare performance and experiences with former flexibility decisions taken.

5. DISCUSSION
We studied the employees of an organization, involved in the supply chain processes, making flexibility decisions. As the results indicate, the focus of the flexibility decision makers is in line with their function in the organization and the relationships they are confronted with. These are relationships within the company, such as relationships between operations and market, between planning and production, between purchasing and inbound, but also relationships with external organizations like suppliers, logistic service providers and retailers. Most of the employees simply cannot oversee all the processes (see Figure 4.1) and the influence their decision has on the flexibility of their company in the supply chain. They make flexibility decisions based on their position and processes, if possible in line with the strategy of the company and the supply chain environment. Although, it still remains a struggle levelling all different factors influencing their flexibility decisions as summarized in the schematic overview in Figure 5.1.
First, our results indicate that the flexibility focus of the employee is determined by the place or function the employees fulfill in the process and the relationships they have within their department or the relationships they have to deal with regarding external contacts. The interviews highlighted the differences in focal points in line with the situation the employees are working in (see Figure 4.1). The inbound manager for instance had a broad perspective, including procurement-, production- and logistics flexibilities, while the logistics market director attached more importance to the products the customers requires by focusing on manufacturing and responsive flexibilities. Similarly, the production planner/scheduler, outbound planner, purchaser and inbound manager selected flexibility dimensions that suits their own focal point.

Proposition 1: The place or function the employee fulfils in the processes and the internal and/or external relationships which have to be dealt with, determines the supply chain flexibility dimensions selected.

Second, the organizational strategy is an important determinant of the level of flexibility needed and the amount of flexibility decisions which have to be made. The strategy to sell and deliver the products as demanded by the market leads to an increase in the product assortment. This broadening of the assortment in combination with largely fixed resources and developments as downsizing the inventory levels within the supply chain increases the importance of flexibility. Therefore, flexibility is a key issue within an organization. It is defined by all participants in a similar way: flexibility is a way to adapt or respond to the needs of the customer. Everyone is instructed to be as flexible as possible. This research even shows that there is a lack of critical attitude towards flexibility.

Proposition 2: The importance of supply chain flexibility will be determined by the strategy and the situation of the employee regarding its organization and the supply chain environment.

Third, it is difficult to access accurate information for making proper flexibility decisions. Sometimes the information simply is not available on time, or information stagnates in the information systems or interfaces used. Furthermore, information is often shared within the department or within a certain meeting, but only to a less extent within the rest of the organization. Situations exist where the information is present within the systems, but not available for a certain employee. In addition to the lack of information, sometimes there is too
much information to find the needed data. Finally, every employee tends to make his/her own interpretation of the shared information. In sum, it is hard to find the information necessary to complete understand the context of the flexibility decisions making environment: Why are certain demand changes requested? What will the influences be of the changes within the organization and in its supply chain environment?

**Proposition 3:** It is important to share more (background) information, timely and to all employees involved, so that everyone can trust and directly use this information in their flexibility decision making without undertaking lots of activities and making their own interpretations.

Fourth, the usage of different key performance indicators (KPI) for the departments and the employees involved in different processes intensifies the partial and specific focus on supply chain flexibility. Still, it has to be studied how mutually supportive KPI’s can be developed that incorporate a more holistic supply chain flexibility focus. It simply seems to be too difficult for employees to cover a view of all processes at once, as the supply chain perspective assumes. Only a few people at the (higher) management level may have this holistic view, but they also have to deal with a lot of different issues, besides flexibility. Furthermore, nearly no historical data is available to evaluate or review the flexibility decisions made within the different processes. Key performance indicators in line with the overall company or supply chain goals and historic management information is necessary for development of the employees within the flexibility decision making process. They need an opportunity to review their decisions and performances to improve future flexibility decision making in line with overall company and supply chain goals.

**Proposition 4:** The availability of historical management information and key performance indicators in line with overall company or supply chain goals improves (the understanding of) the flexibility decisions taken.

Finally, the extent and size of the available resources determines the playing field of the employees within the flexibility decision process. The flexibility level the employees can deliver is therefore limited to a certain scope or range. This in combination with their situation (processes, supply chain environment, relationships), the strategy chosen, the information available and understood and the KPI’s on which they will be evaluated makes every flexibility decision a difficult and tricky one.

**Proposition 5:** Management and especially employees struggle to balance all factors in making the optimal supply chain flexibility decisions.

### 6. CONCLUSION

Our study has demonstrated that striving for flexibility within an organization as part of the supply chain turns out to be different for every employee involved. Although their flexibility focus is clear, it is often too difficult for them to oversee all processes within their organization and the entire supply chain. Every employee faces a unique situation. Decisions made by employees regarding supply chain flexibility are organization and situation specific, and linked with their function, processes, activities and relationships in the supply chain. However, also the strategy and some other organization management-, information- and resource factors play a role. Hence, supply chain flexibility will always include different flexibility dimensions, as no situation is the same.
Our study has a number of limitations. We chose a single case study and focus on the processes in one organization within a supply chain to get in-depth insights as to how the managers and the employees handle flexibility issues. Further studies could focus in depth on one of the other supply chain partners such as suppliers, LSPs, and retailers. Furthermore, future studies may want to include the view of several supply chain organizations at once, to shed light on how the supply chain influences flexibility decision making.

The focus of our focal manufacturing organization lies in the fast moving consumer goods, food industry in the Netherlands using a make to order, make to stock context. Comparative studies can be conducted in other countries, other industries or other contexts or sectors where different activities and processes may take place and where strategies and goals may differ from the logistic customer service goal in this case.

The factors mentioned, situation, strategy, organization management, information and resource, influences flexibility decision making. Many company decisions in different areas either directly or indirectly affect the strive for flexibility and the contribution made to supply chain flexibility. Before looking directly into these factors it is important to overview “the bigger picture” and find out if and how much flexibility is needed. Probably, developments in other areas can limit the need for flexibility and the number of flexibility decisions that have to be made. Future studies could expand our focus to the amount of flexibility necessary. The aim is to limit the investment and usage of flexibility only to the necessary situations.

ACKNOWLEDGMENTS

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**Appendix 1: CODING SCHEME CASE STUDY**

<table>
<thead>
<tr>
<th>Main Topics</th>
<th>Subgroups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case characteristics</td>
<td>Organization information</td>
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<tr>
<td></td>
<td>Function participant</td>
</tr>
<tr>
<td></td>
<td>Product-market information</td>
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<td></td>
<td>Process (activities)</td>
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<tr>
<td>Role logistics</td>
<td>Flexibility</td>
</tr>
<tr>
<td>Supply chain flexibility</td>
<td>Definition used</td>
</tr>
<tr>
<td>Flexibility choices</td>
<td>Dimensions prioritized</td>
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</tbody>
</table>
WHEN SIMPLE SAFETY STOCK METHODS OUTPERFORM SOPHISTICATED METHODS: A MULTIPLE CASE AND SIMULATION STUDY

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ABSTRACT

Purpose
The most commonly used safety stock method in practice is to calculate it as estimated number of days times the average demand per day. The literature presents analytical methods based on calculations and targeted demand fill rates as resulting in best performance. The purpose of this paper is to compare the performance effects of a simple number-of-days safety stock method with a sophisticated fill rate method for groups of items.

Design/methodology/approach
Due to lack of analytical relationships between number-of-days and demand fill rate methods, respectively, and order line fill rate performance for groups of items; the research questions dealt with in this paper can only be studied by using event driven simulation. These simulations have been carried out in Excel with macros written in Visual Basic. Data for the simulations has been collected from eight different case companies.

Findings
The conclusion is that using a common number-of-days method can be a more efficient method to use when calculating safety stocks in order to achieve a targeted order line fill rate, than to use demand fill rates. It is explained why the demand fill rate method has a negative impact on the relation between order line fill rate and capital tied up in inventory for groups of items and the number-of-days method a positive impact.

Research limitations/implications
The study of the number-of-days method is limited to eight case companies and using demand fill rate based on a normal distribution for comparison of achievements.

Practical implications
The paper provides information about possible benefits by using the number-of-days method as a means to dimension safety stocks in industrial settings.

Originality/value
No research on the use and the characteristics of the number-of-days safety stock method is found in the literature. Neither has any assessment of differentiation characteristics of and comparison with the demand fill rate method been published.

Keywords: Safety stock, Service level, Demand fill rate, Order line fill rate, Simulation
1. INTRODUCTION

Inventory control is characterized by having to estimate demand in advance of customer orders since the lead time for replenishing stock typically is longer than the delivery lead time required by customers. This means that stock replenishments have to be based on estimates. Since such estimates always are more or less wrong, shortages will occasionally occur. To be able to maintain a stable and competitive delivery performance, safety stocks have to be used. Safety stocks means however capital tied up in inventory. An important issue of inventory control is accordingly to establish an efficient relation between required service levels and the capital tied up in safety stocks.

The most commonly used method to calculate safety stocks in industry is estimated number of days times average demand per day. This method is hereafter denoted the number-of-days method. According to Silver et al. (1998, p. 244) some 80% of U.S. companies used this and similar simple rules of thumb methods to calculate safety stocks. Similar observations were made in the UK (Wilkinson, 1996). A recent survey study made in Swedish industry indicated that the method is still very common: some 48% of average and big sized companies use the number-of-days method to calculate their safety stocks (Jonsson and Mattsson, 2015). This approach is, however, to a very limited extent discussed in the literature.

A great number of other methods for calculating safety stocks can be found in the literature. The most published and well known of these are based on targeted service levels, cycle service or demand fill rate. They are also rather frequently used in practice (Jonsson and Mattsson, 2015). Contrary to the number-of-days method, both service level methods consider variation in demand and the lead time. The method based on cycle service has been criticized for not taking replenishment order quantities into account and accordingly not considering the number of times shortages risk occur. Due to this, Axsäter (2006, p. 33) argues that the cycle service method can’t be recommended for inventory control in practice and Tyworth (1992) argues for the necessity of a paradigm shift and a transition from using cycle service to demand fill rate. The number-of-days method can accordingly be considered as the most widely used method for calculating safety stocks in practice and the demand fill rate method considered as the most scientifically favored method in the literature of those methods also used in practice.

No research on the use and the characteristics of the number-of-days method is found in the literature. Neither has any assessment of differentiation characteristics of and comparison with the demand fill rate method been published. The purpose of this paper is to compare the performance effects of the number-of-days method with the fill rate method for groups of items. The analysis is based on simulation using data from eight cases. Findings explain the importance of assessing safety stock performance for groups of items and not for individual items. It also explains how various planning environment characteristics affect the relative performances of different safety stock methods.

2. THEORETICAL CONSIDERATIONS AND LITERATURE REVIEW

2.1. Theoretical considerations

When studying inventory control in research papers and text books you easily get the impression that if you dimension your safety stock based on a certain demand fill rate, the achieved fill rate to the customers corresponds to the service level from which you calculated the safety stock. This is very rarely the case. Due to not considering undershoot (Mattsson, 2007) properly, due to lack of correspondence between the used standard demand distribution
and the real demand distribution, due to approximations used in the calculations as well as due to inaccurately calculated standard deviations you will always end up with achieved service levels that more or less differ from the targeted one being used to dimension the safety stocks. Most often the achieved service level is lower or much lower than the targeted one. This is the case even if the achieved service level is measured based on the same definition as the service level used for dimensioning the safety stock, i.e. in this case the demand fill rate. The deviations get even bigger if order line fill rate is used as the measure of achieved delivery performance as it typically is in industry. These kinds of discrepancies have been demonstrated by Vaughan (1995), Syntetos and Boylan (2006), and Porras and Dekker (2008).

Since number-of-days has no resemblance at all with order line fill rates, deviations from the dimensioning parameter is not an issue in this case. It is however obvious, that different items will get very different achieved service levels even though their safety stocks have been dimensioned with the same number of days and that these service levels deviate from the average service level for the group of items. The major reasons are that neither demand variation nor lead time is considered in the calculation of safety stocks.

The number-of-days method as well as the demand fill rate method differentiates accordingly inherently achieved order line fill rates. It is reasonable to believe, that this capability can influence the performance of the methods since different items contribute more or less to the total delivery performance and more or less to the total capital tied up in safety stock for groups of items. The first of two sub-purposes of this study is therefore to analyze how and to what extent this differentiation is inherently accomplished by the two studied safety stock methods respectively. Such an analysis could serve as a contribution to the understanding of possible differences between their performances.

Safety stocks are in the literature almost always considered from an individual item perspective. The safety stock for an item is calculated based on its own conditions concerning demand variation, lead time, replenishment quantities etc. without any consideration to other items in a group of items. When applying such an approach, the required safety stock to get a targeted service level for a particular item will be the same whatever method used to calculate it. Accordingly, all methods are equally efficient and equally useful with such an approach. It is just a matter of how easy it is to find the appropriate parameter value, for instance number of days or demand fill rate.

Price per piece is different for various items in every group of items which means that they require more or less capital tied up in inventory if other conditions are equal. Various items also contribute more or less to delivery performance for a group of items as a whole. If for instance order line fill rate is used as measure of delivery performance, items with many customer order lines per period contribute more to the aggregate order line fill rate for the group than items with few customer order lines. As a consequence, it is only reasonable to evaluate methods used for calculating safety stocks from a group perspective. The second sub-purpose of this paper is to analyze and compare the number-of-days method to dimension safety stocks with the fill rate method based on the normal demand distribution from such a group perspective. Since no analytical relationships exist between number-of-days demand and the fill rate service level respectively and order line fill rate as a measure of achieved service for groups of items, the study is carried out by simulation based on data from eight different case companies. An (s,Q)-type of reorder point system (Silver et al., 1998) is assumed.

Uncertainty in demand during lead time is influenced by variation in demand but also by variation in lead time. The lead time is however assumed to be constant in this study since it is close to impossible to get reliable case data concerning this type of variation. This assumption
is not regarded as having any significant importance for the achieved results in this kind of study since existing differences in safety stocks are caused by the combined standard deviation for demand during lead time and not individually from demand variation and lead time variation. The only effect the assumption has is that the standard deviation of the demand during lead time is less compared to if lead time variations had been included. No significant trend or seasonal variation in demand has been identified among the eight case companies. It is assumed that shortages result in back orders and not in lost sales. According to Silver et al. (1998, p. 270) this limitation is of minor importance when the service level is high. The study is limited to single-level inventory systems with single source uncertainty related to demand.

2.2. Literature review

Appropriate dimensioning of safety stocks in environments with independent demand has been the subject of a lot of scientific research and several different approaches have been developed. The vast majority of this research has been carried out during the second half of the 20th century and rather few research efforts in the area has been published more recently (Silver, 2008; Williams and Tokar, 2008).

The various ways to calculate appropriate safety stock levels for individual items published in the literature can according to Silver et al. (1998, p. 241) be categorized into three groups; safety stocks established from what Silver et al. call the use of a simple minded approach, safety stocks based on customer service, and safety stocks based on minimization of estimated shortage costs and inventory holding costs. The cost minimization approach is beyond the scope of this study since, as stated by Gardner (1979), shortage costs and holding costs “are difficult if not impossible to measure in practice”. The same view is pointed out by Schneider (1981) and Sezen (2006), why the cost approach is omitted from this literature review.

Approaches like directly estimated safety stock quantities based on intuition and general judgments are examples within the simple minded approach category. More formal but simple calculations like letting the safety stock be equal to an estimated number of days times average demand or equal to an estimated percentage of the average demand during lead time also belong to this category.

The number-of-days method is to a very limited extent discussed in the literature. The few that have been found are published in less scientific journals. Maranka (1970), Conroy (1977) and Workman and Scheidler (2009) describe how the method is applied at three different companies in the US. Conroy also discusses experiences made from using the method. Jordan (1981) discusses how the approach can be improved by differentiating the number of days based on an ABC dollar value classification. He also demonstrates how the approach can be used in order to relate the dimensioning of safety stocks to the inventory budgeting process. Rivers (1982) argues based on experience that number-of-days “is a method that works well when the total annual usage is highly accurate”.

In the few cases where the approach has been discussed in the more scientifically advanced literature, it has been rather heavily criticized for not relating the size of the safety stock to a targeted service level and for not considering demand variations and the length of the lead time. This concerns for instance leading scientists in inventory control like Edward Silver and Richard Tersine. Silver et al. (1998, p. 244) claim that “this approach is seriously in error because it fails to take account of the differences in uncertainty of forecasts from item to item” and Tersine (1994, p. 241) states that “This approach is poor practice and should be avoided”. After analytical comparisons with service level methods on a number of examples, Brown (1967, p. 193) consider the number-of-days method as “completely out of running”.

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Some theoretical justifications of the method has however been discussed. Brown (1959, p. 94) argued based on empirical data that “you are likely to find that the standard deviation of demand is nearly proportional to the average usage”. There is accordingly a similarity between the established way to calculate safety stocks as a safety factor times the standard deviation and the number of days demand. The implication of this is that the number of days can be considered as some kind of safety factor. Empirical studies carried out by Snyder (2002) supports Browns findings and what he calls the “variance law”. No scientific analysis and assessment of the number-of-days approach nor the percentage-of-lead-time demand approach regarding achieved order line fill rates has been found in the literature.

A second category of approaches is safety stocks based on customer service, occasionally also called statistical methods since the calculations are based on some kind of demand distribution. These approaches mean that some kind of targeted service level is established and that a corresponding safety stock is calculated by means of an assumed demand distribution. According to Zeng and Hayya (1999) two major kinds of service levels are used in the literature to calculate safety stocks, cycle service and demand fill rate service. Both these service levels are single item measures in the sense that they only reflect the conditions concerning individual items. According to Ronen (1983) cycle service is an absolute measure since it has no meaning without specifying a time frame, for instance the length of an inventory cycle. Due to this lack of consideration to delivery frequency, Axšäter (2006, p. 33) argues that the cycle service method "cannot be recommended for inventory control in practice". The measure has also been criticized for not being relevant from a customer perspective and for more representing a vendor type of service level (Lewis, 1997, p. 111).

The demand fill rate service is as opposed to cycle service a relative measure. Compared to cycle service it also has the advantage of being numerically close to typically used performance measures for achieved customer service in practice, i.e. to order line fill rate. It is according to Coleman (2000) much more of a bottom-line measure than cycle service. A comparison of the two service level definitions has been carried out by Zeng and Hayya (1999). They conclude that for single item cases the two types of service levels yield different total inventory costs and different turnover ratios. The extent to which one of them outperforms the other depends on the ratio of the order quantity to the variance of the lead-time demand. The efficiency of using fill rate service from a theoretical perspective has been studied by Zeng (2000). The interdependence between lot size and fill rate based methods to calculate safety stocks has been investigated by Natarajan and Goyal (1994).

Most of the research in the field of safety stock management related to service level methods concerns developing ways to calculate safety stocks under different conditions and with different demand distributions. Assessment of the developed methods have been carried out to some extent, mostly as evaluations of approximate solutions and based on single-item measures. Analytical calculations and in some cases simulations (e.g. Bartezzaghi et al., 1999; Klosterhalfen and Mimer, 2010) have been used to make these assessments. Cost benefits and differences in calculated safety stocks quantities are typically used as criteria in these assessments, to a much lesser extent achieved service levels, van Kampen et al. (2010) have pointed out that current research largely neglects case study based contexts and multi-item situations. No assessments of service level based safety stock methods with reference to in industry typically applied multi-item measures for achieved performance like targeted order line fill rates for groups of items have been found in the literature.
3. DIFFERENTIATION CHARACTERISTICS OF METHODS

Here, the number-of-days and demand fill rate methods are theoretically analyzed concerning their capabilities to inherently differentiate achieved order line fill rate service levels.

3.1. Safety stock as number of days demand

Using the number-of-days method means that the safety stock is set equal to an estimated number of days times the average demand per day. No consideration is accordingly taken to replenishment order quantities, to variation in demand, to item price per piece or to the length of the lead time. An obvious question is then, how can the number-of-days method be expected to perform reasonably well regarding capital tied up in safety stock required to achieve a targeted order line fill rate?

As pointed out in the introduction, an efficient relationship between order line fill rate performance and capital tied up in safety stock for groups of items can only be achieved by differentiating the order line fill rates for the individual items. This means that items with high customer order frequencies and low prices should get higher order line fill rates than items with low customer order frequencies and high prices. How this differentiation is accomplished when using the number-of-days method is logically explained below.

Items with high customer order frequencies, i.e. having many customer orders per year, have typically a higher demand per year than items with low customer order frequencies. Since higher demand means a larger safety stock when the number-of-days method is used, items with high customer order frequencies automatically will get larger safety stocks and accordingly higher order line fill rates than items with low customer order frequencies. Also, items with high customer order frequencies tend to have less variation in demand compared to items with low customer order frequencies which means that less safety stock is required to achieve a certain order line fill rate. In addition to this, items with high demand tend to have lower prices per piece than items with low demand. This means that the capital tied up in safety stock is relatively less influenced by high order line fill rates since these items have lower prices. Calculating safety stocks as number of days times average demand per day contributes accordingly to give high service levels to items with high customer order frequencies and low prices which is exactly the type of differentiation that creates an efficient relation between order line fill rate and capital tied up in safety stock for groups of items. The prerequisite is that there is a positive correlation between demand per year and customer order frequency for the items in the group and a negative correlation between demand per year and price per piece. The more positive and the more negative, respectively, the correlations are, the more efficient the differentiation.
3.2. Safety stock from a targeted demand fill rate

When calculating safety stock from a demand fill rate service level the following equation (1) apply (Silver et al., 1998, p. 255).

$$ SS = k \cdot \sigma \cdot \sqrt{Lt} $$

(1)

where

- \( k \) = safety factor
- \( Lt \) = lead time in days
- \( \sigma \) = standard deviation for the demand per day

The safety factor is determined by the service function (Silver et al., 1998, p. 268) (2):

$$ SF(k) = (1 - FR) \frac{OQ}{\sigma_{Lt}} $$

(2)

where

- \( SF \) = service function
- \( FR \) = demand fill rate
- \( OQ \) = order quantity
- \( \sigma_{Lt} \) = standard deviation for the demand during lead time.

The analysis of this equation below is made under the assumption that there is a reasonable resemblance between the level of demand fill rate and the level of achieved order line fill rate. This is normally the case with some exceptions under conditions of very low customer order frequency and large customer order quantities. The two measures are in fact identical when the customer order quantities are one piece.

It is from equation (1) obvious, that when calculating safety stocks from a targeted demand fill rate, consideration is taken to the variation in demand. The bigger the variation in demand, the bigger the safety stock will be. The size of the safety stock is also indirectly influenced by how large the variation in demand is since the standard deviation is included in equation (2).

From equation (2) it can be seen that the order quantity is included in the calculation of the service function. Accordingly, the way the order quantity is calculated will influence the
relation between order line fill rate performance and required tied up capital in safety stock, i.e. has an effect on the performance of the number-of-days method in relation to the performance of the demand fill rate method. The most common way to calculate replenishment order quantities in industry is the square root formula, i.e. the economic order quantity (Jonsson and Mattssson, 2015). In order to study what it means to calculate the order quantity by the square root formula, equation (2) can be rewritten in the following way (3):

\[ SF(k) = \text{const} \cdot (1 - FR) \frac{\sqrt{\frac{240}{\sigma_d^2}}}{} = \text{const} \cdot \frac{\sqrt{\sigma_d^2}}{\text{var} \cdot \sqrt{\text{d} \cdot \sqrt{\frac{1}{P}}}} \]

where
- \( D_d \) = demand per year
- \( P \) = price per piece
- \( \sigma_{lt} \) = standard deviation for the demand during lead time
- \( \sigma_d \) = standard deviation for the demand per day
- \( \text{Var} \) = coefficient of variation

According to equation (3), the service function is decreasing with increasing average demand per day and increasing with lead time. Since the service function is decreasing with increasing safety factor this means that the safety factor, and as a consequence the safety stock, increases with increasing demand and lead time. From equation (3) it can also be found that the smaller the demand variation during lead time, the larger the service function and as a consequence the smaller the safety stock. Accordingly, the larger the number of customer orders per period and as a consequence the smaller the variation in demand, the lower the achieved service level will be. This is contrary to what is desirable in order to achieve an efficient relation between order line fill rate performance and capital tied up in inventory for groups of items.

From equation (1) and (2) it can also be found that the demand fill rate method does not directly consider that various items have different prices. If, however, the square root formula is used to calculate economic order quantities this is indirectly the case according to equation (3). The value of the service function will be less the higher the price per piece with an increasing safety stock quantity and capital tied up as a consequence. The demand fill rate method has accordingly a negative impact on the relation between order line fill rate performance and capital tied up in inventory since high prices lead to larger safety stock quantities. This is true even if the square root formula isn’t used to calculate order quantities. It is enough if the method used to some extent entails smaller order quantities for items with high prices and low demand. This is normally the case also when order quantities are manually estimated.

Based on the above discussion it can be concluded that the inherent differentiation of order line fill rates for various items generated by the demand fill rate method is contra productive. This may deteriorate the relation between achieved order line fill rate for groups of items and the capital tied up in safety stock for the group as a whole. A way to compensate for this deficiency is to use different demand fill rates for different classes of items when calculating safety stocks, i.e. apply differentiated demand fill rates. This has for instance been demonstrated by Kranenburg and van Houtum (2008) and Teunter et al. (2010).

4. CASE STUDY AND SIMULATION

Based on the result of the theoretical analysis in the previous section, it can be concluded that under the assumption of using the same value for the dimensioning parameters on all items in a group of items, the number-of-days method seems to differentiate achieved service levels in a more efficient way than the demand fill rate method. As a consequence, the number-of-days method might also provide a more efficient relation between achieved order line fill rates for
groups of items and capital tied up in inventory than does the demand fill rate method. To assess whether this is the case or not, a comparison of the two methods has been carried out.

Differentiation of achieved order line fill rates may not only be a consequence of differentiation due to inherent mechanisms in the two studied methods to calculate safety stocks. Differentiation can also be accomplished by intensely letting the values for the dimensioning parameters be different for different classes of items to improve performance. Fogarthy and Hoffmann (1991, p. 169) state for instance that single service level measures used across all items “is bound to be deceptive.” The assessment of the two methods has therefore also included the combined effect of the two ways to differentiate service levels.

Due to lack of analytical relationships between number-of-days demand and demand fill rate respectively and order line fill rate performance for groups of items, discrete event–based simulation on data from case companies is the only possible research method. This analysis comparing the performance between the two safety stock methods is based on data from eight case companies. Excel with macros in Visual Basic has been used to carry out simulations.

4.1. Case companies and collected data

To carry out the simulations, data on 250 randomly selected stocked items from each of eight different companies have been used. Since the data needed for these items represents a rather large amount of work to collect, process and to put together in a scientific way from ERP-databases, it has not been possible to randomly select case companies. Instead, convenience sampling is applied, where case companies have been picked based on personal relationships with logistics managers and from relationships established in earlier research projects. In order to generalize the findings, the objective when selecting the companies was to get representatives from several types of inventory based operations and to have reasonable number of case companies to analyze and compare. The case companies included in the study can briefly be characterized as follows:

- One manufacturing company with stocks of purchased and semi-finished items (B)
- Three manufacturing companies with stocks of finished items (C, E, H)
- Two distribution companies with stocks of finished products distributed to local warehouses (D, F)
- One distribution company with a stock of spare parts (A)
- One wholesale company (G)

The data collected for each of the 250 items in each case company include lead time, price per piece, replenishment order quantities, number of customer orders per year and demand per day during one year. In some cases extreme demand values per day have been found, so-called outliers. The reason might, for example, have been that some exceptional large customer orders have been received or that there has been delivery problems resulting in peaks of deliveries when the stock has been replenished. To avoid that such extreme demand values influence the comparison of the two safety stock calculation methods, the demand data has been processed before the simulations were run. This has been done by identifying the outliers by statistical methods and replacing them by the average demand per day.

One year of daily demand is a too short period to achieve stability in a simulated material flow and too short to be able to eliminate an acceptable long start up period when calculating the outcome from the simulation. To get an acceptable long period of demand data, six thousand days of demand corresponding to twenty five years was generated by bootstrapping from the collected demand data.
For various reasons the results from the simulations can be expected to differ between the involved case companies. To be able to explain such differences and try to draw general conclusions from the case companies, it is necessary to characterize the items and demand conditions with reference to inventory control in each of the case companies. These characteristics are displayed in Table 4.1 and 2.

**Table 4.1 Characteristic data concerning lead times and demand**

<table>
<thead>
<tr>
<th>Company</th>
<th>Lead times</th>
<th>Demand</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average lead times in days (1)</td>
<td>Correlation lead time/demand (2)</td>
<td>Average number demand days per year (3)</td>
</tr>
<tr>
<td>A</td>
<td>28.0</td>
<td>0.03</td>
<td>67</td>
</tr>
<tr>
<td>B</td>
<td>16.0</td>
<td>-0.09</td>
<td>42</td>
</tr>
<tr>
<td>C</td>
<td>29.7</td>
<td>0.00</td>
<td>71</td>
</tr>
<tr>
<td>D</td>
<td>4.3</td>
<td>0.03</td>
<td>63</td>
</tr>
<tr>
<td>E</td>
<td>7.5</td>
<td>0.07</td>
<td>71</td>
</tr>
<tr>
<td>F</td>
<td>11.0</td>
<td>-0.05</td>
<td>96</td>
</tr>
<tr>
<td>G</td>
<td>1.5</td>
<td>0.08</td>
<td>81</td>
</tr>
<tr>
<td>H</td>
<td>9.2</td>
<td>-0.02</td>
<td>57</td>
</tr>
</tbody>
</table>

Table 4.1 displays conditions concerning lead times and demand for the eight case companies. Column 1 contains average lead times for stock replenishments of the various items. Obviously company A, B and C has considerably longer replenishment lead times than the rest of the companies. The correlation between lead times and demand is of interest to see to what extent differences in lead times is of any significance for the number-of-days method since this method doesn’t consider its length when calculating safety stocks. From the data displayed in column 2, it is obvious that almost no correlation exists in any of the studied case companies which means that differences in lead times can’t be expected to have any major effect on the performance of the number-of-days method in relation to the demand fill rate method.

The average number of demand days per year for the various companies are displayed in column 3. These data indicate the degree of low demand frequency and accordingly how reasonably it is to assume that the variation in demand corresponds to the normal distribution. Company F and G have many demand days per year while company B and H have comparatively very few. In these two companies customer orders are only received every fifth day as an average per item. Additional information about how reasonable it is to assume a normal distribution when using the demand fill rate method to calculate safety stocks can also be found in column 4. The data refer to the percentage of items that has a coefficient of variation for the demand during lead time that is larger than one. The lower the coefficient of variation, the more accurate the calculated safety stock will be (Silver et al., 1998, p. 273). Achieved service levels will accordingly be less differentiated. A high percentage of such items exists in company D and G while company A, C and F have a large majority of items for which the assumption of normal distribution can be expected to work well.

The conditions in the case companies concerning prices and customer orders are displayed in Table 4.2. In column 1 the relations between the average price per piece for the 20% most
expensive items and the 20% least expensive items are displayed. Company B, C and D show much larger ratios between high and low price items than what is the case for the rest of the companies. Parallel to what was the case concerning a positive correlation between demand and customer order frequency, a prerequisite for achieving an efficient relation between service level performance and required capital tied up in safety stock is a negative correlation between demand and price per piece. Calculated correlation coefficients are displayed in column 2. The data show that the correlations are negative in all of the case companies. The correlation coefficient is more negative in company A, C and D compared to the rest of the case companies.

Table 4.2 Characteristic data concerning prices and customer orders

<table>
<thead>
<tr>
<th>Company</th>
<th>Prices</th>
<th>Customer orders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relation high/low prices (1)</td>
<td>Correlation demand/price (2)</td>
</tr>
<tr>
<td>A</td>
<td>180</td>
<td>-0.30</td>
</tr>
<tr>
<td>B</td>
<td>390</td>
<td>-0.14</td>
</tr>
<tr>
<td>C</td>
<td>720</td>
<td>-0.25</td>
</tr>
<tr>
<td>D</td>
<td>30</td>
<td>-0.25</td>
</tr>
<tr>
<td>E</td>
<td>12</td>
<td>-0.15</td>
</tr>
<tr>
<td>F</td>
<td>97</td>
<td>-0.20</td>
</tr>
<tr>
<td>G</td>
<td>34</td>
<td>-0.18</td>
</tr>
<tr>
<td>H</td>
<td>579</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

The data in column 3 represent shares of items for which less than 24 customer orders are received per year, i.e. less than two customer orders per month. It is accordingly a measure of customer order frequency. Company B has a large share of items with very low customer order frequencies while company G has a very little share. The degree of low demand frequency influences to what extent the assumption of normal distribution is valid and accordingly to what extent the demand fill rate method differentiates service levels.

The degree of variation in demand is influenced by customer order quantities and affects accordingly the fit between the normal distribution and the real distribution of variation in demand. The averages of these quantities are displayed in Table 4.2, column 4. Companies C and H show considerably larger customer order quantities than the rest of the case companies, especially compared to companies F and G. The differences are of importance regarding the extent to which the number-of-days method differentiates service levels. One of the major reasons that the number-of-days method might require less capital tied up in inventory is, as was discussed in Section 3, that there is a positive correlation between demanded volumes and the number of customer orders per year. Data in this respect are displayed in column 5. As displayed in the table, this correlation is positive for all of the eight case companies but considerably larger in companies A, B, C and F compared with the rest of the companies.

4.2. Simulation model

The simulation model used in this study is built on a reorder point system of typ (s,Q), i.e. with fixed order quantities. The order quantities have been calculated by the square root formula.
(EOQ). The reorder point system is applied as a periodic review system with daily comparisons of stock-on-hand and reorder point. Accordingly, the undershoot compensating for demand during the review interval has been set to the average demand during a half day and added to the reorder point. Negative safety stocks have been allowed when demand fill rate service is used to calculate safety stocks. The standard deviations for demand variations have been calculated as 1.25 times the mean absolute deviation per month.

Two alternative ways of differentiating demand fill rates have been studied, one based on customer order frequency and the other based on a combination of price and customer order frequency. When differentiating demand fill rates based on customer order frequency the demand fill rate has been set to 98% for the 20% items with the highest customer order frequency, to 97% for the following 30% of the items and to 94% for the 50% remaining items (Table 4.3). When considering both customer order frequency and price per piece, the demand fill rates applied when calculating safety stocks have been according to the table below.

Table 4.3 Customer order frequency and price groups

<table>
<thead>
<tr>
<th>Customer order frequency group</th>
<th>Price group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>97</td>
</tr>
<tr>
<td>2</td>
<td>95.5</td>
</tr>
<tr>
<td>3</td>
<td>94</td>
</tr>
</tbody>
</table>

Price group 1 represents the 20% items with the highest prices, price group 2 the 30% items with the next highest prices and price group 3 the remaining items. Frequency group 1 represents the 20% items with the highest customer order frequencies, frequency group 2 the 30% items with the next highest customer order frequencies and frequency group 3 the 50% items with the lowest customer order frequencies.

According to Ronen (1983) delivery performance for groups of items should be measured by multi-item measures. Fogarthy and Hoffmann (1991, p. 166) have provided a number of such measures. Since order line fill rate is the most widely used multi-item measure in industry (Forslund and Jonsson, 2010) and that firms according to LaLonde et al. (1988, p. 41) prefer this measure, it was selected as measure when comparing the performance of the two safety stock calculation methods. Order line fill rate is also used as performance measure in the Supply Chain Councils SCOR model for order-to-deliver processes. It is defined as the percentage of order lines that during a period have been shipped completely directly from stock without any delay. The aggregate service level for group of items was calculated as weighted averages of the achieved order line fill rates for the individual items in the group. The weights applied have been the number of customer orders per year to reflect the various items different contributions to the total delivery capability.

In the simulations, the start values for number of days and demand fill rate respectively when calculating safety stocks have been set to lower values than could be expected to be required to reach the targeted order line fill rate for the group. Based on these start values, issuing from stock, comparison of stock-on-hand and the reorder point, releasing replenishment orders, updating deliveries and updating stock-on-hand figures were carried out on a daily basis during the simulation over a period of six thousand days. Shortages were backordered for later
deliveries. After each simulation run, the order line fill rate for the whole group of items was calculated as a weighted mean where the weights were number of customer orders per year. For each new simulation run the number of days and the demand fill rate respectively were increased until the targeted order line fill rate level of 97% was reached. An excess of less than 0.05 percent units was accepted. When using differentiated demand service levels, all the different service levels were increased step wise with the same amount until the targeted average order line service level for the group as a whole was achieved.

When the targeted order line service level was achieved, the average capital tied up in safety stock over the simulated period was calculated item by item and finally summarized to a value representing the total capital tied up in safety stock for the group as a whole. The achieved safety stock is according to Herron (1987) defined as the quantity in stock when a new replenishment arrives times price per piece.

5. RESULTS AND ANALYSIS

The results from the simulations concerning differences in capital tied up in safety stocks between the two studied methods are summarized in Table 5.1. The figures in the table refer to percent higher capital tied up in safety stock when using the demand fill rate method as compared to using the number-of-days method to achieve the same order line fill rate performance for the whole group of items.

<table>
<thead>
<tr>
<th>Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent increase of safety stock when using the demand fill rate method compared to number-of-days to achieve the same order line fill rate performance for the whole group of items</td>
<td>20</td>
<td>19</td>
<td>89</td>
<td>18</td>
<td>35</td>
<td>45</td>
<td>37</td>
<td>15</td>
</tr>
</tbody>
</table>

From the results displayed in Table 5.1, it is obvious that the number-of-days method performs a lot better than the demand fill rate method in all the eight case companies regarding amount of capital required in safety stock to reach the targeted order line fill rate. Especially big differences are found for companies C and F. One reason why the differences are especially high in these two companies is that the positive correlation between demand and customer order frequency as well as the negative correlation between demand and price are much larger in these two companies than in the rest (Table 4.2, columns 2 and 5). The correlation between demand and customer order frequency as well as the correlation between demand and price per piece, is quite the opposite for company H. As a consequence, the difference in capital tied up in safety stocks is the lowest among the eight studied case companies.

In company C as well as company F the prerequisites to use the normal distribution are satisfied to a greater extent since, according to Table 4.1, columns 3 and 4, the number of days with demand per year is larger and the coefficient of variation lower than for most of the other companies. The same is the case for companies A, C and F who, as displayed in Table 4.1 column 1, have the longest average lead times which according to the central limit theorem tend to make the variation in demand during lead time more like the normal distribution.

The more the actual distribution of demand corresponds to the normal distribution, the better the compliance between the dimensioned service level and achieved service level. The
consequence is, however, that the differentiation of achieved service levels for the various items will be weaker and accordingly the relation between order line fill rate performance and required capital tied up in inventory less efficient. In addition, company C has an exceptionally high relation between high prices and low prices, which according to Section 3.2 also has a negative influence on the performance of the demand fill rate method.

To demonstrate the extent of differentiation in achieved service levels, the items were ranked from lowest to highest customer order frequency and price per peace, respectively, and then grouped in five classes with twenty percent of the items in each. Within each class the weighted average achieved order line fill rate was calculated. The results from these calculations are displayed for case companies A, B and C in Table 5.2.

Table 5.2 Order line fill rates for each class of customer order frequency and price per piece

<table>
<thead>
<tr>
<th>Frequency class / Price class</th>
<th>Customer order frequency</th>
<th>Price per piece</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Company A</td>
<td>Company B</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>DFR NOD</td>
<td>DFR NOD</td>
<td>DFR NOD</td>
</tr>
<tr>
<td>Lowest</td>
<td>93.2</td>
<td>79.3</td>
</tr>
<tr>
<td>Next lowest</td>
<td>94.2</td>
<td>86.2</td>
</tr>
<tr>
<td>Medium</td>
<td>96.4</td>
<td>91.6</td>
</tr>
<tr>
<td>Next highest</td>
<td>97.1</td>
<td>97.8</td>
</tr>
<tr>
<td>Highest</td>
<td>97.4</td>
<td>99.3</td>
</tr>
</tbody>
</table>

Note: Figures show on average achieved order line fill rates. DFR = Demand fill rate method. NOD = Number-of-days method

The results clearly illustrate that various items get different achieved order line fill rates even though the same parameter values are used for all items when calculating the safety stocks. It is also obvious that the number-of-days method differentiate the order line fill rates a lot more than the demand fill rate method does. This is especially so regarding price per piece in which case the differentiation of order line fill rates is very low when applying the demand fill rate method. These findings support the analysis made in Section 3 and conclusions made Syntetos and Boylan (2006) as well as Porras and Dekker (2008).

The weaknesses of the demand fill rate method concerning its ability to inherently differentiate achieved service levels can be compensated by intensely differentiating the demand fill rate parameter when calculating safety stocks. The results from the simulations in this respect are displayed in Table 5.3 and show that the performance of the demand fill rate method is improved when the demand fill rates are differentiated since the differences in capital tied up in safety stock relative to the number-of-days method is smaller than those displayed in Table 5.1. The number-of-days method is however still a more efficient approach to use when calculating safety stocks in the eight case companies. The results from the simulations also illustrate that differentiating demand fill rate based on customer order frequency and price performs better than just differentiating based on customer order frequency. The difference between the two ways to differentiate is however not very significant for most of the case companies.
Table 5.3 Percent higher capital tied up in safety stock when using the demand fill rate method with differentiation compared to the number-of-days method

<table>
<thead>
<tr>
<th>Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent increase when differentiating demand fill rate by customer order frequency</td>
<td>6</td>
<td>14</td>
<td>64</td>
<td>15</td>
<td>39</td>
<td>32</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Percent increase when differentiating demand fill rate by order frequency and price</td>
<td>3</td>
<td>5</td>
<td>48</td>
<td>11</td>
<td>33</td>
<td>25</td>
<td>1</td>
<td>11</td>
</tr>
</tbody>
</table>

6. CONCLUSIONS AND LIMITATIONS

The outcome from the simulations indicates that the demand fill rate method requires a lot larger safety stocks than the number-of-days method in all of the eight case companies. On average the required tied up capital is 35% larger. Based on the results, it is also obvious that the number-of-days method differentiates the achieved order line fill rates more than the demand fill rate method does. Why such differences exist between the two methods has been explained analytically and by logic reasoning. If the demand fill rates used on various classes of items are differentiated with respect to price per piece and/or customer order frequency when calculating safety stocks, the differences in capital tied up in safety stock was less but still not insignificant.

The extent with which the number-of-days method performs better than the demand fill rate approach is mainly due to some characteristics of the demand data. Two of these characteristics are the degree of positive correlation between customer order frequency and demanded volumes and the negative correlation between demanded volumes and price per piece. The larger these correlations, the better the number-of-days method performs relative to the demand fill rate method. Two other characteristic that influence the relative performance of the two methods are the length of the replenishment lead time and the coefficient of demand variation since both influence the fitness of the normal distribution. The better the normal distribution fits the actual distribution of demand, the better the compliance between the dimensioned service levels and achieved service levels. The consequence is, however, that the differentiation of achieved service levels for the various items will be weaker and accordingly the relation between order line fill rate performance and required capital tied up in inventory less efficient. A fifth characteristic is the differences in prices per piece for the various items since the demand fill rate method tends to generate higher safety stock quantities for items with high prices.

The main conclusion that can be drawn from the study is that the number-of-days method seems to be a more efficient method when calculating safety stocks in order to achieve a targeted order line fill rate than does the demand fill rate approach. This is contrary to general opinions in numerous text books and research articles which typically argue that safety stock should be calculated based on targeted service levels rather than by simplistic methods based on estimations. Some authors even strongly recommend that the number-of-days method should be avoided. The major reasons for this discrepancy regarding the view on the value of using the demand fill rate approach is that assessments made in the literature typically are carried out on individual items rather than on groups of items and that they are typically based on single item service measures like the demand fill rate rather than group measures like the order line fill rate.

The major contributions of this paper is the analysis of reasons why and how the one in industry mostly used, and the one by scientists mostly recommended, method for calculating safety stocks inherently differentiate achieved service levels in groups of items and the comparison of
performance of the two methods concerning required capital to achieve a targeted order line fill rate. No such analysis and comparison has been found in the literature.

For obvious reasons this study has its limitations. This concerns the limited number of case companies, types of inventory operations and demand distributions studied. Analysis of additional cases with other planning characteristics could further validate and generalize our findings. Another limitation concerns the differentiation of dimensioning demand fill rates. This is in the study based on rather simplified classifications of items and estimates of demand fill rates for the various classes. A more optimized item classification and selection of fill rate services might improve the performance of the fill rate method and make it more competitive with the number-of-days method. The study does not either include any analysis of critical levels on how low the correlation between demand and customer order frequencies and prices respectively can be, still letting the number-of days method perform better than the demand fill rate method. The study does not either cover to what extent the fit between the actual demand distribution and the normal distribution is critical for the achieved differences in performance. No other standard demand distributions than the normal distribution has been included. In addition, no influence on performance by differentiating number of days for various classes of items has been considered in the study. Enhancements in these respects are of major interest for further research.

REFERENCES


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ABSTRACT

Purpose
This paper aims to assess and estimate the potential efficiency gains that might result from vessel speed adjustment policies enabled by a greater level of ship-port dynamic information sharing.

Methodology
The estimation of economic benefits is based on arrival and departure data for cargo vessels in the Port of Gothenburg. The estimated impacts of speed adjustment and subsequently reduced waiting time are categorized as bunker cost savings and emissions cost reductions. To compensate for lack of certainty regarding the correct valuation of emissions, three alternative sets of costs are used.

Findings
The findings of this paper indicate that implementing a well-functioning system for information sharing in ports has the potential to unlock significant cost savings for the shipping industry and for society as a whole. The median estimate of annual benefits in the Port of Gothenburg is 13.1 million euros. This figure is however subject to considerable uncertainty and a scope of 8.5 to 20.5 million euros is estimated with regard to different emission valuations. This study also discusses barriers to the information sharing. An important obstacle to this development is the weak or non-existing incentives for certain actors to participate in information sharing practices. A key conclusion is that advocates of integrated information sharing need to specify whether such a scheme would require mandatory participation, and how this would be achieved.

Research limitations
The limitations of the dataset poses questions of sample sensitivity and representativeness. Extrapolations of the results should therefore be interpreted with caution.

Original/value
This paper presents original findings on the potential economic benefits of improved port efficiency through information sharing, which is of relevance to transport policy. This paper also presents a framework for assessing benefits of information sharing in maritime ports.

Keywords: Port efficiency, Short-sea shipping, Port-ship coordination, Emission
1. INTRODUCTION

In 2001 the European Commission stated in its White Paper on European Transport Policy for 2010 that improving the competitive strength of short-sea shipping could alleviate congestion problems of road transport and bottleneck problems of rail transport (European Commission, 2001). The main measures of EU policy action that were taken to promote a modal shift toward shipping was the launch of projects Marco Polo I and II. The purpose of the Marco Polo programs was to subsidize ventures that develop and make use of efficient maritime expressways (so called “motorways of the sea”). The Marco Polo programs were active during the years 2003-2013. Despite these subsidization schemes and mechanisms put in place by the European Union to promote short-sea shipping as a modal alternative to road and rail transport, intra-European shipping of goods has grown slower than road during the last decade. In fact, during 2003-2013 short-sea shipping performance (measured in tonne-kilometers) in EU-28 declined by 2.7 % while road performance grew by 7 % (European Commission, 2015). In the logistics chain of short-sea shipping, maritime ports constitute both a crucial link and a potential bottleneck. It has been noted that the ability of short-sea shipping to compete hinges on a higher level of port efficiency (European Commission, 2010, Medda and Trujillo, 2010).

The European Commission has recognized that systematic information exchange between actors in the shipping industry can not only reduce administrative burdens on captains, but also lead to improvements in terms of safety and pollution (European Commission, 2001). The Trans-European Transport Network (TEN-T) finances the project MONALISA, which suggests that the implementation of systematized real-time information sharing would increase efficiency in ship routing and port approach processes (MONALISA, 2015). An objective of MONALISA is reducing costs related to excessive ship laytimes and suboptimal speed choices by allowing ships to conform to a dynamically planned route based on the behavior and plans of other vessels, capacity availability in ports, as well as other external factors (Lind et al., 2015).

The purpose of this paper is to assess and estimate the economic value of operational improvements that could potentially be realized through speed adjustment in ship arrivals, enabled by information sharing in maritime ports. To this end, the Port of Gothenburg is used as a case example.

The paper is structured as follows: First is a brief review of previous research on efficiency and information sharing in the context of maritime ports. This is followed by a description of the applied methodology and the main assumptions underlying the analysis. Then, the data is introduced. After having presented the main results, a more general discussion regarding the feasibility of the proposed change is included. Finally, a few conclusions can be drawn regarding the economic potentials of digital infrastructure for information sharing in ports.

2. THE ROLE OF PORT OPERATIONS IN SHORT-SEA SHIPPING

It is rather difficult to evaluate the efficiency with which port operations are carried out, owing to the fact that port operations are performed in complicated networks with many actors responsible for the outcome. However, the amount of time spent by a ship in the port area is a simplifying yet useful measure (see Suarez-Aleman and Hernandez, 2014, Suarez-Aleman et al., 2014). Turnaround time is an attractive measure because it may capture the efficiency with which resources such as berthing slots and cranes are allocated. With regard to the competitive power of short-sea shipping relative to modal alternatives, efficient port services are essential.
to the position of short-sea shipping as a strong modal competitor (Ng, 2009, Paixao and Marlow, 2001). Arof (2015) argues that efficient turnaround time is important for short-sea shipping as an intermodal competitor since this can mitigate the relatively low speeds of carriers. Becker et al. (2004) find that investing in better cargo handling in ports is likely to have a greater impact on short-sea shipping capacity than investing in faster ships.

The logistically complex multi-actor network of a port necessitates an organizational structure that facilitates communication and incentivizes efficiency for every actor. Increased intermodal competition to ports has led to a particular need for innovative and market-oriented organizational structures, such as information sharing through integrated information and communications technology (ICT) platforms (Cepolina and Ghiara, 2013). Du et al. (2011) show that collaborative planning of berthing by the port and the shipping line through dynamic sharing of information can lead to win-win results both in terms of economic and environmental gain. The aforementioned research project MONALISA finds standardization of communication in ports to be a driver of berth productivity (Lind et al., 2015). Standardized communication refers in this case to ships being able to subscribe to information regarding for instance delays in terminal readiness, and being able to respond by adjusting speed.

Lacking the framework, the tools or the incentives for informed speed decisions based on terminal capacity may, according to recent studies, result in inefficiencies. In a case study observing ships belonging to the fleet of a bulk shipping company operating in the North and Baltic Seas, it is found that ships may spend 40% of their time in port and that a large portion of this time is dedicated to unproductive waiting (Johnson and Styhre, 2014). It is noted that a reduction of unproductive time in port of 1 to 4 hours per port call is a conservative estimate of what appears possible through measures such as improved ship to shore communications. In a case study of short-sea shipping container operations in the North Sea, Bråthen and Schøyen (2015) find that current levels of real-time information sharing among shipping actors are not sufficient to enable gains from speed optimization.

In a report using a dataset that overlaps the one used in this study, SSPA and Viktoria Swedish ICT (Holm and Grundevik, 2015) estimate bunker savings potential for anchoring vessels approaching the Port of Gothenburg. Using automatic identification system (AIS) data, the authors investigate to what extent ships approaching the Port of Gothenburg are able to travel straight to the port (the so-called non-anchoring track), and respectively, to what extent approaching ships anchor outside the port area before continuing to port (anchoring track). It is found that 17% of vessels approaching the port were part of the anchoring track, meaning that they lay at anchor for more than 1 hour before continuing to a terminal. The median time spent at anchor for these vessels was 17.9 hours. Out of the studied sample of 320 vessels, 39 vessels, or 12%, could have saved fuel by slowing down prior to approaching the area. The authors find that anchoring vessels could have reduced bunker consumption and CO₂ emissions through speed adjustment policies. However, the reasons for the anchoring behaviors of the observed vessels or the details of arrival planning are not further investigated in the report. The analysis of bunker and emission savings by Holm and Grundevik (2015) assume that speed-adjustment policies are implementable 10-20 hours before the ship arrives in the port area.

Several studies have investigated the impacts of speed-adjustment policies, or so called “slow steaming” policies, in general (see for instance Ronen, 1982, Wang, 2009, Alvarez et al., 2010). A reason for focusing on the speed of approaching vessels is that the consumption of fuel (and the release of emissions) is approximately cubically related to vessel speed (Stopford, 2009). There are suggestions that maritime ports may play a role in the reduction of emissions in the maritime transport chain through implementing policies that promote speed reductions of approaching vessels (Gibbs et al., 2014).
3. METHODOLOGY

Previous research has indicated that implementing speed-adjustment policies in order to reduce waiting times at anchor could lead to significant reductions in bunker consumption and release of emissions for ships approaching the Port of Gothenburg. However, no investigation regarding existing communicational efficiency has been undertaken. In this study, assessment of the existing inefficiencies in communication is performed through studying transmitted estimates of arrival, berthing and departure times, and comparing these to actual outcomes. For a scope of plausible impacts of information sharing on speed adjustment, potential cost savings are then estimated.

The major costs involved in shipping are manning costs, bunker (fuel) costs, and capital costs (Stopford, 2009). Since, however, the objective of this paper is to estimate the benefits of more optimized arrival planning, there are no assumed impacts on manning or capital costs. The transfer of waiting time at anchor to a more efficient (slower) approach does not reduce total trip or turnaround time, and therefore a constant level of manning and capital are assumed to be required. Rather, the speed adjustment policies that may be enabled by information sharing are expected to lead to savings in bunker costs. In addition to bunker costs, there are external costs to wider society, in the form of emission costs. This paper treats economic costs as synonymous with total societal costs, including both internal costs borne by shipping businesses and external costs borne elsewhere in society.

The valuation of reduced waiting time is composed of bunker and emissions cost savings enabled by speed-adjustment. The realized total cost savings for society are subject to the effectiveness of increased information sharing policies. The analysis of cost savings in this study can be described in the following way:

\[ \Delta C = f(I, \Delta BC, \Delta EC) \]  

Where \( BC \) and \( EC \) are bunker and emission costs respectively, and \( I \) represents the impact factor of information sharing policies on turnaround efficiency and subsequently on the total costs (\( C \)). The estimates of fuel, emissions and average operational speeds are based on Swedish Environmental Protection Agency’s estimates (SEPA, 2010). Because these estimates of fuel consumption are specific to certain vessel sizes, some interpolations are needed to estimate figures for every ship in the sample. The assumed vessel category characteristics are described in Table 3.1.

**Table 3.1 Assumed vessel category characteristics (Authors calculations based on SEPA (2010) and Swedish Transport Administration (2015))**

<table>
<thead>
<tr>
<th>Vessel type</th>
<th>GT</th>
<th>Assumed baseline speed (km/h)</th>
<th>Emissions cost per km (euros)</th>
<th>Fuel cost per km (euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large container ship</td>
<td>140,000</td>
<td>35</td>
<td>397</td>
<td>243</td>
</tr>
<tr>
<td>Small container ship</td>
<td>10,000</td>
<td>46</td>
<td>63</td>
<td>38</td>
</tr>
<tr>
<td>Tanker</td>
<td>64,000</td>
<td>20</td>
<td>109</td>
<td>66</td>
</tr>
<tr>
<td>RoRo</td>
<td>18,000</td>
<td>33</td>
<td>61</td>
<td>39</td>
</tr>
</tbody>
</table>

1 It is worth noting that the \( CO_2 \) emission factor given by SEPA is slightly higher than that of the IMO Second GHG Study (Buhaug et al., 2009). This is because the value in the IMO report is an EU average, while the observed factor has tended to be higher for traffic in the North and Baltic Sea (SEPA, 2010).
The estimation of cost savings from speed adjustment are based on fuel-speed relationships approximated by estimated coefficients in US container simulations (see Wang, 2009). Wang (2009) estimates these relationships in a scenario where ships travel at optimally profitable speeds with respect to fuel prices and freight rates, and then stepwise reduce speed in response to policy mandates. This relationship is presented in Table 3.2.

Table 3.2 Speed reduction rates and CO\textsubscript{2} emission reduction rates (Wang, 2009)

<table>
<thead>
<tr>
<th>Reduction in speed (%)</th>
<th>Reduction in fuel consumption and CO\textsubscript{2} emissions (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>30</td>
<td>49</td>
</tr>
</tbody>
</table>

Valuations of emissions costs are subject to some discussion. This paper uses a wide scope of pollution valuations, to compensate for uncertainty regarding the relevant pricing of emissions. The main estimates of emission unit values are those recommended by the Swedish Transport Administration (STA) (2015), and the differing unit values used as low and high sensitivity estimates are from the EU program Clean Air for Europe (CAFE) (Holland et al., 2005) and the Stern Review (Stern, 2006). The uncertainties and methodological differences that persist in the research of emission valuation warrant the use of different sources. The unit values\textsuperscript{2} per kg of air pollutants emitted are shown in Table 3.3.

Table 3.3 Emission unit values in euros per kg (from STA (2015) unless otherwise stated). All values are converted to 2014 prices.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Low unit value</th>
<th>Main unit value</th>
<th>High unit value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{x}</td>
<td>3.08 (CAFE)</td>
<td>9.23</td>
<td>9.23</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0</td>
<td>0</td>
<td>41.32 (CAFE)</td>
</tr>
<tr>
<td>SO\textsubscript{2}</td>
<td>3.11</td>
<td>3.11</td>
<td>12.97 (CAFE)</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>0.07 (Stern)</td>
<td>0.12</td>
<td>0.40 (ASEK, high)</td>
</tr>
</tbody>
</table>

Regarding bunker costs, there are reasons to consider what type of marine fuel that is to be used as a benchmark for costs. From January 1:st 2015, the limit values for sulphur content in fuel in emission control areas (ECA), including the North Sea and the Baltic Sea, have been changed from 1 % of weight to 0.1 % (IMO, 2015). The implications of this is that ships that were not already using marine fuel with a sulphur content lower than 0.1 % would have to switch to a

\textsuperscript{2} The terms emission value and emission cost are used synonymously. The reasoning for this is that the figures represent the both value of emissions reduction and the economic cost associated with increased emissions.
fuel type that satisfies this regulation. The type of fuel that is generally considered to be in use from 2015 is marine gas oil (MGO). Therefore, the appropriate benchmark cost for shipping fuel should be the price of MGO, and not previously used fuel types, such as LS180 (which has a sulphur content of lower than 1 %). The Rotterdam price of MGO stood at 654 euros per ton in August of 2014, which is the time that the sample used in this study concerns (Ship and Bunker, 2015).

4. DATA

4.1. The Port of Gothenburg and the sample

The Port of Gothenburg is the largest container port in Scandinavia, with a throughput of roughly 840 000 twenty foot equivalent unit containers (TEUs) in 2014 (ESPO, 2014). The Port of Gothenburg also handles significant amounts of liquid bulk and RoRo (roll on - roll off) tonnage (see Figure 4.1). The total number of port approaches to the Port of Gothenburg during 2013 was 5581.

This study utilizes a set of port approach data collected during the month of August in 2014. The data includes details of 276 cargo ship approaches, including occurrences and estimates related to each vessels approach process. A summary of vessel types and capacities in the dataset is presented in Table 4.1.

Table 4.1 Sample vessel characteristics

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Mean DWT</th>
<th>Mean GT</th>
<th>Total tonnage capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container</td>
<td>62</td>
<td>34,253</td>
<td>31,605</td>
<td>2,123,680</td>
</tr>
<tr>
<td>Tankers</td>
<td>111</td>
<td>13,454</td>
<td>8,595</td>
<td>1,493,423</td>
</tr>
<tr>
<td>General Cargo</td>
<td>12</td>
<td>4,252</td>
<td>3,290</td>
<td>51,022</td>
</tr>
<tr>
<td>RoRo</td>
<td>91</td>
<td>12,363</td>
<td>28,105</td>
<td>1,125,052</td>
</tr>
<tr>
<td>Total</td>
<td>276</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Figure 4.1 an attempt is made at analyzing the representativeness of the sample. Since actual cargo carriage in the sample is not known, the distribution of total deadweight tonnage (DWT) of the sample is compared to the distribution of annual cargo throughput in the port. This comparison shows that there appears to be an overweight of container traffic and an underweight of tanker traffic in the sample compared to annual throughput. Since container ships have higher rates of bunker consumption per ton (see Table 3.1), there is a risk of overestimating costs of fuel and emissions in the sample compared to annual figures. However, the relationship between DWT distribution and throughput distribution can only be expected to equal if there are no differences in load rates among different categories of vessels. The extent of this misrepresentation is therefore difficult to know, since load rates are not observable from

---

3 Where information regarding the deadweight or gross tonnage of a particular vessel was missing, this information was retrieved via the website www.marinetraffic.com.

4 Deadweight tonnage is, in simplified terms, a measure of how much weight a ship can safely carry (Stopford, 2009).
the data. If containers ships tend to have lower load rates than tankers, this discrepancy could be somewhat evened out.

Figure 4.1 Distribution of cargo in the Port of Gothenburg

5. RESULTS

5.1. Time at quay and error in estimates

For all 276 vessels, total time spent at quay can be defined as (ATD-ATB), where ATD signifies actual time of departure from quay and ATB signifies actual time of berthing. The distribution of hours spent at quay can be seen from Figure 5.1. The average time at quay in the sample is 14.7 hours.
For 83 of the 276 observed vessel approaches, the dataset includes logs of dynamic updates of when the vessel is expected to arrive at berth (ETB: estimated time of berthing). These continuing updates are compared against their respective outcomes. Figure 5.2 plots the average estimation error (ATB – ETB) in hours against the time until berthing actually took place.

It is noteworthy that there is an upward shift in average estimation error towards the last hours of the approaches. This can be seen as a symptom of inefficiency in communication, and marks an inconsistency with an efficient scenario where uncertainty regarding arrival and availability should be strictly decreasing as a vessel nears its terminal of destination. This could be described as an anomaly, and the underlying causes are difficult to know. The standard deviation in estimation errors is highest in the first period (225-49 hours prior to arrival), which indicates a large variability in estimates in the early stages of long hauls. The standard deviations then have a similar pattern as the average errors: the variability is higher during the last two periods than during the preceding (excepting the first period). This may be interpreted
as an indication of high uncertainty during the latter stages of arrival planning. This subsample of data may be too small to draw precise conclusions regarding arrival planning in the port. A general indication is however that there are inefficiencies in planning of estimated arrivals, and that this inefficiency is primarily affecting short term planning. If estimated times of arrival are systematically optimistic with regard to berthing times, as is indicated by the data, there will be foregone opportunities for slow steaming. This finding is supported by previous research, which has found evidence of poor possibilities for speed optimization in North Sea shipping operations (Bråthen and Schøyen, 2015, Johnson and Styhre, 2014).

5.2. Benefits of speed adjustment

The method of estimating benefits of speed adjustment is defined in equation (1) in section 3. The sum of bunker cost ($BC_i$) per kilometer for all vessels $i$ in the sample is calculated as:

$$\sum_{i=1}^{n} BC_i = \sum_{i=1}^{n} \left( \frac{GT_i}{GT_{type}} \times FC_{type} \times Fuel\ price \right) \tag{3}$$

Where $GT_i$ is the gross tonnage of vessel $i$, and $GT_{type}$ is the gross tonnage for the corresponding vessel type (see Table 3.1). $FC_{type}$ is the fuel consumption per kilometer of the vessel type. Accordingly, emissions costs ($EC_i$) per kilometer for all vessels $i$ is calculated by multiplying relative ship size by emissions production ($EP$) per kilometer of the vessel type and emission unit values (see Table 3.3).

$$\sum_{i=1}^{n} EC_i = \sum_{i=1}^{n} \left( \frac{GT_i}{GT_{type}} \times EP_{type} \times Emission\ values \right) \tag{4}$$

Multiplied by the assumed speeds of the vessels in the sample (Table 3.1), the costs of fuel and emissions per kilometer can be used to determine hourly costs for the entire sample. The total hourly costs of bunker and emissions in this sample amount to approximately 952,700 euros.

As indicated by the preceding analysis of efficiency in arrival planning, there appears to be inefficiency in communication during the last hours in the port approaches. The impact analysis of speed adjustment will therefore be confined to the final hours of approaches. The effectiveness of increased information sharing in arrival planning is discussed in two dimensions. The first dimension is how many hours ahead information regarding for instance a delay in terminal availability can be transmitted and responded to by slowing down. The scenarios estimated in this analysis have a scope of 1-4 hours. Four hours is chosen as the maximum amount of time prior to arrival that speed adjustment can be implemented in order to reduce the risk of overestimating the benefits that can be enabled by information sharing. The second dimension is how much ships can slow down and still arrive on time. If speed adjustment prolongs the trip time more than the expected waiting time, the ship will arrive late. For the low and high ends of the estimated scope, a speed decrease of 10 \% and 30 \% respectively are chosen. In the lowest impact scenario, where the ship decreases speed by 10 \% for one hour, the corresponding trip time impact is 11.1 \% or 0.11 hours. For a vessel that is 4 hours away from its destination at baseline speed, the impact of a 30 \% speed reduction (highest impact scenario) is an increased trip time of 43 \%, or 1.7 hours. The possible slow down also depends on the assumed original speed of the vessel; a ship that is already slow steaming will only make marginal if any fuel gains by slowing down.

The total costs for the sample for varying levels of impacts is presented in Table 5.1. The purpose of estimating a wide range of scenarios is to mirror the uncertainty of both current levels of speed adjustment policies and of waiting times.
Table 5.1 Monetary impact of speed reduction scenarios for sample

<table>
<thead>
<tr>
<th>Scenario (I)</th>
<th>Emission cost savings (euros)</th>
<th>Bunker cost savings (euros)</th>
<th>Total monetary impact (euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 % reduction in speed for 1 hour</td>
<td>105,392</td>
<td>66,100</td>
<td>171,492</td>
</tr>
<tr>
<td>10 % reduction in speed for 2 hours</td>
<td>210,784</td>
<td>132,199</td>
<td>342,983</td>
</tr>
<tr>
<td>10 % reduction in speed for 4 hours</td>
<td>421,568</td>
<td>264,399</td>
<td>685,966</td>
</tr>
<tr>
<td>20 % reduction in speed for 1 hour</td>
<td>199,074</td>
<td>124,855</td>
<td>323,928</td>
</tr>
<tr>
<td>20 % reduction in speed for 2 hours</td>
<td>398,147</td>
<td>249,710</td>
<td>647,857</td>
</tr>
<tr>
<td>20 % reduction in speed for 4 hours</td>
<td>796,295</td>
<td>499,419</td>
<td>1,295,714</td>
</tr>
<tr>
<td>30 % reduction in speed for 1 hour</td>
<td>286,900</td>
<td>179,938</td>
<td>466,838</td>
</tr>
<tr>
<td>30 % reduction in speed for 2 hours</td>
<td>573,800</td>
<td>359,876</td>
<td>933,676</td>
</tr>
<tr>
<td>30 % reduction in speed for 4 hours</td>
<td>1,147,601</td>
<td>719,752</td>
<td>1,867,352</td>
</tr>
</tbody>
</table>

5.3. Estimated benefits under alternative emission valuations

In the preceding section, a range of speed adjustment scenarios was introduced. As is shown by Table 5.1, the estimated emissions cost savings is larger than bunker cost savings by a factor of 1.6. The total estimated impact is therefore heavily dependent on the emission valuations that are used. As presented in section 3, two alternative sets of valuations can be used to perform a sensitivity analysis of the results with respect to this uncertainty. The summarized impacts of such an analysis are presented in Table 5.2, where a low and high scenario are presented, corresponding to the lowest and highest impact scenarios (I) defined in Table 5.1. The low-impact scenario thus corresponds to a 10 % speed reduction implemented 1 hour before arrival, and the high-impact scenario corresponds to a 30 % speed reduction implemented 4 hours prior to arrival. These scenarios are not chosen because they appear more likely than any other scenarios outlined in Table 5.1, but rather because they encompass the range of impacts. Out of the range of impacts outlined in Table 5.1, the scenario of 20 % speed reduction implemented 2 hours before arrival represents a median outcome.

---

5 The estimates presented in this table are based upon the estimated speed-fuel reduction relationships described in Table 3.2. The main emission unit values in Table 3.3 are used for calculations of emission cost savings.
Table 5.2 Total benefits for the sample under alternative sets of emission valuations

<table>
<thead>
<tr>
<th>Scenario (I)</th>
<th>Emission values</th>
<th>Low-impact (million euros)</th>
<th>Median impact (million euros)</th>
<th>High-impact (million euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td>0.112</td>
<td>0.421</td>
<td>1.214</td>
</tr>
<tr>
<td>Main</td>
<td></td>
<td>0.171</td>
<td>0.648</td>
<td>1.867</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>0.268</td>
<td>1.014</td>
<td>2.921</td>
</tr>
</tbody>
</table>

The benefits in Table 5.2 can be expressed as an annual estimate by scaling up benefits by the quota of annual cargo ship volume to sample volume. According to this procedure, the scope of the estimated annualized benefits under the median impact scenario is 8.5 to 20.5 million euros, ranging from the low emission cost case, to high emission cost case. The annualized median impact, main emission cost estimate is 13.1 million euros.

Figure 5.3 illustrates the relative magnitudes of emissions and bunker cost savings under the median impact scenario with different sets of emission costs. The estimated figure of 5 million euros in bunker cost savings can according to this analysis be seen as shipping businesses’ break-even level of annualized costs for implementing and maintaining a privately financed system of information sharing. Under all estimated scenarios, a large part of impacts is related to emissions reduction. Since the reduction of emissions is an external effect benefiting society, public policy makers may consider subsidizing a move toward information sharing practices in maritime ports for Pigouvian reasons.

Figure 5.3 Distribution of annualized cost savings under three sets of emission costs (median impact scenario)

---

6 This factor is \( \frac{5581}{276} \)

7 Pigouvian principles of taxation involves taxing or subsidizing in order to correct inefficient market outcomes in the presence of externalities. For readers unfamiliar with Pigouvian taxation, see Mankiw (2014) or any economics textbook.
5.4. Limitations

It should be noted that these results have some limitations, the most obvious of which is the wide scope of estimated annual benefits presented in the previous section. This is a reflection of both the innate uncertainty in society’s valuation of emission reductions, and the range of identified plausible impact scenarios. With more comprehensive data or a stricter set of assumptions, this range could be narrowed. Given the resources available and with respect to uncertainty, the results nevertheless present a feasible scope of bunker and emissions cost impacts.

There are a few other limitations to address. Firstly, since speeds of the vessels in the sample have not been directly observed but have instead been approximated as average vessel type operational speeds, it is possible that the actual benefit potential is smaller. This is because some shipping lines may already adopt some kind of speed adjustment policies. However, the aforementioned study by SSPA and Viktoria Swedish ICT confirms that a significant portion of vessels would be able to make gains by slowing down, which hints that there is in fact an underutilized speed adjustment potential. It may also be noted that the assumed operational speeds in this study are somewhat lower than the speed profiles described in the IMO Second GHG Study (Buhaug et al., 2009), which leads to a smaller risk of overestimation of benefits.

Secondly, there are issues associated with annualizing the results of a sample that is limited both in size and in scope of time. As shown in Figure 4.1, the month of August does not appear fully representative for annualized traffic, in terms of cargo type distribution. The extent of this misrepresentation is however difficult to determine from the data.

Thirdly, shipping is an industry that is characterized by both seasonality and cyclicality, where supply factors are more or less rigid in the short run. This means that a fluctuating level of demand will likely have a rather large impact on capacity utilization and waiting times in the port (see for instance Jansson and Schneerson, 1980). As the observed month of August appears to be a less busy month in terms of port approaches, the potential for arrival planning may be lower than during a peak. The market also plays a role in terms of whether ships are primarily taking spot contracts or longer freight engagements. Trading on the spot market may reduce the possibilities for planning and the incentives for speed optimization (Johnson and Styhre, 2014).

6. DISCUSSION

This study is focused on estimating the benefits of speed adjustment that could plausibly be enabled through enhanced ship-port communications in arrival planning. While this study describes the potential impacts of implementing a system for efficient communication in port, it does not attempt to explain how such a system would work, or what the investment and maintenance costs of such a system would be. However, the estimation of benefits do give some indication about what maximum level of costs would be acceptable to achieve cost-effectiveness. Under the main scenario, a level of information sharing that enables speed-adjustments in arrival planning appears profitable for shippers as long as the annual costs do not exceed 5 million euros. It would however be socially profitable as long as the annual costs do not exceed 13 million euros.

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8 The extent to which speed adjustment is already being implemented is an uncertainty factor, which was one of the motivations for using different impact scenarios.
A question that is not addressed in this study, but which might prove interesting in the long run is whether increased information sharing in the maritime industry is institutionally feasible. Though it may intuitively appear that a system that enables beneficial outcomes should be implemented, one might ask why such an implementation has not already been seen through. The fact that there appears to be an efficiency gap in shipping (see for instance Johnson et al., 2014, Buhaug et al., 2009) indicates the existence of a market failure. A potentially distorting aspect that could be considered is whether there are contractual incentives that prohibit efficiency gains from being realized. Given the collaborative nature of port processes, the full potential of integrated information sharing hinges on contracts being formulated in such a way that there is not an incentive for involved actors to contribute to inefficient behavior. Shipping contracts that require chartered vessels to arrive in their destination port as soon as possible, or at “utmost despatch”, are standard practice (Alvarez et al., 2010). A related instance of contractual inefficiency that may limit the potential for speed optimization enabled by information sharing is demurrage. Demurrage is compensation paid to a ship operator for days in port spent waiting, for instance because of congestion (Buhaug et al., 2009). If demurrage is high relative to fuel costs, there is an obvious tendency for the ship operator to arrive as early as possible, even if not contractually obliged to do so. This diminishes the fuel (and emissions)-reducing incentive.

The analyzed effects of information sharing are network effects, in the sense that the value of the services ought to be increasing with the number of shippers and port planning actors participating in the sharing of information. The rational decision of whether or not to participate in information sharing services is to a large extent determined by the expectations of each actor, and the amount of certainty regarding the outcome. A products or services market that is characterized by network effects can be hypothesized to have two extreme points of equilibria (see for instance Katz and Shapiro, 1994). If it is assumed by each shipping company that no other companies will participate in the service, no one will participate. This constitutes the first point of equilibrium, and a fulfillment of expectations. If it is on the other hand assumed by each shipping company that many other shipping companies will participate in the services, many will participate. This constitutes a fulfillment of expectations and a point of equilibrium where virtually all actors will choose to be a part of information sharing services. The implication of this is that proponents of information sharing services need to illustrate convincingly the benefits of participating in its services to all concerned actors, and should facilitate coordinated action from the industry, making possible joint declarations of participation. This could for instance be done in industry council bodies.

7. CONCLUSIONS

The purpose of this study has been to identify economic benefits of increasing communicational efficiency in maritime ports, and to estimate these benefits in the Port of Gothenburg. To this end, an analysis of transmitted arrival estimates has been performed, which indicated that there exists some current inefficiencies in communication, and that this inefficiency is particularly prevalent in the later stage of voyages. From this analysis, scenarios representing the potential gains in this stage were constructed and estimated. It is important to underline that no specific policy or system has been investigated, which is why this paper does not attempt to value investment and maintenance costs of implementation. The projected benefits do however give an indication of acceptable cost levels for economic efficiency.

The results indicate that speed adjustment policies in arrival planning, facilitated through increased information sharing, have the potential to deliver significant bunker cost savings for
shippers and emission cost savings for society as a whole. A median estimate of annualized total benefits of 13.1 million euros is estimated when the hypothesized impacts are evaluated for the Port of Gothenburg. Approximately 60% of these cost savings from enabling speed adjustment are related to the reduction in emitted air pollutants, indicating that there are significant positive externalities linked to increased information sharing.

Two major factors of uncertainty affect estimations in this study. Firstly, the results show that the extent to which an increased level of information sharing would benefit society excluding shipping companies is ultimately dependent on how emission reductions are valued. Secondly, the bunker savings expected to benefit shippers are primarily dependent on the extent to which speed optimization could actually be enabled by information sharing. Given these factors of uncertainty, this paper presents a framework for economic impact evaluation by assessing a wide range of scenarios for speed adjustment potential. These hypothesized impacts could however be narrowed and more explicitly evaluated, given more comprehensive data resources.

Another caveat is that the feasibility of a voluntary information sharing system would assume that the institutional structure of the shipping market is such that every actor is incentivized to share its information. Presumably, every shipping actor is benefitted by a more efficient turnaround in port, but if information-sharing practices contribute to less queuing and congestion there is an obvious free-riding incentive for the individual shipper. The case for a voluntary system is however desirable to make, since the imposition of mandates is challenging at the international level. A conclusion is therefore that the institutional side of information sharing processes in shipping deserves a more devoted academic effort.

ACKNOWLEDGEMENTS

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ABSTRACT

Purpose
The purpose of this paper is to gain insight into the research area of consumer logistics (CL). So far, logistics literature – in contrast to marketing channel literature – does not include consumers as active members of a supply chain into their considerations, even though consumers are also performing logistics tasks.

Design/methodology/approach
We have performed a content-based literature analysis and assessed the identified papers based on their content and methodological considerations. We further developed a model for future research on CL by adding the notions of consumer value and co-creation.

Findings
We found limited number of papers dealing with CL. These papers refer to four research areas, consumer logistics, shopper logistics, consumer performance and inventory management. They remain on a descriptive level and lack a theoretical discussion against the notion of consumer value and co-creation. We suggest to use Grönroos’ (2008) idea of consumer dominant logic (CDL) as a theoretical fundament for a better understanding of the role of CL within a supply chain.

Research limitations/implications
The paper is of conceptual nature and does not present empirical findings.

Practical implications
The paper offers insights into the field of CL which can be used for manufacturers and retailers of the grocery industry.

Original/value
This paper presents the first state-of-the art in the area of consumer logistics

Keywords: Consumer Logistics, Shopper Logistics, Consumer Value, Service Logic, Co-creation, Consumer Dominant Logic
1. INTRODUCTION

1.1. Problem background

Marketing channels evolve in order to fulfill the optimal service output for end-users offering them advantages in spatial convenience, bulk-breaking, waiting/delivery times and product variety (see Coughlan et al. 2006). Manufacturers and retailers have tackled these challenges by designing new marketing channels and enhancing the existing ones. Besides offering a wide product range, service becomes a unique selling proposition to increase shopper’s loyalty towards outlets and brands (Terblanche and Bishop, 2006). Basically, service is expressed by offering convenience to the consumer meaning to make shopping more easily (Coughlan et al., 2006).

Pushed by the technological change and the resulting mobility people receive, consumers want to achieve a special value – ‘consumer value’, which is defined as the ability of delivering the right quality at rapid response in a convenient manner at superior service at fair prices to the consumers (see ECR Europe, 1999).

However, when we think of the weekly or even daily made purchases – ‘shopping’, we observe a low involvement when it comes to a product choice (Beharrell and Denison, 1995). On the other hand, when we decide on which store to visit, it could be either heavily based on our routines, or depending on our other activities we’re conducting during the day. If other circumstances, such as time pressure, or just the uncertainty arise, not to have relevant information of particular product, we have to face different options of procurement, and shopping becomes a ‘complicated’ task. Then, planning and conducting shopping starts conditioning a high involvement (Beharrell and Denison, 1995).

This notion expresses the importance of the interplay between the entity ‘retailer’ and the supply chain’s last link, the ‘household’. Shopping has to be seen as the industry’s tool to improve the overall supply chain performance. It becomes necessary to integrate the consumer’s logistical procurement processes in order to increase consumer value. Including the consumer in the retail channel is an accepted view in marketing literature (see e.g. Coughlan et al., 2006), whereas logistics literature still ‘ignores’ the consumer’s role in distribution (Cochoy et al., 2014).

Granzin and Bahn (1989) founded a new research field under the term ‘consumer logistics’ (CL), which sets the fundamentals to examine the aforementioned gap. CL encompasses decisions and activities of households related to the central function of logistics – ‘bridging space and time’. Analogously to a business entity, a household can be viewed as a logistics system, too. A household consists at least of one person, or more. The need to consume provokes the household (the group leader) to engage in management and leading, in order to coordinate activities and decisions to keep the household running. The goal to fulfill the need of consumption is done by procuring and replenishing the right products and services. Once, a product is consumed, it may be disposed or even redistributed. This input-throughput-output perspective resembles a value creating process, as the better the system runs, the more output (consumption) is generated and value becomes added (Granzin 1988a, 1988b; Granzin and Bahn, 1989).

1.2. Problem statement, research question and structure of the paper

The purpose of this conceptual paper is to critically assess and reflect on the existing literature on the phenomenon of CL. The underlying research question is:
• What is the state-of-the-art of research in the field of consumer logistics?

By this we attempt to identify existing topical research streams and how these streams are methodologically attempted. Furthermore, research deficits shall be identified in order to propose a future research guide towards the challenges of retail channel management and its attempts of integrating the consumer to participate from the benefits of value-co-creation.

The remainder of the paper is as follows: After presenting the problem background and the need for this research, we present in section 2 our methodological considerations for our project. In section 3 we present and discuss the state-of-the-art of CL research, its research streams and methodological foundations. In section 4, we critically assess the results of our state-of-the-art and present the notion of value-co-creation as an alternative way for researching in this area. The paper closes with a critical discussion of our findings and a suggestion for future research.

2. METHODOLOGICAL CONSIDERATIONS

For the purpose of this paper we conducted a content-based literature analysis as suggested by Seuring and Gold (2012). The character of this paper is conceptual and is based on the findings of our secondary data collection and analysis. We attempted the research domain from a marketing channel and supply chain perspective and searched the databases ‘google scholar’, ‘business source premier’, and ‘WorldCat’. We started to conduct a title, author provided keywords, abstracts search for the terms ‘consumer logistics’, ‘shopper logistics’ or ‘household logistics’. Sighted hits included international journal articles, conference papers, abstracts, as well as ‘grey literature’. This preliminary search offered round about 600 hits, whereof ca. 500 were resulting from ‘google scholar’ and ‘WorldCat’, and approximately 100 from ‘business source premier’. The list of preliminary finding was then checked on content-based relevance meaning that we tried to get hold of the documents, read them and made a decision on its relevance. This process was done by two researchers in order to get a validated sample. The selection process resulted in body of literature consisting of 18 papers, as shown in table 1. These papers were further analysed.

3. RESEARCH STREAMS OF CONSUMER LOGISTICS

3.1. State-of-the-art on consumer logistics research

Our literature search revealed a sobering number 18 academic papers, which deal with consumer logistics issues. We have tried to cluster these papers into four topical areas, which are shown in Table 3.1.
<table>
<thead>
<tr>
<th>Stream</th>
<th>Authors</th>
<th>Methodology and research approach</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer Logistics</td>
<td>Granzin (1984)</td>
<td>Conceptual modeling, according to the ‘General Living Systems Theory’</td>
<td>Conceptualization of consumer logistics based on systems view; consideration of a household logistic system; sequential sequence of activities and decisions that determine an individual purchasing decision.</td>
</tr>
<tr>
<td></td>
<td>Granzin (1988a)</td>
<td>Conceptual modeling, from the perspective of distribution channels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Granzin (1988b)</td>
<td>Conceptual modeling, using an input-output system’s approach</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Granzin and Bahn (1989)</td>
<td>Conceptual model building, consumer logistics as a process within a household system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Granzin and Painter (1996)</td>
<td>Empirical Study – Survey of 202 married persons. Gender-role constructs are used to explain CL participation.</td>
<td>Embedding consumer logistics in the buying behavior of consumers based on logistic activities during the purchasing process</td>
</tr>
<tr>
<td>Shopper Logistics</td>
<td>Teller and Kotzab (2004)</td>
<td>Empirical Conceptual modeling according to the notions of Granzin and Bahn (1989). The Shopper as the center of decisions and activities.</td>
<td>Identification and specification of shopper logistics as part of consumer logistics; focusing on logistic activities of shoppers at point-of-sale, and willingness to outsource</td>
</tr>
<tr>
<td></td>
<td>Rovsek and Beskovnik (2015)</td>
<td>Empirical Study – Survey of 240 students, with the focus on identifying students’ readiness for outsourcing their logistics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gehrt and Rajan (2007)</td>
<td>Two focus group interviews conducted in U.S.A. and Japan offered an empirical attempt to derive factors explaining CL efficiency and effectiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gehrt et al. (2007)</td>
<td>Similar study to Gehrt and Rajan (2007)</td>
<td></td>
</tr>
</tbody>
</table>
3.2. Research stream: consumer logistics; the pioneers work from Granzin and colleagues

This research stream offers a generic CL approach, which is open to be applied of any kind physical and non-physical products. Further it includes a value adding perspective, whenever consumption goals are fulfilled, the household gains new resources in form of matter and/or energy.

The very first attempts of defining a research taxonomy reach back to 1984. Coming from a marketing perspective, Granzin (1984) stress out the importance for examining the consumer’s role in distribution. The simple fact that distribution ends when consumption starts, leads to the beginning of examining the logistics activities between the point-of-sale and the point of consumption (Granzin 1988a). By adapting the main logistics function (Bowersox, 1978), constituting the characteristics of distribution, a household composes its own channel of distribution, as consumers carry (transportation), replenish (inventory), place (location), unitize (handling & storage), and buy (communication) products in order to meet their consumption goals. They are performing a self-service by “(...) transferring a product (...) in space and time (...)” (Granzin, 1984 p. 168).

![Figure 3.1 Consumer Logistics Decision Model (Granzin and Bahn, 1989)](image)

The boundaries of CL are the peripheral of the household. The elements of the CL system are different tasks undertaken by the household members. The linkages between the elements are
concerned with matter/energy processing. The logistic system household can therefore either add or lose matter. Energy on the other hand is always the 'power unit', which lets the system perform.

The CL system is driven by the household’s want to achieve consumption goals. This perspective requires, that consumers are striving for a certain quality of life. Following this thought, ‘satisfaction’ becomes a measure for consumer logistics performance in this conceptualization (Granzin, 1988b).

A detailed formulation of the CL system can be found in the work from Granzin and Bahn (1989), in which they transferred their beginning thoughts in a consumer logistics process model, which constitutes the first milestone of CL. The model (illustrated in Figure 3.1) expresses a general sequence in which CL is performed in the system household. The CL process can be divided into 10 main decision areas.

Figure 3.2 Consumer Logistics Functions (adapted from Granzin, 1990)

The process of the system household is formed by the individual tasks household members have to perform in order to reach their consumption goals. Because, households are individual, objectives in regard to consumption are individual as well. Therefore, it becomes important to identify the main CL function households perform (Granzin 1990). Figure 3.2 gives an overview of the main CL functions, which determine the process of CL.
Further research from Granzin and colleagues was about the attempt to embed consumer logistics activities in the buying behavior. Granzin and Painter (1996) investigated CL participation of married persons in regard to their gender-roles within their household. By relating typical consumer logistics activities to the properties of shopping behavior such as e.g. shopping time, frequency, planning activity, and expenditures, Granzin et al. (1997) revealed six CL segments: ‘household captains’, ‘minimizers’, ‘extended shoppers’, ‘family shoppers’, ‘flexible shoppers’, and ‘helpers’.

The empirical study on the attempt to connect shopping behavior with CL was very much focused on ‘personal characteristics’ (e.g. store loyalty, and food preparation) and on household demographics (e.g. household size, and marital status). They could identify differences among the logistical engagement in shopping and named the segments: ‘searchers, sovereigns, communicators, carriers, out-sourcers, and uninvolved’ (Granzin et al., 2005).

Bahn, et al. (2015) offered the latest publication within this research stream of CL. Quite similar to the work from Granzin (1990) consumer logistics functions were derived via conducting a series of exploratory studies. In contrast to earlier research, this investigation was conducted against the background of a service-dominant perspective (Vargo and Lusch, 2004; Vargo, et al., 2008). The study revealed 10 logistics functions, in which retailers, or at least firms can contribute in the ‘end-users’ value creation process as the role of co-creator.

3.3. Research stream: shopper logistics

The second research stream is dominated by the research from Kotzab and Teller. In contrast to the consumer logistics model from Granzin and Bahn (1989), their notions concentrate rather on the shopper than on the household. This restricted perspective allows to neglect the intra-household processes and further refers shopper logistics to a pure procurement activity independent from the consumption (Teller and Kotzab, 2004).

Because ‘last mile logistics’ can either be conducted by the consumer in terms of a classic stationary retail outlet, or can be outsourced to third party logistics provider when it comes to distance retailing. Coming from this perspective Teller and Kotzab (2004) examined the consumer’s willingness to pay for a such a service. An empirical investigation with 611 face-to-face interviews however revealed that consumers only perceive their logistical tasks to a certain degree. This finding supports the notion that consumer logistics are conducted habitually. Further investigations in this stream, therefore concentrated on the influencing variables which determine the consumer’s decision to outsource their logistics activities, meaning e.g. shopping online. Kotzab and Teller (2005) further examined the effect of ‘logistical shopping constraints’ such as shopping frequency, distance between point-of-sale and point-of-consumption, and size of shopping basket, on the perception of consumer specific transportation costs in respect of the aforementioned willingness to pay.

Coming from the opposite perspective in regard to logistical constraints, Teller, et al. (2012) examined store-based retail formats in relation to shopper logistics. Their assumption is that according to a Stimulus)-Organsim)-R(isponse)-model, that properties of store formats influence the way shopper logistics are conducted. So the more convenience is offered by given store attributes, the less effort the consumer has in regard to their shopper logistics. This could be confirmed only to a certain degree, as it might be applied for utilitarian shoppers and not for hedonic ones (Teller, et al., 2012).

A broader perspective of CL was taken by Rovsek and Beskovnik (2015). They investigated students’ readiness to outsource their logistics activities under the context of being mobile in their daily routines.
Currently, Meyer et al. (2016) continued these notions by empirically identifying four management functions that determine shopper logistics. In their work, they also were able to distinguish between planning and execution of shopper logistics as well as the overlap between those. The overlap is due to internal as well as external disturbances and extends the total shopper logistics process as additional planning activities occur.

3.4. Other research streams

There are two more approaches of consumer logistics. One approach deals with application of consumer logistics in the field of financial services. Here, O’Brien et al. (2003) examined the performance of CL in terms of efficiency and effectiveness and their impact on consumer satisfaction. The same approach was repeated by Higuchi and Sakano (2003). A shared sample size of nearly 400 respondents offered the basis for structural equation modeling to test the hypothesized relations between CL tasks, its performance and consumer satisfactions. The results from this stream support these relations and emphasize the importance CL has for suppliers to enhance convenience to the end-user. Later work from Gehrt and colleagues applied the afore conceptualized CL framework in field of public railway transportation (Gehrt and Rajan, 2007; Gehrt et al., 2007).

An alternative conceptual approach to consumer logistics is offered by Boyd and McConocha (1996). Their conceptual thoughts are very much similar to the Granzin and Bahn approach from 1989, but are made independently. They name their model, consumer model management of household goods. In contrast to the CL model, they describe the household system according to three dimensions of motivations to which consumers are engaging in the procurement of goods: own, use, or reuse (Boyd and McConocha, 1996).

3.5. Critical reflection

The research by Granzin and colleagues is mainly characterized by conceptual considerations. They are describing consumer logistics according to a system approach, which offers a wide perspective and automatically connects the household’s contribution in logistics with activities and decisions of consumption. Therefore, the roles of household members and their engagement in consumption were examined from a logistics point of view. The interplay between the system’s elements was described according to the functions from Bowersox, (1978). In order to gain a broad understanding of what is going on in the field, CL functions were derived that constitute the process of CL. Further, CL activities were connected to shopping behavior in terms of patterns and segments. A very similar approach to CL was developed by Boyd and McConocha (1996). Other approaches (see e.g. Higuchi and Sakano, 2003) follow these notions and are more prescriptive in nature, as they refer CL performance (efficiency and effectiveness) as an indicator for consumer satisfaction.

In contrast to this, Teller and Kotzab developed a more specific conceptualization of CL, which disconnects CL from consumption in that way, that intra-household logistics are neglected, and e.g. activities such as food preparation are seen as pure consumption activity. Shopper logistics therefore comes rather from a logistics point of view and tries to examine CL as the logistical component of shopping. Because of this, retail store formats on the one hand, and consumer’s self-assessment of CL was investigated towards their impact on CL performance (Teller and Kotzab, 2004).

When we critically view the investigations made on the phenomenon CL in respect to value creation, we identify differences in the between CL and SL (see Figure 3.3). Coming from a value creating perspective, consumers add value whenever consumption can be realized.
Because, the Granzin and Bahn approach defines the point-of-consumption as the starting point of consumption activity, consumption preparation activities are included in CL, and value automatically refers the accomplishment of consumption goals. SL however, defines the POC as the peripheral of the household, which means that SL refers only to the pure provision of goods and services ready to enter the process of consumption. So value is coming from the service-output of SL.

In both conceptualization value is seen as an output of the logistical service conducted by the household or least the shopper. Having this in common, it is necessary to further extend CL on value-creation, to gain insight on how value is added, and how the actors of the whole value chain can support value creation.

4. Bringing Value Creation to Consumer Logistics

4.1. Choosing the right logic

When it comes to how consumer value creation can be described, marketing literature offers three different logics: Goods-Dominant-Logic (GDL), Service-Dominant-Logic (SDL), and Consumer-Dominant-Logic (see e.g. Anker et al., 2015).

While our economic thinking is generally based on GDL, we observe a logical shift to SDL thinking (see e.g. Vargo and Lusch, 2004 or Prahalad and Ramaswamy, 2004). GDL provides a view, in which value is created by firms and delivered to the consumer through products.
Because, consumers carry products from a point-of-sale to a point-of-consumption (in a typical shopping setting), this logic is not well suited to describe the value-creation derived from the consumer’s logistical effort. SDL associates however consumer value creation to interaction between the service-provider (e.g. a retailer) and the customer. The service is centered in this perspective, and is seen as the facilitation of value to the end-user. According to SDL, consumer value creation can be described within a CL framework, whereby the consumer is involved as a co-creator, because he makes the service (goods) available at the point-of-consumption. Quite similar to SDL is CDL. CDL centers around the consumer, who is at the same time user of the service and creator of value. Once, a service is ready to use, value creation (creation of value-in-use) can take place (Grönroos, 2012).

Thinking in terms of CL and SL, the CDL logic allows describing shopper logistics as a value facilitating process performed by the consumer, and value creation as the output from the SL-service in order to consume. Due to the scale and scope of this study, we opt for CDL as logic for value creation in a SL framework.

**Figure 4.1 Consumer Dominant Logic and Consumer Value Creation (adapted from Grönroos, 2008, 2012)**

Figure 4.1 illustrates the CDL between the supplier and consumer. The supplier plays the role of a value facilitator. Within the supplier’s sphere value-in-exchange is created (resources embedded in products, core-service, information, etc.). It is determined by the price, which the user is paying at the time of purchase. Once the service is utilized or consumed, value-in-use is created by the consumer, as long as value is emerging from the usage of the service (or product) (Grönroos, 2008, 2012).

**4.2. Value creation in consumer/shopper logistics**

In a typical retail setting, wherein the consumer is bridging space and time by carrying products home, the retailer facilitates their resources by providing the goods and infrastructure at the POS (creation of value-in-exchange). The shopper creates value-in-use once SL is conducted. Thereby he facilitates resources as well (e.g. using a car, spending energy) in order to make products available at the POC. So, in this case retailer and consumer are participating in the value creation process of the overall logistics service. Once the products are ready to consume,
value-creation ends. The following propositions give a starting point for further conceptual contributions:

- **Value-in-use-Proposition (VIUP):** The value that comes from the availability of having a service/product ready to consumer.
  - **VIUP1:** The more the consumer is involved in SL, the less value-in-use is he receiving.
  - **VIUP2:** The less the consumer is involved in SL, the more value-in-use is he receiving.
  - **VIUP3:** Value-in-use is directly influenced by SL performance in terms of efficiency and effectiveness.
  - **VIUP4:** Creation of value-in-use happens during SL.

- **Value-in-exchange (VIEP):** The value, which is created by the supplier by facilitating its resources (e.g. products) in form of logistics service delivery at the POS.

In this framework the consumer is the value creator, the retailer is the value facilitator, and may become a value co-creator under given circumstances.

### 4.3. A suggestion for future research in this area

CDL offers a new perspective from which consumer logistics/shopper logistics can be described in relation to its output: ‘the value coming from having products available to consume’.

The very first thoughts on CL already comprised a value creation and defined the value-added as consumers’ quality of life and suggested satisfaction for generic measure (Granzin, 1984). The latest publication from Bahn, et al. (2015) called attention to consumer’s logistical contribution in co-creation. Future research of CL should be dominated by conceptual works and focusing on consumer logistics value creation from CDL point of view. A distinction between SL and CL approach is not compulsory necessary. Rather a common ground has to be found. Here, the most challenging tasks are the differentiation of activities and decisions in regard to consumption and logistics. Thinking in terms of management dimensions on a strategic and operative level, offers an alternative way of interpretation (Meyer, Kotzab, and Teller 2016). Variables that affect CL should be investigated heavily to drive conceptual expansion. A so far neglected aspect of CL is the role of interaction between the shopper and the retailer and its impact on value co-creation (Grönroos 2008, 2012).

In order to gain a broad understanding of how value creation in consumer logistics works, a means-end approach might help (see e.g. Mentzer et al., 1997). According to means-end-theory, people have ideals and therefore follow specific goals. The ideals (values) affect consumer behavior. This theoretical approach views products as ‘means’ to achieve a goal (‘end’). This connection includes three association-levels, whereby attributes refer to consequences, and consequences refer to value (Reynolds and Gutman, 1988). Transferring the means-end model to consumer logistics would allow investigating value-creation from a consumer’s point of view. Attributes could be defined as the value facilitation in terms of store assortment and channel properties (infrastructure), consequences involve activities and decisions of consumer logistics and value could be defined as value-in-use, which comes from efficiency and effectiveness (see chapter 4.2). This could be realized by qualitative field research, using in-depth-interviews and participant observations.
5. SUMMARY AND CONCLUSION

The purpose of this study was to identify and to assess the state-of-the-art on research in the area of CL. Based on our findings and discussions we can answer our research question as follows.

Our literature review identified only a limited number of papers dealing with CL. These, we were able to group into four different areas of research referring to consumer logistics, shopper logistics, consumer performance and inventory management. Within these four areas, two research streams are dominating: consumer logistics and shopper logistics. Taking the notion of consumer value, we were able to see that earlier research on CL had already supported the discussion against a suitable marketing logic.

Having a marketing channel/supply chain understanding of logistics, we spotted the literature based on this perspective. This can be seen as a limitation to our literature search, which may lead to a neglect of other CL terminologies. For future studies, we need to identify also other perspectives, which may be of relevance for this topic, e.g. operations, consumer behavior, retailing or transport geography.

However, in total, research in the field of CL remains on descriptive level with a low integration of theory, e.g. theory on consumer value. In order to close this gap, we suggested to integrate Grönroos’ (2008) notion of CDL to the field of CL/SL as an instrument to describe value-creation in this area.

Furthermore, this study has revealed the need for more conceptual work with focus on variables affecting CL, and its creation of consumer value. From a methodological point of view, we propose a means-end approach for future research.

Retailers and manufacturers can gain new insights on how to design distribution channels in respect to their resource facilitation for increasing and/or supporting creation of value-in-use (consumer value). Research in CL/SL may also offer insights in channel choice behavior and further could reveal approaches to better attract consumers with online-sales-channels.

REFERENCES


ABSTRACT

Purpose
The business implications of additive manufacturing (AM) are explored; specific focus thereby lies on the impact of AM technology adoption in customized parts production.

Design/methodology/approach
Based on two explorative case studies from the hearing aid industry, the impact of AM technology adoption on supply chain business processes and management components is analyzed. General systems theory and a supply chain management framework serve as theoretical underpinning.

Findings
Not only primarily manufacturing firms’ internal processes and management activities, e.g. in material flow management, are affected by a changeover to AM, but also business processes and management components relating to the supply- and demand-side of a company’s supply chain.

Research limitations/implications
It is proposed that AM’s ability to economically build custom products provides the potential to alleviate the common dilemma between product variety and scale economies.

Practical implications
Manufacturing firms are encouraged to consider the potential effects of AM on supply chain processes and management components when deciding about the adoption of AM technologies in the manufacturing of industrial parts.

Original/value
The research adds to the widely unexplored effects that AM technology usage in customized parts production has on supply chain business processes and management components. Moreover, the general lack of case studies analyzing implications of AM technology adoption from a supply chain perspective is addressed. The resulting propositions may serve as a starting point for further research on the impact of AM in engineer-to-order supply chains.

Keywords: additive manufacturing, 3D-printing, supply chain management, customization, engineer-to-order, business processes, management components
1. INTRODUCTION

Due to increasing competition and heightened customer requirements, there is an increased need for firms to differentiate themselves in order to secure a competitive advantage. The customization of products may be an effective option to increase profit margins and customer satisfaction. One way to economically produce innovative, custom products with high added value is additive manufacturing (AM) (Mellor et al., 2014). Whether products are customized based on a standard set of components (mass customization) or are completely engineered and built to order: offering customer individual products provides the opportunity to satisfy unmet customer needs (Hart, 1995). There is also evidence that consumers tend to have a greater willingness to pay and wait for customized products than for standard products (Lee et al., 2002). However, this all comes at a price: customized production calls for a tighter integration of customers into the value creation process (e.g. co-design), which requires appropriate information systems (Da Silveira et al., 2001). Moreover, additional costs compared to mass manufacturing can arise from a loss of scale economies (e.g. due to the need for object-specific tooling), greater complexities in production planning and control, lower capacity utilization rates and a higher need for qualified labor (Piller et al., 2004). AM, commonly known as “3D-printing”, has the potential to change the common dilemma between unit costs and technological flexibility. The building process in AM typically happens “layer upon layer, as opposed to subtractive manufacturing methodologies, such as traditional machining” (ASTM Standard, 2012). Since it does not require object specific tools, the production of small lot sizes – even of lot size 1 – may become economically feasible (Berman, 2012). Especially in industries, where individual products are built using a high amount of manual labor, adoption of AM technologies has the potential to cut costs since design changes can quickly be conducted (Holmström et al. 2010). This reduces the need for manual labor. Despite the immense potential in the production of customer individual parts, there is a lack of case studies, which examine how AM technology adoption may affect the business processes and management practices in engineer-to-order supply chains. There is however reason to believe that AM may alter the way that such supply chains operate and are managed.

The present paper aims at filling this research gap by exploring the changes in supply chain business processes and management components, which result from two medical product manufacturers’ transition from manual to additive manufacturing of in-the-ear hearing aid shells. The hearing systems industry is well suited for case studies on AM applications in customized production, because there is a high need for individual products, which provide an optimal fit to the customer and ensure wearing comfort. Moreover, this is currently one of the fields (besides the dental and the jewelry industry) where AM technologies are most heavily used in industrial parts manufacturing – as opposed to rapid prototyping and “household 3D-printing” by private consumers. To date, over 10 million custom hearing aid shells have been produced worldwide using AM technologies (Crain’s Chicago Business, 2014).

This paper aims to answer the following research questions:

- **RQ1**: How does AM technology adoption in customized parts production impact supply chain business processes?
- **RQ2**: How does AM technology adoption in customized parts production impact supply chain management components?

Two explorative case studies from the hearing aid sector shall help to address these questions. General systems theory (Bertalanffy, 1969) serves as the theoretical basis for the examinations. In our study, the supply chain with its different actors (suppliers, focal firm, customers) as well as its inherent business processes and management components forms the “system” that is
regarded. In order to yield a supply chain perspective, the cases are not only constructed from interviews with representatives from the focal firms (i.e. the hearing aid manufacturers), but also include the perspectives of direct suppliers (i.e. material or AM machine suppliers) and customers (acousticians). The paper builds upon the supply chain management (SCM) understanding outlined by the Global Supply Chain Forum, according to which SCM is defined as “[...] the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders” (Cooper et al., 1997, p. 2). Moreover, the SCM framework presented by Lambert et al. (1998) is used to structure the examinations on the effects of AM technology adoption on supply chain business processes and management components. The terms “customized”, “custom”, and “customer individual” products are used interchangeably to describe products which are tailored to individual customer needs.

2. LITERATURE REVIEW

This section presents condensed findings of previous literature on additive manufacturing (AM) and its implications on supply chain management (SCM). The literature review culminates in the identification of research gaps, which lie at the heart of our study.

2.1. Additive manufacturing

In AM, products are built layer-by-layer based on a digital representation of the object, stemming e.g. from CAD-files or three-dimensional scans (Berman 2012). Commonly used synonyms for AM are “rapid manufacturing”, “digital manufacturing”, “direct manufacturing”, and “generative manufacturing” (Ebert et al., 2009; Holmström et al., 2010; Hopkinson and Dickens, 2001; Vinodh et al., 2009). Compared to other, more “traditional” manufacturing technologies such as milling and injection molding, AM technologies may offer distinct advantages (Berman, 2012; Holmström et al., 2010; Khajavi et al., 2014; Walter et al., 2004): since no object-specific tools are needed in AM, the manufacturing costs may be reduced, especially when producing small batches. This can render AM economically feasible for the production of customer individual parts. Furthermore, design changes can quickly be realized in AM since the tooling requirement is eliminated and the underlying CAD-files are easily adjusted. Material usage during parts manufacturing might also be reduced because – apart from potential support structures – material is only applied where it is needed to build the desired object. AM technologies also offer an increased freedom of design: even complex geometries can be realized, which would not be possible otherwise. Moreover, AM technologies are suitable for the creation of lightweight objects, because grids or even hollow structures may be produced. Finally, AM allows for the functional optimization and integration of products, e.g. by building objects, which formerly consisted of several subcomponents, in a single piece.

Current limitations of AM technologies include the restricted choice of materials and finishes, the lower level of precision compared to other manufacturing technologies as well as higher costs and a lower speed in the large-scale production of standardized products (Berman, 2012). However, AM machine vendors are actively addressing these issues. Thus, with ongoing technological advances, these limitations may become less relevant in the future.

2.2. Additive manufacturing in the context of SCM

Although AM is per se not a new topic, it is still widely unexplored from a research perspective. Current research on AM can broadly be classified into six different research streams: (1) Studies
outlining the current state-of-the-art in AM, e.g. with regard to industry applications and technological maturity (e.g. Bak, 2003; Berman, 2012), (2) engineering-focused studies, which aim to develop new or improve existing materials or technologies for AM (e.g. Murr et al., 2012), (3) studies analyzing the adoption of AM technologies (e.g. Oettmeier and Hofmann, 2016), (4) research examining the costs of AM (e.g. Hopkinson and Dickens, 2003; Ruffo et al., 2006), (5) studies on the implementation of AM and make-or-buy decisions (Mellor et al., 2014; Ruffo et al., 2007), and (6) research addressing AM in the context of SCM (e.g. Holmström et al., 2010; Khajavi et al., 2014). The major part of the latter regards the opportunities and impact of AM in spare parts supply chains. There seems to be a consensus about AM’s potential to enable a distributed production of (spare) parts, which may even take place on-demand (Holmström et al., 2010; Khajavi et al., 2014; Mellor et al., 2014).

Several studies indicate that AM technology usage may have an impact on different actors in the supply chain, such as suppliers, manufacturing firms, and customers. For example, Holmström et al. (2010) note that AM has the potential for simpler (shorter and narrower) supply chains. This is probably because AM technologies provide the opportunity to integrate more functionality into products and to optimize products for function (Holmström et al. 2010), which can reduce the number of subcomponents needed and hence of suppliers. Berman (2012) suggests that small batch production could be transferred back from low- to high-wage countries since AM may lower the need for manual labor. This seems to be particularly relevant for firms offering handmade, customized products down to a lot size of one, as these are particularly labor-intensive. With AM, a firm’s operations could also become more agile (Vinodh et al., 2009), e.g. due to the technologies’ ability to rapidly alter product designs. Customers of additively manufactured products could benefit from higher service levels as production may be decentralized and thus occur closer to the customer (e.g. Holmström et al., 2010; Khajavi et al., 2014; Walter et al., 2004).

The insights from the literature indicate that AM technology usage may not only have implications on the configuration of supply chains, but also on business processes and management components employed by different actors. For example, to seize the increased opportunities in product design enabled by AM technologies (e.g. lightweight construction and functional integration), new or adjusted processes and management practices in research and development seem to be inevitable. In their framework for AM implementation, Mellor et al. (2014) point out that – among other aspects – a transition to AM may also evoke changes in process planning and product design as well as in quality control and the required workforce skills. Although the identified elements help to localize potential areas of impact of AM technology adoption on processes and management practices, there is still substantial room for further research in this area. To our knowledge, no study has systematically analyzed the effects of AM technology usage in customized parts production on supply chain business processes and management components. While the potential impact of AM on supply chain structures has already been examined to a certain extent (although not in a systematic fashion), the effects on business processes and management components have been rather neglected. Moreover, the implications of AM technology adoption on SCM have only been pointed out generically, but have not been discussed in a differentiated way.

2.3. Résumé of the literature review and research gaps

The review of the literature has shown that in recent years, AM has increasingly been gaining attention from researchers. This is due to the fact that AM technology usage may have far-reaching business implications, which could go beyond a mere technological innovation. An analysis of the existing literature reveals two research gaps: (1) Although different studies
mention potential benefits of AM (e.g. Berman, 2012; Holmström et al., 2010), which may have an effect on SCM, the impact of AM technology usage in customized parts production on supply chain business processes and management components has never analyzed in a systematic way. Moreover, (2) there seems to be a general lack of case studies, which explore the implications of AM technology adoption from a supply chain perspective. By analyzing how AM technology adoption in customized parts production impacts supply chain business processes and management components, this paper aims to fill these gaps in research.

3. METHODOLOGY

In order to close the identified research gaps, the case study method is used. This seems appropriate since our research is of explorative nature and aims to contribute to new theory building (Eisenhardt, 1989; Yin, 2009).

3.1. Study design and conceptual framework

As our research questions focus on the impact of AM technology adoption on supply chain business processes and management components, we take a network perspective as our level of analysis. The scope of the analyzed supply chain encompasses the triadic network formed by the focal firm (hearing aid manufacturer), its direct suppliers (material or AM machine suppliers) and customers (acousticians). Interviews were not only collected from key informants of the hearing-aid manufacturers’ production, logistics or R&D departments, but also from liaison persons from sales or R&D of their suppliers (material or machine suppliers) and customers (acousticians). In order to increase construct validity, we employed multiple sources and types of data collection. Semi-structured interviews are the main source of information for this study. They lasted between 30 minutes and 5 hours and were all carried out by the same research team. The interviews covered the topics laid down in a semi-structured interview guide, which was based on the elements of supply chain business processes and management components outlined by Cooper et al. (1997).

To explore the impact of AM technology usage on supply chain business processes and management components, we analyze how these two SCM elements have changed due to AM technology adoption (see Figure 3.1). Following the understanding of Cooper et al. (1997, p. 5), we define supply chain business processes as “activities that produce a specific output of value to the customer.” We distinguish between 5 types of such processes: (1) order fulfillment, demand, customer relationship and service management, (2) manufacturing flow management, (3) procurement, (4) product development and commercialization, and (5) returns. The SCM components are specified as “the components by which the business processes are structured and managed” (Cooper et al., 1997, p. 5). In our study, we specifically focus on how planning and control structures, organizational, IT and work structures, as well as management methods are altered due to the adoption of AM technologies in customized production.
3.2. Case selection and sampling

Our study examines the impact of AM technology adoption in customized parts production on supply chain business processes and management components. To analyze these aspects, we chose firms, which (1) currently use AM technologies to build customized parts and (2) had engaged in traditional manufacturing of customized parts before changing to AM. The case companies both stem from the same industry (hearing systems), but differ with regard to their experience with AM as well as the way and extent to which the technology is deployed within the supply chain. By collecting such diverse cases, we aim to increase external validity and thus make the results more generalizable (Eisenhardt, 1989; Yin, 2009). The hearing aid industry appears to be an appropriate focus for this study because there is a high need for customized products in order to guarantee the best possible accuracy of fit to the customer. In-the-ear hearing aids consist of shells, which are shaped according to the individual consumer’s ear canal. Typically, acousticians take silicone ear impressions from consumers, which then depict the basis for (manual or additive) shell manufacturing. Apart from the shell, in-the-ear hearing aids contain a kit with electronics (e.g. battery, volume control, microphone, and buttons for selecting between different programs). It is a standard part that can be adapted to specific customer needs if necessary. The electronics are usually mass produced using traditional manufacturing technologies, whereas the integration of the kit into the shell is mostly a manual process. The hearing systems industry depicts one of the few fields – apart from the dental
sector – where AM technologies have already been extensively used in industrial parts production for more than 10 years. It is assumed that the full scale of changes in supply chain business processes and management components due to AM technology adoption can best be studied in such an industry, where AM is an established technology, as opposed to sectors, which are currently undergoing the transition towards AM. Before their switchover to AM, both case firms engaged in “manual manufacturing”, meaning that hearing aid shells were handcrafted. The high share of manual labor is typical for the hearing systems industry, because the small size of the final products with dozens of tiny components and complex geometries requires a great level of precision in manufacturing, which cannot be easily automated. We suspect that in industries with a high share of manual labor, the potential impact of AM technology adoption will become particularly apparent. An overview of the cases is provided in Table 3.1. Greek letters replace the company names as we promised anonymity to the interviewees.

Table 3.1 Case overview

<table>
<thead>
<tr>
<th>Study perspective</th>
<th>Case characteristics</th>
<th>Number of interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Selection criterion</td>
<td>Size</td>
<td>Origin</td>
</tr>
<tr>
<td>Alpha</td>
<td>Large-scale worldwide customized production of AM technologies, long-term experience with AM technologies in industrial parts manufacturing</td>
<td>Large</td>
</tr>
<tr>
<td>Beta</td>
<td>Medium-scale customized production with AM technologies, short-term experience with AM technologies in industrial parts manufacturing</td>
<td>Medium</td>
</tr>
</tbody>
</table>

In line with Eisenhardt (1989) and Seawright and Gerring (2008), we pursued a two-step analytical sampling approach. In a first step, we aimed to identify a relatively homogenous sample with regard to origin (Europe, to ensure that all firms operate in a similar legal and market environment), firm size (only large or medium-sized companies), and area of AM technology usage (production of customized in-the-ear hearing aid shells). Large firms were selected because we suspected that the impact of AM technology adoption on supply chain business processes and management components will be more visible here than in small
companies, as more efforts need to be taken to integrate the technology into existing systems. In a second step, we identified firms that had different levels of experience with AM technology usage in customized production. Therefore, apart from a firm with a long-term history in large-scale AM, we also included a company in the sample, which had only recently started to use AM technologies for medium-scale production. In this way, we aimed to obtain a better understanding of business processes and management instruments or practices, which are immediately impacted by a transition to AM as well as those, which may be altered or implemented in later stages of AM technology deployment.

3.3. Data analysis

We followed the qualitative data analysis approach by Strauss and Corbin (1990), as our collected data was rich in information but unstructured. First we conducted a within-case analysis to understand the supply chain business processes and management components used by the firms and the way in which AM technology adoption impacted these. We triangulated data, using not only insights from the transcribed interviews, but also from our observations during the site visits as well as official company documents (e.g. information from the company website). Thereafter, we performed a cross-case analysis to spot common patterns among the cases. Finally, we chose those business processes and management components, which were particularly affected from AM technology adoption and promised to be most interesting for future research.

4. RESULTS

In this section, the observations from our explorative empirical analysis on the effects of AM technology adoption on supply chain business processes and management components are presented.

4.1. Procurement

With the adoption of AM technologies in the production of hearing aid shells, Alpha (fictitious company name) had to change its supplier base and purchasing process. While in the past, the liquid acrylic for shell manufacturing was sourced from local suppliers in a decentralized way, the firm now centrally procures the acrylic via the machine manufacturer. The material is specifically tuned to the AM machines to ensure optimal product quality. Therefore, the machine manufacturer works closely together with a material supplier, who exclusively produces the acrylic for the AM machines. This “closed system” creates a lock-in effect for Alpha as the company cannot easily qualify another material supplier. Apart from setting up a centralized system for the procurement of AM materials and processes, the firm also increased standardization: “We have the same processes, the same materials, the same equipment and the same processing time [in all our plants where AM technologies are employed for in-the-ear hearing aid shell production].” This was due to a greater need to gain control over product quality as the AM machines are not only very sensitive to different parameter configurations, but also to material properties. Consequently, the acrylic procured for AM is the same for all plants worldwide and a centralized incoming goods inspection for machines and materials was implemented. Moreover, Alpha’s purchasing department now has to pursue a more long-term vision when spotting and evaluating new AM technologies, because “[t]he machines that are in place today will also be in place in the next 5 years.”
With its transition to AM, Beta (fictitious company name) also had to include a machine supplier into its supply chain. However, the company did not need to change its material supplier as the acrylic producer offers material that is compatible with Beta’s AM machine. The hearing systems firm chose an “open system”, according to which the machine supplier does not oblige manufacturers to obtain their AM materials from a single source. Beta also had to develop new criteria for supplier selection: “One topic during machine selection was the integration into our strategic production planning, i.e. the reduction of lot sizes and the shortening of lead times.” Such considerations were not relevant for procurement in times of the manual production of customized hearing aid shells, because lot sizes were always one, regardless of which material was used. Beta’s remaining criteria for supplier selection remained unchanged: The firm has always placed great emphasis on service quality and the technological reliability or availability of procured machines. However, in the past, the latter criteria did not apply to the purchasing activities for shell manufacturing as no machines were used in hearing aid shell production. Overall, it is proposed that:

Proposition 1a (business processes): Considerations concerning strategic production planning and potential lock-in effects are more relevant in the selection of suppliers for AM than for manual manufacturing.

Proposition 1b (management components): The transition from manual to additive manufacturing of custom products requires the buildup of specific know-how in procurement about the characteristics of AM machines and compatible raw materials.

4.2. Manufacturing flow management

Before changing to the usage of additive technologies in hearing aid shell manufacturing, Alpha and Beta engaged in manual shell production. The production processes before and after this transition are similar for both firms and are summarized in Figure 4.1.

It becomes apparent that Alpha and Beta now produce the customized shells in batches of 12 to 40 parts per building job (depending on the part size and the size of the AM machine’s building platform). In the past, shell manufacturing was a single part production, where the formation of batches was not possible at any point in the process. Moreover, the division of labor in manufacturing has increased since AM technology usage. While the production of a hearing aid was originally oftentimes carried out by a single person, there are now various employees involved in this process, e.g. 3D modelers, AM machine controllers (who also carry out post-processing of the shells) and specialists, who build in the electronics and conduct the testing. This specialization of manufacturing staff is enabled by the outcomes of the 3D modeling process: a printout of the customer individual hearing aid model visualizes the shape of the finished product and illustrates where the electronics is to be placed inside the shell. The information is transmitted to every employee who is involved in the production of the specific hearing aid. The higher separation of labor has had positive effects on process and product quality. A strategy and operations manager at Alpha said concerning this aspect: “[In the past,] everything was often done by one person: from the beginning until the end, including the testing. Today one person only carries out one step, e.g. the modeling. This kind of industrialization certainly makes people become much more experienced and gets them to fulfill their tasks at a hundred percent.” From a management perspective, the transition to AM helped the firms to improve the training and evaluation of manufacturing staff. For example, the informant from Alpha expressed: “Nowadays we can better control and train these things [how hearing aids are to be built]. There is a relative consensus, e.g. about how an impression is cut electronically and in which angle it is build best, so that in the end, the finger can reach the device […] In the past, this was harder or actually not possible. Previously, you did not really know what was
“done there – it was just done.” Alpha’s order lead time of 5 days (inbound delivery of the impression: 1 day, hearing aid production: 3 days, outbound delivery of the final product: 1 day) has not decreased substantially due to the transition from manual production to AM. However, changing from single unit to batch production of shells greatly improved process reliability. Thus, the firm’s aim of manufacturing its products within 3 days was increased from only 50% (with manual production) to 80% (with AM).

![Hearing aid shell production before and after AM technology adoption](image)

**Figure 4.1 Hearing aid shell production before and after AM technology adoption**

According to the plant and operations manager at Beta, building up the know-how for modeling the hearing aids was a challenging task, as very specific expertise is needed. The required visualization skills could not always be found among the existing manufacturing staff. Therefore, the company also had to recruit employees who had the required skills and could bring in new know-how. Due to the transition to AM, the firm not only needed to include a 3D modeling process in their supply chain, but also had the opportunity to bundle its modeling competences and differentiate between product design (i.e. modeling) and manufacturing. For example, the digital blueprints for the hearing aids for the North American market are created by Beta’s plant in Germany, since the company’s US plant lacks the required modeling know-how.

**Proposition 2a (business processes):** The adoption of AM technologies in customized production increases industrialization of manufacturing. Scale economies can be generated in product modeling (e.g. due to a bundling of design authority) and through batch production.

**Proposition 2b (management components):** AM offers greater quality management and employee training possibilities than manual manufacturing. It requires new skill profiles and work structures since technical experts are needed for operating the 3D scanning and modeling programs as well as the AM machines.
4.3. Product development and commercialization

The adoption of AM technologies also has implications on product development and commercialization. The informant at Alpha notes that due to their switchover to AM, there are less barriers to what can physically be realized. For example, thanks to AM technologies, the hearing aid shells have a smaller and better controllable thickness, which allows engineers to integrate more functionality into the shell. Compared to that, the design opportunities during the original casting process were rather limited. Additionally, Alpha’s developers are supported in their modeling tasks by CAD software, which limits the risk of conceptual flaws. However, the increased design opportunities due to AM technologies also require the buildup of specific know-how in R&D in order to seize this potential. Alpha’s switchover to AM did not evoke any substantial improvements in the overall time-to-market. In the future, the company is hoping to develop better materials and modeling strategies thanks to a more accurate input database fed with automatically generated data captured during AM.

Alpha and Beta both use AM technologies for building prototypes (“rapid prototyping”). According to the R&D manager at Beta, whenever possible the AM machines employed in serial production are used in order to quickly visualize new product ideas. Otherwise, external service providers build the prototypes based on 3D model data. Due to rapid prototyping, Beta has been able to increase the market acceptance of new products since customers (acousticians) can earlier be integrated into the product development process, e.g. for usability studies. The firm also managed to decrease its time-to-market due to AM technology adoption, although only to a small extent. New product developments at Beta typically take 2 years – a duration, which seems to be hard to shorten. According to Beta’s R&D manager, the most important advantage of using AM technologies in prototyping is the higher level of product security, which could be achieved. Instead of developing products that do not function as desired, errors can be detected early in the process. Thus, although product development has hardly accelerated in terms of duration, it has become more cost efficient. The informant also notes that due to rapid prototyping, the tasks in product development have become modularized and interaction between developers has increased: “Nowadays there is a completely different way of communication, which is of course also new to the elderly colleagues. They sometimes have trouble coming over with their drafts at an early stage and putting them up for discussion.”

The above analysis indicates how the usage of AM technologies in prototyping may impact processes and management activities in product development. However, a clear distinction should be made between the effects in rapid prototyping and the changes that AM technology adoption in industrial parts manufacturing evokes in the field of R&D. Numerous manufacturing firms have already seized the opportunities of rapid prototyping to speed up development processes. However, a transition to AM in industrial parts manufacturing does not necessarily imply that firms will also engage in rapid prototyping, although in practice this often seems to be the case. Overall, the analysis shows that despite an increased freedom of design and corresponding employee training needs, the impact that AM technology adoption in customized production has on product development and commercialization, is rather small. Greater effects in this area can be found when AM technologies are also used for rapid prototyping. Overall, it is proposed that:

Proposition 3a (business processes): AM technology adoption fosters the development of new or improved products by providing detailed input data about the manufacturing process.

Proposition 3b (management components): The buildup of new know-how in R&D is required to seize the greater freedom of design enabled by AM technology adoption.
4.4. Order fulfillment, demand, customer relationship and service management

Due to the transition to AM of hearing aid shells, Alpha is driving for a stronger digitization in its relationship to the customers (acousticians), particularly in order fulfillment. The company already has a process with around 2% of its customers in place, where the acoustician scans the ear impression and digitally transmits the 3D data to Alpha along with the order form. In this way, a physical delivery of the impression is omitted and the production process can begin quickly. For the remaining customers, the firm still receives the impression and conducts the scanning process itself. The interviewee from Alpha notes that thanks to AM technology usage, the firm’s customers could benefit from a constant order lead time, a greater fitting accuracy as well as a smaller size of the in-the-ear hearing aids.

Since AM of hearing aid shells is still rather new for Beta, the firm has not started to use 3D scanning with its customers yet. However, the firm has already introduced a process where the physical impressions received from affiliate stores are all scanned, even if they are destined for other hearing systems manufacturers. The third party manufacturers thus do not receive any physical shipment with impressions but only the 3D data along with the order information.

The representatives from Alpha and Beta both expect that in the future, ear impressions from final consumers may be substituted by 3D ear scanning. Such a higher degree of process integration could strengthen the relationship with customers. The case studies do not show any impact of AM technology adoption on demand forecasting. The plant and operations manager from Beta explains: “We still have a make-to-order production. The demand on the market has not really changed due to additive manufacturing.” These findings culminate in the following propositions:

*Proposition 4a (business processes):* Demand forecasting remains unchanged when switching from manual to additive manufacturing of custom products, whereas order lead time is reduced.

*Proposition 4b (management components):* AM technology adoption in customized parts production leads to a tighter integration of customers into the value creation process (especially virtually by using electronic means).

4.5. Returns

Since AM allows for a greater precision than the traditional shell manufacturing process, the thickness of the shells can be decreased and the amount of unnecessarily cured acrylic during the building process is minimized. According to Beta, the material utilization rate has increased to around 98% while overall material usage has declined. The material, which is not cured throughout the additive building process, can be reused and filled up with additional liquid acrylic. In contrast, excess material from the traditional casting method was typically disposed.

Furthermore, the informants from Alpha and Beta note that due to their transition to AM, complaint processing is accelerated and object replicability greatly improved. This can be traced back to the automated production process and the fact that the firms have established a database where they keep the 3D model data. “[...] when a new shell has to be built, you have the possibility to quickly react to it with additive manufacturing. You do not need another impression for that. [...] If you still have the 3D data of the impression, you can instantly newly produce [the shell]” (plant and operations manager from Beta). Based on our findings in the field of returns, we propose the following:
Proposition 5a (business processes): The adoption of AM technologies in customized parts production speeds up complaint processing and increases material utilization compared to manual engineer-to-order production.

Proposition 5b (management components): Firms can only benefit from accelerated complaint processing due to AM technology adoption, when IT systems are in place for storing the 3d model data.

5. DISCUSSION

Based on our empirical analysis, we developed five propositions which touch upon the impact of AM technology adoption in customized parts production on supply chain business processes and management components. It becomes apparent that AM may not only have far-reaching implications on manufacturing flow management, but also on procurement, product development, order fulfillment, demand, customer relationship and service management, as well as on returns.

The findings with regard to production suggest that a change from manual engineer-to-order production to AM has the potential to increase the division of labor in manufacturing. Scale economies may be generated by bundling 3D modeling competences and by simultaneously producing several customized parts in the same production job. AM’s ability to economically build custom products provides the potential to alleviate the common dilemma between product variety and scale economies. Thus, unit production could shift to customer individual mass production (see Figure 5.1). We propose that the smaller the products are and the greater the ability to build entire custom products with AM technologies is, the greater the decline in unit costs and the increase in batch sizes will when switching from manual production to AM.

Our research also shows that AM technology adoption may help to improve quality management, including employee training and evaluation. This seems to be particularly relevant in an engineer-to-order environment such as in the production of customer individual hearing aid shells, jewelry, dental crowns and implants. Differing customer requirements per product and the higher need for manual labor compared to mass manufacturing make it harder to ensure object replicability and a consistent product quality.

On the supply-side, AM technology adoption seems to increase the need for collaboration between material and machine suppliers, because AM materials and machines have to be compatible with each other to yield quality products. This may not only hold true for customized parts manufacturing, but also for other potential fields of AM application, such as spare parts or lightweight construction. Furthermore, manufacturing firms may have to extend their supplier selection criteria by longer-term considerations such as strategic production plans, since a potential transition from single unit to batch production needs to fit the overall production system. It can be argued that the need to acquire new know-how in procurement concerning AM machines and materials generally depicts the “price” of switching from manual to automated production. However, this does not seem to be completely accurate for AM: while materials for traditional manufacturing processes (e.g. metal blocks for milling or drilling) can typically be used in both, manual and automated production, the materials for AM are often specifically developed for AM machines. Thus, the materials here are usually different from those employed in manual manufacturing.
On the demand-side, AM of custom products may increase the level to which customers are virtually integrated in a manufacturer’s supply chain. This can eliminate certain inbound or outbound deliveries and reduce order lead time. Demand forecasting does not seem to be affected by a changeover from manual to additive manufacturing because the demand in innovative supply chains with a high product variety is typically unpredictable (Fisher, 1997). With regard to returns, AM may not only increase material utilization, but can also speed up claims processing by replicating parts based on digital representations of the object.

6. CONCLUSION

Based on two in-depth case studies from the hearing systems industry, this paper analyzed how AM technology adoption in customized parts production impacts supply chain business processes and management components. The findings reveal that not only primarily manufacturing firm-internal affairs (e.g. material flow management) are affected by a changeover to AM, but also business processes and management components that touch upon the supply- and demand-side of a firm’s supply chain (e.g. procurement and customer relationship management). It is suggested that AM’s ability to economically build custom products provides the potential to alleviate the common dilemma between product variety and scale economies. Therefore, thanks to AM, firms that engage in the traditional production of customized objects may realize a transition from single unit to batch production while at the same time maintaining their flexibility to offer customized products.
The contribution of this paper is manifold. From a theoretical perspective, it adds to the widely unexplored field in the literature that studies the effects of AM technology adoption in engineer-to-order supply chains. Moreover, we hope to foster theory-building research in operations management in general, and on the business implications of AM in particular, through the proposed matrix about AM’s potential in customized parts production. Practitioners can benefit from a better understanding of the opportunities and challenges that AM technology usage may bring in customized parts production. Manufacturing firms are encouraged to consider the potential effects of AM on supply chain processes and management components when deciding about the adoption of AM technologies in the manufacturing of industrial parts.

The explanatory power of this study is somewhat limited due to the relatively small sample size and the focus on the hearing systems industry. Consequently, the findings cannot easily be generalized. Although the questions posed to the interviewees always emphasized on the changes that can directly be attributed to AM technology adoption, it cannot fully be ruled out that other influencing factors (e.g. general improvements in operations) may also have had an impact on the firms’ supply chain business processes and management components.

Future research should provide more detailed insights in the supply chain implications of AM technology usage in an engineer-to-order environment. The areas of impact identified in the mark of the present paper could provide a starting point for such investigations. Especially research which further investigates the proposed potential of AM to alleviate the common dilemma between scale economies and product variety would be interesting. Moreover, case studies from other industries that apply AM technologies in engineer-to-order supply chains (e.g. the dental and jewelry sector) would be of value.

REFERENCES


ACCESSIBILITY OF MATERIAL LOGISTICS SERVICES IN HEALTHCARE

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ABSTRACT

Purpose
This research aims to optimise the accessibility of material logistics support services of healthcare in sparsely populated area by the delivery efficiency and geographic reach. The strategic choice between centralised and decentralised service models is considered.

Design
The characteristics of material logistics services of different kinds of healthcare units in the case area are researched through interviews from five hospital districts (Finland and Sweden). Geographic information systems (GIS) based accessibility analytical framework of vehicle routing and heuristic computations are applied to assess suitability of different warehouse sites and their combinations in sight of efficiency of potential delivery network.

Findings
The great majority of health centres and hospitals in the case area can be served by delivery network based on one or two warehouses. Efficiency of the delivery network does not increase remarkably by increasing number of warehouses, when measured as a driving time.

Research implications / limitations
Geographically reasonable accessibility is reached even with lower amount of warehouses. However, the used calculations may simplify the phenomena leaving out describing characteristics of the healthcare context. Suitable approach to continue the analysis would be to calculate warehouse and delivery network setting with the best geographical coverage and capacity needs comparing to the most effective setting.

Practical implications
Public healthcare systems in sparsely populated areas have potential in finding efficiency through geographically centralized model of material logistics services.
This study gives new insights by the mixed methods (GIS method used jointly with the qualitative data) and multidisciplinary approach.

Keywords: Healthcare, Accessibility, Logistics, Services, Trade-off

1. INTRODUCTION

The public healthcare systems are facing complexities in providing quality care at affordable cost (Jarret, 1998). This has led healthcare organisations and societies internationally to consider macro and micro level reforms to reduce costs and still receive more value (Kaplan and Porter 2011). One way of reducing costs and increasing service level is by improving material logistics in health care (Poulin, 2003).

Despite remarkable development of logistics and logistics services during the last 60 years (Klaus 2009), healthcare remains far behind the manufacturing industry and retail business. The main reason for that are unique features of healthcare as a context. This affects the applicability of logistics and supply chain management knowledge from the industrial sector (de Vries and Hujisman, 2011). The unique features are so strong that healthcare should not be considered as one “industry”. However logistics and SCM may have good potential in getting cost reductions and better services in healthcare organisations. (Jarret, 1998.)

This paper introduces case from the area of Northern Finland, characterised by sparsely distributed population and long distances. The public healthcare system consists hospital districts (hospitals) offering special healthcare and municipals (health centres) offering general medical practices.

Material logistics in the area is fragmented in many ways. Although procurement of the different organisations may have joint organisations, material logistics is taken care of separately. Despite some exceptions in Northern Finland nearly all the municipals and hospitals have their own warehousing functions for the care items and other articles needed in healthcare processes.

In the case area there is pressure to rationalise warehousing functions of health care and to centralise activities to one or a few locations. Centralising warehousing functions, cost-effectiveness is sought by rationalising the number of stocking points, diminishing needed driving time, reaching the economies of scale, reducing wastage, rationalising stock items and inventories etc. To examine these possibilities, this paper introduces a geographic information systems (GIS) method and its application for an analysis of optimal locations for one or a few warehouses on the base of accessibility.

Geographic accessibility analysis lends itself to quantify opportunities and constraints of freight deliveries in the context road transports (Rodrique et al., 2006). GIS may be effectively applied in managing coordinated data of freight delivery demand and potential warehouse sites, and in generating optimised routes for delivery network by using the digital model of road network (Miller and Shaw, 2001). On this basis, a set of simulated delivery networks may be used to evaluate the suitability of different potential warehouse sites and their combinations in sight of efficiency.

This research aims to optimise the accessibility of material logistics support services in healthcare in sparsely populated area. In broader perspective this can be seen as making the services accessible by optimising the logistics delivery network. The aim of this study is approached through three research questions:
1. How dense service network is required in assuring logistics services for healthcare in sparsely populated area?
2. What are the most efficient centralised warehouse locations by minimised travel time of potential delivery routes?
3. How GIS-optimised freight delivery network could be beneficial for logistics support services in long distance healthcare?

The paper is organised as follows: Chapter 2 begins with a brief overview of healthcare material logistics followed by the concept of trade-off. Chapter 3 details the used methods, both qualitative and quantitative parts. Chapter 4 brings in the findings of this paper specifying the healthcare material logistics services in the case area and the opportunities for centralised delivery. In conclusions (chapter 5) the findings are brought into wider entity of logistics and services in the context.

2. HEALTH CARE MATERIAL LOGISTICS AND ACCESSIBILITY

2.1. Health care material logistics

For more than three decades, health care has drawn considerable attention to its optimisation problems (Rais and Viana, 2011), and the changes in health care have been rather quick during the last decades (de Vries and Huijsman, 2011). However, the changes in logistic activities have been slower, due to characters of several metrics in performance and the complexity of concepts like quality of care (de Vries and Huijsman, 2011), and system uncertainty (Böhme, Williams, Childerhouse, Deakins and Towill, 2014). These issues among others have put logisticians and executives in health care into situations where they have difficulties to measure logistic costs and control or project their production schedules. It has further led health care organisations to see themselves operationally different from other business, mainly because they cannot predict their supply consumption or patient mix (Jarret 1998).

Healthcare logistics research is divided roughly in two genres by the unit of analysis. Most of the research has the main focus on patient flows, which means examining the actual healthcare operations where care processes follow each other. Some of the research has more traditional view on logistics and SCM by focusing on physical products in healthcare supply chains. These processes can be seen as supporting material flows (Vissers and Beech, 2005: 26; Olsson, Wiger and Aronsson, 2014.) Moreover, Hesse and Rodrigue (2004) divide activities composing logistics into two material management and physical distribution. Materials management includes production and marketing activities and physical distribution represent the derived transport segment. Physical distribution is a collective term including activities in the movement of goods from production to sale and consumption as well as functions of movement, handling of goods, transportation services, transshipment, warehousing services etc.

This research focuses on the supporting material flows and logistics services particularly between healthcare units and supporting warehousing functions. The main focus is in comparing the elements of cost and accessibility.

2.2. Trade-off between accessibility and cost

Central to the scope and design of the logistics system is trade-off analysis, which, in turn, leads to the total cost concept. The cost trade-off is the recognition that cost patterns of various activities frequently display characteristics that put them in conflict with one another. This conflict is managed by balancing the activities so that they are collectively optimised (Ballou
The total cost concept is the trade-off of all costs that are in cost conflict with each other and that can affect the outcome of a particular logistics decision (Ballou 2004: 47). Trade-offs between cost-generating activities form trade-off-relationships (Bowersox 1993: 289). Traditional logistics management finds significant cost trade-offs between inventory and transportation (Bowersox et al., 1986: 290).

Comparing trade-off between service level and cost identify optimum or improved solution for logistics system. Separate elements of service are then analysed to find the most reasonable entity (Christopher 1998: 51). Traditionally service level in logistics is measured by the density of supply network – more the service/stocking points – better service level. In this research service level is defined by the accessibility of the services. As a result, the analysis of service accessibility and cost trade-off gives solution for shorter driving distance for yet reasonable accessibility (Christopher 1992: 155, 125).

Good accessibility is traditionally achieved through dense service network. However, retail- and manufacturing industries has examples of increasing cost efficiency and service level simultaneously by making structural changes in supply chain towards centralised delivery network (e.g. Abrahamsson and Brege, 1997). Also in Healthcare material logistics centralised material logistics is considered to redesign supply chain. (Kumar, Ozdamar and Ning Zhang, 2008).

2.3. Specifying healthcare material deliveries in Northern Finland

In healthcare material supply chains the shipped materials are care items, instruments such as knives, medicine, food, laundry, laboratory samples, assistive devices – in other words all the materials that are needed in providing healthcare services. In this examination these materials are used by the care personnel and to some extent patients in hospitals and healthcare centres. Despite somewhat centralized procurement, hospitals and healthcare centres in the case area are managing these supply chains by separately by themselves.

The hospitals and healthcare centres in the case region have alternating needs for freight volumes and frequencies of the deliveries. In comparative hospital district Satakunta, where centralised model is in use the materials are collected and packed in trolleys by the needs of the units. Trolleys are then further delivered to healthcare units´ own warehouses. The deliveries should be scheduled in high volume places twice a week, but most of the units would suffice with only once a week delivery.

“Two times a week is more than enough for these (primary health care) points. When talking about these (specialised health care) points it is different. But (primary health care points) twice a week is more than enough. Most of them once a week is enough.” (Logistics Manager, Satakunta)

Logistics managers of four hospital districts in the case area estimated their average freight volumes in one week. These estimates are listed in Table 3.1. The healthcare units are divided in three groups: health centres, minor hospitals and major hospital. Health centres (n=92) are situated in almost all municipalities and they take care of the basic health services. Minor hospitals (n=5) in the area take care of special health care and are located at the cities Rovaniemi, Kemi, Kajaani, Kokkola and Oulaskangas. Major hospital is the university hospital that has the main responsibility of the the most specialised health operations and services. It is located in Oulu.
Table 2.1 Estimated volumes (m3) of incoming freight (no laundry, food and medicines) per week to different size health care units (health centre, minor hospital, major hospital) in northern context.

<table>
<thead>
<tr>
<th>Health centre</th>
<th>Minor hospital</th>
<th>Major hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Ostrobothnia hospital district, Finland</td>
<td>1.6</td>
<td>7.5 / 11</td>
</tr>
<tr>
<td>Lapland Hospital District, Finland</td>
<td>1.4/0.7¹</td>
<td>30</td>
</tr>
<tr>
<td>Länsi-Pohja Hospital District, Finland</td>
<td>1.7</td>
<td>&gt;30</td>
</tr>
<tr>
<td>Norrbotten Hospital District, Sweden</td>
<td>1.2</td>
<td>11.7</td>
</tr>
<tr>
<td>Indicative nodal reference weight applied for route generation</td>
<td>1.5</td>
<td>7.5, 30</td>
</tr>
</tbody>
</table>

¹ Health centre / other distribution target
² Incoming to hospital / incoming including deliveries to other units

The amounts of material coming into health centres vary between 0.7 m³ and 1.7 m³. Minor hospitals receive materials between 7.5 m³ and 30 m³. The major hospital receives 264 m³, but the amount increases if counted also materials that are sent further and not used in the particular hospital.

Most of the hospitals in the care area offers order-replenishment service for their units and clinics. This service is produced in-house by the warehouse personnel for the customers in the hospitals. In comparative hospital districts Satakunta and Norrbotten the central warehouse offers order-replenishment model for their hospital and also for the health centres in their region. This service takes time and is therefore good to be noticed in this examination. Convergent scheduling would be suitable, but the replenishment would take time, which would increase the stopping time, and therefore optional ways to conduct the replenishment should be considered. For example, the replenishment could be bought from the unit in a way that employee is educated for that operation and therefore is suitable for the operation.

“It is just about one-hour job, to do the replenishment. That, by using common sense, it is pointless for us to keep the truck there an hour, so that the driver does the replenishment. We can train someone, for example unit secretary, who does the job. And buy the service from it…” (Logistics Manager, Satakunta)

Thus, there is not only one option how to offer the support services through the calculated network. In other words, there are options for tailoring support services by using the existing resources of the customer unit or using partially or completely resources of the logistics service provider.

3. RESEARCH DESIGN

Data of this research is two-faceted. Firstly, the characteristics of the support services is researched in a pre-research on 2012 and defined in interviews on 2015 (detailed in Table 3.1). This data also consists estimates about the freight volumes of the different size health units (health centre, minor hospital, major hospital) in the area. Secondly this paper uses GIS data of road network and health care facilities (detailed in chapter 3.2).
3.1. Understanding the logistics services in the context

To recognise the characteristics of healthcare logistics in the particular case, this research firstly adopts qualitative approach. A qualitative case approach is recommended when issues are complex and in cases where alternating between the empirical field and different theoretical frameworks can be useful for generating additional insights (Orton, 1997; Yin, 2003). The case focuses on geographical area with different organisations that have the same mission of storing and delivering the needed materials for the hospitals and care centres. The qualitative part of this study conducts scientific reasoning through the application of abductive logic, which may be regarded as an approach suitable for theoretical development in operations management when making additions to theory (Voss et al., 2015).

The empirical data was collected with variety of methods. Firstly, background knowledge of the organisations was achieved in making a pre-study of the university hospital logistics (in 2012) and in discussions with the hospital districts (2013-2014). The pre-study in 2012 consisted field work that gave understanding of the conditions in the hospital

Table 3.1 Interviews

<table>
<thead>
<tr>
<th>Interviewee(s)</th>
<th>Organisation</th>
<th>Date</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics manager</td>
<td>Satakunta hospital district, Finland</td>
<td>15.4.2015</td>
<td>Semi structured interview</td>
</tr>
<tr>
<td>Transport manager, warehouse manager, sourcing manager</td>
<td>Northern Ostrobothnia hospital district, Finland</td>
<td>5.5.2015</td>
<td>Group interview</td>
</tr>
<tr>
<td>Transport/warehouse manager</td>
<td>Norrbotten Hospital District, Sweden</td>
<td>15.9.2015</td>
<td>Structured telephone/email</td>
</tr>
<tr>
<td>Logistics – and material manager</td>
<td>Lapland Hospital District, Finland</td>
<td>25.9.2015</td>
<td>Structured telephone/email</td>
</tr>
<tr>
<td>Warehouse manager</td>
<td>Länsi-Pohja Hospital District, Finland</td>
<td>16.10.2015</td>
<td>Semi structured interview</td>
</tr>
<tr>
<td>Procurement manager, development manager, procurement expert, CEO</td>
<td>PPSHP, LSHP, Ouka, NHG</td>
<td>27.5.2015</td>
<td>Group discussions</td>
</tr>
</tbody>
</table>

The primary qualitative data part of this paper is collected through interviews between April and October 2015 (see Table 4.1) One interview is a group discussion because of the separated areas of responsibilities in the biggest hospital in the area. Two of the interviews are traditional semi-structural interviews carried out in hospitals facilities. Two of the interviews are managed through email and telephone, which gave interviewees time and possibility to use other experts from their organisations to get the needed digits and to form estimations of the volumes of the deliveries. Although two of the interviews is carried through telephone, all the respondents and the hospitals are met personally by the researcher during the research project.

Two group discussions with the professionals in the area were organised 27th May 2015 to evaluate the output of pre-calculated GIS-model and its implications into the logistics services.
Before each group discussion, the model and pre-results were presented for the members of the group discussion and the members filled the gaps in understanding the services.

3.2. Geographic information analysis of warehouse locations and delivery routes

To consider the geographic characteristics of transports in healthcare logistics, the research continues analysis by quantitative approach to analyse freight delivery accessibility by simulated delivery routes (see e.g. Bosona and Gebresenbet, 2011). Transport geographic accessibility analysis has a deep research tradition in measuring locational characteristics of human and goods transports by geographic infrastructure network data (Black, 2003). Aim of the analysis is to measure opportunities to centralise warehousing functions efficiently in sight of health care freight deliveries. Analysis is based on coordinated data, geographic information systems (GIS) and its transport accessibility analyses (Miller and Shaw, 2001). Aim of the analysis is, more practically, to find a solution for locating one or a few warehouses to limited number of potential sites so that number of warehouses is minimised in relation to efficiency of deliveries and geographic coverage of the network.

In the analysis, simulated delivery networks are generated for evaluating efficiency of different warehouse location settings. Delivery networks consist of a set of optimal delivery routes having start and end point at warehouse site and optimal route to reach freight demand nodes efficiently. Routes are optimised on the basis of demand and travel time by applying Digiroad, GIS model of road network (Finnish Road Administration, 2014), and locational freight delivery demand data (Table 2.1). Digiroad data offers numerical data of the routes in the selected area and the geographical locations of the healthcare facilities. Digiroad enables to use travel speed as impedance to transport, and thus travel time is applied to assess the ‘cost’ of transports (see Kotavaara et al., 2011).

In generating delivery routes ‘vehicle routing problem’ algorithm of ESRI (2012) was applied. Circular routing was applied instead of traditional location allocation analysis relying on back-and-forth travels (Figure 3.1), to gain more realistic metrics for the analysis. The efficiency of networks considered on the basis cumulated sum of delivered freight (m³) and time spent (h) to driving and unloading. In the analysis, all potential warehouse location combinations are considered with the presumption that one or a few warehouse(s) are located within some of the six major hospitals of the region. Number (n) of different potential locational settings of one or more warehouses to (S) sites is,

\[ n = 2^S - 1 \]  \hspace{1cm} (1)

when at least one warehouse will be located. Thus, by six potential sites, the number of warehouse location combinations was 63. In each of these cases, delivery routes accessing customers are generated by VRP and efficiency of each setting is then assessed by time accumulation (hours) and by successful freight delivery accumulation (applied attribute for deliveries was cubic-meter estimate).

To establish operable service network consisting of driveable delivery routes in GIS environment, three preset parameters were applied. First, maximum time of each route was set to be nine hours (on the basis maximum allowed driving time in legislation). Second, minimum cost-effectiveness threshold of each route was set to be 1 cubic meter of freight delivered within 2 hours (corresponding to 4.5 m³ in nine hours, i.e. at least on hospital or three health centres). Third, minimum reach of the network in relation to maximum potential reach was set to be 90 %, to ensure some service level also to distant customers. Time of each route within delivery network consists of driving time and penalties of starting the route and unloading freight which
estimated to take 10 minutes. Reference route setting for each warehouse setting was selected on the basis heuristic iterative computation, aiming to maximise cost effectiveness of the delivery network until the minimum reach of the network in relation to maximum potential reach was achieved in computation. Maximum volume of one load was set to be 60 m³, which was constraining factor only for the freight of hospitals. Due to this, freight demand of Oulu (264 m³) was divided to five even size parts.

Figure 3.1 Examples of location allocation analysis and used vehicle routing problem analysis.

Key difference between traditional location allocation analysis (Figure 3.1 a) and vehicle routing problem based location allocation (Figure 3.1 b) applied in this study, is ability to generate circular routes instead of back-and-forth routes. Route composition generated by location allocation analysis targeting to minimum travel impedance generates unreasonably great extent of back-and-forth routes. Vehicle routing problem based analysis generates almost as extensive service network by 12 routes. Both approaches apply maximum travel time of 9 hours for each route to meet the local legislation for driving hours.

4. RESULTS

Question of accessibility and opportunities for centralised model is in this paper approached through delivery efficiency. GIS-analysis applying optimised delivery routes gives different scenarios of how the selected metrics change by the amount of warehouses. The used metrics
are driving hours needed to access the healthcare unit locations and the amount of materials that can be delivered through the network. Efficiency is calculated by dividing delivery cubic metres by the needed hours. In Table 4.1 Delivery route efficiency and number of warehouses by most optimal delivery network settings. Table 4.1 is presented six most efficient (m³/h) (of total 63) options for number of warehouses in the area. These six sites Kokkola, Rovaniemi, Kemi, Oulainen, Kajaani and Oulu are the locations of main hospital in the case area.

*Table 4.1 Delivery route efficiency and number of warehouses by most optimal delivery network settings.*

<table>
<thead>
<tr>
<th>Warehouses N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving time (h)</td>
<td>71.7</td>
<td>76.1</td>
<td>79.6</td>
<td>73.8</td>
<td>79.1</td>
<td>82.5</td>
</tr>
<tr>
<td>Deliveries m³ %</td>
<td>95.2</td>
<td>96.3</td>
<td>96.6</td>
<td>97.2</td>
<td>98.6</td>
<td>99.2</td>
</tr>
<tr>
<td>Efficiency m³/h</td>
<td>7.0</td>
<td>6.7</td>
<td>6.4</td>
<td>7.0</td>
<td>6.6</td>
<td>6.4</td>
</tr>
<tr>
<td>sites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kokkola</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rovaniemi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Kemi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Oulainen</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Kajaani</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Oulu</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

If all the deliveries are centralised into one warehouse, it would require 71.7 hours of driving time and 95.2 % of all the materials could be delivered by 9 hour routes. Best location for the one centre by accumulated driving time would then be in Oulu. If the deliveries are driven through two warehouses would it require 76.1 hours of driving time and 96.3 % of the materials could be delivered. Another key finding of the study is that the amount of needed driving time does not decrease when the number of the warehouses increases. Variation in accumulated driving time in relation to number of warehouses does not change inversely. Main reasons to this is that when the number of warehouses increase, geographic extent of the delivery network increases too and more distant freight demand can be included to routes having maximum of 9 hour driving time. So, when the number of warehouses is low, the most distant locations are left out from the delivery network. Hence, when locating warehouse(s) for centralized delivery network in this specific context, increasing number of warehouses does not seem to give remarkable benefits in relation driving time, but it benefits geographic coverage of the delivery network.
Figure 4.1 a) Trade-off between delivery efficiency and geographic reach delivery network and b) geographic distribution of freight delivery demand of health care units and potential warehouse positions (within hospital sites). c) Zoomed figure of trade-off between delivery efficiency and geographic reach delivery network.

All the 63 options for potential warehouse locations and their combinations are visible in Figure 4.1a and Figure 4.1b. The location options with one warehouse are marked by black square, and all the location options with two warehouses by white triangle. Most of the location options appear on the upper right corner of the Figure 4.1a. Two most optimal locations, only Oulu and Oulu with Kokkola are mapped on Figure 4.1b.

In Figure 4.1a most of the location options appear in the upper right corner, which refers to high efficiency and good reach of the delivery network. In Figure 4.1c the same setting is zoomed to better recognise the differences between the options. The most optimal situations are on upper right corner, where most of the locations can be reached and driving time is minimised.
In one or two warehouse settings 95.2 - 96.3 % of all the needed materials could be delivered. The minority 3.7 - 4.8 % would then be left out from this network and should be reached by some other way. Most of these map points outside these calculated networks are small health centres that appear in rural areas with the longest distances.

5. CONCLUSIONS

In this study the trade-off between service level and cost is finding the optimum for shorter driving distance for yet reasonable accessibility. The reasonable accessibility is defined in this paper by the amount of the needed materials that are possible to be delivered through the calculated network. Even in the most centralized version of the scenarios, where driving time is the lowest (71.7 hours), at least 95 % of the materials can be delivered. Increasing the number of warehouses increases the coverage of the network but when counted with the costs caused by the driving distance the optimum is in 1-2 warehouse model.

The key practical outcome of empirical analyses of this study is that the great majority of the freight deliveries of health care facilities in North Finland could be efficiently served by one or two centralised warehouses. In the one warehouse scenery, the centre is situated in Oulu and in two warehouse setting in Oulu and Kokkola. Increasing the number of logistics centres increases delivery network efficiency hardly at all. This approach then encourages to centralise healthcare material logistics in the area into one or two logistics centres. Nevertheless, this examination leaves out the cost of the actual warehouse facilities, which makes the one warehouse setting even more efficient in comparison.

Warehousing functions of the extremely distant health centres are poorly integral to centralised delivery network. GIS-optimised freight delivery network offers calculated setting for logistics support services in long distance healthcare and this study approaches research questions by the efficiency of the delivery network. However, maximising delivery efficiency would be part optimising that neglects the need to see the whole logistics entity. Also service solutions for the “leftovers” 3.7 - 4.8 % that are not delivered through the planned network are needed to be consider carefully. Although, the amount of demanded material is low, the “leftovers” represent geographically big areas in the rural parts of the country with the longest distances and some other solutions are needed to face their healthcare material needs more efficiently. Serving material logistics services to the most far locations cannot be done effectively by robust delivery network, and thus more innovative solutions are needed.

When considering logistics entity, the delivery network is one part of the services it is supporting. This should be put in perspective with the context and the features of the services that are supported. Materials considered in this paper, are mostly care items. These can be delivered into health centres with the given frequencies (e.g. once a week in small health centres) but how is it with other support services in healthcare that have logistical elements in them such as pharmacy, laboratory, instruments and equipment, food supply, laundry, etc. Also logistics and accessibility of people come in question too within long distances.

Logistics centre is mainly considered as a warehouse. In this paper the, but more widely the centre could be considered to include wide range of material logistics services in healthcare. This kind of service centre would be an expert organisation researching, refining, testing and serving the healthcare units and operators in the area. The organisation could then consider the how the logistics needs could be served through physical material network. The network could then be seen not only one-way pipeline from warehouse to healthcare locations but also flow for reverse logistics including laundry, laboratory samples etc.
GIS environment is adjustable calculation framework to approach accessibility and cost trade-off problemacy of service supply. Similar results could plausibly be reached with more specialised route calculating programs. However, the created GIS model offers wide range of possibilities to enhance analysis and to use the model in more advanced research settings taking account different type of transport impedances from CO2 emissions to monetary attributes as well as flows of population (Kotavaara et al., 2015) in addition to flows of goods.

Optimal locations for logistics centres is in this paper approached through delivery network efficiency. Interesting approach to continue the analysis would be to calculate warehouse and delivery network setting with the best geographical coverage and capacity needs comparing to the most effective setting. An essential role of vehicle routing algorithm in locating warehouses is clear. Generating routes by very exiguous or very ample fleet of delivery vehicles seems to set a challenging conditions of “vehicle routing problem” tool in ArcGIS of ESRI (2012). Thus, comparing different routing algorithms would be an interesting and necessary but demanding target for further analysis. Moreover, the method introduced in this paper would be suitable in revealing locational opportunities of centralising warehousing functions in other areas too, when suitable coordinated data for delivery demand are available.

ACKNOWLEDGEMENTS

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REFERENCES


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LONGER AND HEAVIER ROAD FREIGHT VEHICLES IN SWEDEN

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ABSTRACT

Purpose
Longer and heavier road freight vehicles, so called High Capacity Vehicles (HCVs) are likely to be implemented by the Swedish government in the near future. This paper analyses the effects on tonne-kilometres, vehicle-kilometres, CO\textsubscript{2} and socio-economics of three possible implementation strategies (HCVs on all roads, a designated road network, a designated road network with km-based truck charge).

Design/methodology/approach
Two well-established scenarios for transport development in Sweden were used as bases for calculations. Changes per tonne-kilometre are modelled for 10 product groups with considerations taken of the transport network. Socio-economic effects are analysed using the Net Present Value Rating method over a 40-year period.

Findings
The study shows the amount of induced transport and modal shift, from rail and sea to road, in terms of tonne-kilometre, vehicle-kilometre and CO\textsubscript{2} emissions for three implementation strategies of HCVs in two scenarios. The only implementation strategy with a stable positive social net-benefit for HCVs was the implementation of HCV combined with a km-based truck charge.

Research limitations/implications
The results reveal potential benefits to implement HCVs on a designated road network in combination with a km-based charge for trucks. The results are limited by possible over/under-estimations of effects considered in the calculations, due to uncertainties and assumptions.
Practical implications
The results highlight expected levels of modal shift and induced transport for different implementation strategies of HCVs and how that depends on transport and climate policies and the expected growth of tonne-kilometres.

Original/value
The calculations consider socio-economic effects, particularly from higher CO₂ emissions due to modal shift and induced traffic, which is lacking in previous studies. From a socio-economic perspective, the implementation of HCVs should be accompanied by other policy measures in order to balance conflicting goals. The results are based on the Swedish context, but the model can be adapted to other countries or regions and also for studying other freight transport reforms.

Keywords: Climate, HCV, LHV, Modal shift, Road transport, Socio-economic costs, Tonne-kilometre

1. INTRODUCTION

Sweden allows for trucks of 64 tonnes and 25.25 meter, which is heavier and longer than most of the European countries where 40 tonnes/18.75m dominates. The maximum gross weight was recently increased from 60 to 64 tonnes, and the Swedish government is considering implementing even longer and heavier road freight vehicles so called High Capacity Vehicles (HCVs) in the near future. Such an implementation would affect several areas with direct and indirect effects on society as a whole in the short and long term. HCVs can improve transport efficiency both in terms of costs and the environmental impact. Improved transport efficiency may affect transport prices and thus the competitive advantage of Swedish firms competing on an international basis. Other potential effects are a shift between modes of transport, from rail and sea to road, and induced transport due to improved transport efficiency and lower transport prices. Allowing for HCVs also necessitates measures on the road infrastructure, for instance, reinforcement of bridges, longer stopping areas and changed need for maintenance. From a traffic safety perspective, HCVs and particularly longer vehicles might affect the risk of accidents.

There are experiences from some countries when it comes to HCVs, but unfortunately the effects of these reforms are only reported to a limited extent in the scientific literature. However, some estimations are reported in non-academic literature, such as governmental investigations. As the first European country to implement HCVs, Finland allows 76t/25.25m on the entire road network except on certain designated bridges since October 2013. Outside of Europe, in Australia, New Zealand, South Africa, Canada, the US and most of the countries in South America HCVs are used to various extent.

This paper aims to provide insights into system effects of implementing HCVs in terms of transportation efficiency, environmental impact and socio-economic effects. We analyse the effects on tonne-kilometres, vehicle-kilometres, CO₂ and on socio-economics of three possible implementation strategies (HCVs on all roads, a designated road network, a designated road network combined with km-based truck charge). In this paper, HCVs are referred to as road vehicles that have the capacity to carry more load than those commonly used today. The study examines two options: allowing for 74t/25.25m or 74t/34m in Sweden. Thus, in the first option, it is only the gross weight that increases, while in the second option both the gross weight and the maximum length increase. This paper is based on the results of a multidisciplinary quantitative system analysis. The results can support political decision-makers and authorities
to select an implementation strategy for HCVs and design policy measures to mitigate potential negative effects.

This paper is organised as follows. A literature review of HCVs is presented in the next section. Thereafter, the methodology including scenarios, implementation strategies of HCVs and the modelling approach is presented. This is followed by results, discussion and conclusions.

2. LITERATURE REVIEW

A review of previous studies on the system effects of HCVs reveals knowledge gaps. Most of the studies investigate a change from 40t/18.75m to 60t/25.25m in a central European context. The system effects of such a change have some relevance for our study in terms of how it affected the various areas we are considering, at least for comparisons. However, the magnitude of the effects is not that relevant since Sweden already uses these vehicles.

2.1. Effects of changed transport costs

Literature on socio-economic effects of increased weight and/or length is limited. Overall, there is consensus that HCVs lead to improved transport efficiency on roads with lower resource consumption both per tonne and per tonne-kilometre, which is also reflected in lower transport costs (McKinnon, 2012). The impact on the entire transport system is less agreed upon, which mainly depends on different assessments of changes in modal split and induced transport (Trivector, 2014). Further, it can be seen that effects can vary due to country-specific conditions, such as geography, rail network and which industrial sectors that dominates the economy.

HCVs lead to lower transportation costs, but to what extent varies in studies due to different assumptions on the amount of weight and length changes. In previous studies, the evaluated change varied between 5% and 20% depending on weight/length change (Trivector, 2014). The previous weight change for trucks in Sweden, from 51.4 to 60 tonnes, lead to approximately 20% cost reduction per tonne-kilometre (Nelldal 2000; 2001).

The reduced transport costs per tonne-kilometre on road by using HCVs are predicted to increase both tonne-kilometres and vehicle-kilometres on roads (Steer et al., 2013; Döpke et al., 2007). This depends on modal shift and induced transport. Modal shift due to HCVs depends on the relative cost shift between the modes of transport. While HCVs lower the cost for road freight, rail and sea freight costs are unchanged as long as counteractions are not taken. Some studies predict a major effect on modal shift (de Ceuster et al., 2008; Doll et al., 2008; Knight et al., 2008), while others predict it to have less effect (Salet et al., 2010). Induced transport demand means that price changes of transportation changes the transport demand. Based on a meta study, de Jong et al. (2010) recommend a price elasticity of -1 to changes in the transport cost per tonne-kilometre, meaning 1% reduced price increases the transport demand by 1%. In this price elasticity (-1), modal shift accounts for -0.4 and induced demand for -0.6. In a recent study of modal shift in Sweden, Nelldal (2015) found that the cross elasticity between rail and road was 0.44 and between sea and road 0.18.

2.2. Experiences from Swedish truck weight reforms in Sweden

In Sweden, the maximum length and weight for trucks has increased in several steps (Table 2.1).
Table 2.1 Changes in maximum allowed length and weight for trucks in Sweden (Vierth et al., 2008)

<table>
<thead>
<tr>
<th>Year</th>
<th>Max length (m)</th>
<th>Max weight (tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1930</td>
<td>Unlimited</td>
<td>10</td>
</tr>
<tr>
<td>1930</td>
<td>&quot;</td>
<td>12</td>
</tr>
<tr>
<td>1947</td>
<td>&quot;</td>
<td>23</td>
</tr>
<tr>
<td>1951</td>
<td>&quot;</td>
<td>34</td>
</tr>
<tr>
<td>1966</td>
<td>&quot;</td>
<td>37</td>
</tr>
<tr>
<td>1968</td>
<td>24</td>
<td>37</td>
</tr>
<tr>
<td>1974</td>
<td>&quot;</td>
<td>51.4</td>
</tr>
<tr>
<td>1990</td>
<td>&quot;</td>
<td>56</td>
</tr>
<tr>
<td>1993</td>
<td>&quot;</td>
<td>60</td>
</tr>
<tr>
<td>1997</td>
<td>25.25 m</td>
<td>&quot;</td>
</tr>
<tr>
<td>2015</td>
<td>&quot;</td>
<td>64</td>
</tr>
</tbody>
</table>

The effect on modal shift of previous weight reforms is debatable. In an analysis of the reforms in 1974, 1990 and 1993, Vierth et al. (2008) concluded that these reforms do not seem to have had dramatic immediate effects on modal shift. In the longer perspective, Nelldal (2000; 2001) found that the combination of the two weight reforms, from 51.4 to 56 and 56 to 60 tonnes between 1990 and 1993 resulted in modal shift from rail to road. Before the 56 tonne reform, the share of tonne-kilometres for long-distance transportation was approximately 50% on road and 50% on rail, but after the two weight reforms (from 51.4 to 56 and 56 to 60 tonnes) road had approximately 60% and rail 40% (Nelldal, 2015). The increased cost competitiveness of road transport versus rail made road transport more competitive even on long distances and for many tonne-kilometres, which have traditionally been a strong market for the railways. Nelldal (2015) shows that previous weight reforms coincide in time with changes in the share of road transport of long-distance freight transport.

2.3. Environmental and safety effects

Each HCV emits more, have higher fuel consumption, higher energy use and cost per vehicle-kilometre than conventional trucks (Christidis and Leduc, 2009; Döpke et al, 2007; Steer et al, 2013; Vierth et al, 2008; Honer and Aarts, 2011). However, the increased loading capacity in HCVs leads to fewer vehicles needed to transport the goods. Thus, HCVs reduce emissions per tonne-kilometre. It reduces both emissions of air pollutants and CO₂ (de Ceuster et al., 2008; Vierth et al., 2008; Leach and Savage, 2012).

Road safety for HCVs focuses on safety changes on roads, primarily based on experiences of previous implementation. It is important to separate heavier from longer and heavier vehicles, for example when it comes to accidents related to overtaking. A common message is that road safety is not likely to become worse by implementing heavier vehicles (OECD/ITF, 2010; Sandén, 2015). For longer vehicles there is an indicated increased risk of accidents per vehicle kilometre, but due to fewer vehicle-kilometres the number of accidents is not expected to increase.
2.4. Infrastructure investment and wear

The road infrastructure is pointed out as a major challenge for introducing HCVs. Increased weight and/or length of trucks affect the carrying capacity and lifetime of the infrastructure, for example, bridges. Many bridges are not designed for HCVs and have to be reinforced in order not to wear down prematurely. In Finland, about 500-600 bridges do not comply with the new weight restrictions (Lilja, 2014). Wear and degradation of the road infrastructure depends primarily on the axle weight, the number of axles, the time between the passages of the axles, construction of the road body, and how wet or frozen the body is. More loads per vehicle leads to less traffic, which means that investments in increased road and rail capacity in order to handle the increase in tonne-kilometre can be postponed.

3. METHOD

3.1. Scenarios for future transport development

Two well-established scenarios for transport development in Sweden were used as a basis for the calculations. These are (i) a baseline scenario of the Swedish Transport Administration (STA) and (ii) a climate scenario (CS) which was developed in a governmental investigation about fossil-free road transport (SOU 2013:84). These scenarios were used to estimate effects of HCVs in a scenario based on forecasting social and transport development and a climate-focused scenario. All calculations are based on comparisons between 60t/25.25m-vehicles and HCVs due to lack of data for 64t/25.25m-vehicles which were allowed during this study. The tonne-kilometres used in the analyses were derived from the national model for freight transportation in Sweden, which is termed Samgods. This model constitutes the most comprehensive data available for road, rail and sea transport for various product groups in Sweden. For each scenario studied, three implementation strategies were analysed.

3.1.1. Swedish Transport Administration (STA) scenario

This scenario is based on the baseline scenario in the Swedish infrastructure capacity investigation 2012 and its update 2015 Trafikverket (2015a). In this scenario, GDP increases by 2.2% annually until 2030 and then by 2.1% annually until 2050. The population in Sweden, around 9 million now, increases by 1.3 million people between 2006 and 2050. The scenario assumes that urbanisation continues, which affects the transportation of consumer goods. To handle increased congestion, distribution and logistics centres are established outside the city centres. A growing e-commerce market means increased city distribution. Freight flows are more intermodal with an increase in container shipping and unitised goods. Specialisation and economies of scale in industry lead to increased average transport distances, which results in a concentration of freight flows on major routes and nodes. Both imported and exported goods in tonnes increase significantly until 2050. The transport demand in tonne-kilometre increases by 131% for road (from 43 to 99 billion tonne-kilometre)\(^1\) and by 52% for rail (23.5 to 35.7 billion tonne-kilometres) from 2006 to 2050. It is assumed that fossil-free fuel on road in this scenario increases from 0% in 2015 to 5% in 2030 and 20% in 2050. In between, a linear progression is assumed.

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\(^1\) The starting point differs slightly between the two scenarios, 40 vs. 43 billion tonne-kilometres, due to different data sources but the overall effect is negligible.
3.1.2. Climate Scenario (CS)

The focus of the climate scenario (SOU 2013:84) is that society actively supports the development of biofuels and electric power for transportation and energy-efficient vehicles. In this scenario, the transport system is more climate efficient than in the previous scenario. This is accomplished through modal shift from road to rail and sea, and through more transport-efficient logistics structures. Society supports the development of alternative fuels. The long-term climate goals are important when promoting and developing innovative and technical solutions. The transport demand in tonne-kilometre is expected to increase by 7% for road (from 40 to 42.8 billion tonne-kilometres) and by 100% for rail (23 to 46 billion tonne-kilometres) from 2006 to 2050. It is assumed that the share of fossil-free vehicle-kilometres by truck increases from 0% in 2015 to 90% in 2030 and 100% in 2050. In between, a linear progression is assumed.

3.2. Implementation strategies

The implementation strategy for HCVs includes the share of the infrastructure that should be allowed for HCVs, implementation pace to reach full infrastructure allowance for HCVs, control systems and policy measures. Three potential implementation strategies with different underlying purposes were analysed:

A. Implementation of HCVs on all roads
B. Implementation on designated roads
C. Implementation on designated roads combined with a distance-based charge of 0-1.60 SEK per kilometre for all trucks

Table 3.1 Implementation strategies in the two scenarios

<table>
<thead>
<tr>
<th>Implementation strategies for HCV on road</th>
<th>STA scenario</th>
<th>Climate scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Implementation of HCVs on all roads</td>
<td>74t/25.25m</td>
<td>74t/25.25m</td>
</tr>
<tr>
<td></td>
<td>74t/34m</td>
<td>74t/34m</td>
</tr>
<tr>
<td>B. Implementation on designated roads</td>
<td>74t/25.25m</td>
<td>74t/25.25m</td>
</tr>
<tr>
<td></td>
<td>74t/34m</td>
<td>74t/34m</td>
</tr>
<tr>
<td>C. Implementation on designated roads combined with a distance-based charge for all trucks</td>
<td>74t/25.25m</td>
<td>74t/25.25m</td>
</tr>
<tr>
<td></td>
<td>74t/34m</td>
<td>74t/34m</td>
</tr>
</tbody>
</table>

For each implementation strategy two alternatives: heavier vehicles (74t/25.25m) or longer and heavier vehicles (74t/34m) were analysed and compared with a reference scenario. Thus, we have six combinations in each scenario that we analysed (Table 3.1). We also developed scenarios without HCVs for the two scenarios STA and CS. The effects of introducing HCV were calculated as the difference between the scenario with and the scenario without HCV. This means that everything else was kept the same.

3.2.1. Strategy A: Implementation of HCVs on all roads

HCVs are allowed in the whole road network, which is currently allowed for 64t/25.25m. According to the Swedish Transport Administration, initially there will be restrictions for
bridges and some road sections until they have been reinforced. On sections without infrastructure restrictions, HCVs can be used from the first day of the changed regulation. For trucks heavier than 64 tonnes mandatory truck certification and a self-control system should be implemented. The implementation pace (the percentage of the maximum potential for HCVs that is realised) is assumed to be 20% by 2018, 60% by 2020, 90% by 2025 and 100% by 2030.

3.2.2. Strategy B: Implementation on designated roads

HCVs are allowed in a designated road network, which will open up for HCVs in steps as reinforcements are made on critical sections of the road network. The vehicles with a total weight above 64 tonnes should be certified to meet the technical requirements to be allowed on these roads. Compliance with route and weight regulation should be monitored through a system of self-control and that actual routes and weights are reported to the authorities afterwards. In total, the designated road network in implementation strategy B represents about 60% of the road network in implementation strategy A. The core network can be opened for HCVs approximately one year after a decision is taken, while reinforcements for the whole road network is expected to be finalised by 2030.

3.2.3. Strategy C: Implementation on designated roads combined with a distance-based charge for all trucks

This implementation strategy is similar to the previous one, but it is combined with a distance-based charge of 0 to 1.60 SEK per vehicle-kilometre for road transport. If HCVs are allowed, the relative competitiveness between modes of transport shifts. A way to modify the relative competitiveness between modes of transport is to add a policy measure to make road transport less competitive. In this implementation strategy, we used a kilometre-based charge for all road freight transport in order to promote rail and sea transport by decreasing forces for modal shift. In order to finance the costs of necessary reinforcement of bridges and roads, which is estimated to 12 billion SEK., a charge of about 0.4 SEK/km would be required. To analyse the impact of a lower and a higher charge, effects of 0.55 and 1.60 SEK/km were also calculated.

3.3. Modelling system effects

The structure of the analysis carried out is presented in Figure 3.1. Introducing heavier or heavier and longer vehicles in Sweden has an effect on parts of the transport system, while other parts are unaffected. To estimate the proportion of the transport system that is affected by HCVs a two-step analysis was carried out. In step one, the gross potential, i.e. the maximum potential of 10 product groups, were estimated under the assumption that heavier or heavier and longer vehicles can run on all the roads where 60t(64t)/25.25m-vehicles are currently permitted. In the estimation, the transport system was divided into three types: terminal transport (a transport that ends in a freight terminal), direct transport (no use of freight terminals), and distribution transport (a transport to a receiver). For each type of transport, the maximum potential proportion of HCVs in the transport system was estimated for each product group. This was referred to as the gross potential of HCVs.
Figure 3.1 The structure of the analysis

To assess the actual proportion of the transport system that would benefit from HCVs, i.e. the proportion of the gross potential that can be realised, we analysed the size and type of road network that can be made available to HCVs. This is referred to as the net potential. These assessments were made in a workshop by a group of seven transport researchers. The assessments were made per product group according to the following steps:

1. The localisation structure of shippers and receivers within each product group was determined, from very peripheral locations (e.g. agriculture and forestry) to locations with a high level of accessibility to major roads (e.g. large industries and large stores).
2. The main starting points and destinations for each product group were identified from the current transport flows in Sweden as modelled in Samgods. Herein lays an assumption that the structure of the flow of goods will not change significantly until 2050.
3. The proportion of tonne-kilometres for each product group that can be carried out on a road network designated to HCVs, as identified by the Swedish Transport Administration, were assessed. In the assessments, variations between regions were considered through the proportion of HCVs on the roads.

The number of tonne-kilometres for each product group relevant to be transported more effectively by HCVs were estimated in each scenario and implementation strategy by multiplying the number of tonne-kilometres with the net potential. The analysis recognised that an introduction of HCVs has the potential to make road freight transportation more efficient and that a price reduction of road freight transport can lead to both changes in the choice of transport mode and an increased demand for road transport. Estimates of the increased cost efficiency for road transport by the introduction of HCVs were based on detailed cost calculations and past experiences. Estimates of transferred tonne-kilometres from rail and sea to road are based on cross-price elasticity combined with detailed cost calculations for HCVs. Induced road transport due to price changes were based on the price elasticity from De Jong et al. (2010). Based on these effects, the total change in tonne-kilometres on road, rail and sea were estimated.

In the next step, the effect on the number of tonne-kilometre was calculated per mode of transport. In order to calculate the number of vehicle kilometres, the number of tonne-kilometre was divided by the average load for different types of vehicles within each product group. In the final steps the main system effects of the introduction of HCVs were calculated and assessed in terms of CO$_2$-emissions, business effects and socio-economic effects.

3.4. Socio-economic cost analysis

The analysis of the socio-economic costs and benefits follows a standardised CBA framework, the ASEK guidelines (Trafikverket, 2015b) by which all major national transport investments
in Sweden are evaluated. The benefit valuations used are mostly derived from willingness-to-pay estimates. The exception is the value of carbon emissions, which is based on the current carbon tax on fuel. The valuations of costs and benefits are assumed to increase over time proportionally to the forecasted growth in GDP/capita. All costs and benefits are summarised to the net present value using a discount rate of 3.5% per year and the project appraisal evaluation period is 40 years.

In the socio-economic cost-benefit calculation, comparisons were made between a reference scenario where all HCV-relevant transportation (transportation that are included in the net potential of HCVs) are carried out with 60t/25.25m vehicles and two scenarios with HCV vehicles (74t/25.25m or 74t/34m) and the implementation strategies A, B and C. All options assumed an increase in the share of HCV-vehicles from 2018 to the saturation point in 2030 (higher pace at the beginning of the studied period) and a constant share between 2030 and 2058. The CBA includes:

- Producer/consumer effects for road transport (vehicle costs, driver cost, maintenance cost, fuel costs, other operations costs)
- Public budget effects for road transport (fuel tax and VAT)
- External costs for road transport (traffic safety, emissions (CO₂, NOₓ, SO₂, particles), wear and tear of roads, travel time delay for other road users)
- Investment costs for reinforcing and adapting bridges and roads for HCVs.

Noise is omitted from the assessment due to lack of reliable noise effects. Furthermore, the calculated costs and benefits focus on the effect of HCV on the road transport system due to limitations in the dataset. Thus, for transportation transferred to road from other modes, consideration was only taken to the increased transportation costs on road and not reduced costs of operation and external costs for sea and rail. This could, for instance, relate to postponement of investments in rail capacity due to less traffic. The same focus on road transport was applied for the investment cost where the possibility to postpone capacity investments, e.g. in railway infrastructure, was not included. Positive effects on the competitive situation of the Swedish industry as a result of HCV vehicles, was not estimated in isolation. In relation to the results, these possible over/underestimations were discussed and a sensitivity analyses was performed to estimate how large these omitted costs have to be to change the sign of the net present values for the different scenario/strategy combinations analysed.

The total investment costs were assumed to be 12 billion SEK until 2030 (1 billion in ferry berths, 8 billion in bridges, 3 billion in roads) for implementation strategy B, and C. The investment rate was assumed to be higher at the beginning of the period. For implementation strategy A (free access) there will be additional costs after 2030 when bridges and roads continue to be strengthened and rebuilt until the whole current 64t/25.25m network is available for HCVs. Based on historical data and forecasts, the cost was estimated to be 220 million SEK per year. The investment cost was assumed to be the same whether longer vehicles were allowed or not. The additional cost that may arise due adjustments for 74t/34m-vehicles was assumed to be negligible. The social cost of the investment was calculated as the investment cost multiplied by the marginal cost of public funds (factor 1.3). This reflects the deadweight loss (efficiency loss) of collecting tax for public expenditures. For each option the socio-economic analysis was presented as the NNK ratio which equals the ratio: Net Present Value of all costs (incl. investment costs) and benefits, divided by the Net Present Value of the cost of the investment.
4. RESULTS

The results of the calculations are presented as effects on tonne-kilometres, vehicle-kilometres and socio-economics.

4.1. Effects on tonne-kilometres

Due to lower costs of road freight, implementation of HCVs leads to modal shift and induced transport if countermeasures are not taken. The effects measured in tonne-kilometres for 2030 compared to the base year 2006 are shown in Tables 4.1 and 4.2.

Table 4.1 Modal split and induced road transport 2006-2030 for 74t/25.25m-vehicles in two scenarios in combination with implementation strategies A, B and C with a road charge of 1 SEK/km (billion tonne-kilometres)

<table>
<thead>
<tr>
<th></th>
<th>Impl. strategy A</th>
<th>Impl. strategy B</th>
<th>Impl. strategy C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STA scenario</td>
<td>Climate scenario</td>
<td>STA scenario</td>
</tr>
<tr>
<td>Road induced transport</td>
<td>6</td>
<td>4.3</td>
<td>5.6</td>
</tr>
<tr>
<td>Road from sea</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Road from rail</td>
<td>2</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Total change</td>
<td>8.1</td>
<td>6.6</td>
<td>7.8</td>
</tr>
<tr>
<td>Total increase (%)</td>
<td>9</td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 4.2 Modal split and induced road transport 2006-2030 for 74t/34m-vehicles in two scenarios in combination with implementation strategies A, B and C with a road charge of 1 SEK/km (billion tonne-kilometres)

<table>
<thead>
<tr>
<th></th>
<th>Impl. strategy A</th>
<th>Impl. strategy B</th>
<th>Impl. strategy C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STA scenario</td>
<td>Climate scenario</td>
<td>STA scenario</td>
</tr>
<tr>
<td>Road induced transport</td>
<td>8.8</td>
<td>6.4</td>
<td>8.1</td>
</tr>
<tr>
<td>Road from sea</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Road from rail</td>
<td>2.5</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Total change</td>
<td>11.4</td>
<td>9.2</td>
<td>10.9</td>
</tr>
<tr>
<td>Total increase (%)</td>
<td>13</td>
<td>17</td>
<td>12</td>
</tr>
</tbody>
</table>

For both implementation strategies A and B the general effects on tonne-kilometres are similar, both for 74t/25.25m and 74t/34m. The general effects are that the tonne-kilometres on road increase due to induced transport and modal shift from rail and sea. The effects have similar patterns, but are greater for 74t/34m than for 74t/25.25m. Implementation strategy C compensates the road freight price decrease with a kilometre based charge for all road transport. For this implementation strategy, the modal shift is negligible while some induced transportation still occurs. With a lower charge (0.55 SEK per km), the general effects are
similar to those for implementation strategies A and B. A higher charge (1.60 SEK per km) increases the road transport costs causing the modal shift to go from road to rail and sea, instead of the other way around for both 74t/25.25m and 74t/34m. There is no induced transportation if only 74t/25.25m is allowed, but some if 74t/34m is allowed.

4.2. Effects on vehicle-kilometres

In both scenarios and for implementation strategies A and B, the vehicle-kilometres are only affected to a minor extent when it comes to 74t/25.25m vehicles in both. There is, however, a significant decrease in vehicle-kilometres with both implementation strategies for 74t/34m-vehicles. With implementation strategy C the reduced vehicle-kilometres are significant both for 74t/25.25m and 74t/34m in both scenarios. Both a lower (0.55 SEK per km) and a higher charge (1.60 SEK per km) reduce the vehicle-kilometres. The decrease in vehicle-kilometres is shown in Table 4.3.

Table 4.3 Change in vehicle-kilometres 2006-2030 for implementation strategies A, B and C with a road charge of 1 SEK/km (million vehicle-kilometres)

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Impl. strategy A</th>
<th>Impl. strategy B</th>
<th>Impl. strategy C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STA scenario</td>
<td>Climate scenario</td>
<td>STA scenario</td>
</tr>
<tr>
<td>74t/25.25m</td>
<td>-90</td>
<td>-10</td>
<td>-65</td>
</tr>
<tr>
<td>74t/25.25m*</td>
<td>-2%</td>
<td>-0.5%</td>
<td>-1%</td>
</tr>
<tr>
<td>74t/34m</td>
<td>-290</td>
<td>-120</td>
<td>-250</td>
</tr>
<tr>
<td>74t/34m*</td>
<td>-6%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
</tbody>
</table>

*The total kms are greater in the STA scenario than in the climate scenario

4.3. Socio-economic effects

The socio-economic analysis of implementation strategies A and B based on the STA scenario indicates a higher NNK ratio for heavier and longer vehicles than for only heavier. The effects are only positive for longer and heavier vehicles (Table 4.4). Heavier and longer vehicles have the greatest effect on reducing the tonne-kilometres and thus provides greater benefits in terms of reduced transport costs and external costs. The reduction in fuel consumption is seen both as benefits for transport buyers (producer/consumer effects) and a loss to society through reduced tax revenues. In producer/consumer effects for heavier vehicles, there are increased fuel costs per vehicle-kilometre, but also reduced fuel consumption and total transportation costs due to fewer vehicle kilometres (greatest for implementation strategy A).
Table 4.4 Socio-economic cost calculation for the STA scenario

<table>
<thead>
<tr>
<th>Present value, million SEK</th>
<th>Implementation strategy A</th>
<th>Implementation strategy B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>74t/25.25m</td>
<td>74t/34m</td>
</tr>
<tr>
<td>Producer/consumer benefits</td>
<td>Vehicle owner or transport buyer</td>
<td>816</td>
</tr>
<tr>
<td>Budget benefits (- indicates cost due to less tax revenues)</td>
<td>Diesel tax and VAT</td>
<td>6 118</td>
</tr>
<tr>
<td>External benefits</td>
<td>Road wear (excl. bridges)</td>
<td>1 312</td>
</tr>
<tr>
<td></td>
<td>Air pollution</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>CO₂</td>
<td>3 405</td>
</tr>
<tr>
<td></td>
<td>Accidents</td>
<td>1 234</td>
</tr>
<tr>
<td></td>
<td>Time delay</td>
<td>341</td>
</tr>
<tr>
<td>Sum benefits - cost</td>
<td></td>
<td>13 342</td>
</tr>
<tr>
<td>Investment cost</td>
<td></td>
<td>13 425</td>
</tr>
<tr>
<td>NNK</td>
<td></td>
<td>-0.01</td>
</tr>
</tbody>
</table>

The socio-economic analysis of implementation strategies A and B based on the climate scenario indicates a negative NNK ratio for all cases (Table 4.5). In the climate scenario the producer/consumer effect for heavier vehicles is negative since the introduction of HCVs has a minor effect (or a slight increase in strategy B) on the tonne-kilometres and at the same time generates higher production costs like higher fuel consumption, materials and wear and tear. The minor effect on tonne-kilometres is also seen by low values on reduction in external costs (or slight increase in strategy B).
Table 4.5 Socio-economic cost calculation for the climate scenario

<table>
<thead>
<tr>
<th>Present value, million SEK</th>
<th>Implementation strategy A</th>
<th>Implementation strategy B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>74t/25.25m</td>
<td>74t/34m</td>
</tr>
<tr>
<td>Producer/consumer benefits</td>
<td>Vehicle owner or transport buyer</td>
<td>-18 927</td>
</tr>
<tr>
<td>Budget benefits</td>
<td>Diesel tax and VAT</td>
<td>7 212</td>
</tr>
<tr>
<td>External benefits</td>
<td>Road wear (excl. bridges)</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>Air pollution</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>CO₂</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Accidents</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Time delay</td>
<td>22</td>
</tr>
<tr>
<td>Sum benefits</td>
<td>-11 290</td>
<td>11 865</td>
</tr>
<tr>
<td>Investment cost</td>
<td>13 425</td>
<td>13 425</td>
</tr>
<tr>
<td>NNK</td>
<td>-1.84</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

A kilometre-based charge affects the socio-economic analysis in two ways; an increase in transportation cost and an increase in tax revenue. Since these cost items offset each other, the socio-economic cost analysis displays the effect on tonne-kilometres of the increased cost per vehicle-kilometre. The introduction of only heavier vehicles shows a negative NNK for the lowest cost charge per kilometre in the climate scenario, but otherwise positive results (Table 4.6). The impact, however, is generally considerably less for only heavier vehicles than for heavier and longer vehicles.

Table 4.6 NNK for implementation strategy C dependent on various km-based charges (0 charge is equal to strategy B)

<table>
<thead>
<tr>
<th>km charge (SEK)</th>
<th>74t/25.25m</th>
<th>74t/34m</th>
</tr>
</thead>
<tbody>
<tr>
<td>STA scenario</td>
<td>-0.22</td>
<td>2.73</td>
</tr>
<tr>
<td>CS scenario</td>
<td>-2.24</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

The change in CO₂-emissions has the greatest effect on the socio-economic analysis for heavier vehicles based on the STA scenario and its relatively strong growth in freight. The climate scenario assumes a greater share of non-fossil fuels which leads to reduced CO₂-emissions even when the tonne-kilometres are not reduced.
Heavier and longer vehicles primarily affect the costs for the transport buyer, for both transport scenarios. Changes in external costs such as costs for CO₂, accidents, wear and tear then have less effect on the total socio-economic analysis.

The socio-economic calculation is limited to the effects of road transport. The omitted cost items include, for example, measures to increase capacity on the network and costs for noise abatement measures. Effects on shipping and rail are excluded (e.g. reduced traffic costs) likewise effects with respect to the competitiveness of Swedish industry. In order to capture the magnitude of the omitted effects, the annual costs and benefits that would change the sign of the NNK are estimated. The result is presented both as the total present value of benefits for the entire calculation period and the annual benefit or cost (calculated as annuity) (Table 4.7).

Table 4.7 Compilation of benefits/costs that change the sign of NNK, SEK million.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Benefits/costs</th>
<th>74t/25.25m</th>
<th>74t/34 m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Implementation strategy</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>STA</td>
<td>Total present value</td>
<td>83</td>
<td>2 342</td>
</tr>
<tr>
<td></td>
<td>Annual benefits/costs</td>
<td>4</td>
<td>110</td>
</tr>
<tr>
<td>Climate</td>
<td>Total present value</td>
<td>24 715</td>
<td>23 992</td>
</tr>
<tr>
<td></td>
<td>Annual benefits/costs</td>
<td>1 157</td>
<td>1 123</td>
</tr>
</tbody>
</table>

The table shows that if the socio-economic analysis underestimates the annual benefits arising from the HCVs to about 116 million SEK, the NNK would be positive for all implementation strategies, except for heavy vehicles based on the climate scenario. In this case, benefits in the order of 1 billion SEK per year are needed in order to change the sign of the NNK ratio. It requires additional costs in the range of 3 billion SEK per year in order to change the sign of the NNK ratio when introducing longer and heavier vehicles based on the STA scenario.

5. DISCUSSION

The calculations show that an introduction of HCVs leads to reduced costs for road transport which, in turn, leads to modal shift from rail and sea to road, and increased demand for road freight transport. Thus, tonne-kilometres on road, sea and rail are all affected by the introduction of HCVs.

In all the three implementation strategies, the tonne-kilometres on road increases. There is a minor difference between the strategies A and B since the road network to be used by HCVs designated by the Swedish Transport Administration comprises most of the existing freight transport routes. In scenario C, the increase in tonne-kilometres on road is smaller, due to the parallel introduction of a distance-based road charge. If a charge of 1.6 SEK/km is introduced, the tonne-kilometres on road remain essentially unchanged. From an environmental point of view, this is positive, but it also means that the introduction of HCVs contributes less to the economic growth and increased competitiveness of Swedish industries.
The introduction of 74t/25.25m-vehicles following strategy A or B leads to little difference on vehicle-kilometres on road compared to the case when no HCVs are introduced. If the longer (34m) HCVs are also introduced, there is a small reduction in vehicle-kilometres. In scenario C, the tonne-kilometres and thus also vehicle-kilometres are reduced.

The socio-economic calculations show a negative NNK of introducing HCVs, especially if only heavier vehicles are allowed. The calculations are limited though and do not include investments in non-governmental roads and changes in road wear due to HCVs, which means that the cost for society is somewhat underestimated in the calculations. On the other hand, the cost savings of postponing investments in increased capacity of rail and road infrastructure are not included either, which would reduce the cost. Furthermore, the calculation excluded the positive social impact of a stronger business sector. A conflict arises here between the desire for a rapid introduction of HCVs to maximise the benefit of the business community and the desire to control the HCV implementation to prevent premature degradation and wear of the road infrastructure.

The impacts on CO$_2$-emissions depend on assumptions in and content of the scenarios and on the timeframe applied. The logic is that the more the tonne-kilometres on road increase in the scenario, the greater impact HCVs have on the CO$_2$-reduction. However, it is important to note that an introduction of HCVs leads to a higher competitiveness of road freight compared to rail and sea transport if countermeasures are not implemented. Countermeasures could increase the competitiveness and capacity of rail and sea operations. This is an important consideration, since the policy to shift from road to rail or sea is usually pointed out as a way to reduce CO$_2$-emissions. However, in the longer term the climate scenario it is assumed that all trucks use fossil-free fuel by 2050. Then, modal shift between road, rail and sea will not have a direct effect on CO$_2$. However, since rail and sea transport uses less energy per tonne-kilometre than road transport do, even with HCVs, the indirect impact on the climate is still prevailing in 2050.

6. CONCLUSIONS

The introduction of HCVs has the potential to support economic growth and the competitiveness of Swedish industry, while reducing the need to invest in increased infrastructure capacity and reducing the transport system’s climate footprint. However, the system analysis performed in this study shows that the positive environmental impacts are strongly reduced due to modal shift effects and induced freight transport. Additionally, increased tonne-kilometres on road in combination with induced freight transport may result in structural changes and path dependencies that may make it difficult to shift freight transport to rail and sea in the long term. At the same time, the introduction of HCVs may pave the way to the introduction of road charges.

In order to counteract the potential negative environmental impacts of the introduction of HCVs, an introduction can be combined with other measures. These complementary measures need to be well-designed to balance benefits in environmental protection, infrastructure wear and investment and economic growth. It is also important to note that this system analysis shows that the trend of freight transport growth, as well as the proportion of clean vehicles in the scenarios, have a greater absolute impact on reaching national and EU CO$_2$-emissions goals than the introduction of HCVs has.

The study contributes to theory development by calculating and describing the socio-economic effects of HCV implementation. The quantitative model calculated detailed effects when HCVs replace conventional vehicles divided on ten product groups, which are equal to ten sectors.
Each product group were analysed with three different transport chains with different fill rates and empty haul, in two alternative background scenarios over 40 years. The theoretical framework and methodological approaches and models can be adapted to analyse not only different HCV-strategies in other countries but they can also be generalised to analyse other types of freight transport reforms.

Future research could apply this methodology in other contexts. It would also be beneficial to expand the calculation model with the variables excluded in our analysis, such as countermeasures on rail and sea and other secondary effects of introducing HCV.

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A MULTI-CRITERIA DECISION-MODEL FOR PRIORITISING STAKEHOLDER MOTIVES IN CITY LOGISTICS

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ABSTRACT

Purpose
The purpose is to provide a structured method for prioritising among the diversity of motives and goals of stakeholders involved in city logistics.

Design/methodology/approach
The paper is based on a three-year participant observation study in a city logistics project including ten stakeholders. The data relate to the understanding gained during the three years of study and nine semi-structured interviews with the stakeholders dedicated to the purpose of this paper. The data are analysed with a multi-criteria decision model, which utilises the analytic hierarchy process (AHP) to rank alternative motives and their importance in a stakeholder value matrix.

Findings
The AHP and the stakeholder value matrix provide a structured approach to manage the multiple stakeholders in city logistics and their motives (values). The approach provide the possibility to identify which overall values that need the most attention and which and to what extent values need to be considered for each stakeholder.

Research limitations/implications
The structured method is applicable to other city logistics projects. The specific insights from the long-term city logistics project in this paper provide inspiration to future city logistics projects about how to manage stakeholders and their motives over time.

Practical implications
The results can guide city logistics organisations how to manage stakeholders and how much emphasis to put on various values.

Original/value
The research applies a multi-criteria decision-model from stakeholder theory to address the complexity of managing numerous stakeholders with varying motives and goals.

Keywords: Analytical Hierarchy Process, City Logistics, Decision-model, Participant Observation, Stakeholder
1. INTRODUCTION

Through the decades, urban areas have been drawing increased attention. The ongoing growth of urban areas presents challenges for sustainable supply and disposal of goods. These are related to pollution, congestion, safety and the attractiveness of cities (Benjelloun et al., 2010; Crainic, 2008; Kennedy et al., 2005; OECD, 2003). For instance, the number of freight vehicles in cities is growing and believed to continue to do so (Crainic, 2008). To address the challenges related to supply and disposal of goods, many cities have tested concepts related to city logistics, which is defined as, "the process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic conditions, congestion issues and combustible consumption, with a view to reduce the number of vehicle on the cities, through the rationalization of its operations" (Taniguchi et al., 2001). A majority of these initiatives have used urban consolidation centres (UCCs) to bundle the deliveries within the cities by separating the distribution activities in and out of the urban area from the distribution activities to and from the urban area (Yamada and Taniguchi, 2006; van Rooijen and Quak, 2008). The initiatives often include environmental zones, access restriction schemes, use of environmentally sound vehicles and non-road modes such as tram systems for freight movements (Allen and Browne, 2010).

Unfortunately, a large proportion of the city logistics initiatives has failed to become permanent (Browne et al., 2006). Over the last 27 years the failure rate was 96% with only five of the initiatives having survived (Lindholm, 2010). Two major reasons for failure are related to collaboration and lack of aligned motives and goals. Analyses of a number of city logistics projects in BESTUFS (2007) revealed a lack of collaboration between the public and private sector. In Lindholm (2010), the analyses identified the number of the involved stakeholders and their different interests and perspectives as reasons for failure. Other identified reasons were policy measures, which resulted in opposition against the UCCs since they were considered too unfair to support the UCCs, reluctance in the transport industry to use the UCCs, economic problems and rules and regulations that allowed companies to start their own UCC and receive the same advantages as the municipality’s UCC (Schoemaker, 2002).

This paper addresses the importance of collaboration and alignment of motives and goals between stakeholders in city logistics. The stakeholders can in general be divided into five categories: shippers, freight carriers, administrators, residents and others (Benjelloun et al., 2010; Taniguchi, 2001). The last category can, for instance, include non-governmental organisations (NGOs) and property owners.

The motives and goals of the different stakeholders in city logistics vary. Usually, shippers are interested in timely and cost efficient deliveries with a high service level. Freight carriers aim for as much business as possible and being able to perform cost-efficient deliveries. City administrators and governments primarily look for minimal environmental effects of city distribution while also promoting economic activity to have a vibrant and attractive city (Benjelloun et. al., 2010). NGOs can play a crucial role in implementing the provisions of city logistics, either directly through their own activities and research, or indirectly by helping to build capacity within government, city’s administrators and other institutions to better meet the city logistics commitments.

Thus, all these stakeholders do not hold the same points of view to improve the whole system and conflicts of interests may arise. Few studies have considered the behaviour of the stakeholders, but their diversity and heterogenic needs are great challenges in city logistics (Anand et al., 2012; Taniguchi and Tamagawa, 2005) and barriers for communication between private and public sector (Taniguchi, 2014). Thus, the coordination and collaboration between
the stakeholders are necessary to obtain more sustainable and liveable cities (Lindholm and Thalenius, 2006; OECD, 2003).

This paper addresses stakeholder behaviour in city logistics and particularly the challenges of stakeholder collaboration and managing the diversity of motives among stakeholders. The purpose is to provide a structured method for prioritising among the diversity of motives and goals of the stakeholders involved in city logistics. The paper is based on a three-year participant observation study in a city logistics project including ten stakeholders. The data relate to the understanding gained during the three years of study and nine semi-structured interviews with the stakeholders dedicated to the purpose of this paper. The data are analysed with a multi-criteria decision model, which utilizes the analytic hierarchy process (AHP) to rank alternative motives and their importance in a stakeholder value matrix.

The paper is organised as follows. Next, a literature review of stakeholder theory and its relation to AHP as well as stakeholders in city logistics is presented. Thereafter, the methodology describes the steps in the AHP method and the data collection, followed by a case study description. Then, the results from the analysis are presented. The paper ends with discussion, conclusions, implications and recommendations for future research.

2. LITERATURE REVIEW

The literature review consists of two parts. The first part reviews stakeholder theory and its relation to AHP. The second part reviews the collaboration, interdependence and motives of stakeholder in city logistics.

2.1. Definition of stakeholders

This paper applies a stakeholder value matrix to analyse the decision-making behaviour of stakeholders in city logistics. Stakeholders can be defined as “any group or individual who can affect or is affected by the achievement of the organisation’s objectives” (Freeman, 1984). In a project, stakeholders are those that have a stake in the outcomes of the project. The stake could be an interest or a right (Carroll and Bunchholtz, 2000). An interest is a circumstance in which a person will be affected by a decision. A right is the moral and legal right when a person of group has a legal claim to be treated in a certain way. It is suggested to consider what a stakeholder’s stake actually is when trying to define expectations or project impacts.

Stakeholder theory attempts to identify the fundamental question of which groups of stakeholders deserve or require attention. This refers on how the demands of stakeholders are prioritised. An additional focus is on the relationship dynamics among the stakeholders, where stakeholders have direct relationships with one another (Rowley, 1997).

The relationships between a project organisation and its stakeholders are essential for success (Leana and Rousseau, 2000). It is also the most appropriate way of coping with environmental turbulence and uncertainty (Savage et al., 1991). Stakeholders can contribute to the value creation, knowledge, insight and support in shaping the project vision and objectives.

2.2. Stakeholder collaboration in city logistics

The categories of stakeholders in city logistics vary slightly between authors (e.g. Barceló, 2003; Benjelloun et al., 2010; Taniguchi, 2001), but a synthesis results in five general categories: shippers, freight carriers, administrators, residents and others. In the latter category can, for instance, NGOs and property owners.
The stakeholders of city logistics continuously interact with each other, which reflect their behaviour (Taniguchi and Tamagawa, 2005). The importance of these stakeholders’ interaction in city logistics solutions is commonly acknowledged (Anderson et al., 2005). Interaction is required for the stakeholders to form mutual goals and strive in the same direction (Bertolini et al., 2005). Stathopoulos et al. (2012) emphasize the importance to analyse the interaction between the stakeholders and their different needs and constrains in relation to city logistics strategies. According to Awasthi and Proth (2006) consideration of interactions is a success factor for city logistics measures. Without a common understanding among stakeholders it might be difficult to obtain solutions for city logistics. Prerequisites for urban planning is a comprehensive understanding of the different stakeholders’ relationships and power asymmetries (Stathopoulos et al., 2012). Asymmetries of power can determine the level of adherence to the strategies and the level of collaboration and the circulation of expenses and advantages among the stakeholders (Stathopoulos et al., 2012).

Based on the stakeholder interactions, Taniguchi and Tamagawa (2005) created an example to describe how the behaviour of stakeholders can result in a vicious circle unless the behaviour is properly managed. The vicious circle can start with that the shipper charge a delay penalty when the carriers miss the delivery time. To avoid penalties, the carriers increase their delivery frequencies which lead to lower fill rates in the lorries and thus increase the environmental impact. When the environmental impact reaches a certain level the residents are affected negatively, and accordingly complaining to the administrators. Then, the administrators implement city logistics measures, which in turn affect the carriers. The vicious circle pinpoints the need for collaboration and aligning motives.

The overall goal of city logistics is to improve the cost and environmental efficiency of urban freight transportation and reduce traffic congestion, but the individual stakeholder groups often have different motives to participate in urban consolidation initiatives. Administrators and residents often focus on environmental and social considerations leading to a more attractive city, such as less noise, fewer trucks, less pollution and increased safety, while shippers, freight carriers and receivers tend to concentrate more on cost efficiency and increased sales. Thus, the motives and goals to participate in city logistics vary among the stakeholders which may lead to conflicts. According to Taniguchi et al. (2001), city administrators should be neutral and play a major role in resolving conflicts among the stakeholders and facilitate city logistics initiatives. However, city administrators and the government usually disregard to involve carriers in the decision-making of city logistics due to inadequate consideration of the carriers’ prerequisites within urban development (Browne et al., 2007). Hence, carriers are considered more as an obstacle to policy implementation rather than as core participants (Stathopoulos et al., 2012). As a result, the distribution of goods has been regarded as a problem rather than an essential activity. Therefore, authorities have focused more on the policies for individual vehicle activities than on the supply chains that these activities are part of (Browne et al., 2007).

3. METHOD

The paper is based on a three-year participant observation study in a city logistics project including ten stakeholders. The data relate to a variety of participant observation activities, such as monthly consortia meetings, weekly implementation meetings during one year, study visits and interviews. This paper is based on the understanding gained during the three years of study and nine semi-structured interviews with the stakeholders dedicated to the purpose of this paper. The stakeholder group citizens were not interviewed per se, but based on information from the interview with a consumer organisation. The data are analysed with a multi-criteria decision
model, which utilises the analytic hierarchy process (AHP) to rank alternative motives and their importance in a stakeholder value matrix.

In the participant observation study, five general motives for participation in the project were identified. This was done in individual meetings with the different stakeholders and discussions about motives and goals in project meetings. The motives that were raised by the stakeholders were then checked against motives described in city logistics literature (Anand et al., 2012; Benjelloun et. al., 2010; Taniguchi and Tamagawa, 2005; Taniguchi, 2014; Pålsson, 2014). The five constructs were defined as follow. Environmental efficiency means that the city logistics project should lead to minimise emissions, particles, noise etc. Economic efficiency relates to that the goods are delivered at the lowest possible cost. A third motive is that the goods should be delivered with few and small trucks for having an attractive city with minimal congestion, physical disturbance and traffic safety. Delivery quality means to receive goods on time, with minimal stops and deliveries, but with the needed frequency. Finally, marketing advantage is the possibility to differentiate the delivery service offering in the marketplace.

3.1. Research design

The overall approach is based on a multi-criteria decision model developed by Hosseini and Brenner (1992). This decision model utilises the analytic hierarchy process (AHP) to rank alternative motives (preferences) and their importance in a stakeholder value matrix. The AHP is a measurement theory which can take several factors into consideration simultaneously (Saaty, 1987). It can synthesise or conclude various factors in decision problems by making numerical trade-offs between these factors. According to Saaty (1987, p. 161), the AHP “is used to derive ratio scales from both discrete and continuous paired comparisons. These comparisons may be taken from actual measurements or from a fundamental scale which reflects the relative strength of preferences and feelings. The AHP has a special concern with departure from consistency, its measurement and on dependence within and between the groups of elements of its structure. It has found its widest applications in multi-criteria decision making, planning and resource allocation and in conflict resolution.”

The AHP and the value matrix were useful in this study of multiple stakeholders and motives (values) as it provided the possibility to identify which overall values that need the most attention and which and to what extent values need to be considered for each stakeholder. The development of the multi-criteria decision model involves three basic steps. A summary of the main elements of each step follows. A detailed description of the methodology and its approach is provided in Hosseini and Brenner (1992). The following three steps and the calculations are in line with the descriptions in Hosseini and Brenner (1992).

Step 1. Describe a complex multi-attribute problem as a hierarchy

The first step included the creation of a hierarchical decision model with three levels as illustrated in Figure 3.1. In the first step, the overall objective of the decision model was stated in level 1, the various stakeholders were identified and described in level 2, and the value concerns, i.e. the stakeholder motives for engaging in urban consolidation, were described in level 3 of the model.
Step 2. Estimate the relative weights for importance (or preference, influence, likelihood, etc.) of various criteria on each level of the hierarchy.

In the second step, the influence weights (R) and the value concerns of each stakeholder (W) were calculated and described in level 2 and level 3 respectively of the model. The methodology suggests that influence weights should be calculated by first making pairwise comparisons of all stakeholders to calculate influence ratings (R_{1,2} to R_{n-1,n}) as described in Figure 3.2. Empirically, the data points were collected from semi-structured interviews using the ratio scale described in Table 3.3 in the next section. Next, a matrix describing the relative influence of each stakeholder versus each of the other stakeholders should be created by using the influence ratings and all stakeholders on both axes (see example in Table 3.1). The matrix should be created from the perspective of the stakeholder on the y-axis (left column). If stakeholder 1 (on the y-axis) is more influential than stakeholder 2 (on the x-axis), the influence rating value (in this example R_{1,2}) should be used, otherwise the inverted value should be used (i.e. the stakeholder 2 is more influential than stakeholder 1). The matrix is completed when all n * n cells are filled in a similar manner. Thereafter, each cell in the matrix (Table 3.1) should be normalised for each stakeholder (1 to n) on the x-axis (each column) as shown in Table 3.2. Finally, the influence weights of each stakeholder (R_{1}-R_{n}) should be calculated as the average value of the normalised matrix for each stakeholder (Table 3.2). Accordingly, the influence weight shows the average influence of each stakeholder compared to the others. To measure the consistency of the judgement in the data, a consistency ratio was calculated as suggested by Hosseini and Brenner (1992). The inconsistency ratio was 0.1, which was considered acceptable (Saaty, 1980).

Figure 3.1 A hierarchical decision model
Figure 3.2 Example of data collection for calculating influence ratings ($R_{1,2}$ to $R_{n-1,n}$)

Table 3.1 Relative influence of the stakeholders

<table>
<thead>
<tr>
<th>Stakeholder 1</th>
<th>Stakeholder 2</th>
<th>Stakeholder n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder 1</td>
<td>1</td>
<td>$R_{1,n}$ or $1/R_{1,n}$</td>
</tr>
<tr>
<td>Stakeholder 2</td>
<td>$R_{2,1}$ or $1/R_{2,1}$</td>
<td>1</td>
</tr>
<tr>
<td>Stakeholder n</td>
<td>$R_{n,1}$ or $1/R_{n,1}$</td>
<td>$R_{n,2}$ or $1/R_{n,2}$</td>
</tr>
<tr>
<td>Sum</td>
<td>$\Sigma$Column 1</td>
<td>$\Sigma$Column 2</td>
</tr>
</tbody>
</table>

Note: The values compare the stakeholder in the left column with the other ones. The inverted value is used when the other stakeholder is the more influential one.

Table 3.2 Influence weight calculations

<table>
<thead>
<tr>
<th>Stakeholder 1</th>
<th>Stakeholder 2</th>
<th>Stakeholder n</th>
<th>Influence weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder 1</td>
<td>$R_{1,1Norm}=1/\Sigma Column 1$</td>
<td>$R_{1,2Norm}=(R_{1,2}$ or $1/R_{1,2})/\Sigma Column 2$</td>
<td>Mean ($R_{1,1Norm} : R_{1,2Norm} : R_{1,nNorm}$)</td>
</tr>
<tr>
<td>Stakeholder 2</td>
<td>$R_{2,1Norm}=(R_{2,1}$ or $1/R_{2,1})/\Sigma Column 1$</td>
<td>$1/\Sigma Column 2$</td>
<td>Mean ($R_{2,1Norm} : R_{2,2Norm} : R_{2,nNorm}$)</td>
</tr>
<tr>
<td>Stakeholder n</td>
<td>$R_{n,1Norm}=(R_{n,1}$ or $1/R_{n,1})/\Sigma Column 1$</td>
<td>$R_{n,2Norm}=(R_{n,2}$ or $1/R_{n,2})/\Sigma Column 2$</td>
<td>Mean ($R_{n,1Norm} : R_{n,2Norm} : R_{n,nNorm}$)</td>
</tr>
</tbody>
</table>

The value concerns should be calculated in a similar manner for each stakeholder, from $W_{1,1}$ to $W_{n,n}$ using the data collected in the semi-structured interviews. The consistency ratio was acceptable as the inconsistency ranged from 0.07 to 0.1 for the value concerns for the different stakeholders.

Step 3. Integrate the relative weights to develop an evaluation of the hierarchy with respect to the overall objectives of the problem.
The overall weights per stakeholder were calculated by multiplying the influence weight (R) with the value concern (W) resulting in composite stakeholder value matrix weights. The values in this matrix describes which and to what extent the different value concerns need to be considered for each stakeholder in order to manage the decision-making of urban consolidation.

3.2. Data collection

The empirical data used in the model in this paper origin from nine semi-structured interviews conducted within a three-year participant observation study. The data collection was carried out by two researchers, one has been involved for three years and the other for one year. The data from the participant observation study were documented in a protocol as suggested by Yin (2003) which logged data regarding meeting minutes, notes, events, observations, interviews and archival data. The main data source for this paper were collected in semi-structured interviews. These interviews were conducted in October-November 2015 with a representative of each of the stakeholders of the city logistics project. Throughout the project, each organisation was represented by at least one participant in the city logistics project. These participants were responsible for the project within each organisation and were accordingly selected as respondents in the interviews.

For a further description of the stakeholders, please see the participant observation study section. The semi-structured interviews focused on two parts that generated data for the model: the motives of the stakeholders to participate in the city logistics project and the influence of the stakeholders on the city logistics project. For contextual understanding and insights into each stakeholder’s participation, the interviews also covered general information about the organisation, their learning and output from the project, and challenges in the project. In the first part of the interviews, the stakeholder motives were discussed in terms of the five constructs (economic efficiency, environmental efficiency, few and small trucks, delivery quality, and marketing advantage). First, the interviewer described the meaning of these constructs and opened for the possibility to add motives, but none of the stakeholders needed to do so. Next, the constructs were discussed in terms of pairwise comparisons using the ratio scale by Saaty (1988) meaning that each construct were compared to the other four constructs one by one. For example, economic efficiency was first compared to environmental efficiency where the respondent could reply that these motives were equally important, that one of them was moderately more important than other, etc. as described in the ratio scale (Table 3.3).
Table 3.3 The ratio scale (Saaty, 1988)

<table>
<thead>
<tr>
<th>Intensity of importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
<td>Two elements contribute equally to the property</td>
</tr>
<tr>
<td>3</td>
<td>Moderate importance of one over another</td>
<td>Experience and judgement slightly favour one element over another</td>
</tr>
<tr>
<td>5</td>
<td>Essential or strong importance</td>
<td>Experience and judgement strongly favour one element over another</td>
</tr>
<tr>
<td>7</td>
<td>Very strong importance</td>
<td>An element is strongly favoured and its dominance is demonstrated in practice</td>
</tr>
<tr>
<td>9</td>
<td>Extreme importance</td>
<td>The evidence favouring one element over another is of the highest possible order of affirmation</td>
</tr>
<tr>
<td>2,4,6,8</td>
<td>Intermediate values between the two adjacent judgments</td>
<td>When compromise is needed between two judgements</td>
</tr>
<tr>
<td>Reciprocals</td>
<td>When activity i compared to j is assigned one of the above numbers, then activity j compared to i is assigned its reciprocal.</td>
<td></td>
</tr>
<tr>
<td>Rationals</td>
<td>Ratios arising from forcing consistency of judgements.</td>
<td></td>
</tr>
</tbody>
</table>

The second part of the interview, which covered the relationships between the responding stakeholder and the other stakeholders, captured data regarding the relative importance of each stakeholder to the responding stakeholder. This part investigated how the responding stakeholder perceived their relative influence on the city logistics project compared to each of the other stakeholders. The responding stakeholder described their contribution in the project, their experience of each of the other stakeholders and how they were affected by and affected the other stakeholders. Based on this part of the interview, next the relative influence on the city logistics project of the responding stakeholder compared to each of the other stakeholders were discussed based on the ratio scale by Saaty (1988).

Afterwards, the interviews were transcribed and summarised by the interviewer. Then, both researchers first individually and then together completed the scores for influence ratings (Figure 3.2) and the motives ratings. In this process, the results of the interviews were reflected in the participant observation data in order to triangulate the data. The intensity of importance was gathered from the interviews and translated into figures as described in Hosseini and Brenner (1992). For example, if the respondent responded that two motives were equally important, that cell of the motives matrix received the value 1. To verify our understanding of influences and motives, the results of the model were presented to and discussed among the stakeholders in the project group.

4. PARTICIPANT OBSERVATION STUDY

A city logistics project including ten stakeholders was followed during three years. The project focuses on a multicultural middle-sized city in Sweden with approximately 300,000 residents and about 170 nationalities. The city is one of the commercial centres of Sweden undergoing a transition from being an industrial city to a city of knowledge. The strongest sectors of the city are logistics, retail and wholesale trade, construction, and property. Over the last years the city has received international awards for its focus on sustainable city development.
The overall goal of the city logistics project was to develop and provide green and bundled deliveries of goods and value-adding logistics services for stores in the city centre. Practically, goods are consolidated in an urban consolidation centre (UCC) from where goods deliveries are sent out. The goods are either sent directly to the stores or via a micro terminal located in the city centre.

The genesis of this city logistics project can be dated back to 2013, where the idea of the city logistics emerged. The idea evolved into a novel business model through a pre-study including user needs examination, stakeholder collaboration and inspiration from public conferences and seminars. To implement the business model two transport operators were involved in the project. Based on an offering, transport companies could apply in competition to become the transport operators within the city logistics project. The novelty of the project was to create a sustainable, coordinated goods distribution centre that meets users’ needs for efficient transportation and services with minimal environmental impact for an attractive urban environment in interaction with the urban development. The project was externally funded. As a first step of the project, a business model for a sustainable supply system for an attractive city was developed. The business model is based on a survey of needs of stores and property owners in the Swedish city. The idea was to obtain a user perspective in the business model by providing demanded logistics services along with bundled deliveries.

To support the concept development of the project, a number of policy measures was implemented. For instance, a policy measure supports the transport providers to be allowed to drive on the pedestrian road. The municipality made an exception to give permission to drive in the pedestrian zone. A requirement was that the drivers had to pass a road safety education to drive in the pedestrian zone. Another policy measure was to use text on the vehicles to declare that the vehicles were dispensed and allowed to use specific stop lights in the pedestrian zone. The dispense were given to support the project in optimising transport activities by private and public companies while considering the traffic environment, congestion, safety and the energy savings within the framework of a market economy.

The project consists of ten stakeholders including the municipality (M), two transport operators (TP1 and TP2), a property owner (PO), a city cooperation organisation (CCO), a haulier organisation (HO), the Confederation of Swedish Enterprise (CSE), a retail consumer organisation (RCO), the stores (S), and citizens (CZ) in order to develop and implement a concept for city logistics. Each organisation had a representative in the project. The municipality is an active member and driving force of the project. It promotes the economic, environmental and social development of the city and is engaged in service to the citizens. TP1 is a leading logistics company with a focus on innovation, quality, safety and environment while TP2 is mainly expert in recycling; they collect, treat and recycle waste and residues from industry, organizations and households throughout Sweden. PO is a trade association of real estate entrepreneurs. It has 2300 members, which together manage over 7000 properties. The task is to create the best possible conditions for the real estate business life. CCO is a platform for supporting business in the city through various projects and initiatives in collaboration with other partners. The goal is to create and maintain an attractive and vibrant city centre. HO is a haulage industry organisation dedicated to promote a healthy and profitable development of the haulage industry. It participates in haulage issues related to transport and social policy to strengthen the Swedish haulage trade, competitiveness and improve the conditions for trucking companies. CSE represents the businesses in Sweden. Their long-term goal is to ensure the best possible conditions for companies in Sweden to operate and grow. CSE represents almost 60 000 businesses. RCO is a cooperative association founded in 1899 and was based on the idea of good food at a good price. This idea expanded and considers the creation of economic
benefits, while making it possible for members through their consumption to contribute to sustainable development for citizens and the environment. There are about 665 RCO stores throughout Sweden and are owned by 3.4 million members in 32 consumer associations. S are the retail establishment offering a wide range of consumer goods in various product categories. Some are part of a retail chain, while others are independent retailers. Main shopping activities are carried out through walking streets that host many stores. These stores have different opening hours depending mainly on their types, which makes transportation challenging. CZ live in the city and are affected the most from city logistics initiatives and solutions. They care about the environment and health and require that all the activities take place in the city must always be in harmony with what they prioritize and demand without affecting the environmental impact of the safety of the city. The interview with RCO covered both the stakeholder perspective of this organisation and provided data for analysing the CZ perspective.

All the stakeholders play a role in implementing the provisions of city logistics, either through activities and research, or by collaborating with one another to build capacity within the city, city’s administrators and other institutions to meet the city logistics commitments. The city is dependent on goods transport, and the transport operators on the city. M collaborates with the other stakeholders to develop the project. There is a constant information flow between the involved stakeholders. PO collaborate mainly with the municipality, the CCO and the transport operators due to their interest in the project, which is to improve the attractiveness of the city. TP2 is subcontracted by TP1, which mainly collaborates with the M, the PO and the CCO.

Within the project there is a fruitful dialogue between the stakeholders in meetings organised by the municipality. The meetings started by stating the long-term objectives for the project that are available in a variety of sectors and include reduced emissions of greenhouse gases from the transport sector, improved air quality and road safety, more attractive and livable city for residents, visitors and businesses in the form of fewer vehicles and improved services to retailers and public sector. The meetings consist of implementation meetings and consortia meetings. The implementation meetings take place once a week and are held by M, TP1, TP2, CCO and HO. The aim of these meetings are to exchange and analyse information on current progress of the project and its performance. During such a meeting, the project manager distributes performance reports among the participants to allow the team and stakeholders to gain visibility into current performance levels and task progress. Status review meetings are also known as performance reviews. The consortia meetings take place once a month where M, PO, CCO, RO, HO and CSE participate. These meetings aim to review and guide the project in the overall direction. The direction and follow-up actions for the project are decided upon. The actions include, for instance, goods flow modelling, business model review, and analyses related to environmental and economical sustainability performance of the project.

5. RESULTS

To develop a decision model that describes the values that need the most attention and which and to what extent values need to be considered for each stakeholder, the analysis followed the three steps described in the method section.

5.1. The city logistics management organisation’s behaviour

The results are summarised in Figure 5.1. In the first step, a hierarchy with three levels representing the overall objective, the stakeholders and their decision criteria, which are based on their motives and goals, was developed. Based on the nature of the city logistics organisation
and the project aim, the overall objective for the decision model was described as the decision-making behaviour of city logistics. In level two of the hierarchy, the stakeholders were presented, followed by their motives and goals, which also are referred to as value concerns in level three. The ten stakeholders are described in section 4. The value concerns emerged from the participant observation study as described in the method section and were investigated in detail in the interview study. Five value concerns were identified and analysed: improving the environmental efficiency, improving the economic efficiency, utilisation of few and small trucks in the urban area, delivery quality and obtaining a marketing advantage.

In the second step, the influence weights (R) and the value concerns (W) of each stakeholder were calculated and described in level 2 and level 3 respectively of the model. The influence weight shows the average influence of each stakeholder compared to the others. As an illustration, the results show that the most influential stakeholder was M with an influence weight of 0.320, which was approximately 20 times more influential than the CZ with an influence weight of 0.015. All influence weights are presented in Figure 5.1. The value concerns were calculated in a similar manner for each stakeholder. In level 3 in Figure 5.1, the results of the value concerns for each stakeholder are shown. The results show, for instance, that the transport providers primarily focus on cost efficiency and that PO emphasises few and small vehicles in the city.

In the third step, the relative influence weights of each stakeholder and their value concerns were combined in a composite stakeholder value matrix for city logistics (Table 5.1). The results highlight which and to what extent the different value concerns need to be considered for each stakeholder in order to manage the decision-making of urban consolidation. The matrix shows that to keep stakeholders motivated thus creating possibilities for long-term success of CL from a management perspective, the most essential combinations of value concerns and stakeholders in the decision making process are to manage and highlight:

![Figure 5.1 A hierarchical decision model for city logistics management](image-url)
The composite stakeholder matrix weight related to marketing advantage is quite low for all stakeholders. According to the decision model, it should be considered to some extent, but not prioritised. The results also show that the value concerns of five stakeholders should be ranked lower in the decision making of CL as their integrated relative weights of influence and value concerns are low. These stakeholders are CCO, CSE, HO, RCO and CZ. Out of these, the value concerns of CCO should be considered the most, because of the highest combined weights and that they represent the stores, which are among the focus areas above.

Table 5.1 Composite stakeholder value matrix weights for city logistics

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Environmental efficiency</th>
<th>Economic efficiency</th>
<th>Few and small trucks</th>
<th>Delivery quality</th>
<th>Marketing advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport Operator 1 (TP1)</td>
<td>0.00</td>
<td>0.06</td>
<td>0.00</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Transport Operator 2 (TP2)</td>
<td>0.00</td>
<td>0.04</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Municipality (M)</td>
<td>0.15</td>
<td>0.02</td>
<td>0.10</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Property Owner (PO)</td>
<td>0.02</td>
<td>0.01</td>
<td>0.09</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>City Cooperation Organisation (CCO)</td>
<td>0.00</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Haulier Organisation (HO)</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Confederation of Swedish Enterprise (CSE)</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Retail Consumer Organisation (RCO)</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>Stores (S)</td>
<td>0.01</td>
<td>0.05</td>
<td>0.02</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>Citizens (CZ)</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Overall value concern</td>
<td>0.20</td>
<td>0.23</td>
<td>0.24</td>
<td>0.21</td>
<td>0.12</td>
</tr>
</tbody>
</table>

6. DISCUSSION AND CONCLUSIONS

This paper addresses the challenge of collaboration and alignment of motives and goals between stakeholders in city logistics by introducing a structured method for managing stakeholders and their diversity of motives and goals. The method helps to prioritise both between stakeholders and between their motives/goals. The AHP method, which is based on stakeholder theory, helps to numerically evaluate the relative significance of various stakeholders and their motives and goals. This evaluation provides actual data for an improved understanding of how decision-making within city logistics should be influenced by these factors. The patterns of the stakeholder values and the value concerns can be useful for understanding stakeholder behaviour in city logistics.

Stakeholder theory attempts to identify the fundamental question of which groups of stakeholders deserve or require attention, which can be translated into how stakeholder demands should be prioritised. The application of stakeholder theory and the AHP to city
logistics is novel. The AHP combines several factors in decision problems by making numerical trade-offs between these factors. The AHP and the value matrix were useful in this study of multiple stakeholders and motives as it provides the possibility to distinguish which overall values need the most attention and to what extent as well as to what extent each stakeholder needs to be considered.

Current literature points out the importance of committed and driven individuals (BESTUFS, 2007) and that the municipality takes a leading position (Taniguchi et al., 2001) as success factors for city logistics. Our results complement these insights by balancing the importance of various actors. Our results support that the municipality is the single most important stakeholder and that it might be useful to have committed individuals in the municipality, but the results also highlight the importance of transport operators, property owners and stores in our case study.

The analysis reveals patterns of goals and motives for the stakeholders. From a management perspective, the analysis showed that the goals and motives cannot always be aligned, but needs to be fulfilled to various extent for the different stakeholders. In this case, the city logistics project should be managed so that the municipality experience improved environmental efficiency and utilisation of small trucks, the property owners experience extended utilisation of small trucks, the stores perceive improved economic efficiency and high delivery quality and the transport operators obtain improved economic efficiency by participating. Noticeably, the goals and motives of the other five organisations involved is not that important to consider in the management of this city logistics case. These stakeholders can be informed about the proceeding of the project.

Many city logistics projects in previous research focus mainly on environmental efficiency (Allen et al., 2012), while our approach helps to balance the environmental efficiency gains with other motives and goals so that all stakeholders are satisfied. According to our results, only focusing on environmental efficiency only satisfies the municipality, which can be part of the explanation why so many city logistics projects have failed. They simply do not address the other stakeholders’ motives, which is required for their long term participation.

Another research stream in city logistics focuses on environmental policies of administrators, such as the municipality, as a way to obtain long-term success of city logistics (Anderson et al., 2005). Our results, which are based on stakeholder theory, do not conflict such policies, but suggest that they should be combined with diversified management of various stakeholders, and that all value concerns should be addressed to various extent. Thus, instead of focusing mainly on environmental considerations, the stakeholder theory approach shows that by emphasising different value concerns all stakeholders can be motivated, which is likely to contribute to less city logistics failures (Lindholm, 2010) and help to make informed trade-offs for more creative power in the project (Basset-Jones, 2005).

A potential limitation of the stakeholder approach could be that some stakeholders have unrealistic motives and goals. For instance, it might not be possible to reduce the size of the vehicles as perceived by a stakeholder or it might not be possible to obtain economic benefits as stakeholder expect. Such considerations are primarily a management issue. If it is impossible to find an acceptable solution, it might be possible to exchange stakeholders, particularly if it regards transport operators who are exchangeable. Another limitation is that even though the method points out to what extent various value concerns should be addressed, it may still be challenging to combine the value concerns. Finally, the method presents an opportunity to base decision-making within city logistics management on quantified data, but it is important to highlight that this should be complemented with relationship management.
The theoretical implications of this research can be summarised as follows. Stakeholder theory, operationalised with the AHP, provides some explanatory power for city logistics management as it helps to prioritise both between stakeholders and between their motives. It explains numerically the relative importance of various stakeholders and their motives. Thus, it contributes to the challenge of managing the diversity and heterogenic needs of multiple stakeholders in city logistics (Anand et al., 2012; Taniguchi and Tamagawa, 2005). The insights of stakeholder theory into interactions between the stakeholders through the numerical ranking of the stakeholders in AHP enables operationalisation of interactions between the stakeholders, which has been identified as a success factor for city logistics measures (Awasthi and Proth, 2006; Stathopoulos et al., 2012). The general conception for city logistics projects is that collaboration among stakeholders is necessary to reach viable solutions, but there is a lack of descriptions of forms for collaboration between and within stakeholder groups in city logistics. This study highlights such interactions and the associated challenges. The method applied in this paper structures and supports decision-making within city logistics for prioritisation between both value concerns and stakeholders. Applying stakeholder theory also indicates the relative importance of various stakeholders and their motives and goals for long-term success. Thus, stakeholder theory presents evidence that several stakeholders need to be managed and a combination of motives and goals needs to be fulfilled for a sustainable business model of city logistics.

Practically, the results can help city logistics projects in finding a balance between various stakeholders and their motives and goals. The method and the outcome in this case can help to make informed trade-offs between value concerns and to what extent various stakeholder claims should be considered. It can also provide insights to individual stakeholders about their relative influence on the project and the importance to have trade-offs between different motives.

The method prioritises between stakeholders and between their motives and goals. In future research it would be useful with contributions that report from in-depth cases how such prioritisation is carried out in practice. Future research should also generalise the results of this paper by applying the method to a number of different city logistics projects to get general statistics of value concerns and stakeholder motives and goals in order to quantify stakeholder management based in stakeholder theory.

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HAS ENVIRONMENTAL SUSTAINABILITY ANY ROLE IN SELECTION OF TRANSPORT MODE? 
A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Purpose
In the European Union (EU), transport is the second biggest sector in greenhouse gas emissions. One of the solutions toward environmentally sustainable development suggested in the EU is to increase the share of intermodal transport. Therefore, this study focuses on the decision criteria for transport mode choice, and if and how environmental sustainability is included in the criteria.

Design/methodology/approach
A systematic literature review on the topic was conducted to understand the current state of research on transport mode choice, and the role of environmental sustainability in the selection of transport mode. Also, a review of literature on tenders/request for quotations and transport contracts was conducted, as they are linked to decisions on transport choice.

Findings
The results show that related to the transport mode choice, environmental sustainability is not among the most important decision criteria. In the older articles, sustainability was not among the criteria, however, it is slowly becoming more common. In addition, there are only a few articles in the literature focusing on tenders and transport contracts.

Research limitations/implications
There is a need for theory building and testing and methodological diversity in transport choice research, in order to increase understanding on how mode selection decisions are linked to systems of actors as well as physical transport infrastructure.

Practical implications
Sustainability criteria in the selection of transport solutions are slowly becoming more common. This result might be of interest to policy makers and companies in the field.

Social implications
To enhance sustainable development, the EU should take a more active role in advancing the development of measurement systems for environmental sustainability of transport solutions.

Original/value
To the authors’ knowledge, a systematic literature review on this topic seems to be the first attempt presented in the current body of literature.
1. INTRODUCTION

The European Union (EU) and the international community have agreed on the need to reduce greenhouse gas emissions dramatically. For limiting climate change below 2°C, the EU needs to reduce emissions by 80-95% below 1990 levels by 2050. (European Commission White paper, 2011). In the EU’s greenhouse gas (GHG) emissions, transport is responsible for 24%, being the second biggest sector in emissions after energy sector (Reducing emissions from transport, 2016). Without further explanation, this number unquestionably evidences the importance of needs for sustainable development in the transport sector. A reduction of at least 60% of GHGs by 2050 with respect to 1990 is expected from the transport sector. By 2030, the goal for transport will be to reduce GHG emissions to around 20% below their 2008 level. This would still put those 8% above the 1990 level. (European Commission White paper, 2011).

The EU has promoted sustainable transport, and in particular intermodal transport for twenty years in order to make transport greener (Reis, 2014). Currently, the most widely used modes, road and air transport, are the less environmentally efficient (Lammgård, 2012). Road transport was responsible of 71.9% of GHG emissions in 2012, whereas for example railways only 0.6% (Reducing emissions from transport, 2016). Thus, rail-based intermodal transport has been suggested as one of the key means in transforming the sector towards sustainability. After all efforts, transformation towards sustainability has been slow and the share of rail transport is still low, about 10% of all transports. The EU aims at that 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors (European Commission White paper, 2011).

The systematic literature review method is used to explore the current stage of research on the choice of transport. The method is described next, and then the findings. Then results are discussed and conclusions are drawn.
2. METHOD

This study uses the systematic literature review method. A review of relevant literature is important for all academic research, as it helps ground the authors’ research on the state of the art of existing research and shows the authors’ contribution to the specific research field (Seuring and Gold, 2012). Systematic literature review follows a certain protocol for managing the diversity of knowledge in a specific research theme (Tranfield et al., 2003; Burgess et al., 2006). An integrative research review summarizes past research and draws conclusions from separate studies (Cooper, 1989; Tranfield et al., 2003). With classification of previous studies, it is also possible to identify gaps in current research and opportunities for future research (Srivastava, 2007; Ashby et al. 2012). Tranfield et al. (2003) has pointed out that for practitioners and policy-makers “systematic reviews could provide with a reliable basis to formulate decisions and take action”. The method has been applied in a number of contexts; in intermodal transport (Bontekoning et al., 2014), in sustainable supply chain management (Seuring and Muller, 2008; Srivastava, 2007; Gold et al., 2010; Carter and Easton, 2011; Ashby et al. 2012; Gimenez and Tachizawa, 2012), in third party logistics (Selviaridis and Spring, 2007; Marasco, 2008), to name a few. Systematic reviews adopt a detailed process that aims at minimizing bias through exhaustive literature searches and provide an audit trail for the reviewer decisions, procedures and conclusions (Tranfield et al., 2003). Seuring and Müller (2008) describe that literature reviews can be understood as content analysis mixing both quantitative and qualitative aspects for assessing structural and content criteria. For the content analysis in this study, three stages are followed: 1) planning (objectives and review protocol for a review i.e. defining sources and procedures for article searches, definition of the unit of analysis), 2) conducting the review (descriptive analysis, where the formal aspects are assessed e.g., the number of publications per year, definition of selection and classification categories for the articles where structural dimensions and analytic categories are selected forming the major topics of analysis, material evaluation and synthesis of data), and 3) reporting and dissemination (see e.g. Cooper, 1989; Mayring, 2003; Tranfield et al., 2003; Seuring and Müller, 2008).

In the planning stage, we defined our objective to find out what kind of criteria are included in transport choice and how sustainability is present in the mode choice, tender/RfQ and contract literature. To ensure comprehensive search we decided to include three databases; Ebsco Business Source Complete, Emerald Insights and Proquest. We defined the keywords, and the same search strings were used in all three databases. The search strings consisted of different combinations of words “intermodal”, “multimodal”, “transport/transportation”, “contract”, “tender”, “request for quotation”, “sustainab(le)”, “environm(ent)”, “mode choice”, “mode selection” etc. (cf. Appendix 1). A series of databases (not individual journals) and the same keywords were used to reduce any potential bias in the search process (Ashby et al., 2012). A total of 81 searches resulted to 2006 hits, and the results were gathered into a research database. Then two researchers analysed abstracts, and coded their suggestions for inclusion and exclusion in the research database. Thereafter, the results were analysed jointly and preliminary decisions were made. Final decisions were made after checking the whole articles, as the unit of analysis was a single research paper (see e.g. Mayring, 2003). Taking also into account the overlapping articles, the final amount of selected articles was 37 (see Appendix 1).

The first inclusion criterion was that the article had to have an individual decision maker’s or company’s view to the transport mode decision dilemma. Selection between transport modes including rail or intermodal transport as an option for choice had to be mentioned in the article. On articles that included empirical data or examples, we included those having focus on Europe. We excluded articles that did not have a decision maker or company focus, but rather had only
policy or freight flow focus, or that only dealt with logistics outsourcing decisions, or that did not cover any mode choice or intermodal transport aspects. In the selected articles we studied which criteria were used, and if criteria related to environment were mentioned, and what was the role of it in the decision making. Next, the findings of the literature review are presented, including the descriptive analysis, category selection, and material evaluation of the selected articles.

3. FINDINGS OF THE LITERATURE REVIEW

3.1. Descriptive analysis

For categorization, literature reviews were benchmarked to find good classifications and analysis methods. We started to conduct the review by categorizing the selected papers according to publication year (see e.g. Mayring, 2003; Burgess et al., 2006). The literature on the topic has in fact increased significantly after the year 2000, especially in the last decade (see Figure 3.1). Half of them were published in 2010 or later. Half of the selected papers mentioned sustainability issues, and half of them were published in 2012 or later. If we count in all the selected 37 papers, half of them were published before or in 2008, and half in 2008 or later. Two thirds of the selected articles mentioned intermodal transport and others had focus on mode choice. The findings are in line with Bierwirth et al. (2012) who claim that the growing interest in sustainable logistics has also given rise to the rapid progress of academic literature on intermodal transport.

Selviaridis and Spring (2007) follow Croom et al. (2000), and classify papers according to their research purpose (descriptive vs normative) and nature (empirical vs conceptual). Srivastava (2007) uses two classification contexts: problem context and methodology/approach context; and further for the latter context: thought papers and perspectives; frameworks and approaches; empirical studies; mathematical modelling approaches; and reviews. Seuring and Muller (2008) differentiate five research methodologies used in articles: (1) theoretical and conceptual papers; (2) case studies; (3) surveys; (4) modelling papers; and (5) literature reviews. Articles were classified according to if they were based or used case studies (including specifying number of cases, and if there were case interviews or other case material used), surveys (interviews or questionnaire), illustrative examples, or group of experts; if they were presented in mathematical models, or analysed data with quantitative methods. Further, the classification of Croom (2000) was used, and articles were divided into empirical/conceptual and descriptive/normative. In the selected articles, there were 16 articles that were conceptual and normative, and nine that were empirical and descriptive or empirical and normative (see Figure 3.1, and Appendix 2). The selection of articles in this study with most articles conceptual and normative, is rather exceptional, because Croom (2000) and Selviaridis and Spring (2007) in their supply chain and third party logistics literature reviews found out that most of the articles were empirical and descriptive. The most probable explanation is that many articles in the selection have an emphasis on modelling (optimisation and mathematical models) and policy measures. Mode choice problems suit well for modelling, and the studied theme is close to policy considerations.
In the selection, there were 16 articles based on surveys – eight on survey interviews and eight on survey questionnaires. There were only four case studies, all published after the year 2005. Illustrative examples were used in 13 papers. Mathematical models were presented in 23 papers, and other models (usually frameworks) in eight papers. The dominance of surveys compared to case studies may reflect the positivistic research tradition within logistics (see e.g. Mentzer and Kahn, 1995; Ellram, 1996; Gammelgaard, 2004; Selviaridis and Spring, 2007). The big amount of mathematical models and their testing with empirical material or examples can explain the amount of conceptual papers. It can be summarized that at least transport mode selection problems are relatively attractive for developing mathematical models basing on positivistic research approach; mathematical models have not lost their attraction through years. Also surveys are still popular. Case studies have attained increased interest in the last few years.

Among the theories, models or methods used or developed in analyses are among others, agency theory (Halldórsson and Skjøtt-Larsen, 2006; Selviaridis and Norrman, 2014), resource-based view (Colicchia et al., 2013), transaction cost theory (Halldórsson and Skjøtt-Larsen, 2006), utility theoretic models (Mahmassani et al., 2007; Baizrour and Viegas, 2011; Bergantino et al., 2013; Truschkin and Elbert, 2013; de Jong, 2014), inventory-theoretic models (Baumol and Vinod, 1970; Blauwens et al., 2006), stated or revealed preference models (Bolis and Maggi, 2003; Danielis and Marcucci, 2007; Bergantino and Bolis, 2008; Bergantino et al., 2013; de Jong, 2014), optimization and simulation models (Mahmassani et al., 2007; Dekker et al., 2009; Kang et al., 2010; Baizrour and Viegas, 2011; Liedtke, 2012; Bergantino et al., 2013; Reis, 2014), multivariate analysis methods (Jerman et al., 1978), regression analysis (Kapfelf and Mentzer, 1982; Ludvigsen, 1999), and factor analysis (Jeffs and Hills, 1990; Ludvigsen, 1999).

The selected articles were categorized into mode choice, RfQ and contract literature based on the focus of the study. The mode choice category was the largest, containing 31 articles. Six articles focused on transport contracts and only two articles mainly focused on tenders/RfQs. Based on the content, two articles were categorized into two categories (Andersson and Norrman, 2002; Baizrour and Viegas, 2011).

### 3.2. Mode choice articles

Articles in this category including author(s), title of the article, publication year, journal and short summary of main conclusions of the article can be found in Table 3.1. Slater (1979, 1982) argues that mode choice decisions are extremely complex because there are diverse choices available and several evaluation methods for evaluation of each choice. Also Bolis and Maggi
complex, it is unlikely that any universal mode-choice model can be developed. Jeffs and Hills (1990) point out that as freight flows are complex, it is unlikely that any universal mode-choice model can be developed.

Table 3.1 Mode choice articles in the selection.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Year</th>
<th>Journal</th>
<th>Main conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baumol and Vinod</td>
<td>An Inventory Theoretic Model of Freight Transport Demand</td>
<td>1970</td>
<td>Management Science</td>
<td>The optimal choice of mode involves a trade-off among freight rates, speed, dependability (variability in speed) and en-route lossage. Inventory theory makes possible a direct comparison of the four attributes.</td>
</tr>
<tr>
<td>Jerman, Anderson and Constantin</td>
<td>Shipper Versus Carrier Perceptions of Carrier Selection Variables</td>
<td>1978</td>
<td>International Journal of Physical Distribution &amp; Materials Management</td>
<td>The five most important carrier selection variables: Co-operation, Knowledge of a shipper's needs, Carrier reputation for dependability and quality service, Carrier ability to trace shipments. The five most important selection variables to the shipper: Co-operation, Carrier ability to trace shipments, Total transit time, Knowledge of a shipper's needs, Carrier assistance.</td>
</tr>
<tr>
<td>Slater</td>
<td>Choice of the Transport Mode</td>
<td>1979</td>
<td>Int. J. of Physical Distribution &amp; Materials Management</td>
<td>The decision upon the choice of the transport mode is extremely complex because of the vast volume of choice available together with the numerous methods of examination and evaluation of each choice.</td>
</tr>
<tr>
<td>Slater</td>
<td>Choice of the Transport Mode</td>
<td>1982</td>
<td>Int. J. of Physical Distribution &amp; Logistics Management</td>
<td>The decision upon the choice of the transport mode is extremely complex because of the vast volume of choice available together with the numerous methods of examination and evaluation of each choice.</td>
</tr>
<tr>
<td>Krapfel, and Mentzer</td>
<td>Shippers' Transportation Choice Processes Under Deregulation</td>
<td>1982</td>
<td>Industrial Marketing Management</td>
<td>A model of shippers' transportation choice processes; variables that the model addresses are: 1. speed of service, 2. shipment losses, 3. trailer or flat car service, 4. common carrier availability, 5. freight rates, and 6. firm size in dollar volume.</td>
</tr>
<tr>
<td>Jeffs and Hills</td>
<td>Determinants of modal choice in freight transport A case study</td>
<td>1990</td>
<td>Transportation</td>
<td>Variables influencing on modal choice decision-making process: customer-requirements; product-characteristics; company structure/organization; government interventions; available transport facilities; perceptions of the decision-maker him/herself. Freight flows are complex; unlikely that a universal mode-choice model can be developed. Data from 100 interviews in printing and publishing sector in UK. Analyses effects of firm size on decisions.</td>
</tr>
<tr>
<td>Pedersen and Gray</td>
<td>The transport selection criteria of Norwegian exporters</td>
<td>1998</td>
<td>International Journal of Physical Distribution &amp; Logistics Management</td>
<td>Transport price factors more important than other transport selection criteria by a high proportion of Norwegian exporters. This may be explained by higher transport costs in Norway, partially explained with topography, location, transport distances, limited domestic competition, and exports of raw materials which are sensitive to transport cost. Studies report carrier selection determinants in a context-free manner; a typology of relevant context features needed for better comparisons. Survey respondents: 69 exporters.</td>
</tr>
<tr>
<td>Ladvigsen</td>
<td>Freight transport supply and demand conditions in the Nordic countries: recent evidence</td>
<td>1999</td>
<td>Transportation Journal, Volume: 39</td>
<td>Shippers' quality requirements for intermodal and single-modal transit are the same. Intermodal solutions score lower, and low price does not substitute for poor quality. Number of intermodal routes is lower than single-modal. Large shippers enjoy high quality of intermodal transit, because they have strong bargaining power. Survey of 46 Nordic shippers.</td>
</tr>
<tr>
<td>Bolis and Maggi</td>
<td>Logistics Strategy and Transport Service Choices: An Adaptive Stated Preference Experiment</td>
<td>2003</td>
<td>Growth &amp; Change</td>
<td>Transport mode choice as a part of a firm's logistics strategy. Adaptive stated preference experiments confirm the relevance of the logistics context (e.g., JIT strategies on the supplier's or customer's side) for transport demand. 22 firms in Italy and Switzerland, 1,271 hypothetical choices. No indication of company size.</td>
</tr>
<tr>
<td>Vannieuwenhuyse, Gelders and Pintelon</td>
<td>An online decision support system for transportation mode choice</td>
<td>2003</td>
<td>Logistics Information Management</td>
<td>Interactive Internet tool to support the transportation mode decision process. A significant gap between the performance perception of users and non-users of the transportation modes. The tool helps to close the knowledge gap. Five performance criteria by shippers and logistics providers: 1) transportation cost, 2) reliability, 3) flexibility, 4) transportation time, 5) safety. Survey in Belgium, shippers and logistics providers in Flanders, over 500 respondents No indication of company size.</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Title</td>
<td>Year</td>
<td>Journal</td>
<td>Main conclusions</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Blauwens, Vaunder,</td>
<td>Towards a Modal Shift in Freight Transport? A Business Logistics Analysis of Some Policy Measures</td>
<td>2006</td>
<td>Transport Reviews</td>
<td>Certain policy measures, e.g. leading to an increase in the transportation costs of road transport or measures resulting in a better lead-time performance of combined transport, can trigger significant modal shifts from road transport to the alternative freight transport modes. Hypothetical market for container transport, based on case study (Antwerp–Germany). No indication of company size.</td>
</tr>
<tr>
<td>Danielis and Marcucci</td>
<td>Attribute cut-offs in freight service selection</td>
<td>2007</td>
<td>Transportation Research, Part E, Logistics &amp; Transportation Review</td>
<td>Manufacturing firms’ difficulty of achieving a modal transfer of freight from road to truck-rail intermodal transport. Minimum requirements for freight services are quite strict, especially on late arrivals, loss and damage, and costs. Some flexibility regarding travel time exists. The firms have little or no knowledge of non-used modes. A sample of 99 Italian manufacturing firms.</td>
</tr>
<tr>
<td>Mahmassa ni, Zhang, Dong, Lu, Arcot and Miller-Hooks,</td>
<td>Dynamic Network Simulation-Assignment Platform for Multiproduct Intermodal Freight Transportation Analysis</td>
<td>2007</td>
<td>Transportation Research Record</td>
<td>Given a multimodal network with known service supply attributes and time-dependent demands, the network simulation model determines the flow of shipments on the road, rail, and sea network for the various time intervals of interest, and the associated service levels and network performance experienced by the shipments. Simulation in a trans-European corridor.</td>
</tr>
<tr>
<td>Kreutzberger</td>
<td>Distance and time in intermodal goods transport networks in Europe: A generic approach</td>
<td>2008</td>
<td>Transportation Research Part A: Policy &amp; Practice</td>
<td>Direct costs /prices most important performance measurers of the intermodal transport system. The relevance of quality performances is less clarified. The times of complex bundling networks are larger than that of networks with direct connections, but nevertheless competitive with unimodal road transport, except for short distances. Rail bundling networks in Europe.</td>
</tr>
<tr>
<td>Tuzkaya and Onut,</td>
<td>A fuzzy analytic network process based approach to transportation-mode selection between Turkey and Germany: A case study.</td>
<td>2008</td>
<td>Information Sciences</td>
<td>Thirty-two sub-criteria to select the best transportation mode under eight criteria clusters, namely product characteristics, flexibility, reliability, speed, traceability, costs, safety problems, and risks. There are dependencies of the criteria (inner/outer) and influences between and within clusters (criteria, alternatives).</td>
</tr>
<tr>
<td>Bergantino and Bolis</td>
<td>Monetary values of transport service attributes: land versus maritime ro-ro transport. An application using adaptive stated preferences</td>
<td>2008</td>
<td>Maritime Policy &amp; Management</td>
<td>Transport service attributes for logistics operators, when a short sea shipping is available: frequency is the most highly rated characteristic together with reliability. The value of time is significantly lower. There seems to be no a priori preclusion for the maritime alternative and, in particular, for the ro-ro services. Freight rates are not the main determinant nor are the time of travel. Interviews with 16 managers of freight-forwarders in south Italy. No indication of company size.</td>
</tr>
<tr>
<td>Dekker, Asperen,</td>
<td>Floating stocks in FMCG supply chains: using intermodal transport to facilitate advance deployment</td>
<td>2009</td>
<td>International Journal of Physical Distribution &amp; Logistics Management</td>
<td>Both storage costs can be lowered and shorter response times be gotten by sending shipments in advance to intermodal terminals. The advance positioning can offset the disadvantage of a longer transit time in intermodal transport. Enables a more thorough comparison of transport modes. Simulation with case company (Vos Logistics) data (Western Europe).</td>
</tr>
<tr>
<td>Kang, Niu, Zhu and Zhang</td>
<td>Research of improved integrated optimization model for mode and route in multimodal transportation</td>
<td>2010</td>
<td>Jisuanji Yingyong Yanju / Application Research of Computers</td>
<td>An integrated model for selecting the transport mode and optimizing the transport path synthetically fits the diversification of the transport path and the transport process. The model gets closer to the actual road conditions and can provide dependable foundation to carriers selecting transport process.</td>
</tr>
<tr>
<td>Wiegmanns</td>
<td>The Freight Transport Portfolio: A New Way to Analyze Intermodal Freight Transport as Compared to Single-Mode Road Transport</td>
<td>2010</td>
<td>Transportation Journal</td>
<td>Transport portfolio management serves as the basis for the analysis of reliability versus cost (via the proxy output) trade-offs that are made in freight transport portfolio management decisions. Current policy should focus on increasing the reliability and decreasing the costs for inland waterway and rail transport to make rail and inland waterway freight transport more attractive. Data from EU countries. No indication of company size.</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Title</td>
<td>Year</td>
<td>Journal</td>
<td>Main conclusions</td>
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<tr>
<td>Baindur and Viegas</td>
<td>An agent based model concept for assessing modal share in inter-regional transport markets</td>
<td>2011</td>
<td>Journal of Transport Geography</td>
<td>Agent based modelling approach. Inter-urban freight transport between two or more trading regions. Application of model to Mediterranean case study: market share gains around 25–30% with policy interventions of financial subsidies to intermodal services and more frequent shipping services in the intermodal transport respectively. Mediterranean case study. No indication of company size.</td>
</tr>
<tr>
<td>Holguin-Veras, Xu, Jong, and Maurer</td>
<td>An Experimental Economics Investigation of Shipper-carrier Interactions in the Choice of Mode and Shipment Size in Freight Transport</td>
<td>2011</td>
<td>Networks &amp; Spatial Economics</td>
<td>Concludes that freight mode choice can be best understood as the outcome of interactions between shippers and carriers, and that mode choice depends to a large extent on the shipment size that results from shipper-carrier interactions. The results do not support the assumption that freight mode choice is solely made by the carriers. UK, US, Netherlands. No indication of company size.</td>
</tr>
<tr>
<td>Eng-Larsson and Kohn,</td>
<td>Modal shift for greener logistics – the shipper's perspective</td>
<td>2012</td>
<td>International Journal of Physical Distribution &amp; Logistics Management</td>
<td>Successful modal shift from a shipper's perspective. Performance of the carrier more important than performance of mode: Purchase convenience more important than price; Low volatility of demand more important than high volume; Minimum distance can be explained only in terms of the relative competitiveness of uni-modal truck solutions; Modal shift successful only if the shipper is prepared to change its system; High transport quality may be suboptimal. Environmental policies part of the case companies’ business strategies, but mostly little or no effect on the transport purchasing process. Swedish case companies. Analysis of company size: Not volume, but volatility of demand influences transport quality.</td>
</tr>
<tr>
<td>Bierwirth, Kirschstein and Meisel</td>
<td>On Transport Service Selection in Intermodal Rail/Road Distribution Networks</td>
<td>2012</td>
<td>Business Research</td>
<td>Generalizes the classical transportation problem to the intermodal transportation problem (ITP): selecting transport modes, transport services, and intermodal terminals. This tactical planning problem yields a variety of solutions being optimal under specific constellations of the transport cost rates. Big case company operating in eastern European market, Ukraine.</td>
</tr>
<tr>
<td>Liedtke</td>
<td>Estimation of the benefits for shippers from a multimodal transport network</td>
<td>2012</td>
<td>Logistics Research</td>
<td>Develops an economic assessment of a multimodal transport network for single pallets. Shows that the new intermodal transportation system has a significant impact on the shipment-size distributions changing them in favor of smaller shipments. Empirical data from two major German corporations.</td>
</tr>
<tr>
<td>Bergantino, Bierlaire, Catalano, Migliore and Amoroso</td>
<td>Taste heterogeneity and latent preferences in the choice behaviour of freight transport operators.</td>
<td>2013</td>
<td>Transport Policy</td>
<td>Operators' attitudes towards time, punctuality and risk of loss/damage enhance the explanatory power of the choice model. Useful information for policy-makers to improve the regional freight mobility system. The “all road” option preferred by hauliers concerned with the risk of loss/damage, but disregarded by those assigning great relevance to punctuality. Survey on road freight firms in Sicily. Analyses the effect of company size: the importance of time increases as the firm size reduces.</td>
</tr>
<tr>
<td>Islam, Zunder and Jorna</td>
<td>Performance evaluation of an online benchmarking tool for European freight transport chains</td>
<td>2013</td>
<td>Benchmarking: An International Journal</td>
<td>Assesses an online benchmarking tool developed for logistics service users and providers to provide alternative service option in Europe, where six Key Performance Indicators are identified: Transport cost, Transport time, Flexibility, Reliability, Quality, Sustainability. The tool makes the strategic planning of intermodal and co-modal transport solutions easier. European freight transport chains.</td>
</tr>
<tr>
<td>Truschkin and Elbert</td>
<td>Horizontal transshipment technologies as enablers of combined transport: Impact of transport policies on the modal split</td>
<td>2013</td>
<td>Transportation Research Part A: Policy &amp; Practice</td>
<td>The technological solutions for the horizontal transshipment of non-liftable semi-trailers allow the decision makers in the transport market to consider an additional transport alternative to road transportation in the mode choice decision: combined transport. Questionnaire to different-sized German forwarders.</td>
</tr>
<tr>
<td>de Jong</td>
<td>New SP-Values of Time and Reliability for Freight Transport in the Netherlands</td>
<td>2014</td>
<td>Transportation Research: Part E: Logistics and Transportation Review</td>
<td>Values of Time (VOTs) and Values of Reliability (VORs) are crucial for converting the impacts of transport projects into monetary units in the Cost-Benefit Analysis (CBA) of these projects. Studies VOTs and VORs in freight transport in the Netherlands. Both for VOT and VOR two additive components are distinguished: a transport cost and a cargo component. Survey in</td>
</tr>
</tbody>
</table>
Successful cases of short-distance intermodal transport reveal untapped market opportunities. The literature fails to explain these successes. The mode choice process for short-distance transport services may be governed by other decision variables. Current policy options should be revised, as they exclude a potential market segment. Case study (transport system) in Portugal.

A ‘carbon-aware’ company makes transport mode selection decision by taking into account emission costs. Large emission reductions can be obtained by switching to a different mode, but the actual decision depends on the regulation and non-monetary considerations, such as lead time variability. European carbon emission regulations.

Several articles (among others, Bolis and Maggi, 2003; Danielis and Marcucci, 2007; Bergantino and Bolis, 2008; Bergantino et al., 2013; de Jong, 2014) discuss valuations or preferences of decision makers related to transport options. Bergantino et al. (2013) argue that it is difficult to design or evaluate a policy aiming at accomplishing a modal shift without a sound understanding of users’ preferences. It can be supposed that a decision maker behaves rationally and selects the alternative that offers the highest utility relating to decision maker’s own preferences (Truschkin and Elbert, 2013). De Jong (2014) studies values of time and reliability among shippers and carriers in the Netherlands, and Tuzkaya and Önüt (2008) developed a model describing mode selection including criteria clusters of product characteristics, flexibility, reliability, speed, traceability, costs, safety problems, and risks. Pedersen and Gray (1998) found that transport price factors are more important than other transport selection criteria among Norwegian exporters. Based on them the reason seemed to be considerably higher transport costs in Norway. Bergantino and Bolis (2008) conclude in their study on freight forwarders in Italy that there are four criteria that are most important defining the transport service, namely price, i.e. out-of-pocket costs, door-to-door transit time, reliability and frequency. However, according to Blauwens et al. (2006) a shipper’s out-of-pocket transportation costs do not directly determine the modal choice; if this was the case, then interestingly rail transport – as the most economical transport mode – should have a bigger share of the freight transport market than it has today.

The performance perceptions of users and non-users of the alternative transportation modes differ significantly, and consequently road haulage gets highest scores (Vannieuwenhuyse et al., 2003). Usually as for example Danielis and Marcucci (2007) state, the actors have little or no knowledge of the modes they do not regularly use; thus, they can describe their typical shipment and its characteristics, but cannot do it for alternative shipments made with a different mode, usually, intermodal transport. Jeffs and Hills (1990) also point out that modal split is based on many people’s cumulative decisions, and the decision maker's quest for alternatives is often prejudiced and limited in scope. Jeffs and Hills (1990) argue that variables affecting the decision making can be categorised into six main groups, namely: customer-requirements, product-characteristics, company structure/organisation, government interventions, available transport facilities, and perceptions of the decision-maker. Vannieuwenhuyse et al. (2003) found five performance criteria important for shippers and logistics service providers when considering transport modes, namely transportation cost, reliability, flexibility, transport time and safety. Correspondently, Hoen et al. (2014) consider a ‘carbon-aware’ company that is reconsidering the transport mode selection decision, by taking “emission costs” into the equation, besides the traditional trade-off between lead time (and corresponding inventory

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Year</th>
<th>Journal</th>
<th>Main conclusions</th>
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</thead>
<tbody>
<tr>
<td>Reis</td>
<td>Analysis of Mode Choice Variables in Short-Distance Intermodal Freight Transport Using an Agent-Based Model</td>
<td>2014</td>
<td>Transportation Research: Part A: Policy and Practice</td>
<td>Successful cases of short-distance intermodal transport reveal untapped market opportunities. The literature fails to explain these successes. The mode choice process for short-distance transport services may be governed by other decision variables. Current policy options should be revised, as they exclude a potential market segment. Case study (transport system) in Portugal.</td>
</tr>
<tr>
<td>Hoen, Tan, Fransoo and Houtum</td>
<td>Effect of carbon emission regulations on transport mode selection under stochastic demand</td>
<td>2014</td>
<td>Flexible Services and Manufacturing Journal</td>
<td>A 'carbon-aware' company makes transport mode selection decision by taking into account emission costs. Large emission reductions can be obtained by switching to a different mode, but the actual decision depends on the regulation and non-monetary considerations, such as lead time variability. European carbon emission regulations.</td>
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</table>
costs) and transportation costs. Islam et al. (2013) create an online benchmarking tool for European freight transport chains, and identify six key performance indicators: transport cost, transport time, flexibility, reliability, quality, and sustainability. However, based on Jeffs and Hills (1990), for some freight movements, choice between modes does not even really exist. The selection criteria mentioned in the literature are summarized in Table 3.2.

### Table 3.2 Mode selection criteria presented in some of the selected articles.

<table>
<thead>
<tr>
<th>Article</th>
<th>Price/cost</th>
<th>Time/speed</th>
<th>Frequency</th>
<th>Reliability</th>
<th>Flexibility</th>
<th>Quality</th>
<th>Sustainability / Carbon emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeffs and Hills, 1990</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vannieuwenhuyse et al., 2003</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bergantino and Bolis, 2008</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuzkaya and Önüt, 2008</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eng-Larsson and Kohn, 2012</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Islam et al., 2013</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>de Jong, 2014</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoen et al., 2014</td>
<td>x</td>
<td>x</td>
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</table>

A few articles discuss or compare actors’ preferences related to particular transport modes. Regarding Nordic shippers, Ludvigsen (1999) found that the shippers did not distinguish between the quality requirements for intermodal and single-modal transit. The surveyed shippers used fewer intermodal routes than single-modal and the quality of intermodal routes was evaluated lower than single-modal, although the Nordic shippers were highly dependent on efficient intermodal, sea-land bridging solutions (Ludvigsen, 1999). Usually large shippers with large volumes and strong market position enjoy a high quality of intermodal transit (Ludvigsen, 1999), but the importance of time increases as the firm size reduces (Bergantino et al., 2013). Therefore, based on these observations it could be concluded that choosing intermodal transport option could be especially challenging for small companies. Eight of the mode choice papers did not mention intermodal transport at all as a choice, but only discussed and compared single-mode options – this, however, was more common in the older papers. Eng-Larsson and Kohn (2012) point out that because the earlier research on intermodal transport as a transport option has been made from a carrier’s point of view, it has emphasised the production perspective and consequently large volumes, long distances, and bulky products, whereas for most shippers the purchase decision is a trade-off between convenience vs price rather than a trade-off between transport quality vs price. However, they also emphasise the systems view and claim that a successful modal shift is likely only, if the shipper is prepared to change the whole system to fit the solution. Bergantino and Bolis (2008) studied freight forwarders’ valuations, and concluded that that frequency together with reliability are the most highly rated characteristic of the service (not price or time). On the other hand, Holguín-Veras et al. (2011) maintain that it is not correct to assume that the mode choice is solely made by the carriers, because the mode choice – depending on the shipment size – is a result of the shipper-carrier interactions.

It can also be pointed out that the mode selection is intertwined with the shipper’s carrier selection decision. Eng-Larsson and Kohn (2012) describe that intermodal transport quality is
more dependent on the performance of the particular carrier than the performance of the transport mode. Jerman et al. (1978) studied the most important selection variables for carriers and shipper, and among them were co-operation between carrier and shipper personnel, knowledge of a shipper's needs, carrier reputation for dependability and for quality service, carrier ability to quickly trace shipments, and transit time for the shipment. Reis (2014) argues that there are some successful cases of short-distance intermodal transport and they reveal untapped market opportunities, because the current literature on mode choice has failed to explain these successes. However, this is an important issue to study further, because approximately 50% of freight transport demand in the EU is for distances less than 400 km (EUROSTAT, 2012). Wiegmans (2010) argues that the reliability of intermodal rail freight transport is low, and therefore, the current policy should focus on increasing the reliability and decreasing the costs for it to make rail freight transport more attractive.

3.3. Tenders/RfQs and contracts

Two of the selected articles had their focus on tenders/RfQs and six on contracts; however one article was overlapping covering both aspects. Andersson and Norrman (2002) point out that often the logistics service as such is unclear for both the buyer and service provider, and there are considerable problems, firstly, in outlining a RfQ that is understandable but not too restricting, and, secondly, in writing a contract that can act as an incentive for sharing risks and rewards, but also for further development of services. They also describe and compare the purchasing processes of basic and advanced logistics services, and conclude that these processes will be increasingly differentiated in the future; on one hand for the purchase of basic services efficient usage of online freight exchanges will increase, but on the other hand, advanced logistics services may require long purchasing processes that cannot always be characterized as clear and linear. Colicchia et al. (2013) study Italian LSPs and find out that most of the interviewed companies considered their customers to be a major driver for adapting environmental initiatives, but that the lack of a standard methodology for measuring environmental impact does not allow companies to share the costs and benefits of environmental initiatives. However, they also point out that even though green requirements were included in a tender, these requirements do not necessarily imply a real change on processes. The selected articles on tenders/RfQs and contracts with main conclusions are summarized in Table 3.3.

Table 3.3 Tender/RfQ articles in the selection.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Year</th>
<th>Journal</th>
<th>Main conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinehart, Cadotte and Langley</td>
<td>Shipper-Carrier Contract Negotiation: A Conceptual Foundation for Logistics Managers</td>
<td>1988</td>
<td>International Journal of Physical Distribution and Materials Management</td>
<td>Current conceptualizations of negotiations are expanded by distinguishing between bargaining activities and the negotiation process. The major conclusion is that negotiation is a process, which can significantly influence the nature of the contract between the shipper and carrier.</td>
</tr>
<tr>
<td>Andersson and Norrman</td>
<td>Procurement of logistics services—a minutes work or a multi-year project?</td>
<td>2002</td>
<td>European Journal of Purchasing &amp; Supply Management</td>
<td>The purchasing process of advanced versus basic logistics services logistics services will in the future need to be more differentiated.</td>
</tr>
<tr>
<td>Colicchia, Marchet, Melacini and Perotti</td>
<td>Building environmental sustainability: empirical evidence from Logistics Service Providers.</td>
<td>2013</td>
<td>Journal of Cleaner Production</td>
<td>LSPs adopt sustainability initiatives, especially related to distribution and transportation, less involving internal management. The lack of a standard methodology for measuring environmental impact prevent sharing the costs and the benefits of environmental initiatives. LSPs consider customers to be a major driver, but sometimes complain about a lack of real commitment from customers. Green requirements in a tender do not imply a real change on processes. Regulation is an</td>
</tr>
<tr>
<td>Author(s) and Year</td>
<td>Title</td>
<td>Journal/Media</td>
<td>Summary</td>
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<tr>
<td>Halldórsson and Skjøtt-Larsen (2006)</td>
<td>Dynamics of relationship governance in TPL arrangements—a dyadic perspective</td>
<td>International Journal of Physical Distribution &amp; Logistics Management</td>
<td>The “relationship governance” emerges and develops over time; TPL dyads are subject to both controllable and non-controllable forces of change. Dynamics relate to learning, competence development, adaptation, but also to relationship governance. Case study in Denmark; dyadic relationship between LSP and a buyer of logistics services.</td>
<td></td>
</tr>
<tr>
<td>Baindur and Viegas (2011)</td>
<td>An agent based model concept for assessing modal share in inter-regional freight transport markets</td>
<td>Journal of Transport Geography</td>
<td>Shows that market share gains of around 25–30% are obtained with policy interventions of financial subsidies to intermodal services and more frequent shipping services in the intermodal transport respectively. Mediterranean case study (Italy–France transport corridor).</td>
<td></td>
</tr>
<tr>
<td>Selviaridis, K., Norrman, A. (2014)</td>
<td>Performance-based contracting in service supply chains: a service provider risk perspective</td>
<td>Supply Chain Management</td>
<td>Performance-based contracting (PBC) entails increased financial risk for providers. Four factors that influence provider willingness to bear financial risk were found: performance attributability within the service supply chain; relational governance in service supply chain relationships; provider risk and reward balancing; and provider ability to transfer risk to sub-contractors.</td>
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Regarding contracts, Björklund and Forslund (2013) study shippers and logistics service providers in Sweden, and found out that even if environmental performance is included in transport contracts, the companies do not necessarily consider how to measure the environmental performance or how to handle incompliance. Findings from an earlier study by Björklund (2005) showed that most of the studied shippers consider the environmental aspect during the purchasing process, 50% include them in the written contract, 13% include how to measure them, and only 2% have a written phrase in the contract regarding how to handle non-compliance. However, encompassing these statements in the contract is important, as they are positively related to performance improvements (Björklund and Forslund, 2013). They found out that the most common performance metrics included in transport contracts are CO2 emissions and energy use. Their findings indicate that transportation managers play a very central role for inclusion of environmental performance in contracts. A larger share of LSPs than shippers state that they have included environmental performance in contracts, and they seem to be more aware of it. This can be explained by that the transport is a core activity of the LSP. Baindur and Viegas (2011) model inter-urban freight transport and demonstrate that more market share could be obtained with financial subsidies to intermodal services or more frequent shipping services.

Rinehart et al. (1988) make a distinction between bargaining activities and the negotiation process leading to contracts. Halldórsson and Skjøtt-Larsen (2006) analyze third party logistics (TPL) arrangements, and describe how “relationship governance” emerges and develops over time between buyer and seller. Selviaridis and Normman (2014) study performance-based contracts in service supply chains and state that the performance can be measured by service “outputs” and “outcomes”, where “outputs” refer to the level of functionality or performance, whereas “outcomes” refer to the customer value resulting from the service. The customer value can be quantifiable (for example monetary savings), but it can also include “customer satisfaction” etc. elements that are harder to measure. They (ibid.) also point out that there should be an alignment between the desired goals and the performance metrics.
4. DISCUSSION, CONCLUSIONS AND FUTURE RESEARCH

Our literature review shows that discussing environmental sustainability criteria together with transport mode selection, tenders/RfQs and transport contracts is a rather new, but slowly emerging topic in the academic literature. Apparently, the role of sustainability has changed over decades; the older literature is silent about sustainability criteria related to the issues of transport mode selection, tenders/RfQs and transport contracts. The first discussions linking these issues together in the literature start only after the year 2000. The first papers related to these topics refer to policy measures for promoting intermodal transport (Garcia-Menendez et al., 2004; Blauwens et al., 2006; Mahmassani et al., 2007; Danielis and Marcucci, 2007). In the last decade the discussion in the literature on environmental sustainability issues together with transport solution and mode selection has increased (Dekker et al., 2009; Wiegmans, 2010; Baindur and Viegas, 2011; Liedtke, 2012; Eng-Larsson and Kohn, 2012; Colicchia et al., 2013; Björklund and Forslund, 2013; Bergantino et al., 2013; Islam et al., 2013; Reis, 2014; Hoen et al., 2014). Moreover, our literature review indicates that when shippers purchase transport services, even though they sometimes take sustainability criteria into account, these criteria are not among the most important decision criteria. For shippers and LSPs, transport costs, time, frequency and reliability are usually far more important than environmental or transport mode issues (cf. for example Danielis and Marcucci, 2007: Bergantino and Bolis, 2008). Actually, only two articles (Islam et al., 2013; and Hoen et al., 2014) in our literature review mention environmental sustainability or carbon emissions linked explicitly to the transport mode decision. However, the results indicate that in practice, including environmental criteria in tenders/RfQs is slowly becoming more common, and today these topics are more often discussed in the negotiations between shippers and LSPs. Nevertheless, it seems that they are still rather seldom explicitly included in transport contracts. Furthermore, even if they are mentioned in the contracts, usually there are no terms about how to deal with non-compliance (Björklund and Forslund, 2013). The lack of a standard methodology for measuring environmental impact may slow down the deployment of environmental initiatives (Colicchia et al., 2013).

The results show that perceptions and beliefs play a significant role in mode choice decisions, users’ and non-users’ valuations on transportation modes differ significantly, and actors seem to have limited knowledge on the modes they do not use (Vannieuwenhuysse et al., 2003; Danielis and Marcucci, 2007; Bergantino et al., 2013). However, Bolis and Maggi (2003) found some indications that the predominance of road transport could be caused by current restrictions rather than by a mode-specific preference. It must also be remembered that the mode selection is related to the shipper’s carrier selection decision, and the perceptions of the performance of the particular carrier are usually more important than of the performance of the particular transport mode (Eng-Larsson and Kohn, 2012). Furthermore, the results indicate that there are deficiencies in practice related to, how the customer needs are translated into flexible intermodal services. This observation has practical and policy implications.

Based on the findings, some conclusions or suggestions for future research can be made. The literature review shows that more research on the mode choice decisions, their characteristics, and future scenarios towards sustainability development is needed. There is not enough understanding about, how customer needs can be translated into implications to intermodal transport services and infrastructures. So far, there is little empirical research on sustainability-related cooperation between buyers and LSPs, and how these actors can jointly manage environmental issues (Wolf and Seuring, 2010). In addition, there seems to be lack of understanding among the shippers about how environmental objectives in transport services can be accomplished, or how they can link their sustainability strategies to transport decisions.
More research is needed on the strategies of companies concerning sustainability ranging from passive (defensive) and reactive to proactive, and the link between the strategies and competitive advantages created by sustainability. Also, more research is needed on performance measurement systems for assessing the environmental impacts of transportation options, as current situation does not allow companies to share the costs and benefits of environmental initiatives (Colicchia et al., 2013). Almost certainly new service development related to environmentally sustainable transport services has a challenge, because there is no clear evidence of their benefits. Therefore, it is important to develop reliable measurement system, where different mode options can be easily compared. The COFRET project (COFRET, 2014) conducted detailed reviews of current methodologies for calculation of the carbon footprint for logistics chains. The reviews showed that there are elements suitable for the calculation of the carbon footprint of transport and logistics, but example calculations with different tools showed variations in results. Thus, a truly harmonised, globally recognized single framework for CO$_2$ measurement is still missing. We would suggest that the EU should prioritize the development of a harmonized tool for the measurement, as a single reliable measurement system could support aims of the sustainable transport development in Europe. Furthermore, it would be interesting to study, how the situation in different European countries differs, and whether the policy or regulation has affected the mode selections.

Our findings indicate, as typical for logistics research (Vafidis, 2007), that the existing body of literature on transport choice has rather weak theoretical linkages. Theoretical considerations need to be strengthened. Gammelgaard (2004) divides logistics research into three schools, namely the analytical school, building on positivism, the systems school, building on systems theory, and the actor school, based on sociological meta-theories. Logistics research is dominated by the positivistic approach and quantitative research methods (Mentzer and Kahn, 1995), and usage of more versatile methodological approach would be beneficial for strengthening the discipline (Gammelgaard, 2004). The views presented in the existing literature on transport choice, dominated by positivistic approach and quantitative methods, mathematical models, simulation and optimization, needs to be extended. A broader view would be beneficial for increasing understanding, how transport selection is linked to the underlying real-life systems of actors and physical infrastructure. Halldorson et al. (2007) claim that there are two broad considerations of supply chain research: firstly, how to build a structure, and secondly, how to manage the structure. By answering these, it is possible to close the gap between research and practice. The research should represent reality and contribute to building of logistics theory (Sachan and Datta, 1995). There are many stakeholders contributing to the logistics systems. Therefore, for example the stakeholder view could be a useful approach for future research, because it builds on a holistic view of different stakeholders, and the challenges and drivers they encounter in selecting or developing more sustainable transport services. In the research related to the selection of environmentally sustainable transports, there is a need for application of theories developed in other disciplines, as well as for building and testing of own theories and theoretical constructs, and usage of versatile methods including case studies, action research, and mixed methods. Lastly, the EU has launched the Green Circular Economy Programme which aims to decrease negative impacts of economy by cutting resource use, reduce waste and boost recycling. There is a call for research linking the aims of the Green Circular Economy Programme to the aims of sustainable transport in the European Commission White paper (2011) “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system”.
REFERENCES


European Commission White paper (2011), Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144 final


Rogerson, S. (2013), Purchasing process for freight transport services and influence on CO2 emissions, Thesis for the degree of licentiate of engineering, Department of technology management and economics, Division of logistics and transportation, Chalmers University of Technology, Gothenburg, Sweden.


## Appendix 1: The searches and amounts of selected articles in each phase.

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### Appendix 2: Descriptive analysis of the selected articles.

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|------|---------|---------------|-----------------------|-------|-------------|-----------------|-----------------|----------------------|------------------------|--------------------|--------------|-------------|-----------|------------|-------------|---------------|-----------------|-----------|
| 1970 | Norrman and Wood | | | Yes | | | | | | | | | | | | | | |
| 1973 | Selviaridis and de Jong | | | | | | | | | | | | | | | | | |
| 1986 | Truschkin and Elbert | | | | | | | | | | | | | | | | | |
| 2002 | Blauwens et al. | | | | | | | | | | | | | | | | | |
| 2003 | Verschooren et al. | | | | | | | | | | | | | | | | | |
| 2004 | Garcia-Menendez et al. | | | | | | | | | | | | | | | | | |
| 2006 | Jerman et al. | x | | Yes | | | | | | | | | | | | | | |
| 2007 | Baumol, and Vinod | | | Yes | | | | | | | | | | | | | | |
| 2008 | Pedersen and Gray | x | | | | | | | | | | | | | | | | |
| 2009 | Holguin | | | | | | | | | | | | | | | | | |
| 2010 | Danielis and Marcucci | x | | Yes | | | | | | | | | | | | | | |
| 2011 | Vermeir | | | | | | | | | | | | | | | | | |
| 2012 | Liedtke | | | | | | | | | | | | | | | | | |
| 2013 | Slater | | | | | | | | | | | | | | | | | |
| 2014 | Inder et al. | | | | | | | | | | | | | | | | | |
| 2015 | Ljungberg | | | | | | | | | | | | | | | | | |
| 2016 | Blaug et al. | | | | | | | | | | | | | | | | | |
| 2017 | Larsson and Koh | | | | | | | | | | | | | | | | | |
| 2018 | Bierwirth et al. | x | | Yes | | | | | | | | | | | | | | |
| 2019 | Truscott | | | | | | | | | | | | | | | | | |
| 2020 | Holguin | | | | | | | | | | | | | | | | | |
| 2021 | Holguin | | | | | | | | | | | | | | | | | |
| 2022 | Kag et al. | | | | | | | | | | | | | | | | | |
| 2023 | Holguin | | | | | | | | | | | | | | | | | |
| 2024 | Holguin | | | | | | | | | | | | | | | | | |
| 2025 | Holguin | | | | | | | | | | | | | | | | | |
| 2026 | Holguin | | | | | | | | | | | | | | | | | |
| 2027 | Holguin | | | | | | | | | | | | | | | | | |
| 2028 | Holguin | | | | | | | | | | | | | | | | | |
| 2029 | Holguin | | | | | | | | | | | | | | | | | |
| 2030 | Holguin | | | | | | | | | | | | | | | | | |
| 2031 | Holguin | | | | | | | | | | | | | | | | | |
| 2032 | Holguin | | | | | | | | | | | | | | | | | |
| 2033 | Holguin | | | | | | | | | | | | | | | | | |
| 2034 | Holguin | | | | | | | | | | | | | | | | | |

Number of papers: 25
PERCEPTIONS OF AUTOMATED PURCHASE ORDER PROCESSING IN MID-SIZED MANUFACTURING COMPANIES IN SOUTH-WESTERN FINLAND

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ABSTRACT

Purpose
Purpose of this research is to find out whether operational efficiencies could be achieved through purchase order automation in mid-sized manufacturing companies.

Design/methodology/approach
To answer the research question, a set of companies was chosen in South-Western Finland in connection to another research project. Case study methodology is used with semi-structured interviews analysed with qualitative methods. The approach to the subject is through application of supply chain and purchasing concepts with lean thinking. Kraljic (1983) model on item classification is reviewed. The development of business-to-business e-commerce and small and medium sized enterprise context are taken into consideration as well.

Findings
While automating parts of a process, the whole process should be considered in terms of information systems as well in order to achieve sustainable change.

Research limitations/implications
The limited sample of companies is limiting the generalizability of this research. Therefore a larger sample with wider geographical spread would open up the phenomena. As well the constant development of information systems is increasing the possibilities of process automation.

Practical implications
Purchase order automation seems to decrease fixed costs and also improve efficiency. It should also be kept in mind that purchase order automation should be accompanied with a larger process improvement and information systems development in supply chain considering supplier processes as well.

Original/value
In this paper, the effects of purchase order automation and the linkages on other business processes are researched through professional experience. The results open interesting avenues for further research in small and medium sized companies.

Keywords: Purchasing, Process automation, Supply Chain Management, Small and medium sized enterprises
1. INTRODUCTION

In 1983 Peter Kraljic titled his largely cited article “Purchasing must become supply management”. In this article Kraljic created an item based classification of supply management strategy. Later on, supply management has become supply chain management that The Council of Supply Chain Management Professionals defined as “…In essence, Supply Chain Management integrates supply and demand management within and across companies” (Mentzer et al. 2008). Purchasing, though, has not disappeared from the field of business. It needs to be performed in order to receive the necessary physical items from upstream of the supply chain. Lean thinking and supply chain management stress that there is a continuous flow where unnecessary stockholding is minimised (Krafcik 1988, Lamming 1996). In purchasing this is translated to supplier partnership and streamlining the relationship with suppliers (Krafcik 1988, Ansari and Modarress 1988). In day-to-day purchasing activities this translates to automation of all routine tasks in order to increase efficiency.

This article investigates the views on automated purchase order with its pros and cons through analysis of interviews made within purchase professionals in manufacturing industries. It is based on the results of previous research presented in Rantala and Hilmola (2010). Purchase order automation serves as part in integrating supply chain through the means offered by information systems and supports the ideas of lean thinking. Objective of this research is to find out whether operational efficiencies could be achieved through purchase order automation. The research is done through analysis of answer of four semi-structured interviews to purchasing professionals in Finnish small and medium-sized manufacturing companies.

This paper continues with discussion on the theoretical frame related to supply chain management, lean thinking, purchasing and business-to-business e-commerce. Finally, the context of small and medium-sized enterprises is discussed. Based on the theoretical discussion, a simplistic model of automated purchase order process is presented followed by data collection and operationalization methods. The results of the interviews are concluded with a discussion and suggestions for further research.

2. METHODOLOGICAL CONSIDERATIONS

Purpose of this research is to investigate on purchase order process automation concept from the practical side. Previous research (Rantala and Hilmola, 2010) has shown that purchase order automation leaves open questions on the benefits of its application. This research attempts to verify, how purchase professionals see the pros and cons of automated purchase order. In order to achieve this goal it is important to define research strategy, type of evidence collected and the data collection method. It is important to clearly define these as there is often confusion around these concepts but their definition is critical in defining case studies (Yin, 1981). In this research, case study is used as a research strategy. The evidence is in form of qualitative data collected with semi-structured interviews.

Yin (2003) defines case studies as examining a contemporary phenomenon in its real-life context in which the limits and the context are not clear, and it uses multiple data sources and existing theory to guide the data collection and analysis. Barrat et al. (2011) see several data sources in qualitative methodology: structured or semi structured interviews, observations and archival sources. In this research purchase professionals are being interviewed with semi-structured interviews. The choice of semi-structured interviews has been made because it allows updating the tool while data is collected. This way emerging, interesting data related to the
phenomena under investigation may be collected even if it is not included in the original plan of data collection.

Selection of case companies was made based on a database collected during a larger research project among manufacturing companies in South-Western Finland. Selected companies were representing the larger side of the participating companies and were found willing to participate to this study. The main criterion for selection was that they were manufacturing companies using typical material planning methods (MRP). The previous experience in automated purchase order was not asked in beforehand. This choice was made because the purpose of the research was to find out perceptions of the purchase professionals in the company, not especially their experience at current employer.

3. CONCEPTUAL FRAME OF REFERENCE

3.1. Supply chain management

Supply chain management can be defined as integrating supply and demand management within and across companies (Mentzer et al. 2008). The discipline itself is quite new and might not be yet called as a discipline in scientific sense. It appeared at first through articles in trade journals written by consultants. (Ellram and Cooper 2014)

Supply chain integration has been discussed several years. One definition of supply chain management integration was developed by Näslund and Hulthen (2012) as follows: "Supply chain management integration is the co-ordination and management of the upstream and downstream product, service, financial and information flows of the core business processes between a focal company and its key supplier and its key customer." In 1996 after a large survey conducted in United States, integration seemed more supported than implemented (Neuman and Samuels 1996) and that there still is little empirical evidence of supply chain management integration (Näslund and Hulthen 2102)

Integrating the supply chain within different partners requires the use of information technology (IT) (Gunasekaran and Ngai 2004). Information technology and information systems (IS) are not only vital inside each company in the supply chain but also in between different organisations of a supply chain (Williamson et al. 2004). Based on these arguments information systems have become an integral part of supply chain management.

In relation to IT, it is important to align the IS in order to manage the supply of goods from upstream of the supply chain (Qrunfleh et al. 2012). Contractual relationship with suppliers that enable information sharing has proven to lower risks and costs (Durugbo 2014) and IT-based sharing capability seems to affect positively firms supply chain flexibilities (Jin et al. 2014). At the same time, integrating the supply chain through transaction automation requires trust between partners (Paiva et al. 2013). In order to achieve the required level of trust, and thus integration, in supply chain, building long-term relationships is vital (Prajogo and Olhager 2012). Supply chain management and integration play an important role when streamlining the relationship between partners in supply chain. Lean thinking as described in next paragraph will complement each other.

The above discussion may be concluded that supply chain integration is a vital part of developing supply chain core business processes. As a tool in improving information exchange as part of supply chain integration, information systems play a crucial role.
3.2. Lean thinking

The roots of lean thinking are in the automotive manufacturing and what was called Fordism with high level of vertical integration but later was adopted by Toyota as Just-In-Time (JIT) with focus on supplier partnerships (Krafcik 1988). The basic idea is that production is a continuous flow where the time elapsed between the start and completing production is minimised. Krafcik (1988) illustrates the idea through opposite concepts of buffered and lean concepts where buffered means buffer stocks all along the production chain and lean the situation where stocks are kept at minimum level at all stages. The supply chain management is naturally involved in lean production thinking because in automotive manufacturing, suppliers and part assemblers have had a large role in added value (Lamming 1996). Womack and Jones (1984) stressed that companies must unite their efforts to build a lean enterprise that forms a value stream to offer superior products and services at lower costs. Ansari and Modarress (1988) ranked major improvement activities of JIT purchasing to include smaller lot sizes, reduction of number of suppliers and forming partnership relations with them. To achieve this, MRP tools are essential in providing a master schedule and requirement picture (Aghazadeh 2003). Through the optimisation of purchase order processing, one stage at implementing lean thinking may be achieved.

3.3. Purchasing

Purchasing in a manufacturing company is, at its very basic, a manual work lead by calculations on material sufficiency in the warehouse. Depending on the size of the company and its manufacturing operations different systems may be used to calculate material requirements. Increased complexity in manufacturing operations often requires advanced enterprise resource planning (ERP) and material requirement planning (MRP) systems in order to form material requirements for purchasing. MRP systems have at least three advantages: it provides the calculations on dependent demand, with basic parameters the calculation is more accurate than with earlier systems and changes in production plan are taken into consideration (Aghazadeh 2003). In large companies purchasing is often divided into operational buying and strategic buying: operational buying performing the daily procurement activities at the same time as strategic buying is concentrating on tasks that have longer effect on general procurement pattern. Dobler and Burt (1996) classify materials management on three different levels: purchasing activities, procurement-process activities and supply management activities. Bilborough and Dale (1985) divide purchasing to corporate and factory buying. These different classifications clearly show the different aspects that purchasing needs to work with. Purchasing activities (Dobler and Burt, 1996) and factory buying (Bilborough and Dale, 1985) by definition are responsible for the day-to-day activities of acquiring required materials to warehouse.

Purchasing is related to items and suppliers. Items are different in nature as well as the suppliers of them. Over time, there have been several classifications of items and suppliers in different categories. In item classification Kraljic (1983) has been probably the most cited author but after, other classifications have followed, namely Olsen and Ellram (1997). Lately, Terpend et al. (2011) have attempted to verify the strategy creation based on the classifications used among professionals in large US companies without any predetermined number of purchase types. They identified similar patterns than Kraljic, Olsen and Ellram but also some new dimension on item-supplier classification. As the original Kraljic classification, the idea is based on the power situation on the market and the strategic meaning of the purchased item to the buyer.
Figure 3.1 Kraljic (1983) stages of purchasing sophistication

In the Kraljic model in the figure above, there are four different stages that classify the purchasing sophistication in two dimensions: importance of purchasing and complexity of supply market. Purchasing management may be used when there is abundant supply of non-critical items (commodities) from local sources. Both importance of purchasing and complexity are low. The move to materials management is characterised by increasing importance of the purchasing to the company in terms of cost of material compared to total cost of the product. Sourcing management stage is characterised by increasing complexity of supply market while importance of purchasing to the company remains low. Items belonging to this category are typically bottleneck items. Not necessary representing important cost factor but posing availability issues and thus threatening the production process of the company. Supply management stage means high market complexity and high importance to profitability of the company. At this stage the importance of the materials require long term contracts on supply with central control inside the company. To shape the supply strategy, Kraljic has four phases: classification, market analysis, strategic positioning and action plans. Through this classification for the strategic items, there are three alternative strategies depending on company strength and supplier strength: where the company strength is highest, it should exploit the relationship. In the opposite, where the supplier strength is highest, the company should diversify sourcing and seek for a balance. Caniëls and Gelderman (2007) pointed out the importance of power and interdependence underlying in the Kraljic model thinking. The results of their survey indicate that a supplier dominated relationship may be found satisfactory from buyer’s perspective. Terpend et al. (2011) also discuss the fact that product based classification might not always be the right one when relationships and performance characteristics are dominant. Clearly, each purchased items have their characteristics. They may be defined by their physical or relational characteristics but it is important to consider their origins and attributes related to those origins. Thus, a buyer needs to consider not only the physical attributes of the purchased items to the company but also the relationship that is created through the business relationship to the supplier of an item.

3.4. Business-to-business e-commerce

Based on previous sections on supply chain management, lean thinking and purchasing the context is finalised with discussion on business-to-business (B2B) e-commerce (EC).

Reason to use EC in B2B relationships is driven from changing traditional business processes to use the possibilities offered by IT. Kettinger and Grover (1993) list in their principles of business process change as fourth principle that “Business process change should leverage
information technology’s process, storage and communication abilities to facilitate knowledge sharing capability”. There are two important concepts of knowledge sharing and IT leveragability that are related to B2B EC. Based on the idea of Kettinger and Grover, efficient sharing of knowledge through IT tools generates performance improvements in the supply chain. To ensure the usability of IT in this knowledge sharing, both tools and standards have been created. At the same time it has to be accepted that B2B EC is only a mean to support supply chain strategies (Cassivi et al. 2005)

MRP and ERP systems are commonly in use in today’s business companies (Aghazadeh 2003). Automation and process integration has often been justified by improvement in general corporate performance. This generation of superior performance has led to the fact that more and more companies and supply chains adopt these solutions. Thus adoption of MRP and ERP is also influenced by pressure from competition (Sila 2013). It has been shown that SCM IT implementations (Dehning et al. 2007) and especially ERP implementations (Bendoly and Schoenherr 2005) improve effectiveness and impact to B2B e-procurement and enhanced time-based delivery performance (Iyer et al 2008).

Implementing B2B EC offer certain advantages as discussed above. EC in B2B relationship often strengthens general business relationships because of the strategic and monetary investments required by collaborative practices (Cassivi et al. 2005; Standifer and Wall Jr 2010). But strengthening of the relationship requires trust in trading partners (Paiva et al. 2013; Sila 2013). Companies with less trust in their trading partners seem to adopt B2B EC less than others (Sila and Dobni 2012). Top management support is essential to the implementation (Sila and Dobni 2012; Sila 2013).

For SME’s system (Fu et al. 2014) and data security and complexity (Sila 2013) are issues while implementing B2B EC systems and SME’s have more difficulties in adopting B2B EC practices. While the information exchange itself seems rather simple matter, apparently the complexity in information exchange technology and different interfaces is not diminishing (Schubert and Legner 2011).

3.5. Small and medium-sized enterprise context

Small and medium-sized enterprises (SME) have been investigated largely on national contexts. Examples of these are lean procurement in New Zealand (Wilson and Roy 2009) and in Sweden (Karlsson and Åhlström 1997), ERP implementation in Norway (Zach et al. 2014) or in the Netherlands (De Loo et al. 2012) and in Portugal (Ruivo et al. 2014). In these examples one source of discussion is the restraining fact of limited resources of the SME’s in relation to larger companies when implementing enterprise systems and philosophies. On purchasing and SME’s the research has been scarce (Ramsay 2008). Through research in UK SME’s it was found that in many companies purchasing was not a separate function and its importance was ranked very low (Quayle 2002), there was great variations in purchase activities, purchasing was not used strategically and there was little evidence of supplier evaluation (Pressey et al. 2009). A research in Swedish SME’s showed that managers are reluctant to source abroad and entries to the market are often more reactive than proactive (Agndal 2006). All previously mentioned give a quite depressing view to the development of SME’s in terms of processes and new technologies. On the contrary, Karlsson and Åhlström (1997) found that most of the lean principles are applicable to SME’s while adaptations must be made in order to fit them into the setting where resources are scarcer than in large corporations.
3.6. Summary of the reviewed concepts

Based on the discussion above, as part of the supply chain management integration, purchasing should select proper strategies in order to fit different item categories and their supply patterns to fit in supply chain management integration strategies with proper information systems. Lean thinking should be applied so that all unnecessary stock holding is minimised and processes run continuously. In routine purchasing of commodities of low added value to the company, the most cost efficient way of acquiring those materials should be introduced. IT tools to apply B2B EC should be analysed to achieve this goal. When small and medium-sized companies are in case, the information systems should be simple and cost efficient to implement for not to waste limited resources of the company.

4. CASE DESCRIPTION

4.1. Definition of the automated purchase order

Cullen and Webster (2007) have created a model of B2B e-commerce that relies on connectivity and purpose. The model includes nine different scenarios for business transactions that are presented in table below

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Purpose</th>
<th>Connectivity</th>
<th>Involve an intermediary?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual trading</td>
<td>Selling</td>
<td>1 supplier – many buyers</td>
<td>No</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Selling</td>
<td>Few suppliers – many buyers</td>
<td>Yes</td>
</tr>
<tr>
<td>Marketplace</td>
<td>Selling / buying</td>
<td>Many suppliers – many buyers</td>
<td>Yes</td>
</tr>
<tr>
<td>Proprietary sales</td>
<td>Selling / integrated</td>
<td>1 supplier – few buyers</td>
<td>No</td>
</tr>
<tr>
<td>Private trading exchange</td>
<td>Integrated</td>
<td>Few suppliers – few buyers</td>
<td>Yes</td>
</tr>
<tr>
<td>Aggregation</td>
<td>Buying</td>
<td>Many suppliers – few buyers</td>
<td>Yes</td>
</tr>
<tr>
<td>Intranet / EDI</td>
<td>Integrated</td>
<td>1 supplier – 1 buyer</td>
<td>No</td>
</tr>
<tr>
<td>Restricted bid, RFQ</td>
<td>Buying</td>
<td>Few suppliers – 1 buyer</td>
<td>No</td>
</tr>
<tr>
<td>Reverse auction</td>
<td>Buying</td>
<td>Many suppliers – 1 buyer</td>
<td>No</td>
</tr>
</tbody>
</table>

First column of the table is the description of the scenario; the second describes the primary purpose of the user who initiates the transaction. On connectivity column is the typical structure of parties involved in the transaction and the fourth column informs if there is typically an intermediary involved in the design of the solution. This research is describing a scenario of the type Intranet / EDI that is integrated one-to-one interaction model and is efficient in dealing with large number of repeated orders (Cullen and Webster 2007). This model clearly calls for established, contractual buyer-supplier relationships and requires investments and trust from both parties.
Schubert and Legner (2011) developed five different scenarios on technical integration of B2B in global supply chains. Their model is based on a dyadic structure that is well described by previously presented as Internet / EDI in Cullen and Webster scenarios. The following table presents these five scenarios.

**Table 4.2 B2B technical integration scenarios by Schubert and Legner (2011)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Main information system</th>
<th>System access</th>
<th>Use of intermediaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Separate / different</td>
<td>Manual</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Separate / different</td>
<td>Data interchange</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Separate / different</td>
<td>Data interchange</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Same / central</td>
<td>Joint use</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Same / central</td>
<td>Joint use</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In Table 4.2, the scenarios are presented with their characteristics in system description, system access and use of intermediaries. Based on the inquiry of Schubert and Legner (2011) in their sample the most common scenario (42% of cases) was scenario 2, where parties were using their own operating system (ERP) with direct data interchange connections between buyers and suppliers. Based on these definitions, an automated purchase order scenario is defined in the following.

A prerequisite to use an automated purchase order is that contractual relationships exist with suppliers. For the items under automated purchase orders, it requires that common rules are agreed on item codes, package size, delivery times and possible safety stocks. This defines the setting to an established relationship between the two parties. To define automated purchase order, a simple definition was made. The following figure illustrates the principle of it. The figure was first presented by Rantala and Hilmola (2010) and is used here as a basis for to illustrate one possible scenario of automated purchase order.
It consists of ERP system with included MRP system at both ends of the buyer-supplier dyad. As part of the ERP system or as separate software, a system that automatically, with a set of parameters, collects purchase order proposals from ERP system and transfers them to predefined supplier in ERP system. Items have defined package sizes and orders are always made on complete packages. This order is received into the ERP system of the supplier, handled automatically and delivered without manipulation from the personnel of the selling company. The ideal situation is to work on a regular (weekly or more frequent) order pattern.

4.2. Data collection / operationalization

The data was collected using semi-structured interviews in 2014-2015. This method was chosen to collect not just answers to the specific questions but also to the logic behind them. The questions were designed to investigate on presumptions of the respondents on implementation of automated purchase order and its effects on inventory turns. A five-step grading was used to answer structured questions and was as follows: very likely, likely, probably, unlikely, very unlikely. After each specific question the respondents were asked to justify their answer. Open questions were asked for to find other possible benefits and pitfalls of the purchase order automation. The questionnaire was mostly directed to the persons interviewed to open their individual ideas as purchase professionals. Information on their current employer was asked in order to reveal some of their current professional background.

As in many IT system implementations, maintaining schedules and budgets are often criticised. Often their complex nature is denied which leads to unsuccessful implementation processes (Wood and Caldas 2001). It seems that the key to success even in smaller companies is to invest in proper planning and staffing of high quality (Petroni 2002). As research on Portuguese
SME:s show, ERP systems take on average 70% of the firms IT investments (Ruivo et al. 2014) and therefore are crucially important to the company’s success, questions were ask in order to review respondents ideas about the cost effects of the implementation process.

There are several means to measure supply chain performance. Gunasekaran et al. (2001) classified supply chain performance measures and metrics. Based on their research, performance metrics may be classified to strategic, tactical and operational metrics. Further, these metrics are divided into financial and non-financial metrics. In financial operational metrics, inventory-carrying cost is the most cited metric in the reviewed metrics. Dehning et al. (2007) found that IT-based SCM systems improved inbound and outbound processes with first improvement in inventory turnover. Based on this information, a question of effects on inventory turns was included to the questionnaire to reflect the impact of process automation to a key financial measure.

Based on the Kraljic (1983) it is important to optimise the cost of acquisition of commodities and items of low value added to the company. In relation to this, questions about the applicability of automated purchase order to items were asked.

4.3. Case companies described

Interviews were made within four manufacturing companies in different industries in order to see ideas of professionals of purchase order automation and possible experiences on the related projects. The companies were divided in the following way: one in electronics industry (company A), one in automotive industry (company B) and two in general machine building industry (companies C and D). The characteristics of the companies are described in Table 4.3. The selection of companies was made with the principle that they had to be manufacturing companies.

Company A in electronics industry is working on contract manufacturing business. Company B in automotive industry is a supplier to automotive manufacturers and the companies C and D in general machine building industry are original equipment manufacturers. Number of purchased items varied between 3 000 and 8 000 items and the number of suppliers of those items was from 40 to 200 different suppliers. The companies were also asked to tell, how many suppliers supply 80% of the purchases in monetary terms. The answers varied between 10 and 30 suppliers. As of monetary volume, the amount of annual purchases varied between 6 and 10 million euros.

The amount of so-called passive items out of monetary value of the inventory was asked. These passive items were defined as items with inventory to be sufficient for a year or more with current demand. Company A had only 6% of inventory of this kind of items. This is easily explained by the fact that items are bought mostly after the orders from OEM companies. This helps in controlling the inventory turns compared to OEM manufacturers. Company D had only 5% of the slow moving inventory. This is due to fact that most of the purchased items are made to measure due to the high customisation of end products. Companies B and C with own product development and their slow moving inventory were 20-30% of the total inventory value. The reasons for high slow moving items were due to discontinued products and safety stocks of discontinued components.
Table 4.3 Characteristics of interviewed companies

<table>
<thead>
<tr>
<th>Company</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>Electronics</td>
<td>Automotive</td>
<td>General</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>manufacturing</td>
<td></td>
<td>machinery</td>
<td>machinery</td>
</tr>
<tr>
<td>Purchase type</td>
<td>Components</td>
<td>Components, parts and products</td>
<td>Components, parts and products</td>
<td>Components and parts</td>
</tr>
<tr>
<td>Number of items</td>
<td>7 000 – 8 000</td>
<td>6 000</td>
<td>3 000</td>
<td>4 000</td>
</tr>
<tr>
<td>Number of suppliers</td>
<td>200</td>
<td>150</td>
<td>150</td>
<td>40</td>
</tr>
<tr>
<td>No. of suppliers delivering 80% of purchases</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Yearly purchase volume (millions EUR)</td>
<td>6-7</td>
<td>10</td>
<td>10</td>
<td>7-8</td>
</tr>
<tr>
<td>Share of slow moving items</td>
<td>6%</td>
<td>30%</td>
<td>20%</td>
<td>5%</td>
</tr>
<tr>
<td>Seasonal demand peaks</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of yearly peaks</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Share of demand during peaks</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>75-80%</td>
</tr>
</tbody>
</table>

There were also questions concerning seasonal peaks in demand. This question was formulated in order to identify the seasonality patterns of the demand. The definition of peaks was left rather open and only characterised by situation where large changes in demand were observed on a seasonal manner. Only company D identified peaks in the demand and in their case the peak was rather large compared to the annual volume: the company estimated that one peak represented 75-80% of annual demand.

Persons interviewed were of different functions in the companies. The main criterion for selecting persons interviewed was the experience in purchase activities. Their current position was also purchase related. In companies B and D the persons interviewed were mostly in managerial positions; in companies A and C the persons were in clerk or expert positions in their respective organisation. The experience in purchase functions for the interviewed persons in companies A, C and D was over 10 years, for the person in company B the experience was only a few years.

For the IT systems used, all companies had ERP and MRP systems in place to support purchasing. In companies A, B and D a regular forecasting pattern towards suppliers was in use. In company B an automated purchase order system was used. All companies purchased the items directly from suppliers but in company B there were also centralised purchases on the corporate level that the company was using in part of the material supplies. Company B thus has a corporate purchase department in addition to purchase departments in regional companies with company B being one of the regional companies. The use of corporate pooling was limited because of the corporate negotiated lot sizes were too large for the subsidiary. Purchase orders in the companies are done one by one. Companies A, C and D use also scheduled orders based on yearly contracts. This means that yearly purchase volume has been agreed with supplier
having certain inventory level reserved. For the company B, an automated purchase order system was in use that was based on a weekly scheduling instead of single purchase orders.

4.4. Perceptions on automated purchase order system

Perceptions on the automated purchase order were quite unanimous in the interviewed group. The technical implementation was estimated to take time by the companies A, B and C. They argued that cleaning up the item basic data was the main obstacle for fast implementation. Some concern was also directed to the technical readiness of the existing systems. Company C pointed out that if there is no reliable sales forecast, the implementation is not possible at all. Companies A and D argued that project management and increased investments were drivers to speed up technical implementation.

The costs of implementation were estimated to remain probably in the budget. When asked for reasons for this answer, the respondents were quite confident that if the plan and current state ERP analysis was made thoroughly, the only risk on cost side was the possible system supplier and the competence of their consultants. Respondents A and D emphasized the importance of the preparatory work and resourcing of the assisting persons inside the company.

The respondents were asked whether all of the company’s purchased items were suitable to be purchased based on the automated purchase order. The answer from all respondents was that it is not possible. There were several reasons mentioned including short life cycles, uncertain forecast, large seasonal variations in demand, project based demand. The obvious result was that only items with stable demand pattern were eligible to automated purchase order. A controlling question was asked whether items with stable demand pattern could be automated. The answers were all very likely. In reasoning the automation was seen only a technical issue.

On question about the influence on automated purchase order on inventory values, the respondents considered the inventory turns to improve moderately due to the purchase order automation. There were many aspects to support this. Firstly, it was seen that the increased control over items in inventory was improving the turns. As well, the impact of human error was mentioned in three out of four answers meaning that when system calculates and regulates the flow of incoming goods, the speculation of the future needs is reduced or eliminated from the order processing.

For the general benefits of the system the most important was the release of human resources to more productive work and reduction in human resource costs. It seemed the benefits depended on the size of the company. More the company had operative buyers, more cost benefits were seen. In smaller companies a shift to more productive work was emphasised.

The cons of the automated purchase order were related to the blindness and loss of control to the order process. When the order processing no longer is under a person’s control, it raises fears of a system that is no longer under control. So it was seen that in case of purchase order automation, some systems should be created in order to monitor the system performance and actions. Threats were also seen in the occurrence of false item basic data that more easily translates into unwanted inventory or problems in supply depending on the failure in setting up basic data.

4.5. Purchase order process and automation experiences of company B

The interviewed company B had been running an automated purchase order system for 18 months and the overall results are positive. The company uses three different purchase order
methods: single purchase orders, vendor managed inventory (VMI) and automated purchase orders. Single purchase orders are applied to items that are rarely needed. The reasoning for this was that then they are not ordered over the actual need. The automated purchase order system was described as follows.

In the automated system, the company does not make any separate orders but updates a delivery schedule. On Fridays, a new requirement plan is run to the system. On Sundays, new supply plan is distributed to suppliers including frozen supply window that will no longer change in the forthcoming plans. This window is from one to four weeks depending on the item type and agreement reached with the supplier. The company B always wishes to freeze the fixed window to a week but suppliers often request a longer period up to four weeks. Items are supplied from the suppliers based on the plan. Only deviations to actual supply are communicated from supplier to company B. If there is no reaction from supplier side, the items will be delivered based on the plan on the frozen periods. The supplier always receives demand information on 12 months but can limit the view for example to three months independently. Company B normally has knowledge of 60% of the demand up to six months in beforehand.

The implementation took some 6 months. Most of the work was related on cleaning the ERP system basic data and correcting purchased item information. Soon after the implementation it became clear that additional reporting is needed on items in the warehouse. Several causes of disturbances were identified: batch arriving to inventory with no future needs, arriving batch was far too large for the current demand pattern. To find answers to these occurrences, the company B needed to improve warehouse reporting. The respondent estimated the item basic data clean-up to take yet more time while the system is in use.

The cost of implementing the system was estimated to have remained in the budget, but this was not completely proved because of the difficulties in following and costing own work in the project. In this case there was support from corporate headquarters to the subsidiary. The system had been implemented previously in other subsidiaries meaning that an internal process had been defined to the implementation process.

The benefits of the purchase order automation were estimated substantial. There was a certain increase in inventory turns but that was mostly attributed to the line-up and cleaning of item basic data. The most important benefit was the reduction of personnel in purchase order management from five to three persons meaning a 40% reduction of costs on that area. There was a change in tasks of the remaining purchase personnel from individual order follow-up to supplier negotiation tasks (eg. prices, lot sizes, quality issues etc.). The current status is that 80% of the items are moved to automated order processing.

A change was also observed at supplier side. Some suppliers realised the benefits of order and lot size reduction to their own processes. Previously, when lot sizes were higher or not controlled, orders created a peak in demand. Through the lot size reduction and increased delivery frequency, there have been improvements in responsiveness and scheduling in suppliers’ internal processes improving also the cash flow in both supplier and buyer. As well, increased visibility was found beneficial as company B was willing to share their demand data for several weeks to come.

Negative experiences relate to the blindness of the situation that creates uncertainty without proper reporting on the inventory. Item basic data must be followed and updated continuously in cases of changes in demand due to end-of-life, product mix change, etc.
5. DISCUSSION

Based on the results of the interviews, the respondents seem to agree on several ideas. Implementing automated purchase order system takes time and effort, notably in reviewing item basic data. The cost seems not to be an issue as long as the implementation process has been well defined. Implementation team has a most important role in the implementation. Crucially important is the commitment of qualified personnel from the consulting company. These same ideas were identified in a study on Canadian SME:s for ERP implementations (Snider et al. 2009) As the example of company B shows, a well-defined implementation process helps the success of the process.

On items to be automated, critical success factor was quite clear to the respondents: it is not possible to automate purchasing of all items but those with stable demand and long life cycle. Based on the interviews a demand pattern based classification appeared: items with unstable demand with classic manual purchase orders, items with more stable demand to be purchased with automated purchase order or through vendor managed inventory (VMI) as was found in case of company B. The underlying idea or even requirement for the purchase order automation is the existence of contractual relationship with a supplier that includes terms in relation to safety stocks and lead times. Safety stocks are not mandatory if supplier is able to produce with a constant volume to ensure availability. Therefore it seems not to be important which items are moved to automated purchase order as long as the buyer supplier relationship and items with it are stable enough in demand and life cycle. This supports the idea of Terpend et al. (2011) that product based classification might not always answer to the question, which strategy to use but also the relationship built in between the parties.

The discussion between automated purchase order and VMI is interesting due to some similarities: both require contractual relationship and some security of demand over a certain time. What is separating VMI from automated purchase order is the fact that supplier is willing to invest in inventory holding in customers premises. This means that in VMI there is an inventory but with automated purchase order inventory holding is not necessary in case the supplier’s production process is able to follow customer demand pattern. Schubert and Legner (2011) concluded that in fact VMI requires stronger information processing needs than order-based relationship. This reveals also something about automated purchase order systems. A system where single purchase orders are sent periodically to suppliers might not be as intensive relationship wise than the example of company B where the customer sent a long term forecast with frozen order period. Even that case might not be as binding between parties because in VMI also the supplier reveals more to customer in terms of inventory holding levels.

This relationship building does not necessary tell about power but certainly of interdependence as well as trust. In case of power, Caniëls and Gelderman (2007) found that suppliers are perceived to dominate satisfactory relationships. This would mean that formation of successful automated purchase order setting would involve a stronger, trusted partner that an SME can rely on in the supply of needed items. Somehow this is in conflict of the model presented by Kraljic (1983): he sees increasing power of suppliers a reason for the company to diversify sourcing. In case of SME’s that would no longer be the case but the most successful strategy would be to build a strong relationship to this dominant supplier. The Kraljic model seems also more suitable to a frame with large organisations and large supply volumes. In case of company B, head office was supporting the subsidiary through supply contracts and system support. This means that the head office has most probably done the tasks of analysing item and supply base, possibly through an application of Kraljic model or similar.
What then comes to the application of corporate policy to the subsidiaries, a decision to transfer an item to automated purchasing may as well fit to a strategic item with stable demand and long life cycle as well as to a commodity with similar attributes. The key is that supply is stable whether it is realised through warehousing of the items or a flexible manufacturing solution (lean, JIT, etc.) and has adapted information systems.

On the other hand, strong relationships with suppliers include the risk of stagnation of the purchasing dynamics. This means that when relationships are built, there might be the possibility that price levels are fixed with less interest to search for alternative sources of supply. Partly, this is probably a result of purchase professionals’ preference of supply security over cheapest price.

From SME’s viewpoint, automated purchase order is a desirable way of following a supply chain integration strategy. It should not be forgotten that purchase order automation is a small part of IT strategy inside supply chain integration. The economic restraints are best seen in reliance on software consultant use. While company B as small subsidiary of a large corporation received guidelines and ready software tools to implement purchase order automation, independent companies need to run towards ready solutions and seek for experienced consultants to find best solutions. As pointed out by Zach et al. (2014) many SME’s do have the IT knowledge to implement complex systems. In view of resources the investments are often quite large for small companies (Ruivo et al. 2014)

The experiences of company B are relevant to the results of the other respondents. Experienced benefits were including reduction of labour in routine purchasing tasks. Persons previously charged with daily purchasing were able to move to more productive and proactive tasks and create value through e.g. price negotiations. This was identified as the root cause of moving to the automated purchase order system. Increase in sharing information and continuous flow of products benefitted both supplier and buyer. The following picture summarizes the perceived benefits of automated purchase orders in company B.

As may be seen, the perceived benefits are in concordance with lean purchasing and their goals (Ansari and Modarress 1988). Through reduction of lot sizes, increased delivery frequencies and trusted partnership with suppliers, both parties can enjoy fixed cost savings and increased capital turnover with more stable production processes.

From the negative effects of purchase order automation the company B identified the blindness of buyers to the real materials flow. This meant that controls needed to be built up to secure
correct function of the system. In other case companies the answers were not so precise but they all identified a sort of “blindness” that was related either to the malfunctioning of the system or to the incorrect basic data. This derives the danger that if the system is uncontrolled and incorrect basic data is influencing purchase orders, the situation may cause either shortages or unnecessary stocks of materials.

As stated by van Hoek (2001) it should be secured that supply chain management and the use of IT in it does not remain on fragmented parts of a supply chain but that higher goals are set in order to achieve strategic and integral view of the e-supply chain. Therefore, in enhancing the supply chain performance will require that supplier management practices are aligned with IS strategy (Qrunfleh 2012). Also the examined phenomenon is a dyadic integration of information between a buyer and a supplier which is still far of real supply chain management integration (Näslund and Hulthen 2012).

6. CONCLUSIONS AND FUTURE RESEARCH

Based on this research, purchase order automation is an important topic in streamlining daily routines in purchase-related tasks. Purchase order automation has potential and some proven track in reducing fixed costs and adding value to the work of purchase professionals. Purchase order automation seems to add rigour to the item basic data update. That finally is the way of improving the use of working capital. Implementation of automated purchase order gives way of increasing the importance of key supplier relationships. Implementation process itself needs focus and rigour to achieve a reliable and cost efficient system. Implementation should also follow and complement the overall IT strategy. For SME’s economic realities may restrain the application of the solution but it is also possible to implement it without large IT investments.

There are also some problem areas. While automated purchase order increases the importance of selected suppliers, it also stiffens the supplier network structure and possibly blurs the price level knowledge of the market. Inside the company “blindness” to the material flows and system total influence to the inventory level requires additional controls to monitor warehouse levels of components and their key performance indicators.

The discussion raises questions about several interesting areas of research. Firstly, automated purchase order processing or B2B EC is a topic that is interesting to professionals. Tools on this area are developing constantly and their applications may be done in many different ways. There are clearly many ways of implementing it and larger samples should be collected to investigate the phenomena. Purchase order processing and use of different ordering methods (purchase orders, VMI etc.) is an interesting topic also on a relationship view as well as their impact on key financial metrics.

Buyer-supplier relationships and their impact on supply strategy is a widely discussed issue. Development for models based on relationships would be interesting viewpoint in addition to current item or product based taxonomies. It seems that a trusting relationship with a supplier does not necessarily limit the spectrum of goods purchased from the supplier.

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CONSIGNMENT INVENTORY MODEL
FOR A THREE ECHELON SUPPLY CHAIN

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ABSTRACT

Purpose
This paper aims at reflecting the effect of delay in payments on net profit of a three echelon supply chain cooperating under a Consignment Inventory (CI) contract. Under CI, buyers delay paying for the goods to the vendor. The paper formulates an optimization model to determine vendor’s wholesale price, buyers’ retail prices and replenishment intervals at each level of the supply chain, while maximizing the total net profit of the supply chain.

Methodology
The optimization problem is formulated as a mixed integer non-linear programming (MINLP) model. An evolutionary meta-heuristic algorithm is then developed to find a good enough solution for the model in reasonable time. Subsequently, the paper performs a sensitivity analysis in the form of a computer simulation to demonstrate the effects of the changes in the input parameters of the problem on the net profit under both scenarios of delay in payment.

Findings
The results show that in the pay-as-sold consignment inventory scenario, the net profit increases as the market scale of a retailer increases while in the order-to-order consignment inventory scenario, it decreases as the price elasticity of a retailer’s demand rate increases. In addition, statistical tests show that the pay-as-sold policy is likely to be more profitable than the order-to-order policy.

Original/value
The paper solves the problem under two scenarios of delay in payment that have been rarely addressed in the literature: (1) pay-as-sold, i.e. real time, and (2) order-to-order consignment, that is, that is, a consignment order is billed when the next order is placed.

Keywords: Consignment Inventory, Multiple-echelon Supply Chain, Purchasing, Optimization

1. INTRODUCTION

In traditional decision making, decisions are only restricted to a single organization and the major concern is to add to the firm's benefit. Whereas, in today's competitive environment, there
is an urgent need for mechanisms that to maintain profitability in coordinated supply chains. The main aim of coordinated supply chain is to optimize the total expected supply chain profit by shifting focus from a single firm into the consideration of the entire system.

One of the coordination mechanisms in supply chain that has received heavy attention in the literature is Vendor Managed Inventory (VMI). In VMI a vendor creates orders for his buyers and benefits from flexible order replenishment and delivery to the buyers. This would lessen the burden of inventory management on buyers’ side (detailed reviews in Gümüs (2006) and Ryu (2006)).

CI (Consignment Inventory) is another coordination mechanism between vendors and buyers in which the customer (buyer) has authority over the timing and quantity of replenishments but does not expend her capital in inventory and delays paying for the goods to the vendor (Molamohamadi et al., 2013). Based on the time of transferring the ownership of goods, four types of CI have been categorized in the literature (Piasecki 2004):

- Pay as sold (real time)
- Pay as sold during a predefined period
- Ownership changes after a predefined period
- Order-to-order consignment (A consignment order is billed whenever the next one is placed.)

The contribution of this paper is to study the first type of delay in payments (pay as sold) as well as to compare its net profit with that of the fourth type of delay in payment (order-to-order). The order-to-order consignment has not been sufficiently discussed in the literature. However, there are works focusing on CI where ownership changes after a predefined period where the credit period is less/greater than or equal to the cycle time (Goyal et al. 2007; Ho 2011; Lin et al. 2012; Liao et al. 2012). The three echelon supply chain considered in this paper consists of a manufacturer, a warehouse and multiple retailers cooperating under CI. The manufacturer produces a single product at a fixed rate then replenishes the warehouse. The manufacturer decides about her own replenishment cycle for the raw materials as well as the warehouse replenishment cycle for the finished goods. The manufacturer also decides on the wholesale price offered to the retailers to maximize her own benefit. Multiple retailers decide about their replenishment cycles for the goods as well as their retail prices offered to customers to maximize their benefits. In this paper, the retailers delay paying back to the vendors according to two aforementioned delay in payments types. In short, the objective of the paper is to determine the wholesale and retail prices as well as replenishment cycles for each level of the supply chain cooperating under CI such that the total net profit of the whole supply chain system is maximized.

The paper is organized as follows: In the next section, a brief review of the literature will be given. Section 3 explains the mathematical optimization model, its assumptions and the corresponding symbols to be used in the formulation. Section 4 explains the proposed evolutionary algorithm. In section 5, the sensitivity of the net profit to the input parameters of the model is analyzed. Finally, section 6 concludes the paper and gives suggestions for further research.

2. LITERATURE REVIEW

In this section, the related literature is reviewed from two perspectives: (1) research related to delay in payments in CI and (2) research related to CI contracts without considering time value
of money. For the former, the focus of review is mostly on the first and third type of delay in payments.

In the first type of delay in payments, which has received little attention in the literature, the ownership and the payment are exchanged when the goods are taken over by the customer. Gümüs et al. (2008) conduct a survey on this type of CI in a supply chain under deterministic demand and provide general conditions under which CI benefits the vendor, the buyer, and the two parties together. Sharifyazdi et al. (2009) consider a CI system and obtain proper values of replenishment cycles at the warehouse and the retailers together with retail prices by solving an integrated model using PSO algorithm.

In the third type of delay in payments, the vendor allows a certain fixed credit period to bill buyer later to stimulate their demand. The buyers can accumulate revenues on sales and earn interest on that revenue during this credit period. However, beyond this period, the vendor charges interest. This type of arrangement that has been extensively addressed by many researchers is called 'Trade Credit'. Goyal et al. (2007) develop an EOQ model for a retailer when the supplier offers a progressive interest charge. Huang (2007) extends Huang (2003) to an economic production quantity (EPQ) model with two-level trade credit. Jaggi et al. (2008) incorporated the concept of credit-linked demand for the retailer and developed an inventory model under two levels of trade credit policy to determine the optimal credit as well as replenishment policy jointly. Chung and Huang (2009) determine optimal ordering policy under conditions of allowable shortages and permissible delay in payments. Balkhi (2011) develops a general finite trade credit economic ordering policy for an inventory model with deteriorating items under time value of money and inflation. The given time horizon consists of multiple cycles each of which has its own demand rate and its own trade credit period which is usually offered from the supplier to the retailer. Ho (2011) proposes a two-level trade credit policy where the demand rate is assumed to be a function of both retail price and the customers’ credit period and determines the optimal retail price, economic order quantity, and the number of shipments from the supplier to the retailer in one production run for an integrated inventory system under both two-level trade credit and price-and-credit-linked demand rate. Kreng and Tan (2011) study a production model for a lot-size inventory system with finite production rate and defective quality under the condition of two-level trade credit policy. Tsao (2011) develops an inventory model with non-instantaneous delivery under trade credit and logistics risk. Liao et al. (2012) determine economic order quantity for deteriorating items with two-storage facilities where trade credit is linked to order quantity. Teng et al. (2012) establish inventory lot-size models under trade credit financing by assuming a linear time-increasing demand function which warrants the growth stage of a product life cycle. Lin et al. (2012) propose an integrated supplier–retailer inventory model under two levels of trade credit where the retailer receives an arriving lot containing some defective items. Tsao and Sheen (2012) consider optimization model in a two-echelon supply chain with credit period and weight freight cost discount. In their study, the optimal credit period of the supplier on one hand and the retailer’s best policy for making multi-item replenishment and pricing decisions on the other hand are determined.

When it comes to CI contracts without taking into account the time value of money, Wang et al. 2012 studied the problem of consignment inventory for deteriorating items in a single-vendor-single-buyer supply chain. They assumed a capacity constraint for the buyer and determined the vendor’s optimal lot size and replenishment cycle (holding cost occurs at both vendor and buyer; however, replenishment costs are only charged to the vendor). Ben-Daya et al. (2013) compared the benefits of three different partnerships: independent vendors and buyers, Vendor Managed Inventory and Consignment Stock (VMI&CS) and centralized supply
chain. They concluded that VMI&CS is more beneficial for the vendor and buyer under the following circumstances; the vendor has sufficient capacity (production rate sufficiently larger than demand rate), vendor’s setup cost is not high and the buyer has significant order costs. Bylka (2013) studied the problem of consignment stock in single vendor and single buyer supply chain under two cases; centralized coordinated supply chain and a non-cooperative supply chain. They determined the number of deliveries under both cases such that the total cost is minimized. Molamohamadi et al. (2013) studied the problem of consignment inventory for a two echelon supply chain consisting of a single vendor and multiple buyers and compared the total net profit of the centralized supply chain for two types of delay in payments; after selling the product to the end user and cyclic payments. They concluded that the first type of delay in payments is more profitable than the latter. Zanoni et al. (2014) applied VMI&CI in a supply chain with a single vendor and a single buyer under emission trading scheme. They determined buyer’s order quantity and number of shipments as well as the production rate at the vendor considering Green House Gas (GHG) emissions generated from production activities and violations from emissions’ quota.

Consignment inventory contracts have advantages and disadvantages at the same time. CI benefits the buyer when final demand is unknown, since it allows the buyer to protect himself against uncertainties in production and sales. There are also some advantages for the vendor in CI system; CI enables the vendor to put the stock into the public domain which will be viewed and purchased. However, this will take up the physical space at the customer’s site that could be put to better use storing supplies the customer actually owns. Also in case of new and unproven products that the customer hesitates to buy, or expensive items difficult for the customer to own, it would be beneficial for the vendor to have them located at the customers while giving them a feel of service satisfaction. In CI both vendor and buyers are responsible for their own holding costs, in particular, cost related to physical storage; however, other holding costs such as capital related ones are only charged to the vendor (Zanoni et al., 2014). CI is widely used in virtual markets where suppliers’ goods are stored at retailers who then sell them to customers (Hu et al., 2015). Recently, Hu et al. (2015) performed risk analysis of two types of consignment contracts; Vendor Managed Consignment Inventory (VMCI) and CI with revenue sharing. The results of their study show that retailers gain more benefit under CI with revenue sharing while suppliers make more profit under VMCI. Xu et al. (2016) modeled the stockout recovery behavior for a manufacturer and a retailer cooperating under CI using principal-agent model. They concluded that CI increases the optimal order quantity while decreases stockout frequency and backorder prices.

3. PROBLEM DEFINITION, ASSUMPTIONS AND NOTATIONS

The optimization problem to be formulated is based on Yu et al. (2009) where there is a supply chain with one vendor (manufacturer) and multiple buyers (retailers) with CI contract for one product. The vendor replenishes a single type of product to multiple buyers and buyers pay to the vendor with delay. Delay has two types: (1) buyers pay to the vendor after the products are sold to the end customers, and (2) buyers pay to the vendor when placing an order at each cycle. The objective is to maximize the total profit of the supply chain consisted of a vendor and multiple buyers. The decision variables are replenishment cycles of the vendor and buyers together with vendor’s wholesale and buyers’ retail prices. The constraints assure that the vendor’s wholesale price is less than buyers’ retail prices and each buyer has a minimum amount of demand to satisfy. In order to formulate the problem as well as to state the assumptions, the following symbols are defined first:
Parameters

$i$ index of the retailers, $i = 1, 2, \ldots, k$

$D_i(p_i)$ demand of the retailer $i$ per time unit which is a function of $p_i$ (retail price),

$e_{p_i}$ price elasticity of retailer $i$’s demand rate,

$k_i$ a constant in demand function $D_i(p_i)$ of retailer $i$, which represents retailer’s market scale,

$l$ lower bound of each retailer’s order quantity,

$M$ quantity of the raw material required for producing one unit of the product

$v_w$ procurement price of the raw material for the manufacturer ($/unit$),

$V_m$ manufacturing cost of the product ($/unit$)

$A_w$ fixed replenishment cost per order at the manufacturer ($/order$),

$A_{bi}$ fixed replenishment cost per order for the retailer $i$ ($/order$),

$\varphi_i$ direct transportation cost for shipping one unit of product from the warehouse to the retailer $i$ ($/unit$),

$\omega$ direct transportation cost for shipping one unit of product from the manufacturer to the warehouse ($/unit$)

$h_{si}$ holding cost of the product at the retailer $i$’s side ($/unit/time$),

$h_w$ holding cost of the product at the warehouse's side ($/unit/time$),

$h_r$ holding cost of the inventory at the manufacturer's side ($/unit/time$),

$r$ interest rate

Decision Variables

$p_i$ retail price of retailer $i$ ($/unit$),

$c_p$ wholesale price of the product set by the manufacturer ($/unit$),

$c_i$ replenishment interval at the retailer $i$,

$c$ replenishment interval at the warehouse,

$c_m$ replenishment interval at the manufacturer

We have made the following assumptions to formulate the problem:

- There are a manufacturer, a warehouse and $k$ retailers cooperating under a CI system. The warehouse belongs to the manufacturer. It is physically located far from the manufacturer but close to the buyers. The manufacturer has authority over the timing and quantity of replenishments. Thus, the profit of the manufacturer and the warehouse is maximized in one profit function.
- The manufacturer procures and turns raw materials into a product with a fixed production rate, and replenishes the product to her warehouse. There is only one type of product.
- The manufacturer’s production capacity is limited.
The manufacturer and retailers decide their wholesale and retail prices independently. Also, the retailers are independent from each other to serve their individual markets.

Each retailer’s demand is a decreasing and convex function with respect to their retail price, and can be described by Cobb-Douglas demand function \( D_i(p_i) = k p_i^{-e p_i} \).

Orders at each level must be equal to or greater than a lower bound denoted by \( l \).

The replenishment orders are placed by the manufacturer, the warehouse and the retailers based on integer-ratio policy. It is worth noticing that if the replenishment interval for a retailer is not less than that of the warehouse \( (c_i \leq c) \), then each time the retailer places an order, so does the warehouse. As a result, the warehouse does not have to hold inventory for this retailer. However, when the replenishment interval of the retailer is not greater than that of the warehouse \( (c_i \geq c) \), the warehouse must hold inventory to satisfy retailer’s demand.

Backorder costs and lead times are assumed to be zero.

The objective function of the model is the total net profit of the supply chain. To formulate the objective function, first, we have formulated the net profit of the retailers and the manufacturer respectively in subsections 3.1 and 3.2. Subsequently, we have summed up these two parts into the total net profit in subsection 3.3.

### 3.1. Each Retailer’s Net Profit

Retailer \( i \)'s revenue is \( p_i(k_i p_i^{-e p_i}) \). However, retailer \( i \) delays the payment to the manufacturer. In the first type of delay in payments, retailer \( i \) pays for the goods as soon as the products are purchased by the end customers.

Here, continuous compounding, single sum, present worth factor is applied to calculate the net present value of the procurement cost. Therefore, the procurement price of the retailer \( i \) becomes:

\[
\int_0^{c_i} c_p k_i p_i^{-e p_i} e^{-r t} dt = (\frac{1}{r}) c_p k_i p_i^{-e p_i}(1 - e^{-r c_i}) \tag{1}
\]

Moreover, retailer \( i \) pays \( h_i \sum \frac{k_i p_i^{-e p_i} c_i}{c_i} \) and \( k_i p_i^{-e p_i} \) for holding cost of the products at her place, replenishment cost and transportation cost, respectively. Thus, the total net profit of retailer \( i \) per unit of time is calculated as follows:

\[
Max \ N P_i = \sum_{i=1}^{m} \left[ p_i(k_i p_i^{-e p_i}) - (\frac{1}{r}) c_p k_i p_i^{-e p_i}(1 - e^{-r c_i}) - h_i \sum \frac{k_i p_i^{-e p_i} c_i}{c_i} - k_i p_i^{-e p_i} q_i \right] \tag{2}
\]

### 3.2. The Manufacturer’s Net Profit

In order to obtain the manufacturer’s net profit, we must have the inventory cost of the CI system first. As an example, Figure 3.1 shows a system consisting of multiple retailers, a warehouse and a manufacturer. It has been assumed that \( c = 3c_i \) and \( c_m = 3c \).

By getting help from Figure 3.1, it can be seen that the manufacturer pays \( \frac{M h_i}{2c m} \sum_{i=1}^{m} k_i p_i^{-e p_i} (c_m + c) c_m \) for holding cost of inventory at her side and \( \frac{h_w}{2c} \sum_{c_i > c} k_i p_i^{-e p_i} (c - c_i) c \) for holding cost of goods at warehouse’s side. Besides the
inventory cost, the direct costs of the manufacturer consists of the manufacturing cost, the raw material procurement cost, fixed replenishment cost and the transport cost, and can then be formulated as follows:

$$V_m \sum_{i=1}^{m} (k_i p_i - e_p i) + MV_w \sum_{i=1}^{m} (k_i p_i - e_p i) + \frac{A_w}{c_m} + \omega \sum_{i=1}^{m} (k_i p_i - e_p i)$$ (3)

Then, since the manufacturer's revenue is:

$$\frac{c_p}{R_i} \sum_{i=1}^{m} k_i p_i - e_p (-\exp^{-rc_i})$$ (4)

**Figure 3.1 The inventory fluctuations of supply chain members**

the manufacturer's net profit will be:
### 3.3. Total Net Profit Of The System For The Pay-As-Sold Type Of Delay In Payments

As mentioned before, when there is power discrepancy between a more powerful buyer and a less powerful vendor, the vendor can apply CI to meet the buyer’s wishes. Here, it is assumed that the buyers (retailers) have more power than the vendor (manufacturer) and could simply refuse to stay in the partnership if they gain less profit than the vendor. Therefore, we assume that \( \omega > \omega_m \) where \( \omega_r \) and \( \omega_m \) are the weights given respectively to the retailers and the manufacturer to merge their corresponding net profit functions within one objective function: the total net profit. Hence, the total net profit and the corresponding optimization model for the first type of delay in payments become:

\[
\text{Max } NP_m = \frac{c_p}{r} \sum_{i=1}^{m} k_i p_i^{-e pi} (1 - \exp^{-c_i r}) - V_m \sum_{i=1}^{m} (k_i p_i^{-e pi})
\]

\[
- MV_\omega \sum_{i=1}^{m} (k_i p_i^{-e pi}) - h_\omega / 2c \sum_{i, c_i > 1}^{m} k_i p_i^{-e pi} (c - c_i)c
\]

\[
- Mh_r / 2c_m \sum_{i=1}^{m} k_i p_i^{-e pi} (c_m + c)m - A_w / c_m
\]

\[
- \omega \sum_{i=1}^{m} (k_i p_i^{-e pi})
\]

subject to:

\[
V_m + MV_\omega \leq c_p
\]
Constraints (7) and (8) make sure that the production cost is less than the wholesale price and the wholesale price is less than the retail price, respectively. In order to force each retailer's demand to be more than a lower bound, constraint (9) is added to the model. Constraint (10) normalizes the weights.

3.4. Total Net Profit Of System For The Order-To-Order Type Of Delay In Payments

The total net profit of the system in this type of delay in payments is the same as the first one, except for the procurement cost that is paid by the retailer in every replenishment cycle. Therefore, the corresponding optimization model can be formulated as follows:

\[
\text{Max. } \text{TNP}_{\text{Order to order}} = w_r \sum_{i=1}^{m} (p_i(k_i p_i^{-e_i}) - \frac{1}{r} c_p k_i p_i^{-e_i} e^{-rc_i} - \frac{h}{2} k_i p_i^{-e_i} c_i - A_{bi}/c_i - k_i p_i^{-e_i} q_{i}) + w_m \left[ c_p/r \sum_{i=1}^{m} k_i p_i^{-e_i} e^{-rc_i} - V_m \sum_{i=1}^{m} (k_i p_i^{-e_i}) - MV_w \sum_{i=1}^{m} (k_i p_i^{-e_i}) - h_{r}/2 \sum_{i: \frac{c_i}{c_i} \geq 1}^{m} k_i p_i^{-e_i} (c - c_i) - M h_{r}/2 \sum_{i=1}^{m} k_i p_i^{-e_i} (c_m + c) - A_{w}/c_m - \omega \sum_{i=1}^{m} (k_i p_i^{-e_i}) \right]
\]

subject to:

\[
V_m + MV_w \leq c_p \quad (12)
\]
\[
c_p \leq p_i \quad (13)
\]
\[
k_i p_i^{-e_i} \geq l \quad (14)
\]
\[
w_r + w_m = 1 \quad (15)
\]
4. METHODOLOGY

The optimization model developed in this paper is nonlinear, multi-variable and multi-constraint. Furthermore, it is not necessarily a convex programming model. Therefore, it could be extremely time-consuming and difficult to solve it using exact optimization methods. Thus, we have chosen to look for near-optimal values of the variables instead of the optimal ones to have a good solution in a reasonable time. In order to do so, a Memetic Algorithm is adopted here. The effectiveness and efficiency of the algorithm is then compared with a Genetic Algorithm (GA).

Memetic Algorithms (MAs) are classified as stochastic global search heuristics in which evolutionary algorithmic approaches are combined with problem-specific solvers. The latter might be implemented as local search heuristics techniques, approximation algorithms or even sometimes exact methods. The hybridization is meant to either speed up the discovery of good solutions, for which evolution alone would take too long to discover, or to reach solutions that would otherwise be unreachable by evolution or a local method alone (Krasnogor et al. 2006).

In this paper, the proposed Memetic algorithm is a combination of Genetic Algorithm (GA) and Hill Climbing Algorithm (HCA). GA provides a wide exploration of the search space while HCA as the local search method can somehow zoom-in on the basin of attraction of promising solutions. HCA is a technique in which the basic idea is to always head towards a solution in the neighborhood, which is better than the current one. When there are no better solution or a predefined goal is reached, HCA terminates (Baskar et al. 2006). GA generated a random population of solutions, namely chromosomes, in the form of arrays of numbers. Then, it randomly selects good chromosomes and tries to combine them in pairs. This operation is called cross-over. GA also has another mechanism, namely mutation, where it randomly selects a chromosome and changes one of its variables (genes). GA produces a new generation of chromosomes by crossing-over and mutating the previous generation and continues this process until one of the termination criteria is met. In MA, each chromosome, i.e. solution, in each iteration of GA is fed to the HCA and the output from the local search part of that iteration is again fed as input to GA in the next iteration. Hence the final solution is normally much better improved. The structure of both the proposed MA and HCA are represented in Figure 4.1 and, Figure 4.2, respectively.
Decision variables are encoded as positive real numbers within the chromosomes. Then, an initial population of feasible chromosomes is generated randomly. At each generation of GA, the new population is chosen from a pooled population of chromosomes, called parents, and products of cross-over and/or mutation, namely off-springs. The probability of choosing a parent is equal to the selection of an off-spring. This mechanism is called enlarged sampling. During the process of crossover and mutation, it is possible to generate infeasible solutions thus various strategies such as, rejecting strategy, repairing strategy and penalizing strategy are applied to avoid infeasibility. Repairing strategy simply removes an infeasible solution while repairing strategy modifies the infeasible solution and turns it into a feasible solution. In penalizing strategy an infeasible solution is accepted by imposing a large penalty to the fitness function.
Figure 4.2 Structure of HCA

For constraints (12) and (14) along the phases of HCA and for generating integer ratios of $c/c_i$ or $c_i/c$ and $c_m/c$ or $c/c_m$, repairing strategy is used. For guaranteeing that $V_m + Mv_w \leq c_p$ and $k_i p_i - e_{pi} \geq l$, rejecting strategy is applied in phases of GA. Penalizing strategy is also applied to ensure that for each retailer $c_p \leq p_i$.

Figure 4.3 shows the structure of chromosome which consists of $3k+4$ genes if there are $k$ retailers.

$\frac{c_1}{c}$ or $\frac{c}{c_1}$ \ldots $\frac{c_k}{c}$ or $\frac{c}{c_k}$ 0 or 1 \ldots 0 or 1 $\frac{c_m}{c}$ or $\frac{c}{c_m}$ 0 or 1 $p_1$ \ldots $p_k$ $c$ $c_p$

Figure 4.3 A genetic representation scheme

The first $k$ genes of the chromosome generate integer ratio values for replenishment cycles of the warehouse and the retailers. The second $k$ bits consist of binary values showing whether the first $k$ genes represent $c/c_i$ or $c_i/c$. If the value of the $(i+k)^{th}$ bit equals 0, it means $c > c_i$; otherwise $c \leq c_i$. The $(2k+1)^{th}$ bit indicates the integer ratio of replenishment cycles of the manufacturer and the warehouse. The $(2k+2)^{th}$ bit contains values of 0 or 1. If this value equals
0, it means $c_m > c$; otherwise $c_m \leq c$. It is necessary to mention that any non-integer values of $c/c_i$ or $c_j/c$ and $c_m/c$ or $c/c_m$ would be rounded up/down to the nearest integer values. The third k genes are dedicated to retail prices and the last two genes are related to warehouse's replenishment cycle and wholesale price, respectively.

The GA operations used in this paper are non-uniform mutation and affine crossover. Non-uniform mutation and affine crossover are both used for real-valued encoding. In non-uniform mutation a lower bound and an upper bound are defined for a variable. A random number is generated to decide whether to apply mutation or not. Then second random number is generated to decide on the jumps either toward the upper-bound or lower-bound. Affine crossover is a type of arithmetic crossover where non-negativity of the convex crossover is relaxed. Population size, probability of mutation, probability of crossover and the penalty are set to 150, 0.02, 0.8 and $10^5$ by test and try, respectively. The termination criterion of this genetic algorithm is that when the maximum change in the best fitness (objective function) observed so far in 10 consecutive generations is smaller than specified tolerance (0.001), the algorithm terminates. The second termination criterion of the genetic algorithm is that the number of iterations becomes 1000 when the first termination criterion is not met yet. Moreover, the termination criterion of the hill–climbing algorithm is also the maximum number of iterations which is equal to 30. The program is coded in MATLAB (Version 7.8) and executed for 500 independent runs.

5. RESULTS AND SENSITIVITY ANALYSIS

In this section, we present a sensitivity analysis of the parameters. Afterwards, we compare the performance of the proposed hybrid algorithm with a pure GA. Parameters are divided into three groups as follows: demand and market related parameters, retailer related parameters and manufacturer/warehouse related parameters. In order to evaluate the effects of the parameters on the final solution, the results of the hybrid algorithm are tested by Analysis Of Variance (ANOVA) with 0.05 as significance level. That is, we have investigated how related each parameter is to the objective function on each scenario. We have produced 500 runs. In order to do so, we have made sets of different values for each parameter. Then, for each run, we chose a specific combination of these values for all of the parameters randomly. Each value in a set has the same probability to be chosen for a combination. To be more precise, first, an interval is assigned to each parameter which is then divided into five subintervals. The beginning values of each of the subintervals are then chosen as the representative of the interval. For each parameter, the assigned intervals are based on Yu et al. (2009) as: $k_i \in [9000, 18000]$, $e_{p_i} \in [1.1, 1.3]$, $l \in [50, 70]$, $r \in [0.05, 0.15]$, $A_{bi} \in [50, 150]$, $h_{si} \in [1, 4]$, $\varphi_i \in [3, 15]$, $h_w \in [2, 6]$, $A_w \in [300, 700]$, $v_w \in [20, 30]$, $v_m \in [5, 10]$, $M \in [0.5, 1]$, $h_r \in [1, 3]$, $\omega \in [10, 20]$ and the number of retailers is assumed to be two.

Table 5.1 shows the p-values obtained from ANOVA. In this table, bold numbers show parameters which have a significant effect on the net profit of the system in both cases of aforementioned delay in payments.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Demand and market</th>
</tr>
</thead>
</table>

Table 5.1 The results of ANOVA for the sensitivity analysis of the net profit of the supply chain to the parameters
Figure 5.1 illustrates the effect of market scale on the total net profit of pay-as-sold consignment inventory. It can be seen that total net profit of the supply chain increases due to the increase of retailers’ market scale in pay-as-sold consignment inventory setting. However, Figure 5.2 shows that the total net profit of order-to-order consignment inventory decreases as the price elasticity of retailers’ demand rate increases.

![Figure 5.1 The influence of $k_1$ and $k_2$ on $TNP_{pay as sold}$](image)
Also, a left-tailed paired t-test with 0.05 as significance level has been performed to compare the performance of the proposed algorithm with a GA with the same structure, i.e. chromosomes, cross-over, mutation, probabilities, etc. The result of the test reveals that the hybrid algorithm performs better than GA. However, more time is consumed in the hybrid algorithm.

Besides, the same test is performed to compare the net profit of supply chain under pay-as-sold consignment inventory setting with order-to-order consignment. The p-value is small enough to reject the null hypothesis and deduce that pay-as-sold policy is more profitable than order-to-order one.

6. CONCLUSION

We have studied a consignment inventory system in a three echelon supply chain where the manufacturer keeps inventory at her warehouse and then supplies it at the same wholesale price to multiple retailers. The inventory becomes in the possession of the retailers, but is still owned by the manufacturer. The retailers pay back to the manufacturer with delay; i.e. retailers pay back to the manufacturer right after they sell the goods to their final customers or when they make the next replenishment order to the warehouse.

The main objective of the paper is to provide a decision making tool for and to compare two types of CI system (pay-as-sold and order-to-order consignment). The paper has formulated optimization models to determine wholesale and retail prices as well as replenishment periods while maximizing the net profit of the supply chain. To find good solutions for the models a memetic algorithm is developed. Then, the performance of the algorithm is compared to that of a pure genetic algorithm. Moreover, a sensitivity analysis is performed to evaluate the effects of the input parameters, such as price elasticity of demand, on the net profit. Statistical tests are then employed to see which parameters have a significant effect.

The findings of our research provides managerial insights for both vendors and buyers on choosing the best replenishment policies as well pricing strategies to maximize their benefits under CI contract. The results of our work shows total net profit of the supply chain system under pay-as-sold delay in payments is statistically more profitable than the order-to-order consignment. In addition, it was observed that retailers’ market scale and price elasticity are influential parameters in terms of total net profit of the supply chain in pay-as-sold and order-to-order consignment inventory, respectively.
For the model presented herein, there are several directions for further research. A few are pointed out here. Backorder costs and lead times can be included in the model. Also, we can further study a game theory model of the studied CI system, and compare the results with this paper. Finding lower and upper bounds for the optimal net profits is another issue worth paying attention. This can show how effective is the proposed algorithm.

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ABSTRACT

Purpose
Physical Internet (Pi) is an emerging concept applying the Internet as a design metaphor for the development of sustainable, interoperable and collaborative freight transport. Considering that Physical Internet is gaining increasing attention in academic literature and a part of the European Commission’s roadmaps and the world’s largest research funding program (Horizon 2020), understanding Physical Internet is important for decision makers in society and industry as well as academic scholars.

Design/methodology/approach
The research design applied for this paper is based on a literature review and a quantitative analysis using Sweden as a macro case. The review investigated the existing academic papers, project reports, specifications and other resources related to the concept Physical Internet. In order to analyze the available material, we have utilized research and frameworks from Supply chain management, Transportation and Information Systems.

Findings
We found that a growing amount of strategies and specifications are developed for Physical Internet, yet the concept appears to have potentially negative effect on sustainability empty running, and currently fails to address underlying causes for low transport fill rates.

Research limitations/implications
While basing physical transports on the digital internet certainly evokes novel design patterns, our analysis shows challenges of the Physical Internet vision in its current form pertaining to lack of clarity, theoretical coherence, cumulative tradition, and parsimony.

Practical implications
The so called “Grand challenge” of sustainability in logistics, needs to be addressed, but the practical implications of this paper are that Physical Internet might not address or improve logistics sustainability. Furthermore, in terms of business model development and adoption feasibility, major challenges remain.

Originality/value
Given the large number of projects, papers and various initiatives related to Physical Internet, this paper, to the authors’ best knowledge, provides a novel technology adoption perspective on Physical Internet research, roadmaps and development plans.

Keywords: Physical Internet, Open Logistics, Intelligent Cargo, Autonomous Logistics, Business model innovation, Grand challenge
1. INTRODUCTION

Logistics today is not environmentally and socially sustainable. Freight transportation accounts for 7% of Global Green House Gas emissions (Stern, 2008) and cost efficiency is many times achieved through drivers working under poor social conditions (Belzer, 2000, Hilal, 2008). Freight transport operations are characterized by a low level of innovation (Wagner, 2008, European Commission, 2011) and uncertainties in various macro and micro factors cause inefficiencies (Sanchez-Rodrigues et al., 2008). Addressing this global unsustainability has been termed the global logistics sustainability grand challenge (Montreuil, 2011) and in a recent issue of Science, Mervis (2014) describes the innovative concept Physical Internet (Pi or π) as a future solution to the sustainability challenges of logistics. What is the Physical Internet?

In 2011 Benoit Montreuil published the first paper on the Physical Internet: “Toward a Physical Internet: meeting the global logistics sustainability grand challenge” (Montreuil, 2011). Montreuil (2011) uses the digital Internet as a metaphor for a future freight transportation system and Ballot et al. (2014, loc. 540) defines it as:

The Physical Internet is a global logistics system based on the interconnection of logistics networks by a standardized set of collaboration protocols, modular containers and smart interfaces for increased efficiency and sustainability.

In a recent issues of Science, Mervis states: “The Physical Internet would move goods the way its namesake moves data” (2014, p.1104). The Internet moves data by standard protocol encapsulating data. Physical internet would move freight encapsulated in designated π-containers acting as globally standardized packaging. The Internet is fully interoperable between all providers and in a similar fashion Physical Internet builds on horizontal collaboration. On the Internet, digital TCP/IP packages are moved through switches automatically and in a similar fashion vehicle and vessel loads of π-containers would be automatically assembled and disassembled in π-terminals.

The Physical Internet should be characterized as a disruptive innovation (Christensen, 1997), potentially changing every aspect of supply chain management, from product design (products need to be designed to fit into π-containers) to distribution and consumption (Montreuil et al., 2012b). Thousands of pages with specifications, blueprints and roadmaps of the concept have been published, largely available on the Physical Internet initiative homepage (Ballot et al., 2016). Physical Internet promises large improvement of the logistics system, and “aims at addressing head on the grand challenge of reverting the huge unsustainability of the current way we transport, handle, store, realize, supply and use physical objects around the world” (Montreuil, 2011, p.84). For example Sarraj et al. (2014a) calculated that fill-rates would improve by 17% in the Physical Internet and others have stated improvements even up to 50% from pooling supply chains (Pan et al., 2013). In terms of Supply chain management (SCM), this means that the Physical internet builds on the concept of all the distribution resources of the entire world becoming globally pooled and optimized.

Several other researchers published ideas similar to the one of the Physical Internet, but using different terms. For example, as early as in 2000 Klaus discussed that e-Commerce leads to an integration of actors that in the end will cause logistics functions to become an integrated part of e-Commerce. He proposed that e-Commerce would eventually evolve into something called the “Material Internet” (in German: “Materielles Internet”), a concept very similar to the Physical Internet (Klaus, 2000). Over the past decades, an even larger number of researchers have introduced a variety of logistics concepts related to the Physical Internet, for example Supply chain pooling (Pan et al., 2013), Internet of things/Intelligent products (Meyer et al.,
2009), Foliated transport networks (Kalantari and Sternberg, 2009, Arnäs et al., 2013) and Intelligent Cargo/decentralized freight intelligence (Lumsden and Stefansson, 2007, Scholz-Reiter et al., 2009).

Regardless of the scientific approach to knowledge creation in logistics (Arlbjørn and Halldorsson, 2002), we need to understand the basis of concepts discussed. As is often the case with bold new visions of future digital innovation in the transport industry, there is a dearth of practical empirically grounded experiences of the Physical Internet. We cannot know the ramifications of an introduced and operational Physical Internet, since there is none to study. While this is to be expected and hardly surprising, there is merit to attempt a first principle analysis of the vision of PI as a whole, acknowledging its constituent parts and the use of the “digital internet” as a design metaphor.

By taking an interdisciplinary approach to literature review in the fields of logistics and information systems, we will analyze the conceptual vision of the physical internet as described in this growing body of literature. A first principle analysis can help illuminate a burgeoning and highly malleable concept, such as physical internet, by illuminating a number of potential limitations of the current concept (Conboy, 2009). In particular, a careful analysis could help detect various issues of incongruence in the epistemological foundations and help us hypothesize the consequences of such challenges.

Over the years, the group of people and organizations developing and supporting the vision of Physical Internet has grown rapidly. The stakeholder group European Technology Platform Alliance for Logistics Innovation through Collaboration in Europe (ETP-ALICE or ALICE) was formed to align stakeholder interests (ALICE, 2016). The ALICE consortia has prepared extensive plans as how to reach the vision of Physical Internet in 2050 by a comprehensive set of roadmaps aimed at influencing research financers, for example the European Commission. The European commission currently supports the Physical Internet by allocating about 4 million Euro\(^1\) in funding for research on the potential of the Physical Internet. Can the concept potentially improve freight transportation and to tackle the grand challenge?

Given the intensified research efforts and the large stakeholder interest in Physical Internet, the aim of this paper is to make a review of the existing literature on the Physical Internet and qualitatively and quantitatively analyse the concept.

This paper starts out with describing the research design, followed by a systematic literature review of the Physical Internet. The review is followed by a section analysing the sustainability implications of the Physical Internet and finally the conclusions are presented.

2. RESEARCH DESIGN

The methodology for this research consists of three parts: a literature review, a macro analysis and analysis of the concept Physical Internet incorporating information systems literature.

To find relevant literature on the Physical Internet and related concepts, the authors used Web of knowledge, Google scholar, the Physical Internet homepage (http://www.physicalinternetinitiative.org) and an ancestry approach to ISI-publications (Colicchia and Strozzi, 2012). We included scientific papers, conference contributions, reports,

\(^{1}\) Preliminary sum as of 2015-12-28 according to the Horizon 2020 web pages (https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2096-mg-5.4-2017.html).
magazine articles, doctoral dissertations and books. In total 24 sources directly addressing the logistics concept Physical Internet were included. Literature on the (Digital) Internet was not included in this part of the process.

When evaluating a concept, it is important not to judge it by technical limitations of concurrent logistics operations. Ballot et al. (2014, loc. 2917) state: “In addition to the technical aspects, not to be underestimated in terms of complexity or investment, the real difficulty that is already apparent is the change of culture required for such a system to be adopted. During presentations, it is not unusual to note that the questions asked are anchored in the reality of current operations, which is not the appropriate framework for assessment.” Nevertheless, distribution is about bridging the gap in time and place between production and consumption (Hesse and Rodrigue, 2004), thus the reality by which we must analyse the Physical Internet, is the derived demand for distribution.

To analyse the potential effects of PI through the derived demand for distribution, we have used Sweden as a quantitative macro case. All national volumes loaded and unloaded in Sweden have been obtained by using the Samgods model (Vierth et al., 2012). The Samgods model divides freight into 35 different categories, based on their characteristics (e.g., palletized, tank, dry bulk, etc.) and type of vehicle required (e.g. freeze trailer, timber vehicle, etc.). To calculate the effects of the Physical Internet on freight balances in Sweden, we focused on the 12 categories of freight in the Samgods model (Vierth et al., 2012) that are generally transported in general cargo vehicle combinations. The 12 categories were selected in collaboration with experts in the industry and after visual inspections of North-South and South-North bound flows as well as visual inspections of parcel flows. We chose to divide Sweden into 3 geographical regions, to highlight the imbalances.

Finally, as the concept of PI draws heavily on the development of the internet as a guiding metaphor, we have compared the concept to extant information systems literature on the development of the internet and associated standards.

3. REVIEW OF THE PHYSICAL INTERNET

In total 24 publications using the term “Physical Internet” were considered for the review: 6 journal papers, 2 scientific magazine articles, 3 reports, 9 papers from conference proceedings, 2 chapters from edited books, 1 doctoral dissertation and 1 book. In addition, three papers addressing supply chain pooling (written by some of the more frequently appearing researchers in the Physical Internet domain) have been included in the review of the Physical Internet effects, since those are frequently referred to by the Physical Internet literature (Ballot and Fontane, 2010, Pan et al., 2013, Pan et al., 2014a). A variety of different methods have been used in the reviewed publications. Some papers are conceptual work (for example, Montreuil, 2011, Montreuil et al., 2012a, Montreuil et al., 2012b) and other use simulation (Furtado et al., 2013, Sarraj et al., 2014a) and/or mathematical modelling (Sarraj et al., 2014b, Tran-Dang et al., 2015). Several of the analytical papers have been using real data, in particular from retailers and suppliers in France (Sarraj et al., 2014a).

To structure the presentation of the literature on the Physical Internet, we have divided it into three subsections: Blueprints, Adoption/Business Models and Effects of the Physical Internet. Most publications contribute mainly to one of the three subsections, with the exception of Ballot et al. (2014), which extensively covers all areas of the Physical Internet.
3.1. Blueprints

Following Montreuil (2011), several authors have published on the workings of the Physical Internet. Central to the blueprints, is the analogy between the ‘Digital’ and the ‘Physical’ Internet. Sarraj et al. (2014b) in-depth addresses the analogy, with a focus on the routing from a network perspective and Montreuil et al. (2012a) create a mapping between the Digital and Physical Internet layers by defining 7 layers of the Physical Internet.

Ballot et al. (2014, loc. 2943) state:

The primary fundamental component of the approach is the Physical Internet’s system of modular containers. This is what will make the shared network possible. It is about assessing the real needs beyond existing conventions and specific requirements.

Most technologies necessary to realize the Physical Internet already exist or will exist in the near future. The EU-project Moduluscha (Modular Logistics Units in Shared Co-Modal Networks) has developed the \( \pi \)-containers for the past 3 years. However, as of the time this paper was written, there were to our best knowledge not yet any public specifications available and attempts by the authors to get in contact with the Moduluscha project team has been unsuccessful.

![Figure 3.1 Unloading of \( \pi \)-containers in a \( \pi \)-hub (Montreuil et al., 2013).](image)

In three reports detailed functional designs of Physical Internet facilities are outlined. Meller et al. (2013) describe the design of a Road-based transit center, which in terms of the Internet has a switch functionality. Ballot et al. (2013) created an outline of a road-rail hub. In the Physical Internet, rail runs according to schedule, in difference to trucks leaving a depot after being filled (some exceptions apply). Montreuil et al. (2013) describe the design of a unimodal road-based crossdocking hub. Figure 3.1 illustrates the concept of automatic unloading of \( \pi \)-containers in a \( \pi \)-crossdocking hub.

On a more detailed technical level, best-paper award winners Tran-Dang et al. (2015) described how to enhance the functionality of \( \pi \)-containers by wireless sensor networks.

3.2. Adoption/Business Model

"Business models can be thought of as the way a company creates value in a competitive landscape” (Montreuil et al., 2012b, p.33). Several publications on the Physical Internet outlines the Physical Internet as a key driver of business model innovation (Montreuil et al.,
Montreuil et al. (2012b) divides the actors in the logistics landscape as $\pi$-enabling and $\pi$-enabled firms.

Pan et al. (2014b) uses the Mechanism Design Theory to make a business model of the logistics service providers/carriers. Every transport is an auction where the lowest bidding carrier wins. Auctioning and nested auctioning (“reallocation requests”) are carried out by proxy agents acting according specific parameters (e.g., cost, capacity, etc.). In order for this process to work, near complete transparency about capacities and constraints is necessary.

The adoption process of the Physical Internet is not specified in any of the reviewed publications, but ALICE has created a roadmap of how the Physical Internet will gradually replace logistics of today (ALICE, 2016), in line with the reasoning in Ballot et al. (2014). The roadmap is built on the idea that progress will follow upon certain developed milestones, as illustrated in Figure 3.2:

![Figure 3.2 Towards a global implementation of the Physical Internet (ALICE, 2016)](image)

Ballot et al. (2014, loc. 2917) writes: “In the context of the Physical Internet, business models are likely to be severely challenged. The ordering customer, or shipper, leads the transportation service provider to have no direct business relationship with the recipient. Consequently, because of the change in flows the parties involved in urban delivery are increasing, with no stakeholder able to propose consolidation of deliveries that can be invoiced to the recipients with different levels of service and where the number of deliveries to a recipient can only be accounted for in volume or weight.” However, we found no literature actually addressing 1. Why logistics service providers would give up their control of supply chains and 2. Why carriers would want to enter a system of continuous real-time auctioning of the lowest price? These difficulties are to some extent acknowledged by Ballot et al. (ibid): This difficulty is all the greater because it runs counter to the components that until now have been firmly anchored in the culture of logistics service providers.
Viewing PI as a complex multi-tiered systemic disruptive innovation, heavily dependent on network effects and critical mass to sustain its hubs, it is imperative not only to gain an understanding of the adoption incentives for all levels (e.g. physical product packaging, information systems and decision making/automation), but also how they relate. A key adoption question is if it is necessary to have widespread adoption of modular physical packages before you can implement an open network of automatic bidding driven hubs, or if these are actually separate innovation entities with no direct causal link. We have not found any research on how PI could become adopted and replace current logistics operations.

3.3. The effects of the Physical Internet

The past two decades we have seen several successful initiatives on inventory pooling (Simchi-Levi et al., 2007), joint distribution centers (Cruijsen et al., 2007, Cruijsen et al., 2010) and shared transport purchasing (Frisk et al., 2010, Palmer and McKinnon, 2011, CO3 Project, 2013). Pan et al. (2013) showed in a simulation how pooling supply chain resources would render great environmental and cost savings. At the heart of the Physical Internet is achieving the potential benefits of pooling logistics and transport resources by creating “The Network of the Logistics Networks” (Ballot et al., 2014). Hence a majority of the previously published research on the potential benefits of collaboration, cooperation and global supply chain optimization, potentially applies to the Physical Internet.

Montreuil (2011) describes 13 characteristics and components of the physical Internet, that addresses 13 unsustainability symptoms of the global logistics system. Several other conceptual papers point identify the Physical Internet as a key to tackle the so called grand challenge of logistics, and as an enabler of new business models (Montreuil et al., 2012b). An experimental computation by Sohrabi and Montreuil (2011) showed how an open supply web would enable strong reductions in customer service time and a mathematical model by Sarraj et al. (2014b) also showed improved routing through the Physical internet. Great improvements have also been the results of models by Lin et al. (2014) and Yang et al. (2015).

Simulations of French retail supply are described in many of the publications on the Physical Internet and Ballot et al. (2014) gives an overview to several of the published studies (e.g., Ballot et al., 2012, Hakimi, 2014, Sarraj et al., 2014a). All studies show great improvements through Physical Internet, though it should be noted that none of the studies include return flows of π-containers. Discussion on the Physical Internet

4. IS THE PHYSICAL INTERNET VISION DESIRABLE AND ATTAINABLE?

Will the Physical Internet contribute to solve “the grand challenge” of logistics sustainability? This section will examine the sustainability effects of the Physical Internet vision. It concludes by comparing the Physical Internet vision with literature on the innovation of the “digital” internet to gain an understanding of the effects of using Internet as a metaphor.

4.1. Calculation of environmental sustainability

Balanced flows is a key to high fill rates and sustainable freight transportation, yet freight imbalances characterize logistics in most parts of the world. In Scandinavia the southbound flows in Norway, Sweden and Finland, are very different from the northbound flows (See for
example Vierth et al., 2012). McKinnon and Ge (2006) analysed potential back-hauling in the UK and found that \textit{incompatibility of vehicles and products} was one of the major factors behind empty-running. If all goods is packaged in $\pi$-containers, the containers will have to be returned to the place of origin. Notably as of today (April 2016), all published studies of the Physical Internet neglect the return flows of packaging, i.e., exclude 50\% of the flows and exclude extra package handling and $\pi$-container warehouses necessary at each retail outlet.

Using Sweden as a macro-case (adding more countries would increase the imbalances in the model), we the 12 selected freight categories account for 57 million tonnes of freight volume, displayed in Table 4.1.

\begin{table}
\centering
\caption{Freight flows in Sweden – 12 compatible categories}
\begin{tabular}{|l|c|c|c|}
\hline
 & North & Mid & South \\
\hline
North & 3577489 & 3420871 & 1347396 \\
Mid & 3200098 & 21463804 & 4540822 \\
South & 1583845 & 8643453 & 9379541 \\
\hline
\end{tabular}
\end{table}

From South of Sweden to Mid and North Sweden, large volumes of retail goods and imported goods are transported. Southbound from North of Sweden to Mid and South Sweden are large volumes of e.g. more or less refined raw material from the forest and metal industries. As of today, the imbalances Sweden are facing are summarized in Table 4.2. If vessels are further specialized, the different flows will be even more difficult to balance. Such specializations inherently creates additional empty-runs and negative environmental impact (McKinnon and Ge, 2006, Lumsden, 2007). Hence more specialized flows and empty back-hauling of $\pi$-containers have a negative effect on both financial and environmental sustainability.

\begin{table}
\centering
\caption{Freight flows in Sweden as of today – 12 compatible categories}
\begin{tabular}{|l|c|c|}
\hline
 & Imbalances (today) & Imbalances ($\pi$ future) \\
\hline
North-Mid & 220 773 & 1 689 000 \\
Mid-South & 4 102 631 & 4 489 541 \\
North-South & 236 448 & 1 080 787 \\
SUM & 4 559 853 & 7 259 328 \\
\hline
\end{tabular}
\end{table}

Separating the goods categories that become incompatible when introducing the $\pi$-containers, imbalances are increasing by 63\%. The additional imbalance of 2 699 475 tonnes, would, assuming that 30 tonnes are loaded on each vehicle combination, correspond to additional 90 000 truck trips, only on domestic regional level. It should be noted that the case of this analysis and simplicity, we are not addressing the large imbalances within the three regions (in particular the imbalances in densely populated Mid Sweden. Including those, would heavily increase the imbalances and additional flows caused by introducing the Physical Internet. At best this suggests the importance of taking a holistic view on where the concept is applicable.
4.2. Social sustainability and the Physical Internet

Social sustainability of the trucking industry has, in particular in Europe, received increased attention over the past few years. Previous research has outlined collaboration and long-term contracts as a way to improve sustainability of the trucking business (for example Mason et al., 2007, Fugate et al., 2009). According to Montreuil (2011, p.85), “Container handling and storage systems” and “Distributed multi-segment intermodal transport” address the issue of truck driver social unsustainability (“Truck drivers have become the modern cowboys”). Pan et al. propose how road haulage will work: “On one hand, new entrance requests will be allocated to the carriers offering lowest price after auction, i.e., auction-based marketplaces; on the other hand the PI network enables carriers exchanging their capacities via auction based real-location in the PI-hubs (Pan et al., 2014b, p.3). “It is not explained in the literature on the Physical Internet how a continuous auctioning will improve social sustainability instead of leading to a “race to the bottom”, enhancing the trend of road hauliers competing with low-wage drivers rather than efficiency (International Labour Organization, 2015).

4.3. The Physical Internet and digital innovation

The physical internet concept requires a strict adherence to a set of future codified standards on how to express the movement of goods. In essence, the standardized communication afforded by the physical internet is a digital infrastructure. It will seamlessly guide all interactions and make decentralized decisions in a manner that essentially goes unnoticed, unless it is disrupted (Star and Ruhleder, 1996). PI is purely conceptual. There are no implementations to study empirically. However, since PI is using the internet as a guiding metaphor, it becomes imperative to examine literature on the development of internet standardization specifically, as well as digital standardization.

The importance of standardization has been increasingly acknowledged in information systems research. Akin to the current development of PI, much of the early work was descriptive and focused on the content of new anticipatory IT standards, rather than examining processes and factors that explain why and how such standards emerge and diffuse or fail to do so. Studies of standardization concepts, processes, the actual impact of ICT standards on industrial coordination and strategy, or the economics of ICT standards, were largely missing. However, a growing body of literature is beginning to address these issues (Lyytinen and King, 2006).

IT adoption rarely produces fully predictable results. Adoption of advanced IT-based services in transportation is no exception. As example in personal mobility is “dynamic ridesharing”. This is a concept where the use of mobile services for instantly coordinating private drivers with free seats and passengers is intended to reduce inefficient use of vehicles and decrease congestion. This bears many similarities with the stated goals of the concept of PI. However, such services have been found to be unable to meet intended goals. Either there are simply too few drivers and passengers with compatible goals within the preferred time window (Andersson et al., 2013). Alternatively, such IT-based coordination give rise to novel business models in which the whole taxi business is disintermediated by actors such as Über – a far cry from the espoused goal of minimizing empty seats in private cars for improved sustainability.

Viewed from an economic perspective, standardization generally helps grow the overall size of a market in which companies compete. However, while some might benefit, others may not. Dominant companies might lose control of standardized markets while competitors benefit from lower barriers to entry. Consequently, companies must choose between fighting for a greater share of a given market and cooperation in a standards-based strategy of growing market size (Shapiro and Varian, 1999). Since it is unclear how the Physical Internet could grow a
market for transports in terms of entrenched business models, it is also not clear on what the necessary cooperation needed to invest in new multicarrier hubs and deploying near total transparency would be based.

The development of the internet was based to a large degree on the notion of simplicity. Foundational Internet standards are clean, formal protocols built at the foundational levels of the system. This kind of design simplicity is evident in the current literature on PI. However, the transport of packets over the internet is by no means subject to the taxing auctioning mechanics suggested. Indeed, adding complex business transactions has proven to be a different process entirely. As an example, Web services choreography standards are intended to encode business practices. The UDDI standard component that would enable transparent access to commercial services has been highly challenging. As seen in research on their development, contractual law and liability makes it inherently difficult to implement simple, elegant technical designs (Nickerson and zur Muehlen, 2006). The foundational mechanics of the internet is successful because it does not take into account business relations, not because it does.

5. CONCLUDING DISCUSSION AND RECOMMENDATIONS

The Physical Internet is an innovative concept promising substantial positive effects on logistics sustainability. However, before further blue-print work is carried out, our review strongly suggests that the sustainability effects of the Physical Internet are thoroughly investigated. Any empirically untested and emerging concept is likely to encompass a host of challenging hurdles to overcome before wide spread adoption occurs. In our review of the literature underpinning the physical internet concept, we have come across a number of such issues. These boil down to lack of clarity, lack of theoretical coherence, lack of cumulative tradition, lack of parsimony, and lack of applicability.

5.1. Lack of clarity

One of the most fundamental attributes of a concept is that it is clearly communicated and easy to grasp (Weick, 1989, Metcalfe, 2004). While the top level assumption of highly efficient and effective disruptive forms of transport arising as a consequence of the introduction of physical internet is immensely powerful, this causality is quite uncertain in roadmaps and projected paths of innovation and adoption. According to our calculations, dedicated π-containers risk adding to the numerous geographic imbalances present in most countries. Additionally, the absence of long term contracts could very well jeopardize previous achievements in terms of social and environmental sustainability.

5.2. Lack of theoretical coherence

Any well formed theory or concept should be supported by a strong underlying logic and rationale. The physical internet relies heavily on the internet as metaphor of decentralization and robust system design. Physical transportation however, is by nature not fully digital. While design by analogy is at the core of PI, limitations of this approach is simultaneously acknowledged in PI literature: “And before we get too far into this definition and how the Physical Internet is enabled, we need to note that the parallels between the Digital and Physical Internets, although significant, are not absolute. That is, information transfer protocols cannot be directly transposed to goods. The physics of information and objects are too different.” Ballot et al. (2014). Digital artefacts have a number of distinct advantages. For instance, they can be duplicated without cost and they can be sent anywhere instantly. Most importantly, they
generate no return flows. The full ramifications of the centrality of these facts are not discussed in the current physical internet literature.

5.3. Lack of cumulative tradition

A sound concept or theory should rest upon prior research, cumulatively adding to existing knowledge by corroborating or disputing previous results in the light of novel insights. There is a wealth of prior research on closely related concepts such as intelligent goods, smart freight, etc. The current inception of physical internet has not properly addressed this crucial dimension of conceptual development. There are two direct consequences. First, lessons learned in the aforementioned history of ICT-driven concept development are not incorporated. Second, that literature is not incorporated thus excluding a crucial body of knowledge that could inform the development of the physical internet literature.

5.4. Lack of Parsimony

A parsimonious approach to concept development entails the constant pruning of the core concept by removing parts that provide no value to its development (Whetten, 1989). The physical internet has a clear conceptual relation to components of prior concepts (such as the notion of effectively decentralizing through the use of IT-services). However, such attempts have been unsuccessful (Sternberg and Andersson, 2014). A careful analysis into what, if any, parts of these concepts actually provide value and explanatory power, and which do not would ensure a continuously refined concept. However, there is little evidence of this type of process in the current conceptualization of the Physical Internet.

5.5. Applicability

The range of application is a key criterion for judging concept quality (Weick, 1989, Metcalfe, 2004). As similar or related concepts have had no application, this is particularly important for a burgeoning concept such as physical internet. However, there is currently little effort spent on hypothesizing the specific impacts of the physical internet to different parts of the global transportation systems and its constituent segments. Crucial questions such as if it will function in a sector characterized by a multitude of small scale actors (Sternberg et al., 2013) or lead instead to a massive centralization of the industry are not being addressed. Indeed, our analysis shows that applying the Physical Internet might have negative consequences for sustainability.

Addressing the current challenges of PI conceptual development listed here would likely provide a solid grounding for eventually evaluating the actual implementations of PI in terms of intended effects.

ACKNOWLEDGEMENT

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ABSTRACT

Purpose
The location of a logistics facility is strategic decision, impacting distribution cost, efficiency and environmental impact. The purpose of this paper is to systemize existing knowledge by a literature review. Based on the literature review we propose a framework in this area of theoretical and practical relevance.

Design/methodology/approach
We have examined the peer-reviewed literature on logistics and distribution facility location decisions. Our search strategy was based on selected keywords relating to terms for facilities and/or locations in logistics and distribution. Due to the lack of holistic approaches to localization, we included practitioners’ publications. Altogether we have identified 67 relevant articles, theses and reports from 1974 to 2015.

Findings
The content analysis shows that a major share of papers focus on mathematical modelling taking a limited number of factors into consideration. Seven categories (cost factors, freight flow, geographical/environmental factors, company specification factors, business development, business climate and others) gather all the different factors that determine the holistic approach of the localization process regarding distribution facility.

Research limitations/implications
Logistics localization plays a large role in Supply Chain Management and the authors identify an important open space for research in the theory. So far demographic data has been considered as one of the most important factors, since Center of gravity is widely used in the planning process. On the other hand, freight flow has been underestimated although it is a crucial logistics activity. Therefore, the authors assume that a change in that trend is going to effect on the current best logistics sports.

Practical implications
Given the lack of validation in existing practitioners’ guides for logistics facility localization decisions, this paper represents a useful guide for practitioners looking for strategic directions.
Originality/value
This paper is to the authors’ knowledge the first review of logistics facility localization literature.

Keywords: Location, facility, supply chain design, region ranking

1. INTRODUCTION

Localization is the physical placement of a logistics facility. Selecting the most suitable location for a logistics facility is a very complex and challenging task (Owen and Daskin, 1998). With the term “logistics facility” we refer to a facility dedicated to logistics operations, such as a warehouse, logistics distribution center/terminal, freight forwarder terminal or a repair facility.

Where should we locate our new logistics facility? It is of great importance for a company’s competitiveness and profitability. Typically the decision is a consequence of the identification, evaluation and ranking of external factors that determine the right choice by basing it at the particular company strategy and set of priorities (Andersson and Segerdahl, 2012). For decades a majority of companies have placed their logistics facilities based on indicators such as cost minimization, infrastructure access, reasoning, land prices, contacts, transport and labor cost (Klaus et al., 2015). Mathematical models have typically been the focus, e.g., solving P-median problems that maximizes profit of terminal location (Hamacher and Drezner, 2002, ReVelle and Eiselt, 2005, Daskin, 2011).

Various theoretical improvements and solutions of the localization uncertainty regarding logistics facilities have been extensively researched, yet many models have been developed but never tested in the industry (Olhager et al., 2015). The actual practice on where to localize such a facility seem at times to be ad-hoc and practitioners frequently refer to e.g., logistics rankings when discussing facility localization. One of the most well-known logistics rankings is “Connecting to compete: trade logistics in the global economy” (Arvis et al., 2014). Many countries have so called “logistics rankings” (or logistics region evaluations) where regions are compared and sometimes ranked in terms of “logistics attractiveness”, e.g. “Top Logistik Lage Schweiz” (Stölzle et al., 2013), “Top 100 in European Transport and Logistics Services” (Klaus et al., 2015) and the Swedish “Sveriges 25 bästa logistiklägen” (Intelligent Logistik, 2016). Common for these logistics evaluations is using a point of gravity method based on population density (although it does not equal the need for logistics services) and infrastructure accessibility. Some include factors such as, e.g., tax rates, access to educated and/or unemployed staff and salary levels.

Given the importance to both industry and policy makers of logistics localization decisions and the lack of literature on how to actually compare logistics geographic areas, the aim of this paper is to present a framework for logistics localization. We carry out a systematic literature review of journal papers and of practitioner’s logistics location evaluations, with the purpose of increasing understanding of logistics facility localization. An important delimitation in the following paper is that it is not going to deal with the location of an intermodal terminal or transport facility, as such decisions typically depend on much fewer factors and have previously been researched (Sirikijpanichkul et al., 2007, Ishfaq and Sox, 2011, Roso et al., 2015).
2. METHODOLOGY

The search strategy for the paper was using selected key words and Web of Science TM database. The following keywords have been used: “logistics”, “location”, “distribution centre”, “terminal”, “facility” and “factors”. In order to narrow down the search to papers that match the purpose of the review, we used a combination of boolean operators (AND, NOT, SU, *) on the keywords. The Web of Science database was used as it includes most high quality and widely cited journals in the research area. The hits have not been limited in time. Only papers written in English were included and the search was limited to “title” or “topic”. About 1700 articles were skimmed, and 67 papers were included (Table 3.1). The final list of sources includes articles, mathematical modelling papers, reviews, reports, case studies and thesis works.

3. LITERATURE REVIEW

Logistics facility location has a crucial impact on the strategic planning for a broad spectrum of public and private economic actors. The acquisition of a new facility represents a long-term investment. Whether a big international company or a city planner selects locations for further development of their opportunities in logistics business they are often challenged by the choice of the determinants that have to be taken into consideration (Owen and Daskin, 1998). Developing models that determine optimum locations for logistics facilities by various attempts that aim upgrading of new and current location models in more inclusive and computationally more efficient ones have been done since the research in the field has been started (Ballou, 1968). Many aspects of evaluation of different locations have been researched for years in a way a comprehensive prescription of the containing determinants to be found. No matter the fact that the contexts in which these models are situated may vary, they are usually determined by several main constantly presented indicators as space, customers whose locations in the given space are known, and facilities whose best and most beneficial location has to be found out by taking into consideration some objective function (Revelle et al., 2008). The general trend is that the number of published papers in the field are increasing. Table 3.1 displays the initial result of the review:

<table>
<thead>
<tr>
<th>Sub-factors:</th>
</tr>
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</table>
**Sub-factors:**

<table>
<thead>
<tr>
<th>Category</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maintenance</strong></td>
<td>Liu et al. (2011), Contreras et al. (2012), Sirikijpanichkul et al. (2007), Xifeng et al. (2008), Melo et al. (2007), Daskin (2011)</td>
</tr>
<tr>
<td><strong>Ordering</strong></td>
<td>Askin et al. (2014), Melo et al. (2007)</td>
</tr>
<tr>
<td><strong>Holding</strong></td>
<td>Owen and Daskin (1998), Nozick and Turnquist (2001b), Ozsen et al. (2008), Nozick and Turnquist (2001a), Melo et al. (2007), Snyder et al. (2007)</td>
</tr>
<tr>
<td>Sub-factors:</td>
<td></td>
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<tr>
<td>-----------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Freight flow to customers:</strong> Jayaraman et al. (1999), Srivastava (2008), Melo et al. (2007), Arvis et al. (2014), Tomic et al. (2014), Kuo (2011), Wang et al. (2012), Lu and Bostel (2007), Kahraman (2003)</td>
<td></td>
</tr>
<tr>
<td><strong>Reverse freight flow from customers:</strong> Melo et al. (2007), Lu and Bostel (2007), Srivastava (2008)</td>
<td></td>
</tr>
<tr>
<td><strong>Infrastructure quality:</strong> Arvis et al. (2014), Voorhees (1976), Tomic et al. (2014), Kuo (2011), Oum and Park (2004), Demirel et al. (2010), Beresnev (2013)</td>
<td></td>
</tr>
<tr>
<td><strong>SC specificity:</strong> Lee (1993), Kahraman (2003)</td>
<td></td>
</tr>
<tr>
<td><strong>Planners' benefit:</strong> Guan et al. (2008), Kucukaydin et al. (2011), Beresnev (2013), Tomic et al. (2014), Canel and Khumawala (1996), Meshkat and Ballou (1996), Sirikijpanichkul et al. (2007)</td>
<td></td>
</tr>
<tr>
<td><strong>Expansion possibilities:</strong> Voorhees (1976), Lumsden et al. (1999), Askin et al. (2014), Melo et al. (2007)</td>
<td></td>
</tr>
<tr>
<td><strong>Administrative efficiency:</strong> Melo et al. (2007), Tomic et al. (2014), Kuo (2011)</td>
<td></td>
</tr>
<tr>
<td><strong>Political risk:</strong> Melo et al. (2007), Ward et al. (1995), Tomic et al. (2014)</td>
<td></td>
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</table>
### Sub-factors:

<table>
<thead>
<tr>
<th>Category</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial stability</td>
<td>Tomić et al. (2014), Melo et al. (2007)</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>Melo et al. (2007), Verter and Dincer (1992), Heizer and Render (2014)</td>
</tr>
<tr>
<td>Inflation rate</td>
<td>Tomić et al. (2014)</td>
</tr>
</tbody>
</table>

#### 3.1. Cost factors

Uncertainty in the customer demand can reflect on production respectively on selling prices, and transportation costs (Louveaux and Peeters, 1992, Teo and Shu, 2004). According to Snyder et al. (2007) the crucial determinant in the localization process of a logistics facility are transport (shipment) costs, lead times and holding/inventory costs. Additional aspects as labor cost has been added to the total cost content by several articles later on. So, the most optimal location choice should consider both the globalization process and the fact that it may change the cost of satisfying the demand of well qualified employees significantly (Ballou, 1968).

The higher the importance of customer responsiveness is, the closer the logistics facility should be to the customers. Underestimation of its significance could lead to disturbance in the holding, transportation and service level cost (Nozick and Turnquist, 2001b). In a way to provide a calculation method that would accumulate how much unserved customers would cost to the company if the logistics facility is located at a particular spot Lieckens and Vandaele (2007) and Shen (2006) included penalty cost as a reflection of unsatisfied demand.

Cost minimization is the most widely used objective in theory and practice of logistics localization. The majority of the articles aim to determine a logistics facility location with the lowest total cost. Respectively “cost” came out to be the category with the biggest amount of sub-factors in the Table 3.2. All the authors are gathered around the idea that the various categories of costs (fixed or variable) are the leading factors that determine the final choice for a logistics facility location. In several papers the entire logistics localization is based only on a cost model of selected cost parameters (Sun et al., 2008, Liu et al., 2011, Contreras et al., 2012, Xifeng et al., 2013), yet several authors state the importance of considering additional factors in order to make a strategically reasonable decision (Lu and Bostel, 2007, Kuo, 2011, Beresnev V. L, 2014, Tomić et al., 2014).

#### 3.2. Business climate

Some regional and local governments attract large facility investments by offering special financing and taxation benefits. Global companies have to consider additional factors related to
e.g., the state regulations in the evaluated region where their future logistics facility is planned. International/national factors such as taxes, duties and exchange rates could influence the result of the final decision (Verter and Dincer, 1992). In some regions factors like government and bank stability as well as stable inflation rates are taken for granted, whereas other particular cases require their reevaluation and risk measure (Ward et al., 1995, Melo et al., 2007, Tomic et al., 2014). Additionally, too complicated administration procedures could contribute negatively to the business activity efficiency (Kuo, 2011).

Business environment changes are out of the managerial control, but management level should be aware of all the possible impacts of such changes on the company, so it would have higher level of adaptability if a change occurs (Geoffrion and Powers, 1980).

Wrong evaluation of the social environment level would generate unexpected cost if it is inaccurately measured since it is related to the impact on the new residents and security level (accident, vandalism and theft) (Rao et al., 2015).

In the literature review we identify 25 distinct factors that have an impact on logistics facility localization. All of them have been found as indicators having a significant influence on the choice of localization. In total, these factors are put forward and discussed by over 40 scholars during the last four decades. Many of the factors have a clear common denominator. Thus, to structure the diverse factors they were categorized into seven distinct factors, see Table 3.2. Two factors, Cost and Business climate, are split into sub-factors since they very general in their definition and varies over different types of industries.

**Table 3.2 Definitions of location factors and distribution in the papers**

<table>
<thead>
<tr>
<th>Factor:</th>
<th>Sub-factor:</th>
<th>In #papers:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td><strong>Logistics facility related cost</strong></td>
<td><strong>Fixed/investment cost</strong> - set-up costs for the location of the facility (Contreras et al., 2012)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Maintenance</strong> - incurred to keep the DC in good condition and working order (Investopedia, 2016)</td>
</tr>
<tr>
<td></td>
<td><strong>Transport related cost</strong></td>
<td><strong>Transportation</strong> - distance cost over the horizon (Owen and Daskin, 1998)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Ordering</strong> - cost for each order (Askin et al., 2014)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Holding</strong> - the associated price of storing inventory (Investopedia, 2016)</td>
</tr>
<tr>
<td></td>
<td><strong>Serving customer cost</strong></td>
<td><strong>Service level and lead time</strong> - cost of servicing the demand of customer changes (Melo et al., 2007)</td>
</tr>
<tr>
<td></td>
<td><strong>Manpower</strong></td>
<td><strong>Labour cost</strong> - the cost of the local logistics work force; includes the total annual payroll, the total number of employees, the average salary and revenue per employee. (King and Keating, 2006)</td>
</tr>
<tr>
<td></td>
<td><strong>Environmental cost</strong></td>
<td><strong>Taxes for produced emissions and waste &amp; recycling cost</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Freight flow</strong></td>
<td><strong>Freight flow to customers</strong></td>
</tr>
<tr>
<td>Factor:</td>
<td>Sub-factor:</td>
<td>In #papers:</td>
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<tr>
<td>(indicator that characterizes the freight volume by direction and sections of a transportation network among corresponding regions) (FarlexInc, 2016)</td>
<td>Reverse freight flow from customers</td>
<td>3</td>
</tr>
<tr>
<td><strong>Geographical &amp; environmental</strong> (differences in the geographical and nature characteristics in various regions)</td>
<td><strong>Infrastructure quality</strong> - versatility, accessibility and sustainability in logistics infrastructure (Intelligent Logistik, 2016)</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><strong>Accessibility level of the location</strong> - access to shipping and railway’s strengths (Intelligent Logistik, 2016)</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td><strong>Geographic/landscape relief &amp; resources availability</strong> (water/wind/sun) - geographic location and all the (visible) features of an area &amp; its renewable resources capacity</td>
<td>7</td>
</tr>
<tr>
<td><strong>Company specification indicator</strong> (factors that can be defined by specific conditions in each company as well as they are related to its specific characteristics as size, globalization level etc)</td>
<td><strong>SC specificity</strong> - the company engagement in the SC</td>
<td>2</td>
</tr>
<tr>
<td><strong>Business development</strong> (availability of new opportunities)</td>
<td><strong>Planners’ benefit</strong> - profitability for the owner of the DC</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><strong>Expansion possibilities</strong> - expansion opportunities to new markets, mergers, acquisitions, and strategic alliances (Melo et al., 2007)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Business climate</strong> - the cooperation climate, business environment and network in the region (Intelligent Logistik, 2016)</td>
<td><strong>Political stability and tax policy</strong></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Administrative efficiency</strong> - the capacity of an institution to produce desired results with a minimum expenditure of resources like energy, time, money, personnel, materiel, etc. (National Center for Biotechnology Information, 2016)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Taxes/ duties rate</strong> - the percentage at which a corporation is taxed (Investopedia, 2016)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><strong>Political risk</strong> - the risk that an investment’s returns could suffer as a result of political changes or instability in a country (Investopedia, 2016)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Demographics and education level of the residents</strong></td>
<td>17</td>
</tr>
<tr>
<td></td>
<td><strong>Availability of un/qualified labour</strong> - Accumulated range of logistics services, relevant academic and training and access to labor (Intelligent Logistik, 2016)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Economic stability</strong></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Financial stability</strong> - financial institutional system is resistant to economic shocks (Schinasi, 2004)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Exchange rate</strong> - lack of extreme fluctuations</td>
<td>3</td>
</tr>
</tbody>
</table>
3.2.1. Factor one - cost

“Cost” as a group gathers all the possible expenses that would be related to a particular location and could occur during the construction process and further exploitation of the logistics facility. In a way a clearer structure of this category to be drawn, it was split in five sub groups: “logistics facility”, “transport”, “serving customer”, “manpower” and “environment” cost. Logistics facility cost has two main aspects: fixed or investment cost and maintenance cost. Fixed cost cannot be influenced by any fluctuations in the amount of the provided services or of any other business activity, it is the set-up costs for the location of the facility (Contreras et al., 2012). On the other hand, maintenance cost incurred to keep the facility in good condition and working order. On the contrary, it is straightly related to the amount of its treatment (Investopedia, 2016). In a way a more detailed analysis to be conducted and the aim of the paper to be fulfilled, transport related cost has been split in three- transportation, ordering and holding cost. The author defines transport cost as an expense generated by moving products or assets to a different place or in a direction to consumers as relevant in the following paper. Than the order cost is seen as the price of placing an order (Askin et al., 2014). The cost of serving customers is the expense of servicing the demand of customer changes (Melo et al., 2007). Further on, manpower category is defined by the cost of the local logistics work force; includes the total annual payroll, the total number of employees, the average salary and revenue per employee (King and Keating, 2006). This paper limits the meaning of environmental cost to all taxes and fees paid for produced emissions, waste and recycling costs. All the listed costs are fixed or variable in their economic nature. The sum of variable and fixed costs give the total cost as a sum of various cost components which has been considered as a main requirement for an efficient localization decision from many scholars (Table 3.1) (Melo et al., 2007).

3.2.2. Factor two – freight flow

“Freight flow” group as an indicator characterizes the freight volume by its direction and sections of a transportation network among the corresponding regions. For the further analysis
and research aim benefit it has been divided in two separate flows in direction to the customer and from the customer (also called reverse logistics flow) (Melo et al., 2007).

3.2.3. Factor three - geographical & environmental indicators

The third big group in the table deals with geographical & environmental indicators which is going to observe the significance of geographical and nature differences in various regions with tide focus on the infrastructure quality, accessibility level of the location and geographic/landscape relief & resources availability (water/wind/sun). The condition of the existent infrastructure is defined by the quality of trade and transport related infrastructure like ports, railroads, roads, airports information technology etc. Accessibility defines to what extent the exact location is easy to be entered, reached and used. Important clarification regarding the geographic/landscape relief and resources availability is that it is limited just to the visible features of an area and its renewable resources capacity (Dictionary.com, 2016).

3.2.4. Factor four - Company specification indicator

The next group is “Company specification indicator” and it stands for specifications in each company like size, globalization level etc. or in other words the factor is supposed to detect the supply chain specificity and to which extend the company is engaged in the whole supply chain.

3.2.5. Factor five - Business development

“Business development” is the group of factors that summarizes the availability of new opportunities characterized by the planners’ benefits (profitability for the owner of the DC) and expansion possibilities (a chance for increase in the level of economic activity, or of the availability of the goods and services) as a consequence of the newly built logistics facility.

3.2.6. Factor six - Business climate

The sixth group gathers all the indicators that according to the literature determine the business climate in the particular region. It defines general trends in the macro economic environment as well as is bound with the government and lending institutions attitude toward businesses and its activity at the local economy and the attitude of labor unions toward employers, current taxation regimen, inflation rate, etc. Similarly to the cost factors group, this one is split in several sub groups—political stability and tax policy, demographics and education level of the residents and economic stability. Political stability and tax policy is the best described by the symbiosis of administrative efficiency (the capacity of a state institution to produce the desired results with a minimum expenditure of resources like energy, time, money, personnel, materiel, etc) taxes/duties rate (the percentage at which a corporation is taxed) and political risk (the risk that an investment’s returns could suffer as a result of political changes or instability in a country) (Investopedia, 2016). By economic stability is seen an absence of excessive fluctuations in the macro economy (Fund, 2015). The stability of financial institutional system and its resistance to economic shocks, the lack of extreme fluctuations in the exchange rate and inflation rate are the most important aspects that are going to be tested in that group.

3.2.7. Factor seven - others

Three additional factors have been added. The general security level of the evaluated region/location translates to threatening antagonistic activities such as thefts, terrorism, vandalism etc. Social sustainability is an indicator for the ability of a community to develop processes and/or structures which not only meet the needs of its current members but also support the ability of future generations to maintain a healthy community (WebFinance, 2016).
3.3. Logistics location evaluation

3.3.1. Demographics vs freight flow

Research and industry agree on the value of identifying the center of gravity as a key component in effective localization. By increasing the average travel distance, the facility accessibility decreases, respectively the location's effectiveness goes down (Owen and Daskin, 1998). As mentioned in the introduction, the logistics localization evaluations in practice use demographics, i.e., population data, to determine the center of gravity. The literature though, has shown that the sum of demographic distances is not a relevant measure of the quality of the service level in the logistics business. Geographical characteristics together with infrastructure determine the accessibility of the logistic center as a significant criteria for allocation of a logistics facility (Revelle et al., 2008, Kuo, 2011). A more suitable alternative to demographics is using actual freight flows. The Swedish National Freight Transport Modeling (SAMGODS) (Abate et al., 2016) is an origin-destination matrix of freight flows, which is more directly related to the need for logistics activities (Alam, 2013).

The main criterion defining localization of a logistics plant is the infrastructure (Demirel et al., 2010). This criterion is composed of three sub-criteria: the existence of modes of transportation, telecommunication, and quality and reliability of modes of transportation (Demirel et al., 2010). Arvis et al. (2014) compared countries according to their score in Logistics Performance Index (LPI) and conclude that the ones with better infrastructure and accessibility are more valuable logistic centers in any aspect as well as they are a better choice for a location of logistics facility. A higher quality of rail, port and airport service have been recorded in favor for particular regions as well (Sirikijpanichkul et al., 2007, Tomić et al., 2014).

3.3.2. Ranking systems

Five location evaluation systems which deal mainly with choosing the best logistics city were explored as well to contribute a broader practical view of the paper. Further investigation found out that although due to the theory there are over twenty factors that have to be taken into consideration during the allocation decision making process, in the business ranking much less have been used. “Intelligent Logistics” (Intelligent Logistik, 2016) ranking system which is applied in a particular region to detect the best Swedish logistics location is the one that includes the biggest amount of factors, although they barely reach the half of the number of all those found in the articles observed in the following paper. Naturally, accessibility to roads, ports, rail lines, bridges etc. and infrastructure condition are the leading factors (King and Keating, 2006, Ishfaq and Sox, 2011, Kuo, 2011, Intelligent Logistik, 2016). Then, factors as fixed cost and labor availability were included as well, although they are not considered as a priority (King and Keating, 2006, Intelligent Logistik, 2012). Arvis et al. (2014) as a part of the World Bank is the only ranking that considers factors as security level and administration performance in its ranking due to its significantly bigger scale in comparison to the rest.

4. CONCLUDING DISCUSSION

For the past thirty years researchers, managers and experts have been challenged by the idea of finding a way to calculate the best spot for a new logistics facility, considering its great significance as a long term investment. Logistics localization decision still to some extent relies reasoning rather than on empirical evidence. “Facility allocation decisions require a comprehensive distribution model that deals simultaneously with interdependent decisions”
seems to be an issue that has not changed even more than 3 decades later (Geoffrion and Powers, 1980).

Our literature review reveals several interesting insights. Firstly, we did not find any scholarly published general location analysis of logistics from the perspective of geographical regions/cities. Secondly, we found over thirty mathematical models of facility localization, which had never been put into practice. This is consistent with the observations of previous reviews of, e.g., global production networks (Olhager et al., 2015).

Based on the existing literature, we propose a framework of factors to take into consideration in the logistics facility localization decision. We found that many reports use demographic data as input to determine center of gravity, despite using freight flows being the more suitable approach. Future investigations would benefit from comparing center of gravity models based on input data. Comparing practitioners’ logistics evaluations and theory on logistics localization show several similarities. An issue of putting the framework to practice, is that despite a strong consensus on some factors, not all factors are of equal importance. Given the lack of practical applications of the theory, only using the quantity of papers addressing a certain factor will not give a sufficient base for investigation. Hence we suggest using survey and further on Analytic Hierarchy Process (AHP) methods to analyze the results and give appropriate weight to each of the factors (Saaty, 2008). So, as a result a valid prescription based on theory and practice would show the exact impact of every factor on the final decision. In real-life decision making, the type of goods and customers play an important role. We propose research looking into how the type of logistics service and/or goods handled affect the localization decision. We conclude that a holistic approach to logistics localization has been missing, despite its importance to companies and regions.

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THE IDEA OF TRANSPORT INDEPENDENCE IN THE RUSSIAN ARCTIC: AN INSTITUTIONAL APPROACH TOWARDS SUPPLY CHAIN STRATEGIES

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ABSTRACT

Purpose
This study explores the implementation of a supply chain strategy intended to ensure full control over cargo transportation and achieve so-called transport independence, developed recently in the Russian Arctic. Academic literature has not explicitly addressed this phenomenon, examining many forms of managing the supply chain without full control to emphasize integrating processes. This study aims to examine how the idea of transport independence has been evolved and translated in the context of one metals and mining company, located in the Russian Arctic.

Design/methodology/approach
This study applies a qualitative case study. The data from 18 semi-structured interviews and archival materials is interpreted through the institutional concept of translation.

Findings
Ensuring transport independence in the Russian Arctic has arisen from the interests’ collision between the mining company and government. There is interrelation between the influence of the supply chain strategy on the environment and, on the contrary, the environmental effect on the strategy implementation into practice. The idea of transport independence has affected the Russian regulation. However, the idea, intended to lead towards disintegration, has been retranslated itself into strategic collaboration with other actors or integrating supply chain management (SCM), but with low-dependent relationships.

Research limitations/implications
Future process-focused research is required to extend knowledge of how supply chain strategies affect SCM practice in local environments different from the Russian Arctic.

Original/value
This study answers the emerging call from earlier research by exploring strategy implementation as a process. It contributes to better understanding of how the implementation of supply chain strategies can affect SCM practice under the changing Russian Arctic environment. It fills a lack of empirical evidence from the emerging economy and extends the use of institutional theory to SCM research.

Keywords: Supply Chain Management, Transport Independence, Supplier Relationships, Organizational actions, Arctic Shipping
1. INTRODUCTION

In the era of globalization and acceleration of the global trade, supply chains cover most of business activities and provide the end-to-end flow of products, services, finances and information sharing from a manufacturer to end users and backwards. For that reason, strategic organizational actions, by means of which supply chains are managed, are of special significance and affect an organization's competitiveness and efficiency. Contemporary markets enforce companies to use their supply chains strategically in order to meet different challenges like cost-efficiency, flexibility, customer requirements in quality and delivery, as well as responding to the influence of the environment they operate in (Zhao et al., 2011). To cope with such challenges, many companies tend to focus on the use of third party suppliers and logistics providers, identifying the cost benefits of this close cooperation and integration. However, in some instances companies have to accumulate own capabilities and resources, ensuring their own transport infrastructure or so-called “transport independence” (Gromakova, 2007).

In global practice, the organizational commitment to ensure transport independence is the most visible in its manifestation in the collision of interests between major mining companies and the government (IBM report, 2009; Volkov et al., 2014). Most of metals and mining companies are located in remote areas close to deposits, but far from major population centers. While remote areas are characterized with the lack of transport infrastructure and sparse transportation networks, most of the minerals and metals mined are destined for export to global markets (Goldsby & Stank, 2000). According to the study of the International Business Machines Corporation (IBM report, 2009), about 82% of metals and mining companies believe that global markets exercise a significant influence on their supply chains. At the same time, their operational activity is a major income for the country’s economy and, thereby, it is of interest to the governmental authorities. In 2004, the idea of transport independence has come into the Russian Arctic, when the Russian mining and metallurgic company “Norilsk Nickel” (hereinafter, MMC “Norilsk Nickel”) announced its development as a new supply chain strategy to ensure its own transport infrastructure. Subsequently, this strategy strongly entrenched itself as the idea of transport independence. The Arctic regions have been well-known for many challenges to shipping and navigation mostly due to harsh natural conditions and limited supply connections. These factors called into question the feasibility of the new supply chain strategy of MMC “Norilsk Nickel”. While this supply chain strategy imposed extra responsibility on the company for organizing deliveries on its own, it required huge investments, which increased transportation costs being non-core assets. However, for the past few years, the company has continued to develop this strategy into practice of the Arctic supply chain management (SCM).

While academic literature has not explicitly addressed the phenomenon of ensuring transport independence by major companies. On the contrary, many forms of managing the supply chain without full control have been investigated and developed, emphasizing the role of integration and collaboration between supply chain partners (Gammelgaard, 2010). Applying a holistic systems approach, most of prior SCM research considers the supply chain as a system in its entirety. Thereby, researchers concentrate on supply chain configuration and interdependence of external and internal components of the supply chain, evaluating institutional issues and market elements to ensure profitability and create customer value (Gammelgaard, 2010). Therefore, the existing body of literature has focused on examining supply chain strategies from both angles, namely the improvement of efficiency referring to decreasing transportation and transaction costs as well as the achievement of effectiveness referring to market and customer responsiveness (Gunasekaran et al., 2008; Ednilson et al., 2008; Gammelgaard, 2010; Nakano.
& Akikawa, 2014). At the same time, Fawcett & Magnan (2002, pp. 359-360) have argued that “supply chain strategies lack specificity and reach” as a consequence of variations and inconsistency in understanding of SCM practices. Moreover, the process of SCM activities within and between organizations in the supply chain is a key characteristic of the conceptual domain (Mentzer et al., 2001). However, SCM research has examined supply chain strategies in isolation from their adoption in supply chain practices (Qi et al., 2011; Qrunfleh & Tarafdar, 2013). Nakano & Akikawa (2014) also point out that scholars have neglected the process of how supply chain strategies are implemented into practice, mostly dwelling on empirical descriptions of supply chain strategies as a model, agenda or hypothesis for supposed organizational actions. The lack of exploring and interpreting the implications of strategy implementation creates a discrepancy between what a company formulates as a strategy and what practices are developed to be appropriate and facilitating to the execution of this supply chain strategy. Without considering SCM practice as a facilitating resource to be deployed, this casts doubt on the feasibility of the strategy in any given SCM practice (Qrunfleh & Tarafdar, 2013). These arguments provide a basis for the given study to address this gap in the current body of knowledge in the SCM field.

Thus, the present study aims to examine how the idea of transport independence has been evolved and translated in the context of one metals and mining company, located in the Russian Arctic.

In doing so, this study represents an empirical story of how the idea of transport independence has come into being in the Russian Arctic, ongoing process of turning the idea into action and what consequences have arisen from organizational change in SCM practice. This study covers strategy making in the emerging economy and, thereby, attempts to fill a lack of theoretical reflection and empirical evidence on how supply chains operate in these settings (Bello et al., 2004; Wong & Boon-itt, 2008; Silvestre, 2015). Emerging economies provide a laboratory for investigating the interaction between an organization’s supply chain strategies and the local context. These settings undergo changes and, thereby, facilitate process-oriented studies (Hoskisson et al., 2000).

This study applies a process-oriented institutional approach. The concept of translation has been employed as to show a process of idea objectification into actions because this study focuses mostly on “not of those who did it (the actors), but of how it was done (the actions)” (Lindberg & Czarniawska, 2006). Thereby, the concept of translation is a useful theoretical tool to address the gap of current literature on supply chain strategies, as being well equipped to interpret how the idea of transport independence becomes appropriate to be embedded into the Russian Arctic and turns again into a new idea or practice. Translation includes “what exists and what is created” (Czarniawska & Joerges, 1996, p. 24) as well as the relationship between actors and ideas, ideas and objects, actors and objects in order to interpret the organizational change in SCM practice.

The study is organized as follows. Section 2 elaborates theoretical framework by reviewing the literature addressing supply chain strategies and presenting an institutional perspective as a theoretical lens. Section 3 describes the research method and presents the research context. Section 4 introduces the study case and empirical findings. Theoretical contributions are discussed in Section 5. The article concludes with implications and future research opportunity.
2. THEORETICAL FRAMEWORK

2.1. Supply chain strategies

Discussing the organizational commitment to ensure transport independence, this study considers the strategy implementation as a process to be deployed from the strategic choice perspective of supply chain strategies and SCM practices. Acknowledged the strategic focus of supply chains, an increasing number of researchers has examined different roles that strategies play in improving SCM practice (Roh et al., 2014).

Most of the SCM literature has examined supply chain strategies from two perspectives. First, a large number of researchers has focused on the improvement of operational efficiency, which refers to decreasing costs (Gammelgaard, 2010) most often through the utilization and building mathematical and simulation models (Min & Zhou, 2002). Strategies, like a lean supply chain strategy, a just-in-time philosophy and redesigning, are mostly aimed at achieving low cost management of product inventory and delivery, thereby improving the quality and efficiency in the supply chain (Qrunfleh & Tarafdar, 2013).

Second, there is an increasing number of theoretical and empirical studies on supply chain strategies, which has emphasized the achievement of market and customer responsiveness or so-called effectiveness (Gunasekaran et al., 2008; Ednilson et al., 2008; Gammelgaard, 2010). This SCM practice recognizes distinct strategies, like strategic supplier partnership, an agile supply chain strategy and postponement, which are aimed at achieving flexibility by adapting quickly to rapidly changing customer needs and demand (Gammelgaard, 2010; Qrunfleh & Tarafdar, 2013). To achieve customer responsiveness, some scholars emphasize the importance of strategic supplier selection and building of close relational tiers with relevant suppliers (Bernardes & Zsidisin, 2008; Vanteddu et al., 2011; Qrunfleh & Tarafdar, 2013), while the others recognize the influence of the social context underlying supply chain transactions (Bakker & Kamann, 2007; Bernardes & Zsidisin, 2008) and the market requirement as well (Miemczyk & Howard, 2008). Purchasing has been also recognized as one of supply chain strategies to receive inputs, which plays a detached role in customer responsiveness, because delayed shipments of components can fail manufacturing process (Qrunfleh & Tarafdar, 2013). However, Miemczyk & Howard (2008) point out that the increase in supply chain responsiveness can in turn affect efficiency of both the operational activity and supply chain.

The implementation of supply chain strategies is largely determined by a company’s capability of sourcing. However, aiming at improving efficiency and achieving market responsiveness, companies have moved in recent decades towards accelerating their flows of products and services by integrating the internal business processes into cross-functional inter-organizational relationships. It becomes no longer important a company’s ownership of capabilities, but rather “its ability to control and make the most of critical capabilities” if or not they are on the company’s balance sheet (Gottfredson et al., 2005). Thus, a growing body of the SCM literature has emphasized the importance of strategic integration with either customers or suppliers and both simultaneously (Mentzer et al., 2001; Vickery et al., 2003; Jüttner et al., 2010; Lin et al., 2014). Most commonly used strategies, which strengthen linkages between companies in the supply chain and, thereby, enable the integrated SCM practice, imply supplier partnering and closer customer relationships (Vickery et al., 2003).

While many forms of managing the supply chain without full control seems to be well presented in academic literature (Gammelgaard, 2010), there appears to be very little research on the implementation of supply chain strategies to ensure full control over the supply chain activities independently by insourcing internal capabilities and investing in the development of own
transport infrastructure. Some studies have indicated that the organizational commitment to ensure full control or transport independence is the most visible in the practice of mining and metals companies located in emerging economies (IBM report, 2009; Größler et al., 2013; Volkov et al., 2014). The essence of emerging economies is that they are dynamic and undergo changes in the institutional environment. They are characterized by high level of uncertainty and complexity (Wong & Boon-itt, 2008; Cho & Ha, 2009), unstable and insufficient governmental norms (Jia & Zsidisin, 2014), being less saturated, less market-based, and more informal (Golgeci & Arslan, 2014). This may adversely affect the implementation of a strategy in practice or produce misleading results concerning the impact of particular strategies (Hoskisson et al., 2000). At the same time, scholars’ opinions vary on whether local contexts affect the implementation of strategies in practice or not. Some studies have emphasized that local contexts considerably affect the supply chain activities, relationships between companies and adoption of new supply practices and strategies (Bello et al., 2004; Yaibuathet et al., 2008; Cai et al., 2010). While Roh et al. (2014) have found that the contextual factors like the size of firms, industry characteristics, and customer and supplier bases mostly influence the extent of implementation of a responsive supply chain strategy rather than the location of manufacturing firms. The contradiction in views provides a motivation to extend the exploration of how supply chain strategies are adopted and implemented in an emerging economy.

2.2. Institutional perspective

This study assumes that organizations, when adopting the idea of transport independence and/or facing the choice of one or another supply chain strategy, turn out to be involved in change process of their meanings and actions. So-called Scandinavian institutionalism has thoroughly discussed intra-organizational dynamics and change in organizational actions, making stress on the circulation of practices (or “ideas”) from their time and place of origin to be objectified and translated into ever-new localities (Czarniawska & Joerges, 1996).

The spread of ideas from a global practice into a new locality is described as a process of translation. The process of “translation” refers to “displacement” and “transformation” and, thereby, implies that “a thing moved from one place to another cannot emerge unchanged: to set something in a new place is to construct it anew” (Czarniawska & Sevón, 2005, p.8).

Ideas become labelled in ways that make them easy to talk about and remember. In such a way, the translation refers to the modification, which an idea or practice undergoes when it is implemented in a new organizational context.

On the other hand, Boxenbaum & Pedersen (2009) further characterize the notion of translation as a process, which “occurs when an idea that seems promising for alleviating an organizational problem is selected and then objectified and materialized” (p. 191).

The process of translation is not only animated by reproducing and altering the existing institutions, but is also guided by a legitimacy order of the institutional environment (Sahlin & Wedlin, 2008). Legitimacy generally means that organizational actions are “desirable, proper, or appropriate within some socially constructed systems of norms, values, beliefs, and definitions” (Suchman, 1995, p. 574). It affects not only how organizations act, but also how they understand to be legitimate (ibid). To remain legitimate, organizations use external evaluation criteria. For example, it has traditionally assumed that supply chains tend to rely on industrial templates and duplicate supply strategies of other organizations proved to be successful in practice (Ketchen & Hult, 2007). In that way, legitimacy helps organizations become more protected and stable to guarantee their survival and to achieve success in opinion of their social culture as well as to reach collectively shared goals (Meyer & Rowan, 1977).
Therefore, the idea appropriateness to a certain locality does not lie in inherent properties or attributes of an idea, but in the success of its presentation (Czarniawska & Joerges, 1996).

Czarniawska & Sevón (2005) argue that the translation of ideas, objects and practices by actors, for their own use, affects not only “what is translated”, but also “those who translate” (p.10). Here, it is worth indicating that organizations, which disregard environmentally legitimated procedures and routines, or create unique structures and practices, can become “vulnerable to claims that they are negligent, irrational, or unnecessary” (Meyer & Rowan, 1977, p. 156).

Organizations traditionally introduce changes through the application of new ideas to gain strategic advantage. According to Holliger’s view: “Ideas […] are instruments that not only can become true by doing their job in inquiry, but can also transform the environment to which they are applied” (Holliger, 1980, p. 87 in Czarniawska & Sevón, 1995).

In such a way, the translation process can cause some editing effects in the local environment, creating and ascribing new meanings, visions and logics to earlier practices and activities. When new objects and actions come in, the local circumstances change and, thereby, a history of earlier experiences becomes reformulated in the light of new visions and present needs (Sahlin & Wedlin, 2008). However, a chain-reaction of consequences after and/or during the materialization of a new idea can become not only unplanned, but also undesirable at the same time (Czarniawska & Joerges, 1996).

3. RESEARCH METHOD AND CONTEXT

3.1. Research method

The research question of how the idea of transport independence has been evolved and translated in the Russian Arctic was addressed through a qualitative case study of the “Polar division” of the Russian mining and metallurgic company “Norilsk Nickel”1 (hereinafter, the metals and mining company). The case company was selected because due to its remote location it has strategically been depended on its see transportation links with other regions and global markets. One of the main challenges for the operational activity and performance of this case company is ensuring cargo delivery from the manufacturing location in the Russian Arctic and backwards.

Several sources of information were used, including 18 semi-structured and in-depth face-to-face interviews with the representatives of 11 organizations, listed in Appendix 1. Sampling of the interviewees was based on their involvement into the investigated area and their availability to be interviewed. The interviews pointed towards tracing the events and actions, associated with the implementation of the idea of transport independence, as well as identifying the role of the case organization, state regulation and other actors in these events and actions. The data collected during the interviews enabled consequently to conceive the meaning and interpret implications of the organizational actions and their change in SCM practice in the Russian Arctic. Most of the interviews were recorded with the consent of the interviewee, while I, as an interviewer, made hand-written notes, and then transcribed, with the exception of several ones when only notes were taken. The interviews were arranged in Murmansk, Saint Petersburg and

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1 The Russian mining and metallurgic company “Norilsk Nickel” (MMC “Norilsk Nickel”) is a group of companies, which core businesses are prospecting, exploration, extraction, concentration and processing of mineral resources; production, marketing, and sales of non-ferrous and precious metals. The main Russian industrial units include the “Polar Division”, located in the Krasnoyarsk region, and the “Kola mining metallurgic company” (the Kola MMC) located in the Murmansk region.
Moscow during four periods of May, 2014, November, 2014, October, 2015 and December, 2015. All of the interviewees were provided with the drafts of my interview protocols via e-mails to enable them to evaluate the validity of my interpretation and description. The additional review process by my interviewees ruled out possible errors in my transcribing of their answers and views, which could took place during oral conversations and transcriptions. This allowed making my findings be more reproducible at other times and that other researchers received almost the same answers and meanings to the investigated phenomenon, including the implementation of supply chain strategies by metals and mining companies in the Russian Arctic. The interviews were conducted in the Russian language and, then, translated into English. If it was necessary and possible, follow-up interviews with additional questions were conducted via email, telephone or personally to obtain more in-depth data. The empirical data was crosschecked through asking similar questions to different interviewees repeatedly to grasp the true meaning of interviewees’ words behind emotions, tone of voice, repetitions and different rhetorical forms of oral language. That allowed to increase validity of the knowledge produced during the interviews and the data analysis.

In addition, secondary data was collected, mostly aggregated from the case organization’s annual reports, internal archival materials, press releases and its official website, as well as the legislation acts and amendments on the Northern Sea Route. The combination of interview transcripts, secondary materials, as well as a number of informal discussions with experienced experts and my personal observations in the Murmansk port enabled to ensure data consistency and reliability.

The study represents a narrative of how the idea of transport independence was evolved and translated into objects and actions in the context of the case metals and mining company, located in the Russian Arctic, and what “unexpected results” and “unintended consequences” could be revealed after those actions.

### 3.2. Mining industry in the Russian Arctic conditions

Mining and metallurgy have become major industrial activities for the economic development of the Russian Arctic. One of main features of these enterprises is that due to large-scale exploitation of natural resources of the North during the Soviet period they created around themselves single-industry towns. Thus, these enterprises have been forced to bear social burden and responsibility besides, taking into account almost all social sphere of these towns, including social infrastructure organization.

These industries are used to be located in extremely remote areas, close to natural resource deposits and extraction that makes more efficient to organize supply chains for processed products than for raw materials as products of a lower quantity and higher value (Plaizier et al., 2012). Their mineral and metal production as semi-products and input to other large industrial complexes is demanded in the global markets like Central Europe, Asia and North America (Høifødt et al., 1995). However, the location in the northern latitudes dictates own terms and challenges. The Arctic remote areas are characterized by severe climate, including ever-changing ice conditions, long distances, sparse transportation networks, an utterly limited choice of supply connections and the lack of transport infrastructure. These factors, thereby, keep metals and mining companies significantly away from the global markets and their customers. Almost all variations of the supply chain are somehow involved in maritime transportation along the Northern Sea Route. This kind of cargo transportation is the only linkage for many northern enterprises with their customers and suppliers. In addition, changing ice conditions is dangerous to shipping and navigation that requires using ice-strengthened ships and the icebreaker. It makes metals and mining companies become involved in the state
regulation of cargo transportation along the Northern Sea Route and dependent on the state
tariff policy, besides the state’s policy and interests in mineral resources extraction.

At the same time, the Russian government intervenes in the activities of mining companies
through regulation and policy because the mining industry in the Arctic has been a major
component of the state and regional economic development (Lindholt, 2007). However, being
a part of the Russian emerging economy, the Russian Arctic is characterized by unstable
regulatory and legal systems. Thereby, the state regulation, along with the Arctic natural
conditions, play a significant role in the activities of metals and mining companies, challenging
their access to the global market. While many metals and mining companies in other parts of
the world have indicated the influence of global markets on their supply chains (IBM report,
2009). Thus, the ability to overcome the natural conditions, and have sufficient power to drive
through ice, accumulating own capabilities or mobilizing resources from third party logistics
providers, becomes essential for Arctic cargo transportation.

4. EMPIRICAL STORY PRESENTATION

Interviews with MMC “Norilsk Nickel” top managers indicated that one of the main purposes
of the case metals and mining company was 100% realization of its production on the market.
In addition, it was mostly export-oriented, since main customers are steel producers, hydro
powers, machine-building plants, located in Europe, Asia and Northern America. However, one
of the main challenge to fulfill that purpose was the availability of almost only one transport
link through the Arctic waters on the sea segment between the ports of Dudinka, Murmansk
and Arkhangelsk. From the interviews with the representatives of the case metals and mining
company, supply chain mapping was illustrated in two options of cargo flows: the delivery of
industrial and commercial cargoes to the Norilsk region and the delivery of finished metal
products from the Norilsk region (see Appendix 2). Mapping gave insight in the selected mining
company’s location, its transport connections with the domestic and international markets, as
well as the flows of cargoes.

During several decades up to the beginning of the 2000s, shipping of finished metals products
to the market as well as of cabotage and commercial cargoes backwards to the Norilsk region
was carried out by only one supplier, namely JSC “Murmansk Shipping Company”. Over a
long period, that supplier was also the operator of the nuclear icebreaker fleet to provide
icebreaker assistance. The case metals and mining company was the largest cargo owners, and
its freight traffic between the ports of Dudinka and Murmansk ensured about 40% of the profits
of its sole supplier as indicated by top managers of JSC “Murmansk Shipping Company” and
the case company. However, the interviews with the case mining company’s top managers
highlighted that the case mining company experienced a strong influence and domination of its
sole shipping supplier and provider of icebreaker assistance in one, being entirely dependent on
its actions and behavior.

The situation of cargo transportation was compounded by the fact that ice-class vessels sailing
along the NSR, as well as the icebreaker fleet became obsolete and demanded renovation. The
limitation in the choice of supply relationships, high icebreaker fees, the issues of the necessity
to renovate ice-class vessels as well as the lack of icebreakers were expressed in the case metals
and mining company’s uncertainty about the reliability of its cargo delivery. In addition, the
case company’s top managers highlighted that: “Any disruptions of cargo delivery could violate
the manufacturing process, which would result at significant economic losses for MMC
“Norilsk Nickel”.

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From my several interviewees, it was apparent that the tariff policy, imposed by JSC “Murmansk Shipping Company” on behalf of the state, was completely inappropriate. The case metals and mining company had to concentrate on the search for alternatives and decisions on restructuring SCM in order to ensure transportation of its cargoes and finished products on the sea segment between the ports of Dudinka, Murmansk and Arkhangelsk.

One of those alternatives was a project developed with the participation of government agencies, to make the Northern Sea Route as a joint-stock company. The case metals and mining company was supposed to be one of possible shareholders of that joint-stock company. In addition, it was going to invest in the construction of a new nuclear icebreaker. At the same time, my several interviewees, including the case company’s top managers, and even some archival materials indicated that the case metals and mining company thoroughly considered a possibility to adjust decommissioned nuclear-powered submarines, specially reequipped for freight transportation purposes.

Among all possible ways of cargo transportation, an idea of building the own Arctic fleet looked most attractive and economically justified. As one of the case company’s top manager emphasized: “The discussions of building the own Arctic fleet began initially since 1996, and then lasted within a few years, sometimes growing up or fading away. It was an idea whose time came in a certain period when new technologies made it possible to build ships of “dual action” capable of breaking 1.5 m thick ice shield and thus creating an ice free sea area around them”.

Thus, in 2004, the case metals and mining company proclaimed “The concept of logistics optimization” (hereinafter, the idea of transport independence), which aimed to achieve transport independence, first of all, of not using icebreaker assistance any more.

The interviews showed that the idea of transport independence was objectified step-by-step. The case company started with restructuring the supply chain and establishing a subsidiary, namely Murmansk Transport Branch, to perform all the transport needs. Cargo turnover of the subsidiary averaged 2.5 million tons per year with 1 million tons transported along the NSR and approximately 1.5 million tons – along the Yenisei River. During a period since 2006 until 2008, the case metals and mining company put into operation five Arctic ice-class container vessels ARC-7 with freight-carrying capacity of 16 thousand tons. Technical capabilities of these vessels allowed it to overcome over 1.5m thick Arctic ice shield creating an ice-free sea area around them. As emphasized by one of the case company’s top manager:

“The own fleet ensured cargo transportation without icebreaker assistance all year round. Thereby, its availability allowed to solve one of our most urgent strategic objectives that was to ensure transport independence from the constant use of icebreaker assistance and governmental policies in the Arctic shipping not to pay obligatory icebreaker fees when sailing along the Northern Sea Route”. The own fleet enabled the case mining company to apply new supply strategies as well as provided with a capacity for extending of its supply chain in the case of the development of new sales and marketing policies.

The project of building and subsequent commissioning its own fleet demanded heavy investments by the manufacturer. According the information presented on the case company’s website, the cost of building the first vessel was 71.7 million Euro, and each of the following four vessels came to about 82 million Euro (Norilsk Nickel Press releases, 2009). From one of my interviews it emerged that the price of building was raised due to the substantial increase in world prices for metal commodities that time. However, despite so significant investments in a non-core asset like the own Arctic fleet, the case metals and mining company covered its costs for a short time. During the interviews, the case company’s top managers highlighted that
icebreaker fees were so much high that the commissioning of the fleet recommenced the case company’s losses related to icebreaker assistance and freight of 3d party vessels.

The next step in the implementation of the idea of transport independence was the construction of MMC “Norilsk Nickel” own transshipment terminal in the Murmansk port, which was completed in 2014. The terminal was designed for transshipping all kinds of the case company’s cargoes: nickel matte from the Norilsk region to the Murmansk region; metal finished products from the Norilsk and Murmansk regions for export to European ports; as well as commercial cargoes from Europe to be supplied to the Norilsk industrial region.

Before the construction of the new own terminal, OJSC "Murmansk sea trading port" was the only stevedore company for the case company’s cargoes, but it increased tariffs for its services every year. Therefore, the construction of the own transshipment terminal relieved the case metals and mining company of tight dependence on the actions and behavior of the Murmansk trading port. According to one of the case company’s top managers: “Now all our cargoes transporting through the Murmansk port are processed at our own terminal. It has made it possible to turn the Murmansk transport branch into a full-rate stevedoring company by now. Thereby, we reduced our costs and improved the company’s stability”.

At the same time, the idea implementation encouraged the case company to implement some supply chain strategies, which were quite young and almost never used before in the Arctic navigation. Those supply chain strategies constituted specific operations, focused on ensuring maritime safety and improving the performance of cargo transportation like containerization, the “open water” principle, and the cargo circulation principle to avoid empty vessel voyages. Containerization has provided safety and security of products at all the stages of transportation as well as reduced products delivery period by decreasing the time of cargo transshipment and handling operations at ports. The following strategy of search for “open water” was implemented mainly because of the tight schedule of vessel traffic. It allowed the case company to adhere to the schedule of vessel traffic and avoid any disruption in its supply chain in spite of the Arctic severe natural conditions. When sailing in the Arctic waters of the Northern Sea Route, shipping companies often encountered an issue when vessels might have to travel empty in one direction due to insufficient cargo accumulation in the northern regions. In order to avoid empty vessel voyages from the port of Murmansk to the port of Dudinka, the case mining company introduced the principle of cargo circulation through insourcing strategy. These strategic steps and actions allowed the case metals and mining company to improve its cargo transportation efficiency and, thereby, to ensure the reliability of its supply chain on the sea segment between the ports of Dudinka, Murmansk and Arkhangelsk (Norilsk Nickel Press releases, 2012). From the interviews with the case company’s top managers, it emerged that the idea of transport independence altered the way of making decisions for the case mining company in the planning and management of its cargo flows. Its implementation allowed reducing the drawbacks of the case company’s remote location in the Russian Arctic and decreased and possibilities for supply chain disruptions, which were a high risk due to the presence of sparse transportation network with a limited choice of the supplier.

From the interviews, it emerged that the implementation of the idea of transport independence by the case company affected not only multiple aspects of SCM practice in the Russian Arctic, but also the behavior and actions of the other players. When the case company commissioned its own fleet, its former sole supplier lost its large loyal customer as the biggest owner of cargoes

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2 Here is a rough calculation to illustrate the amount of transportation costs between the ports of Dudinka and Murmansk before operating the own Arctic fleet. For example, in 2010 the icebreaker fees was about $65 per 1
in the Russian Arctic and, thereby, its cargo turnover as well as profits felt down considerably. New capabilities and resources of the case mining company caused also discontent of those, who provided icebreaker services. From the several interviews, it emerged that the discontent was expressed as claims, complaints and even legal proceedings due to conflicting economic interests between the case company and other main players. Both other players suffered a serious shortfall in profits, being deprived of the regular customer of icebreaking assistance like the case metals and mining company.

On the one hand, so-called “icebreaker independence” provided the case mining company with the capability for making prompt decisions in cargo shipping issues, delivery time and transportation quality. On the other hand, the emergence of the case company’s new capabilities and resources resulted in redistribution of dominance among the major players in the Russian Arctic shipping sector.

In 2012-2013 years, the Russian legislation of sailing in the Arctic waters underwent significant changes. The data from the interviews and some archival materials, including the Russian legislation, showed that one of the major regulatory changes regarded the abolition of the obligatory icebreaker fees. They were determined as charges only for actual services for icebreaker assistance and ice piloting. Ship-owners had to decide for their own, if they needed icebreaker services or not. Thereby, the legislation became more flexible and less coercive with respect to all the players, using the Northern Sea Route.

The next significant change in the navigation along the Northern Sea Route became the recognition of the case company’s vessels as being able to provide the icebreaker services. From the interviews with the case company’s top managers, these regulatory updates stopped any claims and legal proceedings against the case company’s maritime activity. Thus, the case mining company ensured not only the fulfilment of transport independence, but also to some extent achieved independence from the state policy in the Arctic navigation, especially from the tariff policy for icebreaking escorting. However, my personal observations in the Murmansk port and follow-up interviews with several respondents showed that despite the case mining company promoted itself as an independent player in the Arctic sea cargo transportation, it continued to maintain the relationships with other players. The case mining company interacted with other participants only from time to time in order to increase its cargo transportation efficiency. Maintaining relationships implied, in such a case, the strategic behavior of the case mining company for its own benefit rather than in respect of improving the efficiency of other participants of the Arctic maritime transportation. In addition, my different interviewees gave to understand that the Arctic navigation is full of challenges and depends on the complexity of climatic conditions. It follows that, on the one hand, the climatic geographical characteristics of the Arctic region caused challenges to navigation and influenced on decision making in shipping. On the other hand, the pursuit of economic interests induced the case mining company to interact with other players. Therefore, the idea of transport independence itself underwent some changes during its implementation into practice.

5. DISCUSSION AND ANALYSIS

My theoretical assumptions are based on the notion of translation (Czarniawska & Sevón, 2005), which has been chosen to explore the objectification of the idea of transport independence in the Russian Arctic. The empirical findings, presented in the previous section, view the idea of transport independence as one of supply chain strategies, whereby major companies manage their supply chains through accumulating their own capabilities and
resources in order to develop their own transport infrastructure. This idea has come into the Russian Arctic from the global practice of how most of metals and mining companies have viewed their operations in terms of moving their cargoes and products through the supply chain and delivering to customers at completion (IBM report, 2009). Based on the empirical findings, the development of the idea of transport independence in the Russian Arctic roughly passed three periods, each propelled by the emergence of relevant organizational actions and their change (see Table 5.1).

Table 5.1 The translation of the idea of transport independence.

<table>
<thead>
<tr>
<th>Periods:</th>
<th>Status of the case metals and mining company:</th>
<th>Characteristics of the periods:</th>
<th>Consequences:</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1: The idea origination since 2000 to 2004</td>
<td>Owner of cargo</td>
<td>Turning into actions and objects:</td>
<td>- Decision about building the own Arctic fleet &amp; development own transport infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Establishment of a subsidiary;</td>
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<td></td>
<td></td>
<td>- Commissioning of own Arctic fleet with new technologies;</td>
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<td></td>
<td></td>
<td>- Construction of own transshipment terminal in the Murmansk port;</td>
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<td></td>
<td></td>
<td>- New supply chain strategies (containerization, the “open water” principle, cargo circulation principle);</td>
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<td></td>
<td></td>
<td>- New control system of cargo transportation (Oracle)</td>
<td></td>
</tr>
<tr>
<td>#2: The idea translation since 2004 to 2012</td>
<td>Owner of cargo &amp; vessels; Marine carrier</td>
<td>Editing meanings, practices and logic:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The dominance of the case company in cargo transportation on the sea segment between the ports of Dudinka, Murmansk, Arkhangelsk;</td>
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<td></td>
<td></td>
<td>- Icebreaking independence;</td>
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<td></td>
<td></td>
<td>- Independence of the state tariff policy (substantially);</td>
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<td></td>
<td></td>
<td>- Change in behavior of other actors;</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- New legislation</td>
<td></td>
</tr>
<tr>
<td>#3: The editing process since 2013 until now</td>
<td>Owner of cargo &amp; vessels; Dominating marine carrier</td>
<td>- Improvement of cargo transportation efficiency and flexibility;</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- Ensuring the “reliability” of the supply chain on the sea segment;</td>
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<tr>
<td></td>
<td></td>
<td>- Reduction of drawbacks of the remote location</td>
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<td></td>
<td></td>
<td>- Change in SCM practice in the Russian Arctic;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Transformation of the idea of transport independence in practice into a new behavioral form of strategic collaboration</td>
<td></td>
</tr>
</tbody>
</table>

5.1. The idea origination

The first period begins the story since 2000 to 2004. It discusses the circumstances of how and when the image of the idea of transport independence became attractive to the case mining company before to be translated into actions and objects. Therefore, this period is entitled “The origin of the idea”. The findings have revealed that the case mining company had to put the idea of transport independence into action as “an environmental adaptation” rather than as “a planned innovation” (Czarniawska & Joerges, 1996). The environmental adaptation by the case mining company has appeared to be of necessity due to several kinds of its dependency, which are dependency on resources, technologies, unstable coercive state regulation (see Table 5.1)
Scott (2014) argue that one of the most fundamental roles of institutions is to reduce uncertainty for different actors and provide meaning by imposing the rules and norms of organizational behavior and defining the boundaries of how to be legitimate. However, as many of the interviewees have indicated, there were quite weak and insufficient institutional rules and procedures engaged in the organization of cargo shipping along the Northern Sea Route. That resulted in uncertainty over disruptions in moving cargoes through the supply chain of the case mining company. Peng et al. (2009) describe such a situation with high uncertainty as clouding “the judgment of actors” and, thereby, enabling the emergence of informal non-institutionalized decisions, actions and unknown strategies like the idea of transport independence.

The paradox is that according to the theoretical assumptions, proposed by Czarniawska & Joerges (1996), the idea is travelling in time and space, being imitated from those originators that successfully have implemented the idea in their certain contexts. However, in my research case the idea of transport independence was already initiated by some other actors in the Russian Arctic, but was not successful in its implementation. Then, it emerged once again and received the further promotion in this context, being imitated by the managers of the case metals and mining company as a new adaptor.

5.2. The idea translation

The subsequent period since 2004 to 2012 tells how the idea of transport independence has been turned into objects and actions in the Russian Arctic. Many actions have taken place in the process of translation to package the idea into routines, objects and supply chain strategies. The findings have indicated that the idea has been enacted through the establishment of a subsidiary; building own Arctic fleet with new technologies; construction of own transshipment terminal in the Murmansk port; new supply chain strategies like containerization, the “open water” principle, cargo circulation principle; introduction of a new control system of cargo transportation and some other. These new “actions” and “objects” in SCM of the case mining company have encompassed a change in the supply chain characteristics and structure. The case mining company has managed to improve its supply chain effectiveness by reducing transportation costs and improving its supply chain responsiveness to rapidly changing market conditions by ensuring “reliability” of cargo transportation in Arctic waters.

It is worth noting that the translation process has reformulated the earlier experience of SCM practice in the Russian Arctic, creating a new meaning of navigation without icebreaker assistance along the Northern Sea Route. In addition, the translation of the idea in the Russian Arctic has become a never-ending story, which is still going on. It is not surprising that the change process has accompanied the idea objectification, as Berg (2003) argues the same. However, the findings have revealed that when the change in organizational actions carries out in an untraditional way and sense of other actors, the idea objectification stumbles on a number of encounters of actors and clashes of interests between the actors, involved in cargo transportation in the Russian Arctic. Therefore, the objectification of the idea of transport independence has facilitated the case mining company to achieve almost a full control on its cargo transportation on the Arctic sea segment between the ports of Dudinka, Murmansk and Arkhangelsk, as well as has resulted in change of the dependency level in relationship between the case mining company and its suppliers.

5.3. The editing process

The third period encompasses the period since 2013 until now and concentrates its attention on some editing effects in the practice of cargo shipping and SCM in the Russian Arctic after the idea of transport independence has been translated. The case mining company has expanded its
identity to be recognized not only as a major non-ferrous metal producer and a major owner of cargo in the Russian Arctic, but also as a ship-owner and a cargo carrier in this region. Reformulating the earlier practice of SCM and sailing along the Northern Sea Route only with the icebreaker assistance, the idea of transport independence has been recognized by other major actors as illegitimate, though the old legislation rather allowed that. On the one hand, these actors have lost their major client, tariff payer and owner of large volumes of cargo. On the other hand, they have really believed that the case mining company violated the historically established practice, institutionalized over the years. Thereby, the case mining company’s actions to ensure full control over its supply chain activities have sacrificed its legitimacy and made the case company vulnerable to claims of other actors in the Russian Arctic. Moreover, most interviewees have stressed that the idea seemed to be quite irrational and even evasive to be objectified in such a complicate context as the Russian Arctic, full of several challenges and high risk to cargo shipping.

However, the success of the idea implementation and new self-identification of the case mining company have created some editing effects in managing cargo transportation in the Russian Arctic. As indicated by the findings, the translation of the idea of transport independence by the case mining company has appeared a strategic process, which created an efficient imaginative force, quite powerful to ascribe a new vision to the earlier institutional logic in the state policy. In an attempt to interpret this discrepancy between skeptical views and successful implementation, I have addressed myself to a Scandinavian distinctive view of organizational behavior and strategic change. Weick (1987) argues that the implementation of a strategy can be endowed with “a self-fulfilling prophecy”, if it is equipped with necessary artifacts and image. The images, incorporated into the idea by the case mining company, like “independence” and “full control over cargo shipping” have produced a purposeful meaning to the idea for its further translation into objects and actions and also for the case mining company, though its implementation looked like irrational in those environmental conditions. At the same time, its translation has revealed the inconsistency of the legislation to new market realities and, thereby, applied pressure on the Russian government to change the vision of how regulatory procedures of sailing in the Russian Arctic is to be organized. Therefore, according to Weick (1987), this editing effect on the local context can be interpreted that the idea of transport independence has made sense to other stakeholders as well, including the Russian government, to change their behavior and vision of cargo shipping in the Russian Arctic. While this strategic idea has been a necessity to a further rational impetus for the case mining company, rather than a chase of fashion, in order to survive in the environment full of uncertainty and challenges to fulfill regular cargo transportation. It follows that the idea of transport independence has been not only translated or objectified by the case mining company, but also it has determined some prerequisites to affect and translate the environment by creating a new “myth” full of new “rationalized prescriptions” (Meyer & Rowan, 1977) as a framework for cargo transportation and navigation in the Russian Arctic. The legal environment has turned out to be malleable to adopt this new “myth”, inhabited by the idea.

It is worth indicating that the findings have also revealed a discrepancy between the case company’s organizational actions and the images, equipped the idea of transport independence. The idea of transport independence, which was intended to lead to disintegrated SCM practice, has translated itself into a form of strategic collaboration. This editing effect of the case company’s behavior looks like irrational and even contradictory with the image of the idea itself because the case mining company has acquired own capabilities to fulfill full control over its cargo transportation in the Russian Arctic, as highlighted by many of the interviewees. In turn, Berg (2003) argues that the rational behavior of organizations can become just a screen to enchant the world, behind which irrational motives of thinking and acting can lurk. Berg (2003)
metaphorically views these irrational motives as a powerful source, which creates an evasive “magical reality”, being hidden from our eyes, but ruled by “myths” (Meyer & Rowan, 1977). It follows thence that the discrepancy, which the findings have indicated, between the case company’s organizational actions and the idea’s images can be interpreted by the fact that the strategy implementation contains a kind of “magic” component, which works to mobilize collective actions in the contexts full of uncertainty and challenges like the Russian Arctic. In addition, this editing effect on the idea of transport independence itself indicates that the implementation of supply chain strategies can facilitate the mutual collaboration and decision-making process to produce joint activity in cargo transportation by reducing confrontations of interests of the main actors and controversies. At the same time, some interviewees have pointed out that the case company has to interact with the operator of the icebreaker fleet during the winter period difficult for navigation at the mouth of the Yenisei River in order to be efficient, reducing the number of delivery days and fuel consumption. Thus, this finding indicates that the idea of transport independence has been also affected by the Arctic severe mostly unpredictable natural conditions, which in turn have facilitated the increasing necessity for strategic collaboration.

According to Vickery et al. (2003), supply chain strategies, which strengthen linkages between companies within the supply chain, enable integrated SCM practice and, thereby, imply close relationships with other actors involved. In turn, Zhao et al. (2008) argue that integrated SCM practice refers to the degree to which the organization strategically collaborates with its supply chain partners in order to achieve effective and efficient cargo flows, providing maximum value to its customer. Hence, it follows that the local environment, changed after the idea objectification, and the Arctic natural conditions have encouraged the case mining company to introduce integrated SCM practice as a strategic tool in order to survive in the complicated emerging economy and establish reliable cargo transportation. It is worth noting that, according to the findings, integrating processes have been hardly perceptible in the earlier periods of the development of the Russian Arctic cargo transportation because, before the idea objectification, the state redistributed primary functions between the major players since the Soviet times. Despite the significance of supply chain integration as a research area has been highlighted in academic literature over the past two decades (Kauremaa et al., 2010; Kamal & Irani, 2014), the introduction of an integrated practice by the case mining company has become a new SCM practice for shipping and navigation in the Russian Arctic waters. According to Vijayasarathy (2010), mutual dependence between the supply chain participants has a significant influence on integration and development of long-term relationships with the partners. On the contrary, the findings have revealed that the integrating SCM process has made possible to be applied in the Russian Arctic after the case mining company has achieved low-dependent relationships with its sole supplier and the operator of the icebreaker fleet. While academic literature casts doubt on the organization’s ability to survive in similar conditions (Vijayasarathy, 2010), the case study shows that reducing dependence on the behavior and actions of other major actors involved in cargo transportation in the Russian Arctic, the case mining company has been able to secure its survival and supply chain reliability. That can be interpreted by the fluctuating of dependency in relationship between the case mining company and its suppliers due to the asymmetry of power.

6. CONCLUDING REMARKS

The case, which has been presented in this study, tells the story of how the idea of transport independence has been evolved and translated in the context of a metals and mining company,
located in the Russian Arctic. The story starts with a description of the circumstances of its origin in a new locality, then explores the process of the idea translation into actions and objects by the mining company and, finally, reveals the editing process on SCM practice and cargo transportation in the Russian Arctic after the idea has been objectified. The present study attempts to answer the emerging calls from strategic SCM research for use of a process-oriented exploration. Although some earlier researches consider SCM practice as an appropriate resource to facilitate execution of supply chain strategies, most of them have examined strategies just as a model, agenda or hypothesis in isolation from their adoption in SCM practice (Qi et al., 2011; Qrunfleh & Tarafdar, 2013; Nakano & Akikawa, 2014). On the contrary, this study illustrates the process of the strategy implementation and, thereby, it enhances our understanding of how supply chain strategies can affect SCM practice. The findings highlight that although SCM practice already contains quite appropriate activities and resources for the further strategy implementation (Chen & Paulraj, 2004; Qrunfleh & Tarafdar, 2013), the objectification of a supply chain strategy deploys new actions and routines, which are capable of changing SCM practice itself.

This study extends the use of institutional theory to SCM research by interpreting organizational change in SCM practice in the Russian Arctic through the concept of translation. The findings reveal that the translation process of the idea of transport independence in the Russian Arctic has manifested itself in three forms. First, the idea objectification has affected the environment, in my case shipping and navigation in the Russian Arctic, to which it has been applied, that is consistent with Holliger’s argumentation (Czarniawska & Sevon, 1995).

Second, the idea objectification has affected the case mining company as well, which initiated the translation process, by changing its status from being only an owner of cargo into dominating marine carrier in the sea segment between Dudinka, Murmansk, Arkhangelsk. This form of the translation process also relates to how the case mining company understands to be legitimate and uses this interpretation strategically to its own interests. That contributes to a better knowledge of differentiation in understanding legitimacy among various players, operating in the same environment. In addition, this study extends the knowledge of how relationships between supply chain partners can change under the strategy implementation.

Third, the idea of transport independence has been translated itself under the influence of the environment after some changes in the Russian regulation of navigation along the Northern Sea Route. It is worth noting that these changes in the Russian regulation have been caused by the influence of the idea itself on the environment and the behavior of the major actors. Therefore, this finding underlines that there is a certain interrelation between the influence of the idea or a supply chain strategy on the environment and, on the contrary, the effect of the environment itself on this concrete idea and its further objectification into practice. At the same time, the implementation of the idea of transport independence has been intended to lead towards disintegrated SCM practice of the case mining company in order to reduce dependency on resources, technology, other major actors’ behavior and state regulation. In contrast with these expectations, it has been translated itself during its execution into a form of strategic collaboration with the major actors involved in cargo transportation in the Russian Arctic. Thereby, the findings reveal the appearance of an integrating process in managing cargo transportation in the Russian Arctic, but with low-dependent relationships now after the objectification of the idea of transport independence. Therefore, this study contributes to a better understanding of how the implementation of a supply chain strategy can affect SCM practice with unintentional consequences under the influence of a changing environment in the emerging economy.
Moreover, this study has some implications for practitioners. Based on process-oriented approach to the strategy implementation, managers can comprehend how internal SCM process are integrated between departments, as well as be encouraged to integrate supply chain activities externally. The arguments, provided by studying the process of how supply chain strategies are implemented into practice in the emerging economy like the Russian Arctic, suggest managers that collaborative activities, but based on low-dependent relationship between the supply chain partners, can be reasonable, when adopting strategies in complicated environments, in order to make the supply chain more responsive and efficient.

Although this study provides an insightful research of how the idea of transport independence has affected SCM practice and relationships between the case mining company and its supply partners in the Russian Arctic, the same supply chain strategy or “idea” acquires different value, meaning and even name when travelling from one context to another (Czarniawska & Joerges, 1995; Erlingsdottir & Lindberg, 2005). Future process-focused research is required to extend knowledge of how supply chain strategies, intended to improve efficiency and/or increase responsiveness, can affect SCM practice and relationships between the partners in other contexts with different environmental conditions than the Russian Arctic. More empirical research is also needed to examine integrating and disintegrating processes in SCM of major industrial companies located in different contexts than the Russian Arctic and dependent on the governmental regulation, technologies and geographical/natural conditions.

REFERENCES


### Appendix 1: List of respondents, interviewed during May, 2014; November, 2014; October, 2015; December, 2015.

<table>
<thead>
<tr>
<th>#</th>
<th>Organization</th>
<th>Position</th>
<th>Time line &amp; number of interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Director of transport branch</td>
<td>2015, 1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Deputy chief of fleet chartering and fleet operation, Shipping division</td>
<td>December, 2015, 201</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>former Head of procurement, Dudinka shipping division</td>
<td>2015, 1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Northern Sea Route Information Office (in Murmansk) created by Center for High North Logistics (in Kirkenes)</td>
<td>Head of the NSR Information Office</td>
<td>May, 2014, 2014, October, 2015, December, 2015</td>
</tr>
</tbody>
</table>

Total amount of interviews per month:

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Total amount of interviews: 18

### Appendix 2: Supply Chain Mapping of the case manufacturer
Figure 1 illustrates the location of the “Polar Division” of MMC “Norilsk Nickel” in Norilsk town, as well as transportation connections of this manufacturer and the supply chain design for transporting metal finished products and nickel matte from the Norilsk region to the domestic and global markets.

The “Polar Division: of MMC “Norilsk Nickel” uses the next available transportation links:

1. The railway from the manufacturing site to the port of Dudinka, where metal production is transshipped from goods vans to ice-class vessels operated in the Arctic waters;

3. The NSR from the port of Dudinka to the ports of Murmansk and Arkhangelsk. It is the main linkage for the year-round transportation of metal finished products (non-ferrous metals) and nickel matte:
   - to the port of Murmansk for further export;
   - to the port of Arkhangelsk as cabotage\(^3\) for the Russian market.

4. Railways from the ports of Murmansk and Arkhangelsk to domestic customers;

5. The European Arctic corridor from Murmansk to Rotterdam/ Hamburg ports and the North American market by own ice-class vessels and by 3d-parties ships;

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6. The eastern part of the NSR from the port of Dudinka to the Asian region mainly to China since October, 2010.

Figure 2 illustrates the supply chain design of the “Polar Division” of MMC “Norilsk Nickel” for transporting industrial and commercial cargoes to the Norilsk region.

2. Along the Yenisei river only during the summer navigation from the port of Krasnoyarsk by MMC "Norilsk Nickel's" barges - cabotage (construction and industrial) and commercial cargo.

3. To the port of Dudinka by own ice-class vessels: 1) from the port of Arkhangelsk - commercial and cabotage cargo, including dangerous cargo, 2) from the port of Murmansk - commercial and cabotage cargo, excluding dangerous industrial cargo.
URBAN FREIGHT:  
A LITERATURE REVIEW 

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ABSTRACT  

Purpose  
In recent years, the increasing growth of city logistics has considerably affected the quality of life in urban areas. Many cities face multiple challenges such as increased level of noise, air pollution issues, safety concerns, poorly-implemented policies and planning. Thus, making urban freight transportation sustainable has started to be more relevant.  

Design/methodology/approach  
This study presents a comprehensive literature review that aims to provide a better understanding of the contents of the current urban freight transport practices. Research analyses current problems, such as poor integration of networks between/inside cities, the lack of attention from local authorities and stakeholders, and uncertainties of cooperation between them. The framework encompasses four main stages of urban freight: overview, planning, emission reduction and an economic perspective.  

Findings  
Based on this review, areas of concern and the impact of possible new changes are identified; additionally, the methods to overcome this situation, such as policy packages and planning, implemented through private initiatives, which include rescaling city networks and pollution reduction problem. Freight consolidation plays key role in improvement initiatives.  

Research limitations/implications  
Research provides discussion, where the initiatives should be placed in urban freight, and the ways how to overcome the constraints are being proposed.  

Practical implications  
Heterogeneity of interests between stakeholders, local authorities and business representatives leads to financial, social and administrative unbalance in implementing Urban Freight Centres (UFC). In this case, solutions are provided as well as the importance of implementing flexible policies, restrictions and preferences regarding urban freight is explained by the authors.  

Social implications  
Research dedicates a lot of attention to policy strategies aimed on reduction of pollutants (e.g. CO, CO₂, NOₓ, and particulate emissions) emitted by freight vehicles, the importance of increasing the number of low and/or zero emission of freight trucks circulating inside of cities or near areas, and reduction the number of freight vehicles in the urban areas (especially in city centers).
Originality/value
The results of this study bridge the gap in understanding the basic issues in the field of urban freight transport and can be used by companies, stakeholders or local authorities. It is also contemporary literature review from the topic with proposed framework in the end of the research work.

Keywords: Urban freight transport, consolidation centers, sustainable transport, literature review

1. INTRODUCTION

In recent years, many cities have faced a multitude of challenges, because of the huge economic growth with the rapid increase of industrial production, warehousing, transportation and turnover of trade. Also, it highly affects the increasing number of goods flow, especially in the urban areas. The need of paying attention to challenges related to congestion, noise, air quality issues, safety, quality of life and the problem with a multitude of diverting policies started to be more appreciated. It is not only reduction of CO\textsubscript{2}, what is on the agenda of urban freight, but typically O\textsubscript{3}, PM\textsubscript{10} and NO\textsubscript{2} emissions are caused mostly by freight transports at urban areas (Österle, 2015; Liimatainen et al., 2015). A number of reasons make an efficient freight distribution system a crucial element of an urban area. They include increasing the competitiveness of the area, generating income and creating job opportunities (Betanzo-Quezada and Romero, 2010).

The purpose of this paper is to review the works that propose relevant decisions or policy implementation suggestions in the field of urban freight. This review provides valuable information to researchers by summarizing the main issues regarding urban freight, such as: collaboration problem between actors, strategic planning and coordinated policies, statistical data/data acquisition, ecological issues and implementation of new freight technologies for city distribution. Also, current study aims at identifying and evaluating issues in urban freight transport to establish Urban Freight Center (UFC), proposing a discussion regarding policy making process and possible actions to overcome the issues. The specific research questions of this study are: (i) What are the main issues to overcome in the field of Urban Freight and UFCs?, and (ii) What could be the remedies to solve these identified constraints and caveats?

1.1. The review methodology

Despite the fact that article selection was mainly made by forward or backward snowball search, some general selection criteria were defined: (i) Content relevance e.g. availability of analytical data, surveys, questionnaire, project, discussion, providing author’s critical point, (ii) papers published not later than 2008, so that the main issues still could be relevant, (iii) Works published in peer-reviewed journals or conference proceedings were considered, and (iv) Criteria was limited to works written only in English.

Methodology of the review can be summarized as follows: At first, the following keywords were defined for searching the proper articles through scholarly databases Scopus and Science Direct: “urban freight transport”, “transport planning”, “urban freight centers”, “urban consolidation centers”, and “sustainable transport”. All references of the sampled papers were checked as well as the papers they contain. One of the main issues at this stage was related to the term “urban freight/consolidation center”, which has a variety of meanings except the above mentioned ones, among which are (University of Westminster, 2005): public distribution depot,
central goods sorting point, urban distribution centre (could be specified, e.g. retail, construction) and others. This complicated the search, making it more heterogeneous.

1.2. Descriptive analysis

The article selection process could be divided into two parts: “Urban Freight” and “Urban Freight Centers”, which had been made separately in approximate period of half a year. During the review period, for the “Urban Freight” part the total number of references was 34, including books, common practices and sources written in Russian; whereas UFCs review consists of 13 sources. After excluding irrelevant articles or practices based on the criteria defined above, an overall number of 40 articles were chosen. Taking into account the criteria of considering only “fresh” papers, it is still possible to trace the progress from Figure 1.1 i.e. how number of papers increased dramatically between the years of 2004 and 2015, which indicates the relevance given to the field of urban freight transport. In addition, high publication numbers in recent years show that the above mentioned scientific field has developed enough to justify a review of the literature.

![Figure 1.1 Number of sampled articles published per year](https://example.com/figure1.1.png)

Regarding to journals, where studied works were published, Procedia - Social and Behavioral Sciences received highest amount of articles, in total eight. This was followed by Transport Policy with six, Transportation Research Part A: Policy and Practice having three and Journal of Transport Geography also three. It is worth noting that other 15 articles being analysed were published in number of different journals, which probably indicates an interest of urban freight within broader research community.

After analysing the selected literature more deeply, we consider that each of the sections in the proposed literature review (Urban Freight and UFC) can be divided into several content categories: (i) Works that are concerned with relations between all the actors in the field, (ii) Infrastructure issues, road network design, (iii) Economic perspective, planning, and policy making processes, and (iv) Social & ecological issues.

This research is structured as follows: Overview of urban freight through stakeholders, networks, planning and policy packages, emission reduction, and economies is given in Section 2. Thereafter, in Section 3 we concentrate in freight consolidation through urban freight centers. Discussion and built framework is provided in Section 4. Finally, in Section 5 work is concluded, and future research avenues are being proposed.
2. OVERVIEW

While analysing the current state of the urban freight transport field, it can be noticed that there is an evident misunderstanding between actors, who are in charge of achieving the maximum effectiveness in urban areas (Banister, 2002). A weak cooperation and engagement in a joint effort between stakeholders and politicians is responsible for fragile support of services, which are already implemented and lack of desire to develop solutions in conjunction. This leads to a poor integration between all parties involved in the process. Business representatives play no lesser part in this issue.

Relatively little attention has been paid to urban freight transport as for an individual field of scientific studies that entails policy making processes. According to Dablanc (2007), for majority of the scientific community urban freight represents itself as a passenger transport regulation, which undoubtedly is a misapprehension. Lindholm (2010; 2012) connect this idea to the lack of knowledge and scientific materials regarding this field, which suggests (Bjerkan et al, 2014) of giving more attention to awareness of the field. In addition, one more local issue exists: the lack of appropriate data (Genevieve, 2014). By the reason of that, most information is taken on the “one-time” basis, it usually lacks primary statistics regarding in-city monitoring, or any kind of freight movements or characteristics. This results in multiple-case studies using different data collected in different ways. This is relevant especially for individual city areas, which make it impossible to see the whole picture systematically (Genevieve, 2014). Lindholm (2010) and Lindholm and Blinge (2014) support this idea in their research; their questionnaire was performed as a web survey among Swedish municipalities. Authors concern that only 30% of cities, despite of their size, have any kind of statistical data regarding urban freight city transport and its movements.

Besides, local authorities often take each other’s performance indicators and measures without consideration of prerequisites of what are they estimated for with respect to various urban impacts (Van Duin, 2005). This negatively affects planning in cases when local authorities consider economic interests separately from ecological and social ones, by considering them as trade-offs. Because of that, it is problematic to make a balance between them (Lindholm, 2012; 2014). Overall, this shows the complexity of incorporating urban freight transport problems in strategic planning. Lindholm and Blinge (2014) argue that there is no urgent need to focus on planning processes in urban freight, the market itself and local businesses can handle this issue by creating the most cost-efficient transport and distribution system.

Another problem is incompetent surveying approaches. Among respondents, only 10% have a degree in logistics or similar subjects (Lindholm, 2010). The most common pitfall of the majority of measures is its implementation without prior assessment of the results (Filippi et al., 2009). Comparing different approaches in making surveys, it is clearly visible the high dependence on basic studies regarding freight transport (Ambrosini et al., 2010). Other approaches are not suitable due to some units of measurement, which don’t work properly within a field of urban freight.

By taking into account several models of surveying (Japanese, Canadian, and French) it is clear that other approaches (long distance transport indicators) are not relevant within a field of urban transport. Instead, it’s better to combine measures based on local indicators with a close collaboration, making surveys with drivers to get an efficient modelling (Ambrosini et al., 2010). Filippi et al. (2009) offer two strictly separated types of surveys. The first one is regarding traffic surveys and counting the local statistics, interviews with the truck drivers; and another one regarding interviews with retailers.
2.1. Role of Local Authorities and Stakeholders

One of the most common complaints to local authorities is that they often use restrictions and prohibitions in order to influence the situation. It occurs because of a weak collaboration between different local authority internal departments (e.g. environmental, strategic planning and traffic departments) and the heterogeneity of the environment of its operation in order to satisfy various expectations of the stakeholders (Ballantyne et al., 2013).

Besides that, different interest groups have different priorities regarding distribution effectiveness and it is still problematic to implement a common discussion ground for all actors. Bjerkæn et al. (2014) offer a ground based on theoretical representation and practical aid with approaches of measuring the implementation, whereas Iwan (2014) proposes Freight Quality Partnership (FQP) as the basis. According to him, it is a most probable site for various stakeholders for implementing planning and strategies in the scale of local areas and districts.

Ballantyne et al. (2013) don’t support current initiatives for the reason that all these approaches satisfy interests of business and stakeholders, as they take the “business-oriented stance”. It is required to find a solution applicable for all actors, to find a happy medium in restrictions, allowances and awareness between all urban freight participants. In turn, the author suggests a number of possible activities: (i) Changes in the schedule (outside working hours and during the night), (ii) Applying access restrictions in some urban areas, (iii) Allowing commercial vehicles to use bus lines, (iv) Producing guide maps for drivers, including key information about restrictions and routes, and (v) Implementing zoning policies, separating residential areas from freight transport.

2.2. Networks, Planning & Policy Packages

One of the main problems identified by Bertolini et al. (2008) is declining strategic capacity and the need to re-scale the transportation networks. Rapid sprawl in the urban areas occurs due to globalization processes: constant revision of current city territories and attachment of suburb areas without no prior planning both reveal the problem of the declining strategic capacity. For this reason, there is a need to revise planning institutions in order to prevent appearance of negative solutions of strategic capacity in the near future, which already shows a sharp decline (Castells, 1996; Storper, 1997).

Dablanc (2007) argues over these initiatives by saying that it is inappropriate to implement planning in various areas and urban districts without the prior consultation and support with transport department’s representatives. Instead, the author proposes a simple working access to the city for freight delivery trucks, which will be made in close cooperation with business representatives and local authorities. This will help to achieve a bigger part of business participation in the decision making process regarding air quality, fleet modernization and improvements of urban truck operations efficiency.

Planning should be efficient and fair, implementing “easy-to-measure” impacts, using basic and traditional methods of problem solving (Litman, 2012). Litman (2012) doesn’t support the idea of implementing innovative methods of measurement because of its complexity and bias. There is also a need to set targets (using the historical and statistical sources, transport modelling programs) for the near future and to forecast business so that the common scale of assessments could be clearly seen (Hickman and Banister, 2007). Instead of forecasting with the present of short periods of time, Hickman and Banister, (2007) offer the backcasting approach, which represents ‘desirable solutions’ to relevant problems.
Hickman and Banister (2007) and Banister (2008) see a need of combining "push and pull" policy measures into supporting packages. In contrast to Hickman and Banister (2007) and Banister (2008) as well as Ballantyne et al. (2013) consider that policy packages complicate current policy making system. Among main uncertainties the authors mentions: (i) Large number of policy packages, which can become confusing, (ii) Diversity of implementation methods, (iii) Lack of response rate especially to policy packages, and (iv) Response of freight stakeholders.

For most efficient policy implementation and reduction the CO\textsubscript{2} levels, it is necessary to combine policies equally (Eriksson et al., 2008). Usually, this kind of policy implementation called "push & pull". Push measures aim at raising charges to force people to choose more ecologically friendly type of transport, while pull measures aim at improving the current state of transport system, providing alternative options, including public transport. According to Eriksson et al. (2008), systematic application of this framework can help to achieve significant results.

### 2.3. Emissions Reduction

The main problem in the strategy of reducing environmental impacts and making urban freight transport more ecologically friendly is a lack of coordination in planning. While proposing these initiatives, the mobility management is often overlooked as well as the following co-benefits, despite the cases, when it happens on an unpredictable manner (Litman, 2013). To put it simply, the number of vehicles should be reduced, but in close cooperation with other types of policies, otherwise all the initiatives ignored are aimed to congestions reduction, public traffic improvements, mobility for non-drivers, traffic safety and consumer savings (Litman, 2013).

According to research made in small municipalities in Poland, Iwan (2014) consider that the biggest issue, which affects the increasing number CO\textsubscript{2} impacts, is the usage of used vehicles (e.g. old diesel-powered) and low system efficiency (e.g. low loading factor, and low cooperation between actors). In this respect, it is necessary to pay attention to: (i) Decreasing the number of total transported distances inside of cities, (ii) Strictly promoting environmentally friendly engines (or electrically powered) jointly with utilization of used vehicles, (iii) Reduction of pollutants (e.g. CO, CO\textsubscript{2}, NO\textsubscript{x}, and particulate emissions), increasing the amount of low and/or zero emission in urban areas, (iv) Reduction of the number of freight trucks within cities by implementing strong restrictions against most heavy and polluting trucks, and (v) Improving the collaboration processes at the local level among the relevant stakeholders, as well as removing non-technological barriers, promoting public and private initiatives (Iwan, 2014). Ignorance and non-interference in the strategic planning processes increases CO\textsubscript{2} impacts. A bigger number of problems will occur in case of implementing the restriction of access for delivery trucks (Filippi et al., 2009). Freight traffic restrictions are not a cure for making an urban surroundings more sustainable. In turn, Filippi et al. (2009) propose the way of implementing UFCs (Urban Freight Centers), which can give an average reduction traffic movement rate of 15\%, whereas the CO\textsubscript{2} and noise level are reduced by about 24\%. However, there exist empirical research works (such as Österle et al., 2015), where urban consolidation has been experienced by private companies as costly and inflexible – users just can not see the benefits of more frequent material flow (and alas lower inventories) to retail shops.

### 2.4. Economic Perspective

Because of a lack of cooperation in the market, there is a high dependence on the external factors and government involvement, Santos et al. (2010) offer solutions. According to their research, there are two types of economic interventions: command-and-control (essentially
regulations; CAC) and incentive-based (provide financial incentives to consumers; IB) policies. Each of them is categorised as price and quality controls.

In the article, while comparing these two types of policies, Santos et al. (2010) claim that CAC is not efficient enough as IB policies, especially regarding cost effectiveness. Using IB policies is easier to correct externalities on social welfare. Moreover, the political acceptability is higher. In conclusion, they underline the idea of usefulness of any policies by the reason of initial efficiency for the transport sector despite on their competitiveness’ factors.

Nevertheless, the author mentions that such kind of policies should be used punctually even they looked efficiently from the economic point of view. The biggest profit the city could gain from implementing taxes is to reinvest them back to field as a way of supporting green and infrastructure related technologies.

3. URBAN FREIGHT CENTERS

Over time, government and local authorities started to be aware of the dimensions of urban freight logistics. Currently, one of the major roles is given to urban freight centers (UFC), which is also known as urban consolidation center (UCC) or Freight Consolidation Centre (FCC). Generally, most authors consider UFC as a cross-docking terminal with complex installations and multiple functions, in which small consignments are coordinated into batches matching different vehicle capacities. It should be located at the breakpoints in the transport chain and enable to utilise their resources efficiently by separating the distribution activities for inside/outside of the city (Olsson and Woxenius, 2014). By doing so, it results in a minimized number of vehicles entering the city. The idea is to increase the utilization rates of vehicles (Olsson and Woxenius, 2014; Agrebi et al., 2015) and to facilitate vehicle load factors and the reduction in the trips number and vehicle mileage.

Technically, the UFC implies and addition of a stage to an existing supply chain (Marcucci and Danielis, 2007). As for business representatives’ interests, they are following (Malhene et al., 2013): (i) Maximizing retail space and store staff, (ii) Reducing of the ‘final mile’ delivery costs, (iii) Increasing and making more flexible time-windows deliveries for distribution chain, (iv) Supporting social targets, and (v) Managing congestion issue.

The issue attracts attention of local authorities, especially in the field of green logistics. UFCs have been increasingly promoted as an instrument to gain greater improvements in the air quality, CO\textsubscript{2} emissions and noise reduction, achieving high effectiveness of land use (through reductions in the total distance travelled; Malhene et al., 2013; Allen et al., 2014). Several authors (Allen et al., 2014; Chwesiuk et al., 2010) examined UFCs through theoretical perspective. Allen et al. (2014), for instance, subdivided UFC into three categories depending on the area that the UFC serves for: i) UFCs that serve all or part of an urban area, ii) UFCs that serve large sites with a single landlord such as a shopping centre, airport, or hospital, and iii) UFCs that serve major construction sites. Categories, made by Chwesiuk et al. (2010) are slightly similar those made by Allen et al. (2014), defined as local (for specific trade areas, city centers or the whole city), one-owner areas (built as a unit performing services on a specified location, belongs to one owner) and special projects (those which are not connected to retail services).
3.1. Location Problem, Urban Sprawl and Infrastructure Issues

One of the main problems seen by Agrebi et al. (2015) is the location issue; basically, as a way to minimize costs and to fulfill the demand. Long distances between the depot and the customer(s) exacerbate the negative impact of congestion (Tozzi et al., 2014). In other words, just the location itself values future incomes and its profits. In addition, the author also emphasizes: investment costs, the possibility of spread, the availability of hardware acquisition, human resources and proximity to suppliers.

There still exists a problem of traffic congestion. Most of the delivery problems (Vidal Vieira and Fransoo, 2015; Nordtømme et al., 2015; Allen et al., 2014; Chwesiuk et al., 2010) are caused by narrow streets, traffic obstructions in the historical centers, high number of intersections, and limited unloading facilities. Strict timetables and zone circulation for cargo vehicles restrict availability of parking and unloading areas and contribute to an increase in long queue (Vidal Vieira and Fransoo, 2015). Long queues and unsuitable loading/unloading and parking areas cause delays, which disrupt route planning and result in more time spent on delivery (Vidal Vieira and Fransoo, 2015). All of these can in turn cause detour.

To make UFC look more attractive for smaller vehicles and to avoid traffic issues, Nordtømme et al. (2015) propose access restrictions for trucks over 3.5 t. Tozzi et al. (2014) claim that in the context of small cities (e.g. Parma), solving the above mentioned issues will increase the average speed of freight vehicles by 35%. Vidal Vieira and Fransoo (2014) conclude that load/unload interfaces have a huge negative influence on the production and UFCs, which mediate the negative effect of lack of collaboration on logistical performance. Among other initiatives, Allen et al. (2014) consider that it is important to cooperate with ideas proposed by city authorities, primarily on traffic and environmental grounds, and may receive some form of public support.

There is also a trend for retail chains to use central warehouses, supplying a wider area. In this case, as Olsson and Woxenius (2014) consider, local warehouses imply longer distribution distances and a need for additional consolidation points. Also, there is another problem; arrangements and the way of involvement for those companies, which are not based in urban areas.

Hassan and Lee (2015) give a great importance to urban sprawl. According to the authors, dispersed development, shrinkage of open spaces due to immigration, mono-functional land use, and highly increased dependence on private vehicles are usually caused by the urban sprawl. Hassan and Lee (2015) illustrate further, that dependence and weak engagement of government and its fiscal responsibility make transportation issues even worse, especially in municipalities. These kind of problems essentially put the city’s economy under pressure whereas additional investments into infrastructure provide just a temporary relief. In this case, as various researchers consider (Hassan and Lee, 2015; Yang and Deng, 2013), implementing KPIs and policy packages could influence the situation in the better way, towards creating sustainable urban development.

3.2. Collaboration between Residents and Local Authorities

Process of making the system of urban freight transport more sustainable, is not possible without a close collaboration with all the actors within a field, including residents and local authority departments (economy, social and environmental ones). Vidal Vieira and Fransoo (2015) consider, that problems such as traffic congestion, use of unsuitable unloading and parking areas commonly appear from the lack of collaboration between logistics service operators and receivers. Nordtømme et al. (2015), by researching project named GUD, use
surveys with two different focus-groups: examining needs of the stakeholders and aiming at the UFC implementation in Oslo. The preference of authorities was different to preferences of carriers; the former opted for off-hour deliveries and UFC, the latter adopted regulatory measures with high priority to freight distribution vehicles in the city center. Although the end receivers agreed with carriers for the most part, they were negative towards off-hour deliveries. The two largest carrier companies that were affiliated with the GUD project did not have interest in using potential UFC, due to carrying goods that are already consolidated and have strict temperature requirements. A brief change to their routines was also rejected, as this would bring additional costs related to human resources and IT systems. The problem with time-sensitive goods is very relevant in this case. The main difficulty consists of requirement for perishable goods and need to make the delivery chain as short as possible. In the case with centers, uncertainties between partners could extend the cycle and cause delays. As studies have shown (Olsson and Woxenius, 2014; Nordtømme et al., 2015), courier deliveries are difficult to consolidate.

Also, one of the main barriers is represented by resistance to change from stakeholders who have invested in and adapted to existing infrastructure. UFCs at first being a demonstration seemed to be of negative impact to some carriers, as they would not change their routines for “just a trial” of limited duration. This shows the difficulty of engaging private stakeholders in research demonstrations (Nordtømme et al., 2015).

There are several unresolved issues with such an arrangement, involving of freight and service companies that are not based in urban areas as well as involvement a significant proportion of all relevant companies (Olsson and Woxenius, 2014). Van Rooijen and Quak, (2010) combine the problem of UFCs with retailers. In case of Binnenstad in Netherlands, retailers efficiency got themselves under pressure, because of unexpected regulations made by local authorities, such as time-windows, separated ecological zones and truck restrictions. Nevertheless, consolidation is possible, but the concepts of retail distribution and city consolidation centers are different (Van Rooijen and Quak, 2010). Commonly, urban-store deliveries use a combination between these two.

Uncertainties also happen, because of those who should carry the financial burden and how the potential profits could be gained from it. According to UFC project in Oslo, there was no plan for how costs should be financed and who would benefit from saved costs. The stakeholders’ willingness to engage in the UFC relates to their expectations of who should bear the costs for reducing externalities from freight transport. They did not necessarily consider it fair that they should be “punished” for supplying necessities to a living city (Nordtømme et al., 2015).

### 3.3. Role of Government and Policy Restrictions

Governmental regulations aimed at decreasing traffic congestion, harmonising land use, reducing environmental burdens, and improving logistical flows can directly and negatively affect the freight distribution system by exacerbating imbalance between use of “light goods vehicles” and land availability for parking, loading/unloading areas, and traffic safety (Vidal Vieira and Fransoo, 2015).

Nordtømme et al. (2015) maintains that the main difficulties with implementing the UFC are related to recruitment of users and establishing appropriate sign regulations. Legal barriers arise when implementation faces some legal requirements. According to the case of UFC in Oslo, where the difficulty started with a need of adjusting the additional road signs, which haven’t existed at that moment. Those should be signs, developed especially for UFC regulation. That legislation, finally, complicated the practical implementation of the UFC.
Supporting the idea of restrictions, Marcucci and Danielis (2007) had shown the benefits of implementing policies into current system of UFCs. Basically, these policies deal with: free UFC’s service costs (Policy 1; P1), twice-reduced delivery time (Policy 2; P2), paid access to the downtown for freight vehicles (Policy 3; P3), and distance to the stores from the parking bays increased from 0 m to 100 m (Policy 4; P4).

Implementing the P1 policy (zero delivery cost) gives the boost from 13% to 29% in probability of choosing UFC, but all the expenses are carried by public authorities. Using P2 policy (half of the previous time delivery) will increase the UFC choice probability to 21%. P3 (increased cost for an access permit), financially carried by transportation companies and final customers, probably would have a rate of up to 27% of the UFC choice probability. This represents the second best result after P1, but definitely will negatively affect small business located in the city centre by all the categories influenced by it (Marcucci and Danielis, 2007).

Making a matrix with combination of these policies with each other, the authors don’t forget to mention that the average type of goods will be connected to small business such as restaurants, clothes and souvenir stores etc. According to Marcucci and Danielis (2007) opinion, among all the policies, P3 is most likely to be accepted due to political reasons. Overall, for businesses located in the city centre, UFCs are able to increase the rate of attraction by 13%. With an addition of more stringent traffic regulations the rate could achieve the share of 25–27%, whereas time efficiency of the UFC will give the share of 21%. Providing the UFC on the basis of zero costs would raise the share up to 29%. The mix of implementing various policies or the most effective ones might increase that share to up to 50% (Marcucci and Danielis, 2007).

### 3.4. Business Issues

According to many studies (Olsson and Woxenius, 2014; Vidal Vieira and Fransoo, 2015; Nordtømme et al., 2015), there is a lack of cooperation among all actors: Business representatives, carriers, stakeholders and local authorities in case of implementing the UFC. The reason it happens, is the high diversity of interests in freight distribution systems, related to time and local delivery issues and unwillingness to collaborate with each other, assuming their own costs and handling problems independently. Overcoming conflicts of interest is extremely demanding especially in case of actors, who mostly think about the amount of loss rather than approximate profit. It turns out that covering costs and the difference between goals of carriers and end-receivers causes major obstructions to UFCs (Nordtømme et al., 2015).

In case of implementing the UFC in Gothenburg (Olsson and Woxenius, 2014), some 75% of the small road hauliers (SRHs) had no prior experience of consolidation. The majority were negatively disposed towards it, independent of geographical area, with 70–80% of the SRHs feeling that there was either an insignificant opportunity or no opportunity to consolidate freight via an UFC. Many studies have also shown that the estimated number of participating actors prior to the establishment of an UFC is higher than the number actually participating, resulting in lower-scale economies than anticipated (Olsson and Woxenius, 2014).

Also, a survey was conducted in order to find out and discuss commercial issues and pricing, including willingness to pay for the services. Unwillingness to discuss such things is a consequence of acting in an industry, where firms face similar costs, of which several are fixed, offering a commodity that cannot be stored, which results in fierce price competition (Olsson and Woxenius, 2014).

A comparable initiative with a consolidation center failed in Leiden in the late 90’s (Van Rooijen and Quak, 2010). Some delivery companies decided not to join the project by the reason of unwillingness to collaborate with their competitors. Among the failures factors Van
Rooijen and Quak (2010) mention: (i) The location, which was too far from the highways and the city center, (ii) Support of the time windows and vehicle restrictions, which affected UFC in opposite way as expected, (iii) Support of the electric vehicles, which eventually slowed down the traffic in surrounded area, and (iv) Lack of volume (financially not viable).

4. DISCUSSION

The results of the research provide an overview on the relevant barriers regarding movements of goods in urban area, especially in the field of planning and city administrating. At first, cooperation between local actors and their initiatives is seen as a relevant problem. Mostly, collaboration work among all actors, coordinated policies and strategic planning, information, statistical data/data acquisition and implementing new freight trucks technologies for city distribution, are the mains issues to deal with regarding urban freight. In order to provide “a common discussion ground” among all the actors, city-administrating representatives can take the leading role.

Here is the sequence of issues come from: poor planning and lack of private initiatives. About a half of the cities are not capable of planning regarding urban freight transport. Restrictive measures are recommended for the most polluting and heavy freight vehicles; also to improve the cooperation at the local level among the relevant stakeholders, as well as removing non-technological barriers, promoting public private initiatives, etc.

While in the process collection of urban freight data, it is important to keep the units of analysis and classification terms consistent between studies. This would help to ensure greater comparability between the results of different studies. This way it would be possible to combine the results of smaller studies in order to see the whole freight transport activity picture (Van Duin, 2005). It would be also beneficial to introduce permanent or periodic surveys in the field as they provide an important basis for evaluation of suitable measures.

Also, there is a need for paying more attention to focusing at the role of stakeholder involvement in the process of policy making. More attention should be kept to smaller cities as they are aware of the ongoing changes such as new operational and technical possibilities (e.g. traffic management, modelling tolls, enforcement support, etc.), distribution processes (e.g. e-commerce, Intelligent Transport Systems), and policy changes (e.g. scenarios, policy packages) in order to make improvements in the situation.

Finally, it's important to dedicate more attention to reduction of pollutants (e.g. CO, CO₂, NOₓ, and particulate emissions) emitted by goods vehicles, increasing the number of low and/or zero emission of freight trucks circulating inside of cities or near areas, and finally, the reduction the total amount of trucks in the urban areas (especially in city centers).

4.1. Urban Freight Centers

Regarding solutions and practical initiatives, firstly need to mention that on the basis of evidence available, the University of Westminster Report (2005); Marcucci and Danielis, (2007) gives a conclusion that UFCs are basically good with the following conditions:

1. specific and clearly defined geographical areas, where there are delivery-related problems;
2. town centres that are undergoing a “retailing renaissance’’;
3. historic town centres and districts that are suffering from delivery traffic congestion;
4. new and large retail or commercial developments (both in and out of town); and
5. major construction sites.

In order to increase the attractiveness of a UFC to potential users, recent studies emphasize the importance of value added services, that is, services from which end-receivers/users can benefit and are willing to pay for. Business model implemented in Oslo also has shown need on charging for added value services. Such services typically include handling of goods in stores, mail services, and handling return goods and waste (Nordtømme et al., 2015).

A model made by Vidal Vieira and Fransoo, (2015), indicates that detour is directly and indirectly caused by governmental regulations and indirectly caused by lack of collaboration between partners. The results reveal regulations and lack of collaboration appear to be the most important constructs in the model. There is a need to keep more attention to planning processes. In case of implementing a center in Oslo the project itself was first seen as an advantage as it would be limited in time and scope (and hence less binding). Later, however, being a trial was used as an argument not to be involved, as changing routines for a limited time was seen as too costly (Nordtømme et al., 2015). Because of that, it is recommend to keep more attention to planning procedures and involve all potential actors on an earlier stage as possible, despite if it is a trial or not. Moreover, continued focus on collaboration and finding solutions is needed for more environmentally friendly freight that are acceptable to all parties. A formalized network with representatives from stakeholder groups should be established, where problem issues and possible measures are presented and discussed (Nordtømme et al., 2015).

Delays in centers upon loading/unloading give a straight influence, especially to the stakeholders. In addition, acceptability of UFCs among private stakeholders is relatively low. According to their initiatives, there is a need of reducing the number of freight vehicles and availability; to restrict the loading schedule, but that will definitely cause recession in the volumes of goods. Vidal Vieira and Fransoo (2015) suggest more careful cooperation between drivers, shipper partners and freight operators, especially regarding local parking, accessibility, regulations, and flexibility to receive the goods in off-time windows.

Nordtømme et al. (2015) supports the idea of Vidal Vieira and Fransoo (2015), also on the level of collaboration between companies, which can lead to new ways of organizing freight activities, requiring public–private collaboration. Companies could also invest in conducting periodic meetings to share demand forecasting, improve fleet and route planning, and solve some problems related to factors such as delay, mistakes, damaged goods, and theft.

As for green effect and emission reduction, Van Rooijen and Quak (2010) consider that they are limited regarding local air quality and noise nuisance due to passenger transport traffic and the high natural background concentration of PM10 and NO2. However, Olsson and Woxenius (2014) show on the example of UFC in Gothenburg, where former freight delivery routines were replaced with one electric vehicle, it resulted with about 50% of pollution and noise reduction. But the most important fact is that the amount of undesirable traffic and extra vehicle movements was reduced by 30%.

4.2. Relevant Problems of Implementing UFC

As it was previously described, current study aims at identifying and categorizing issues towards implementation of a UFC, which is seen as one of the main relevant solutions in the field of urban freight. To summarize all given barriers, research draws the matrix of relevant problems to achieve sustainable freight transport center solutions. Table 4.1 provides an overview of current identified barriers in the field of implementing UFC. It also gives an author’s assessment to each of the problems based on sampled literature e.g. how do authors...
from the sampled articles evaluate it. The evaluation can be seen from the “Significance” section, where levels divide into: Highly, Quite or Less important ones. Finally, table provides possible ways to overcome mentioned issues.

Table 4.1 Relevant problems in the field of implementing UFCs.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Significance</th>
<th>Actor</th>
<th>Action/Potential Solution</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location problem</td>
<td>Highly important</td>
<td>City</td>
<td>Traffic monitoring, collecting data regarding freight movements</td>
<td>Agrebi et al., 2015</td>
</tr>
<tr>
<td>Poor collaboration between residents, business representatives and local authorities</td>
<td>Highly important</td>
<td>Private stakeholders, authorities and research partners</td>
<td>Implementing common discussion grounds with taking into account public private initiatives</td>
<td>Hassan and Lee, 2015; Olsson and Woxenius, 2014; Vidal Vieira and Fransoo, 2015</td>
</tr>
<tr>
<td>Extra supply chain point for time-sensitive goods, detours</td>
<td>Highly important</td>
<td>Private stakeholders, local authorities</td>
<td>Policy and UFCs usage preferences</td>
<td>Olsson and Woxenius, 2014; Nordtømme et al., 2015</td>
</tr>
<tr>
<td>Congestions; UFC’s ineffective usage in unloading and parking areas</td>
<td>Highly important</td>
<td>Private stakeholders, local authorities</td>
<td>City access restrictions, use of more strict time-windows</td>
<td>Vidal Vieira and Fransoo, 2015; Tozzi et al., 2014; Allen et al., 2014; Chwesiuk et al., 2010; Marcucci and Danielis, 2007</td>
</tr>
<tr>
<td>Urban Sprawl</td>
<td>Quite important</td>
<td>City</td>
<td>Revision of the city’s network, access restrictions (via policy packages)</td>
<td>Hassan and Lee, 2015; Vidal Vieira and Fransoo, 2015</td>
</tr>
<tr>
<td>Ineffectiveness of extra investments</td>
<td>Quite important</td>
<td>Private stakeholders, private authorities</td>
<td>More accurate strategic planning, priority of the policies</td>
<td>Hassan and Lee, 2015</td>
</tr>
<tr>
<td>Poor expected financial profit from UFC</td>
<td>Quite important</td>
<td>Local authorities</td>
<td>Financial planning, early integration of business representatives to documentation and planning</td>
<td>Chwesiuk et al., 2010; Nordtømme et al., 2015</td>
</tr>
<tr>
<td>Reduce of retail efficiency because of restrictions</td>
<td>Quite important</td>
<td>Local authorities</td>
<td>Financial and policy preferences</td>
<td>Van Rooijen and Quak, 2010</td>
</tr>
<tr>
<td>Conservatism of the carriers (no motivation to change their routine for a</td>
<td>Quite Important</td>
<td>Carrier representatives, local authorities, stakeholders</td>
<td>Increase use of financial support and investments, giving some policy preference of usage the UFCs</td>
<td>Nordtømme et al., 2015; Olsson and Woxenius, 2014; Van Rooijen and Quak, 2010;</td>
</tr>
<tr>
<td>Issue</td>
<td>Significance</td>
<td>Actor</td>
<td>Action/Potential Solution</td>
<td>Authors</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>“trial” projects like UFCs</td>
<td></td>
<td></td>
<td></td>
<td>Chwesiuk et al., 2010; Österle, 2015</td>
</tr>
<tr>
<td>Poor sign regulation</td>
<td>Less important</td>
<td>Local authorities</td>
<td>More accelerated processes of implementing new regulations</td>
<td>Nordtomme et al., 2015</td>
</tr>
</tbody>
</table>

5. CONCLUSIONS

Research aimed at identifying and evaluating issues of urban freight transport to establish a UFC, and proposing discussion regarding policy making process and actions to overcome the constraints and caveats. The literature review has shown an evident misunderstanding between all actors, who are part of developing urban areas. Moreover, this leads to a poor integration between all parties, especially when it comes to strategic planning. Economic, social and environmental interests are being separated by local authorities.

Increasing urban sprawl combined with the lack of knowledge, weak support of survey data highly affect the field of urban freight and UFCs. Also, collecting relevant data, freight transport movements or any kind of statistics regarding small cities is complicated due to lack of interest (local authorities and stakeholders). It leads to heterogeneity and unbalance, influencing on policy initiatives and restrictions without having any common discussion ground. Thus, a proper network with representatives from stakeholders, business and local authority should be established. Many of the current approaches regarding implementation of the UFCs are not suitable due to their dependency on arbitrary units of measurement that do not work properly within a field of urban freight transport.

Implementation of UFC has been increasingly promoted as an instrument to gain greater improvements in environmental and financial states as well as in reducing the congestion. In order to achieve these, the importance of value added services must be taken into account (end customers benefit and are willing to pay). For that, it is important to have flexible policies for city-center access, off-time windows, local parking restrictions and so on.

Concerning further research on the field, successful case studies out of megacities and freight transports would be in our interest. Also developed cities (less populous), in process of implementing drastic emission reductions and payment schemes is another further avenue.

REFERENCES


TOWARDS A CHARACTERISATION OF HUMANITARIAN ORGANIZATIONS AS LOGISTICS SERVICE PROVIDERS

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ABSTRACT

Purpose
The humanitarian context has evolved through time, and so have the actors involved. Humanitarian organizations have improved their logistics developing specialised divisions - defined as Humanitarian Service Providers (HSPs) - capable of supporting their own activities, as well as offering logistics services to the humanitarian community. Nevertheless, academic literature on humanitarian logistics does not really explore that evolution, or the characteristics of these dedicated logistics providers. The purpose of this paper is to study the concept of HSP and to characterize these particular players in light of the Logistics Service Providers (LSP) literature.

Design/methodology/approach
This research is based on a two level content analysis based on annual reports from some of the most important Humanitarian Organizations (HOs) performed with the help of a Qualitative Data Analysis Software. First, a manifest content analysis identified the number of occurrences of logistics-related words and later, a latent content analysis studies the use in context of such words to characterize the nature of HSPs.

Findings
The main result of this research is that specialized logistics units from international humanitarian organizations have mainly the same characteristics as commercial LSPs. However, due to the characteristics of the humanitarian context, HSPs can have a wider range of dedicated services offered to clients (other HOs) than commercial LSPs.

Research limitations/implications
Research should complement this analysis with HO’s perspectives both from HSPs and clients in order to produce primary data.

Practical implications
The characterization of HOs as service providers can introduce a new actor to humanitarian supply chains, differentiating them from classic HOs to further investigate their role.

Original/value
It constitutes a first attempt to define and characterize the concept of HSP, thus contributing to the ever-growing body of knowledge of humanitarian logistics research.
1. INTRODUCTION

The humanitarian context is constantly evolving, and so are the actors involved and the roles they play. Logistics in this context, defined as “the process of planning, implementing and controlling the efficient, cost effective flow and storage of goods and materials as well as related information from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people” (Thomas and Mizushima, 2005, p. 60) is mostly performed by Humanitarian Organizations (HOs) as part of their activities. To carry out their main mandate, these organizations have developed “a professional approach in logistics” (Kovacs and Spens, 2011a, p.34), using information technologies to track and trace their goods (Sandwell, 2011) and even performing logistics activities for other organizations (Kovacs and Spens, 2011b). Abidi et al. (2015) note that the need for “timeliness flexibility and reliability of delivery are some key drivers that explain why HOs develop logistics concepts for other HOs”. Heasl i p (2013) presents various examples of these practices such as IFRC providing procurement and transportation, or WFP acting as consignee for other HOs, and later states that “most of the services humanitarian organizations offer to each other fall under the realm of logistics” (2014, p. 116).

HOs could therefore be considered as Logistics Service Providers (LSPs), actors who “manage, control and deliver logistics activities” (Hertz and Alfredsson, 2003, p. 140) given their capacity to perform logistics activities on behalf of other humanitarian actors. Despite the contextual differences existing between humanitarian and business logistics (Van Wassenhove, 2006), “both processes account for the flows of goods between the nodes of a network” (Gosling and Geldermann, 2014, p. 23). Constrained by many complexities (Overstreet et al., 2011), humanitarian logistics players must deal within an embedded network of actors and perform various logistics activities as their counterparts in the private sector.

Although academic literature on humanitarian logistics exhibits a considerable increase of publications since 2009 (Zary et al., 2014), with a very few exceptions (Abidi et al., 2015) the notion of HOs functioning as LSPs is seldom explored. The purpose of this paper is to explore the new role that is played or could be played by humanitarian organisations as logistics service providers. This investigation constitutes one portion of a broader research program that aims at identifying the nature and role of logistics providers (commercial or non-profit) performing in the humanitarian context, but also at studying their distinct activities and their cooperation/coopetition strategies. The paper is structured as follows. Section 1 details our research design. Section 2 presents the results of the qualitative content analysis we performed. Results are presented in section 3 and then discussed (section 4). Conclusion addresses limitations and future research.

2. RESEARCH DESIGN

The following section summarizes the research design and describes the research method as well as the data collection and the analysis techniques used for this investigation. Considering

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1 “Humanitarian organizations are defined as those non-for-profit organizations - regardless of their size, geographical or thematic focus - whose activities facilitate or include the delivery of aid or assistance in order to save lives and alleviate human suffering”. Samii (2008, p. 24).
the emerging state of this topic, an exploratory approach is adopted as it allows to examine a new area and to generate new ideas, conjectures, or hypotheses (Neuman, 2007). Ketokivi and Choi (2014, p.134) argue that when “the research context is novel and unfamiliar”, explanations (theory) can be derived from exploration and analysis. Following their recommendation, this research is not based on any pre-existing theoretical foundation. Instead, an inductive approach was adopted seeking to explore the phenomenon based on the study of HOs’ annual reports. Through the method described in the following section, the activities performed by HOs as described in their annual reports are examined, in order to check if some of those activities can be considered as logistics services and further on, if they are performed on behalf of other organizations. Altogether, the ability of HOs to play the role of a LSP is explored using textual data, seeking for the nature of the services they perform, as well as the organizations for which they do it.

2.1. Research method

From the several research methods used in logistics research, ranging from mathematical modeling and simulation to survey research or from case studies to interview methods (Mentzer and Kahn, 1995), this research relies on one of the methods used to analyze text data: qualitative content analysis. Holsti (1969, p. 14) defines content analysis as “any technique for making inferences by objectively and systematically identifying specified characteristics of messages”. In traditional content analysis, often referred to as quantitative analysis of qualitative data (Morgan, 1993), a set of categories is established by the researchers and then, the numbers of instances that fall into a category are counted and later described using statistics (Silverman, 2006). Instead, qualitative content analysis goes beyond counting words to examining content in order to classify large amounts of text into a number of categories that represent similar meanings (Weber, 1990). In much cases, “content analysis research is motivated by the search for techniques to infer from symbolic data what would be either too costly, no longer possible, or too obtrusive by the use of other techniques” (Krippendorff, 1980, p. 51). Taking into account the scope of this research project and seeking to include the most number of subjects (HOs) in the study, content analysis results as a suitable technique that allows us to explore a large topic that would have been extremely costly in terms of time to conduct directly on the field.

2.2. Data collection

When it comes to data collection, a great importance must be given to the selection of the database that is used for a study and to its relevance to the field. In order to find the most suitable database for this research, a search for global NGO lists or rankings was performed seeking to find a comprehensive array of HOs as varied as possible. The results show a very wide range of lists from the estimated 10 million NGOs worldwide by the Public Interest Registry (PIR). Some of these include the World Association for Non-Governmental Organizations’ (WANGO) worldwide NGO directory (55518 entries), the Union of International associations’ (UIA) yearbook of international associations (68576 entries) or Reliefweb’s directory of organizations (2850 entries). Surprisingly, none of the above present any criteria or explain the method chosen to include (or exclude) organizations from the list.

One result that outstands among the others is Global_Geneva’s 2015 Top 500 NGOs, a ranking that grows out of The Global Journal’s 2012 and 2013 Top 100 NGOs rankings, which have been expanded to the Top 500 from over 2000 NGOs surveyed following three criteria, namely
impact, innovation, and sustainability. As stated by Cannon (2013, p. 10), “no efforts have been made by scholars to evaluate NGOs for the purposes of producing a ranking of organizations [...]. No one prior to The Global Journal’s 2012 ranking of NGOs has published a comparative analysis of NGOs at the international level, assembled according to specific criteria”. This, in addition to the fact that NGOs themselves refer to this ranking (e.g. Care, Handicap International, Mercy Corps), indicates that this database could be considered as a good start for an explorative study such as the one pursued with this research.

In order to produce a targeted sample for this study, the 500 NGOs ranked in the list were filtered using the keywords emergency, humanitarian and relief found in the “sector” filter. A total of 36 NGOs were shortlisted, to which four major organizations (ICRC, IFRC, UNICEF and WFP) were added as these did not make part of the Top 500 ranking due to their tight relationship with governments, which makes them ‘less’ non-governmental. Cannon (2013) points out this limitation on The Global Journal’s methodology and encourages the editor to consider the inclusion. Given the attested importance of these four HOs (Schultz and Blecken, 2010) and the interest on using, as much as possible, a comprehensive database, their inclusion has been considered as appropriate. For each one of the 40 HOs, every available annual report was downloaded from the official websites to constitute the research database for the content analysis. As pointed out by Guthrie et al. (2004), annual reports are useful sources of information, given that companies generally point out what is important through the reporting mechanism. These also have the advantage of being “regularly produced and offer an opportunity for a comparative analysis” (Niemark, 1995, p. 100).

14 HOs were discarded from the study due to unavailable data (AMDA, Doctors Worldwide, NICCO, Taiwan Root Medical Peace Corps), language (CODE, Future Code, JIM-NET – Japanese; German Doctors – German) or type of mandate (Children on the Edge, Consortium of Humanitarian Agencies, Crisis Action, Kindernothlife, Saferworld, U.S. Committee for Refugees and Immigrants) focusing on social work, advocacy or human rights. From the 227 annual reports available online from the final 26 HOs used for this study, the last three annual reports available were selected to avoid discrepancy in the number of documents used per HO. A final database of 76 reports constitutes the sample for this research (Table 2.1).

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2 For more information about the Top 500 NGO Ranking, please visit http://www.top500ngos.net/evaluating-and-ranking-non-governmental-organisations/ for a full methodology description.
Table 2.1 Study Sample

<table>
<thead>
<tr>
<th>Name</th>
<th>Ranking</th>
<th>Country</th>
<th>Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>ActionAid (AAI)</td>
<td>54</td>
<td>South Africa</td>
<td>Emergency - Inclusion</td>
</tr>
<tr>
<td>Action Contre la Faim (ACF)</td>
<td>178</td>
<td>France</td>
<td>Relief - Nutrition &amp; Health</td>
</tr>
<tr>
<td>American Refugee Committee (ARC)</td>
<td>112</td>
<td>USA</td>
<td>Relief - Refugees &amp; Migrants</td>
</tr>
<tr>
<td>AmeriCares</td>
<td>322</td>
<td>USA</td>
<td>Relief - Medical Assistance</td>
</tr>
<tr>
<td>Brot Fur Die Welt (BFDW)</td>
<td>192</td>
<td>Germany</td>
<td>Relief - Food</td>
</tr>
<tr>
<td>CARE</td>
<td>27</td>
<td>USA</td>
<td>Emergency - Inclusion</td>
</tr>
<tr>
<td>CordAid</td>
<td>42</td>
<td>Netherlands</td>
<td>Emergency - Social Inclusion</td>
</tr>
<tr>
<td>Danish Refugee Council (DRC)</td>
<td>3</td>
<td>Denmark</td>
<td>Emergency - Inclusion</td>
</tr>
<tr>
<td>Direct Relief</td>
<td>116</td>
<td>USA</td>
<td>Relief - Emergency</td>
</tr>
<tr>
<td>Handicap International (HI)</td>
<td>12</td>
<td>France</td>
<td>Humanitarian - Inclusion</td>
</tr>
<tr>
<td>International Committee of the Red Cross (ICRC)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>International Federation of the Red Cross (IFRC)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>International Medical Corps (IMC)</td>
<td>73</td>
<td>USA</td>
<td>Relief - Self-Reliance</td>
</tr>
<tr>
<td>International Rescue Committee (IRC)</td>
<td>39</td>
<td>USA</td>
<td>Emergency - Recovery</td>
</tr>
<tr>
<td>Islamic Relief International (IRI)</td>
<td>8</td>
<td>UK</td>
<td>Emergency - Inclusion</td>
</tr>
<tr>
<td>Kimse Yok Mu (KYM)</td>
<td>70</td>
<td>Turkey</td>
<td>Relief - Health - Inclusion</td>
</tr>
<tr>
<td>Médecins Du Monde (MDM)</td>
<td>123</td>
<td>France</td>
<td>Relief - Health</td>
</tr>
<tr>
<td>Médecins Sans Frontières (MSF)</td>
<td>1</td>
<td>France</td>
<td>Emergency - Health</td>
</tr>
<tr>
<td>Mercy Corps</td>
<td>22</td>
<td>USA</td>
<td>Emergency - Inclusion</td>
</tr>
<tr>
<td>Norwegian Refugee Council (NRC)</td>
<td>107</td>
<td>Norway</td>
<td>Relief - Refugees &amp; Migrants</td>
</tr>
<tr>
<td>Operation Blessing International (OBI)</td>
<td>150</td>
<td>USA</td>
<td>Relief - Development</td>
</tr>
<tr>
<td>Oxfam</td>
<td>6</td>
<td>UK</td>
<td>Humanitarian - Inclusion</td>
</tr>
<tr>
<td>People in Need (PIN)</td>
<td>334</td>
<td>Czech Republic</td>
<td>Relief - Disaster Conflict</td>
</tr>
<tr>
<td>UNICEF</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>World Food Program (WFP)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ZOA</td>
<td>60</td>
<td>Netherlands</td>
<td>Relief &amp; Rehabilitation</td>
</tr>
</tbody>
</table>

2.3. Data analysis

The analysis of the selected documents was done following a summative approach to qualitative content analysis (Hsieh and Shannon, 2005). This approach has the purpose of understanding the contextual use of the words found in a specific set. Data analysis begins with searches for occurrences of the identified words, defined as manifest content analysis (Potter and Levine-Donnerstein, 1999), followed by a process of interpretation of content, defined as latent content analysis (Holsti, 1969).

In order to check whether HOs’ activities could be compared with those performed by LSPs, a set of words referring to the activities performed by the latter was required. The set of words is based on a compilation of various definitions of LSPs from the substantial body of literature that exists in the area of Logistics Service Providers (Selviaridis and Spring, 2007). First, the
list of 21 TPL papers compiled by Fabbe-Costes et al. (2009) – for a very similar purpose – was used as a basis. To constitute the list, the authors analyze the LSPs literature seeking for papers dedicated to the roles LSPs played in the supply chains. Those papers explored (through typologies or definitions) the services performed by logistics players. From this list, the different activities or services described were collected until reaching saturation of data. Given that many of those articles share or reuse the same definitions, 7 papers presenting complementary definitions were retained. Later on, recent papers with new definitions or descriptions were added, following the same process until reaching information saturation, leading to a list of 13 papers. As a result, definitions from 13 journal papers covering a period from 1999 to 2014 were used (see Table 2.2). From these definitions, the words describing the concrete activities a LSP can provide were gathered resulting on a list of 53 keywords (see Table 2.3).

Table 2.2 Services performed by LSPs

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Quotations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berglund et al. (1999) p. 59</td>
<td>Activities carried out by a logistics service provider on behalf of a shipper and consisting of at least management and execution of transportation and warehousing (if warehousing is part of the process). In addition, other activities can be included, for example inventory management, information related activities, such as tracking and tracing, value added activities, such as secondary assembly and installation of products, or even supply chain management.</td>
</tr>
<tr>
<td>Skjott-Larsen et al. (2007) p. 269</td>
<td>Although these alliances may start with a narrow range of activities, there is a potential for a much broader set of value-added services, including simple fabrication, assemblies, re-packaging, and supply chain integration.</td>
</tr>
<tr>
<td>Bask (2001) p. 473</td>
<td>Companies focusing on logistics services add value to their customers by providing services in transportation, terminal activities, warehousing, forwarding, packaging, product manufacturing and logistics postponement, distribution, information processing, etc.</td>
</tr>
<tr>
<td>Cui and Hertz (2011) p. 1005</td>
<td>They provide a transport service and move material physically from point A to point B. Consolidating products and connecting carriers and clients. Coordinating clients, logistics intermediary firms and carriers in order to provide and integrated service.</td>
</tr>
<tr>
<td>Fulconis et al. (2006) p. 68</td>
<td>The most efficient LSPs are far from restricting themselves to activities of transport and handling of finished goods. On the contrary they have broadened their value-added services, undertaking activities of shelf display, of site installation, of co-manufacturing and of wrapping or co-packing.</td>
</tr>
<tr>
<td>Fulconis et al. (2007)</td>
<td>Activities of LSPs have considerably evolved over the years from merely transporting to developing a package deal of services including additional customer services (after-sales services, customer billing, archiving, etc.) and new professions (site installation, co-manufacturing, wrapping…).</td>
</tr>
<tr>
<td>Hertz and Alfredsson (2003) p. 140/141</td>
<td>A TPL provider is an external provider who manages, controls, and delivers logistics activities on behalf of a shipper. The activities performed can include alle or part of the logistics activities but at least management and execution of transport and warehousing should be included. Typical services outsourced to TPL providers are transport, warehousing, inventory, value-added services, information services and design, and reengineering of the chain.</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Quotations</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Hsiao et al. (2010)</td>
<td>Advanced value-added services could involve differentiated services for different customers, forming specific packaging, cross-docking, track and trace, offer special security systems, etc.</td>
</tr>
<tr>
<td></td>
<td>Level 1: activities include transportation and warehousing</td>
</tr>
<tr>
<td></td>
<td>Level 2: activities include value-added activities which refers to tasks normally performed by manufacturers but now being moved into distribution as part of final processing</td>
</tr>
<tr>
<td></td>
<td>Level 3: This refers to the outsourcing of logistics planning and control activities, such as inventory management and transportation management.</td>
</tr>
<tr>
<td></td>
<td>Level 4 (total outsourcing): This refers to outsourcing the distribution network management. At this strategic planning and control level, decisions are made concerning supply chain restructuring, for example, changes of the warehouse structure, reassignment of tasks between tiers, redistribution of inventory between tiers, changes in transportation network, mode, consolidation points, reassignment of roles and responsibilities among chain entities</td>
</tr>
<tr>
<td>Lai (2004)</td>
<td>In general, an LSP can be broadly defined as a provider of logistics services that performs all or part of a client company’s logistics function. This consists of at least the managing and operating of the transportation and warehousing functions. An LSP can also provide other services such as materials management services (e.g. inventory management, information-related services (e.g. tracking and tracing) and value-added services (e.g. secondary assembly).</td>
</tr>
<tr>
<td>Pigeon and Servois (2010)</td>
<td>Transport services (road, rail, sea, air) / transport support services (maintenance, handing, navigation, circulation, intermediaries in freight transport) / warehousing and storage services and third-party logistics service providers (all types of storage, labeling, offloading, stock control and management, organization, order input and execution, packing of orders, collection and packaging, marking and organization of transport) / courier and messenger services / logistics consultancy services and external contractors with no physical assets (4PL)</td>
</tr>
<tr>
<td>Prockl et al. (2012)</td>
<td>Basic logistics functions such as transport, transhipment and warehousing services that are relatively easy to define and mainly purchased based on price are increasingly bough into bundles of services and IT services.</td>
</tr>
<tr>
<td>Sharma and Choudhury (2014)</td>
<td>TPL providers cater to customers with services which may extend beyond basic transportation functions such as warehousing, inventory management, information related services as well as assembly and manufacturing of products.</td>
</tr>
<tr>
<td>Sharma and Choudhury (2014)</td>
<td>Historically 3PLs provided traditional logistics services such as transportation and warehouse management. However, the increased volume and scope of services demanded from 3PLs have given rise to their changing role where today they are engaged in strategic coordination of their customer’s supply chain activities.</td>
</tr>
<tr>
<td>Zacharia et al. (2011)</td>
<td>In this article, we argue that the role of 3PL has evolved from a provider of logistics services to that of orchestrator within the supply chain.</td>
</tr>
</tbody>
</table>

**Table 2.3 List of keywords**

- After-sales services, Archiving, Assembly, Circulation, Co-manufacturing, Co-packing, Courier and messenger services, Cross-docking, Customer billing, Customization, Design, Distribution, Distribution network, External contracts, Forecasting, Handling, Information management, Information services,
Based on this list, the content analysis was performed using the qualitative data analysis software (QDAS) NVivo 10. This software has the ability to organize and analyze literature reviews, to conduct secondary data analysis, and to record, collect, analyze and report data (Dean and Sharp, 2006). Two of the QDAS tools were mainly used to perform the analysis. First, a Word Frequency query was used in order to find the number of occurrences of the keywords with respect to the entire content. For this, the ‘stemmed words’ option was used to group the words under the same stem (e.g. supply, supplies, supplied). Later on, a Text Search query allowed us to identify the number of references made to a specific set of words, as well as to conduct a first level of coding (open coding), followed by an axial coding to understand the context in which the words were used and create subcategories (Ellram, 1996). For this, the ‘stemmed words’ option was also used in order to capture all possible use of words. The results from both manifest and latent content analysis are presented and explained in the next section.

3. RESULTS

3.1. Manifest content analysis

As explained above, the manifest content analysis focuses on the number of occurrences words may have in a specific set of data. A word frequency query was used, using a 5 letters minimum length criterion seeking to avoid prepositions (i.e. of, its, the) and dates (i.e. 2014, 2015) but still managing to include the shortest logistics-related words (i.e. supply or stock). The software produces a list of the first 1000 words founded in the material from which a research of the keywords was manually done through the list. The analysis showed that among the most used words, some refer to the general mandate of the HOs (e.g. ‘people’ – 68wt%; ‘support’ – 55wt%; ‘health’ – 49wt%). It also pointed out that some of the keywords presented in Table 2.3 were not found in the first 1000 list. For instance, words such as ‘pack*’, ‘pick*’, ‘warehous*’ or ‘manufactur*’ had very few counts and extremely low weighted percentage (close to zero). For those found on the list, two keywords (i.e. ‘tracing’, ‘materials’) appear among the best ranked although these can have different meanings and thus may not reflect the logistics-related activities performed. Nevertheless, other keywords show a high number of occurrences: for example ‘distribution’ (1601 counts – 9wt%), followed by ‘assembly’ (528 counts – 3wt%), ‘handling’ (452 counts – 3wt%) and ‘logistics’ (439 counts – 2wt%). The concept of logistics is also implicitly found in words such as ‘provision’ (6069 counts – 34wt%) or ‘supply’ (1654 – 9wt%). Table 3.1 presents an excerpt of the word frequency query showing only those words found in the top 1000 that are part of the keywords of this research.

<table>
<thead>
<tr>
<th>Word</th>
<th>Length</th>
<th>Count</th>
<th>wt (%)</th>
<th>Similar Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>8</td>
<td>528</td>
<td>0,03</td>
<td>assemble, assembled, assemblies, assembling, assembly</td>
</tr>
</tbody>
</table>
Going further on the manifest analysis, the next step was to perform text search query with the keywords from Table 2.3 using the ‘stemmed word’ option and coding the surrounding content, which constitutes the open coding. In order to get as much information as possible, keywords were aggregated when necessary (e.g. ‘co-manufacturing’ and ‘product manufacturing’ into ‘manufacturing’), reducing the number of keywords and thus simplifying the search. Then, a matrix coding query was launched in order to cross-tabulate the results from the 42 keywords (now coding nodes) and the sources gathered by organization (see Appendix 1). This query provided a first overview on the use of the keywords by HOs.

From the 26 HOs studied, four (AmeriCares, Kimse Yok Mu, Mercy Corps and Operation Blessing International) had very few matches regarding their logistics activities, while other organizations (CordAid, DRI, MDM, MSF, Oxfam, PIN and Zoa) had between 5 and 15 times more references to the keywords used for the query. One organization that stands out is ICRC with a high number of references to almost any keyword. Nevertheless, some of the results (e.g. design, installation, marking) may be linked to other activities not related to logistics and thus a further analysis is required.

As explained earlier, the manifest content analysis does not provide enough elements to draw conclusions. The number of occurrences of a word is a first element that must be completed understanding the context in which this word is used. Therefore, a latent content analysis was performed as a complementary approach.

### 3.2. Latent content analysis

The goal of the latent content analysis is to examine the content in which the keywords are used in order to explore whether or not, HOs play (or can play) the role of LSPs for the humanitarian context. We examined the data collected through two different lenses corresponding to our research questions: the logistics activities performed by HOs and their fulfillment for the benefit of other organizations.

#### 3.2.1. Logistics activities performed by HOs

HOs in their annual reports claim their ability to operate logistics services namely:

- sorting and shipping basic relief items such as tents, food, blankets, plastic sheeting, mosquito nets (e.g. CordAid, HI, ICRC, IMC, IRW, MSF, NRC),
• packing them into ‘kits’ that respond to specific needs such as hygiene, shelter, cooking or first aid among others (e.g. DRI, HI, MSF, OBI),
• activating logistics operational resources such as vehicles, warehouses and aircraft (e.g. DRI, PIN, IFRC, UNICEF) or,
• increasing the stocks of emergency supplies and improving distribution logistics (e.g. ACF, CordAid, ICRC).

In addition to these activities, many HOs describe other type of services when they mention their logistics activities. For instance ACF (2013) “trucks water into affected areas and installs storage tanks and reservoirs”, and even “drill and decontaminate wells, install hand-pumps, protect natural springs, tap aquifers, rehabilitate damaged infrastructure, and pipe water into hard-to-reach villages and health centers” when water is scarce or unsafe. In the same line, ICRC (2011) launched a project of “elevated water platforms and storage tanks, the rehabilitation of wells and the provision of fuel to keep water systems running”. IMC (2012) “renovates and upgrades latrines, water storage tanks, and rain water harvest systems, which [...] provide local populations with better water quality and improve the overall level of sanitation and hygiene conditions” and MDM (2010) mentions “access to water, makeshift showers, waste management and latrines” for a refugee camp in the north of France as a component of the logistics activities.

Other activity included in the scope of logistics in humanitarian relief is construction. In addition to the building of water systems, ICRC (2011) runs “the repair or rebuilding of houses damaged or destroyed” and supports local health facilities by providing “better access to health services [through] the construction of a community health clinic” to replace those that have been destroyed. Moreover, during emergencies NRC (2014) helps to “plan and prepare camps and settlements, construct spaces for schools and communal infrastructure, and hand out household items”, and PIN (2012) provides the “construction of shelters, community centers [and] storage space in the camps” as well as the “construction and equipment of makeshift schools”. Further activities include the repairing and maintenance of the vehicle fleet directly on the field (DRC, 2012), as well as logistics for spare parts and cash transfers (ICRC 2012).

In a more strategic side, some organizations are also involved in improving their logistics systems through different accomplishments. ACF (2014) for example “uses a set of standardized processes and tools known as “KitLog” to manage and monitor country logistics systems”, UNICEF (2012) “ran a prototype emergency simulation that examined UNICEF’s supply and logistics work, and is praised for its potential to become a hub for innovative emergency response” and ICRC (2012) defines “policies, quality standards and new or updated approaches and solutions, optimizing and documenting processes”.

3.2.2. Logistics service provision by HOs

Latent content analysis offers several insights concerning the type of partners to whom HOs provide logistics services. Some annual reports just evoke “other organisations” (HI, 2013) while others provide a list of different types of partners: “national and international non-governmental organisations” for HI (2014) and ICRC (2011), “United Nations Agencies” (HI, 2014), governments (ICRC, 2011). Finally, some HOs clearly identify example of actors to whom they provide logistics services: MSF for ICRC (2013), Reach Out for DRI (2014) or local associations for MDM in Syria (2011) and MSF in Congo (2012). Among the studied HOs, we can note that HI (2014) mentions as much as 50 ‘client’ organizations for their logistics services.
Collected data also shed light on the type of logistics services HOs provide to other organisations. Some actors mention the ‘logistical support’ (HI 2014, ICRC 2013, MDM 2011) or the ‘logistics resources’ (MSF 2012) among which for example ‘the loan of trucks’ (HI 2014) they provide. HI (2013) indicates to provide partners with ‘access to logistics infrastructure’. More precisely, HOs point out, among the services provided, ‘medical supplies’ (MdM 2011) notably the ‘procurement of equipment and consumables’ (ICRC 2011) or the ‘transport of chemical/medical supplies’ (ICRC, 2011), and the ‘distribution of food and essential non-food items’ (HI, 2013). Finally, ICRC (2011) qualifies both the kind of services provided (as ‘supervision’), the type of supply chain managed (as ‘cold chain’).

Finally, IFRC (2012, 2013) clearly sum up the amount of ‘fleet, logistics and other supplementary services’ fees recovered through contracted logistics services. This HO besides mentions providing services ‘on a non-profit basis for humanitarian actors’ (IFRC, 2013).

4. DISCUSSION: TOWARDS A CHARACTERIZATION OF HSPS

When comparing the weighted percentage of logistics-related words (see Table 3.1) with some of the most used words (‘people’ – 68%; ‘support’ – 55%; ‘health’ – 49%) in the annual reports we studied, we can observe that main themes for HOs are related to their core mandate of relief (Samii, 2008). For some HOs, logistics is not even mentioned! However for others, logistics activities keywords show a high number of occurrences. Some HOs indeed stand out by the importance that logistics play in their operations. Such is the case of CordAid, DRC, ICRC, IFRC, IRW, MSF, UNICEF and WFP. Not surprisingly, most of these HOs have specialized logistics units that have been recognized as leaders in the field of humanitarian logistics (cf. Charles et al., 2010; Pedraza Martinez et al., 2012). Thus the latent context analysis we performed confirms the idea that logistics is “an integral part of humanitarian response” (IFRC 2012) to the point that “remarkable accomplishments would not be possible without logistics” (ACF, 2013). From those results, it is possible to infer that logistics plays an important role in humanitarian relief operations. This is not new as many academics and practitioners point out the outbreak and rapid evolution that this activity has had over the past 10 years or so (Kovacs and Spens, 2011b; Maon et al., 2009).

HOs have followed this evolution and have developed logistics activities able to support their own mandate. Moreover, our results illustrate that HOs are able to perform a large range of logistics activities (see 3.2.1.) and could thus be considered as ‘solution provider’ (Berglund, 1999). HOs, as we discovered in their annual reports, can provide main logistics’ functions as defined by Delfmann et al. (2002): logistical core processes (here for example shipping basic relief items), associated added-value activities (e.g. packing items into kits) and management support and tools (supervision of cold chain transport for example). Performing ‘specialized services’ with ‘high asset specificity’, HOs could be considered as ‘specialized logistics operators’ (Persson and Virum, 2001); some of them evolving to the form of ‘logistics integrator’ (ibid). Moreover, some HOs declaring to serve as much as 50 partners would probably have a role of coordination of the relief chains as an orchestrator (Zacharia et al., 2011).

Our results need to be further explored but constitute a first step in the exploration of HOs providing logistics services for other organizations. This “new” role of humanitarian actors as logistics service providers has rarely been studied and no formal definition has been given to identify such organizations. Based on Berglund et al.’s (1999) recognized definition, and the
results shown in previous sections, we posit a definition for those Humanitarian Service Providers (Vega and Roussat, 2015) as follows:

A Humanitarian Service Provider (HSP) is a humanitarian organization (UN agency or NGO) that carries out activities on behalf of internal customers as well as other humanitarian organizations or governmental structures, consisting of design, management and/or execution of logistics operations (mainly transportation, warehousing and distribution). In addition, other logistics-related activities can be included for example inventory management, pre-positioning of goods, information related activities, value-added activities such as kit assembly and installation of products, but also humanitarian-related activities such as building, reconstruction, sanitation, food distribution, rehabilitation and maintenance of water systems, security, or training and capacity building, to name a few.

Two points about the proposed definition are worth pointing out. First, for some HOs (e.g. ICRC, IFRC, MSF, WFP) the organizational structure is constituted of a number of national offices, sections or agencies that have independent budgets and management under the supervision of the headquarters. When performing logistics activities in these type of HOs, the first customers of the logistics units are their own teams on the field that request logistics services, either basic transportation or more complex tasks. In doing so, National Societies (for the case of the Red Cross) or Operational Centers and National offices (for the case of MSF) become internal clients. Second, many HO performed value-added activities such as LSPs do. This is perfectly in line with Abidi et al. (2015) studying the relevance and value of fourth-party logistics services for humanitarian relief but noting that “actors in the field have (only) taken first cautious steps in that direction” (p. 51). Within those value-added activities, HOs promote a broader definition of logistics than what is found in commercial settings, going beyond co-manufacturing and co-packing example (merging and packaging of the elements of a relief kit) to an important number of activities, here associated with the logistics field (building, reconstruction, etc.) that are not (or at least not yet) be found in commercial settings. The proposed definition takes these two points into account making a first attempt to grasp some unique characteristics of humanitarian relief and the logistics involved.

That first identification and definition of HOs as logistics service providers also allows launching a discussion on the importance that such relatively “new” actors could have for humanitarian relief. In 2012 the United Nations looking forward to improve the coordination of its emergency humanitarian assistance, identified the partnerships for more effective delivery as one of the two main challenges to face. Similarly, Kovacs and Spens (2011a) note that “due to the many phases, actors, and units of analysis, a first important topical area in HL research became that of coordination”. As LSPs, HOs should be able to perform different kinds of partnerships, to work with other organizations in the humanitarian supply chains with other HOs – as a service provider –, with other HSPs as a 4PL or finally with commercial LSPs as supplier/client/partner. First of all, as we have seen in the results, HOs can act as a service provider that “undertakes tasks in the areas of procurement, warehousing and transportation management” Schulz and Blecken (2010, p. 641) considering “other humanitarian organizations not as partners, but as internal or external customers that are to be provided with professional and high-quality services”. As a 4PL, the HSP should be able to manage 3PL service providers and stakeholders along a humanitarian supply chain. Finally, even if the private sector (commercial LSPs) could play an important role on the humanitarian aid (Sackey and Haavisto, 2009), HSPs as specialized service providers could be main actors and form a co-dependent system to cover existing and future gaps (Majewski et al., 2010).
5. CONCLUSION

Academic literature has merely studied the role HOs play as logistics service providers. This research builds on Kovacs and Spens’s (2011b) as well as Heaslip’s (2013) call for further examining services management for humanitarian logistics, and explores the role humanitarian organizations can play as logistics service providers, defined here as HSPs. The results constitute the first phase of a wider study on HSPs and their role, and make part of a broader research program exploring the logistics roles that commercial LSPs and dedicated HSPs can play in the humanitarian context.

Looking at HOs as logistics service providers can change the current perspective of the humanitarian context for both humanitarian and commercial actors, as the relationship within and between these two can change from one based on a partnership to one based on contract or even to one where both HSPs and LSPs see each other as competitors, creating thus new dilemmas and so new avenues of research for academics in this field. In a recent research, Vega and Roussat (2015) pointed out that some of the major commercial Logistics Service Providers (e.g. DHL, Kuehne+Nagel, Agility) have created humanitarian business units that provide dedicated logistics services for humanitarian organizations becoming important players of today’s relief supply chain. Collaboration between HSPs and the private sector is probably a necessity especially in the last mile distribution (Apte, 2009). Obviously, those organizations (apart from the logistics services they perform) have different goals and the implication of LSPs in the humanitarian context (on a profit basis) raise the question of ethics as previously outlined (Vega and Roussat, 2015). Conversely, the situation of IFRC (as exposed in section 3.2.2) leads to another question to be further explored: are HOs acting as commercial service players (on a contract basis) or are they providing logistics services on a non-profit basis? Do they offer services to NGOs and sell them to governments or UN agencies? Exploring the competition/coopetition between LSPs and HSPs could thus be particularly relevant and constitute a basis for further investigation through field interviews.

As in any research endeavour, limitations are inevitable and for the sake of transparency these are worth pointing out. Main limits here concern the methods used to investigate the phenomenon and constitutes the source of data used. When analysing secondary data (i.e. annual reports), the study is limited by what organizations say (size of the report) and the way they use words (style and length) which can be in some cases disrupted from the reality. The answer to this limitation, and which is currently being undertaken, is a deeper exploration of the reality of HOs acting as LSPs through face to face interviews with some of the organizations that came out as major players in the provision of logistics services to other organizations in this study. Another possibility to overcome this limitation is through a survey that could be administered to a large population of HOs, seeking to identify those who could play the role of LSPs, using culture, age, size, mandate, geographical origin and relied focus (child, nutrition, medical) as control variables. This constitutes an interesting avenue and must be considered as a point for further research.

REFERENCES


Morgan, D., L. (1993), Qualitative content analysis: A guide to paths not taken, Qualitative Health Research, Vol.3, pp. 112-121.


## Appendix 1: Matrix query results

<p>| Keyword                  | AAI | ACF |Americares |ARC |BFDW |CARE |Cordaid |DRC |DRI |HI |ICRC |IFRC |IMC |IRC |IRW |KYM |MC |MDM |MSF |NRC |Oxfam |PIN |UNICEF |WFP |ZOA |TOTAL per keyword |
|-------------------------|-----|-----|------------|----|-----|-----|--------|----|----|---|-----|-----|----|----|----|----|----|----|-----|-----|-----|------|-----|-------|-----|-----|------------------|
| Archiving               | -   | -   | -         | -  | -   | -   | 2      | -  | -  | 3 | -   | -   | -   | 54  | -   | -   | -   | -   |-   |1     | -   | -    | -   |14    | -    | -    |74    |
| Assembly                | 37  | 4   | -         | -  | -   | -   | 1      | -  | -  | 2 | 3   | 14  | -   | 241 | 3   | 4   | -   | 5   | -   | -   | 9   | 4   | 2   | -    |12   | 2    |133   |
| Billing                 | -   | -   | -         | -  | 1   | 2   | 3      | 2  | 14 | - | 50  | -   | 13 | 17  | 3   | -   | 6   | -   | 1   | 2   | 5   | -    |7    | 7    |135   |
| Circulation            | 5   | -   | -         | -  | -   | -   | -      | 1  | 10 | - | -   | -   | -   | -   | -   | 1   | -   | -   | 1   | 2   | -    | -    |1     |1     |25    |
| Consolidation          | 10  | 2   | 2         | -  | -   | 4   | -      | 6  | 1   | 2 | 254 | 5   | -   | 13  | 3   | 24  | 1   | 1   | -   | 10  | 2    | 4    |1    |2     |347   |
| Contract               | 10  | 2   | 1         | -  | 4   | 3   | 46     | 12 | 15 | 5 | 72  | 1   | 6  | 3   | 2   | -   | 1   | 16  | 3   | 15  | 18   |3    |4     |31    |273   |
| Courier and Messenger  | -   | -   | -         | -  | -   | -   | -      | -  | -  | - | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 5    | -    | -    |1     |
| Cross-docking          | -   | -   | -         | -  | -   | -   | -      | -  | -  | - | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 0    | -    | -    |0     |
| Customization          | 3   | -   | -         | -  | -   | -   | 14     | 1  | 1   | 1 | 37  | 1   | 1   | 1    | 1   | -   | 1   | -   | 2   | -   | 3    | 7    |3     |1     |81    |
| Design                 | 27  | 19  | 13        | 7  | 5   | 31  | 7      | 14 | 12 | 204|11  |6    | 4  | 24   | -  | -   | 6   | 19  |9    |1   | 22   |21   |16    |3     |41    |522   |
| Distribution           | 5   | 26  | 2         | 6  | 13  | 6   | 24     | 25 | 28 | 30 | 863 |7    | 5   | 14   | 26  | 6   | -   | 31  | 104 | 18 | 12   | 35   |60    |8     |21    |42    |1417  |
| Fabrication            | -   | -   | -         | -  | 2   | -   | 13     | -  | -  | - | 1   | 1   | -   | 2    | -   | -   | 4   | -   | 2   | -   | -    |25    |
| Forecasting            | -   | -   | -         | -  | 4   | 3   | 2      | -  | -  | - | 8   | -   | 1   | 2    | 1   | -   | -   | 5   | -   | 2   | -   | 6    |34    |
| Freight                | -   | -   | -         | -  | -   | -   | 6      | -  | -  | - | -   | -   | -   | 7    | -   | -   | -   | 1   | -   | -   | 1    |14    |
| Handling               | 3   | 1   | 1         | 3  | -   | 6   | 7      | -  | 2   | 350|1    |1    | 1   | 1    | 1    | 2   | 3    | 2   | 4    | 8    |1    |1     |1     |399   |
| Information management | -   | 2   | -         | -  | -   | -   | 1      | -  | -  | 85 | 1   | -   | -   | -    | -   | -   | -   | -   | -   | -   | -    |89    |
| Information Services   | -   | -   | -         | -  | -   | -   | 3      | -  | -  | - | 1   | -   | -   | -    | -   | -   | -   | -   | 4   | -   | -    |1     |1    |
| Installation           | 4   | 5   | 4         | 2  | 1   | 10  | 4      | -  | 1    | 177|1    |1    | 6   | 3    | 1    | -   | 7    | 1   | -   | 7    | 8    |3     |11    |256   |
| Inventory              | -   | -   | 2         | -  | -   | -   | 11     | 2  | 16 | 3   | -   | -   | -   | -    | -   | -   | -   | -   | -   | 26   | -    |15    |75    |
| Invoicing              | 1   | -   | -         | 1  | 1   | 3   | -      | 2  | -   | 21 | -   | -   | -   | -    | -   | -   | -   | -   | -   | 5    | -    |1     |33    |
| Labelling              | 1   | -   | -         | 1  | -   | 24  | -      | -  | 1   | 1   | 1   | -   | -   | -    | -   | 1   | 2   | -   | -   | 2    | -    |1     |34    |
| Line-haul              | -   | -   | -         | -  | -   | -   | -      | -  | -  | - | -   | -   | -   | -    | -   | -   | -   | -   | -   | -   | 0    | -    | -    |0     |
| Logistics              | -   | 16  | -         | -  | -   | 1    | 3      | 6  | 3   | 10 | 228 |15   | 2   | 2    | -   | -   | 11   | 18  | 4   | 1    | 2    |3     |1     |7     |333   |
| Manufacturing          | 1   | -   | -         | 1  | -   | 4   | -      | 8  | -   | 16 | -   | -   | -   | 5    | -   | 2   | -   | 7    |1    | -   | 4    | 50    |
| Marking                | 3   | 7   | -         | 9  | 5   | 2   | 9      | 2  | 70 | 1   | 100 |8    | 49  | 40   | 12   | -   | 3    | 18  | 8   | 5    | -   |10    |18    |10    |3    |4     |396   |
| Materials management   | -   | -   | -         | -  | 1   | -   | 2      | -  | -  | 4   | -   | 4   | -   | -    | -   | 1   | 1   | 1   | 1   | 1    | 1    |1     |19    |
| Offloading             | -   | -   | -         | -  | -   | -   | -      | -  | -  | - | -   | -   | -   | -    | -   | -   | -   | -   | -   | -   | 0    | -    | -    |0     |</p>
<table>
<thead>
<tr>
<th></th>
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<th>ARC</th>
<th>BFDW</th>
<th>CARE</th>
<th>Cordaid</th>
<th>DRC</th>
<th>DRI</th>
<th>HI</th>
<th>KCRC</th>
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CONSUMER LOGISTICS IN GROCERY SHOPPING

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Herbert Kotzab**
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ABSTRACT

Purpose
Logistics plays also an important role for end-users as consumers are also involved in planning, implementing and managing logistics functions in regards to their shopping processes. Thereby, the concept consumer logistics (CL) examines the role of consumers in the logistical processing of goods for the purpose of consumption from point of acquisition to the point of disposal. The objective of this study to test and validate the CL scale as introduced by Bahn et al. (2015) for grocery shopping in a different country setting, here Turkey.

Design/methodology/approach
For the purpose of this study, we developed a self-administered online questionnaire that completed by 474 respondents from different geographical regions of Turkey. We used for the analysis of 356 usable questionnaires Principal Component Analysis (PCA) and Confirmatory Factor Analysis (CFA) for the scale validation.

Findings
Contrary to the ten CL functions as suggested by Bahn et al. (2015), we identified the six CL functions of information search, transportation management and materials handling, storage management & inventory needs assessment, contingent inventory operations & product acquisition, intra-household communication and interdependent transportation operations. There were no significant differences in the CL functions in regards to socio-demographic characteristics.

Research limitations/implications
Limitations refer to the sampling area as these included regions around a selected area in Turkey and did not include the whole country.

Original/value
The CL scale is tested and validated in a different country and different results are obtained.

Keywords: retailing, consumer logistics, grocery shopping
1. INTRODUCTION

1.1. Problem background

Retailing consists of the final activities and steps needed to place and provide products/services to the consumer (Harris, 2000). Among retailers, grocery stores play vital role in the business world, since it is final link of the channel that meets end users’ needs. Grocery stores provide a wide variety of food products, including perishable items such as meat, produce and dairy, together with general merchandise products, such as cleaning supplies, paper products, health and beauty care products. These stores sell many different name brand products based on consumers’ shopping needs (Payne, 2016).

Grocery retailing has undergone – just like other retail segments – a lot of change especially when it comes to market dominance, store formats and Internet. In many countries of the world, few players are covering the majority of the grocery market volume. The market shares have shifted from a lot of small store formats (e.g. Mom-and-pop stores) to few very large stores (e.g. hypermarkets) (Nielsen 2015) and many grocery retailers invested into very modern logistics systems at a central distribution center level (e.g. Kotzab and Bjerre 2005). The Internet though is probably the main driver for a change in the consumer behavior as grocery items can now be purchased online and be shipped directly to the consumers (see e.g. Cude and Morganosky, 2000; Hansen et al., 2004; Boyer and Hult, 2005; Hansen, 2008; Benn et al., 2015). This last-mile-logistics is not only changing the execution of logistics processes of retailers but also the way how consumers perform their purchase actions, in particular those processes which are known as consumer logistics (CL) (e.g. Granzin and Bahn 1989).

While marketing channel literature recognizes end-users as active members of a marketing channel (see e.g. Coughlan et al. 2006), logistics and supply chain literature has not paid a lot of attention to those logistics activities that consumers perform before, during and after their shopping activities so far. Until now, research focus was on the consumers’ shopping behavior, orientation or motives that are generally orientated by their perceptions (Morschett et al., 2005; Sheth, 1983). Shopping activities of individuals are then guided by this behavior and influenced by quality, price and product variety (Doyle and Fenwick (1974). However such perceptions may also be affected by other aspects including store atmosphere, service, orderliness and brand loyalty as well physical proximity to grocery and type of transportation used for shopping can also influence the way end-users perform their (Cude and Morganosky, 2000).

Especially in the advent of home-shopping and internet-based shopping, CL activities are becoming more and more important as companies are required to ‘in-source’ certain activities that consumers were executing in a rather unconsciously manner (see e.g. Teller et al. 2012). CL activities involve planning and managing the purchase actions, therefore increasing home-shopping and internet-based shopping cause retailers to carry out most of the CL activities. On the other hand, while home-shopping and internet-based shopping in grocery is still very low, retailers are in need to learn more about CL activities.

1.2. Problem formulation and research question

The intention of this paper is to gain more insight into CL activities that occur in a grocery shopping setting. Grocery shopping composes an essential and routine type of consumer behavior. Unlike most consumer buying concepts, the grocery shopping experience is identified by multiple buying objectives that must be achieved through the processing of a complex sequence of in-store stimuli such as products, brands, and point-of-purchase information, and repetition at regular time intervals (e.g., once a week). These circumstances create a unique
context in which purchase intentions and outcomes often differ depending on consumer behavior (Kim and Park, 1998).

Grocery shopping is thought of a routine activity that includes ordinary and low involvement of consumers in their planning, implementing and managing of shopping activities (Thomas and Garland, 2004). The routine of the daily or weekly shopping activities for groceries may differ in accordance with consumer behavior. Some grocery purchasers plan their shopping, the others do not. Those who make shopping lists are more likely to be concerned with planning from those who do not. (Bassett et al., 2008). However, the discussion lacks so far the perspective of logistics.

For the purpose of this paper, we continue the work by Bahn et al. (2015) who introduced a scale for measuring consumer logistics activities by testing and validating this scale in a different country setting. By this we want to contribute to gain more insight into this research domain. Our project is driven by the following research question:

- Can the Bahn et al. (2015) scale for measuring consumer logistics be used in a Turkish context?

In order to answer this question, we have examined the literature (see section 2) and developed a research design that was tested amongst more than 600 Turkish consumers (see section 3). The results of our empirical project show that the Bahn et al. (2015) scale needs to be adapted to the geographic area while CL activities differed in terms of dimensions and associated activities in Turkey (see section 4). The Bahn et al. (2015) scale was developed for and tested in the US where the retailing industry is differently developed as compared to Turkey that has an emerging and developing retailing industry. As our results differ from those of Bahn et al. (2015), we concluded that the CL scale needs to be adapted when it is tested in different environments rather than USA. We close our paper with a critical discussion and an outlook for future research.

2. LITERATURE REVIEW

2.1. Consumer behavior and grocery shopping

Bawa and Ghosh (1999) showed that consumers perform different shopping behaviors during a shopping trip and they examined the relationship between frequency of shopping and accessibility to stores. Some household characteristics such as age of household members can be linked to shopping behavior as it affects the household consumption and shopping pattern (Bawa and Ghosh, 1999). Fareed and Riggs (1982) also pointed out that older consumers may do shopping less frequently than young consumers, due to smaller family size and lower incomes. In other words, larger families tend to buy larger amount of products because of their greater need. Larger families are likely to need a greater variety of products, therefore they tend to purchase supplies more frequently than smaller families.

Ackerman and Tellis (2001) found out that consumer behavior is affected by cultural based norms and values. These values and norms are transferred from the community individuals via socialization. Consumers learn values and norms about acquisition, consumption, and disposal of products via socialization in their communities (Moschis, 1987). Therefore, the similarities in behavior of individuals within the community and the differences in the behavior of individuals across communities are likely to be related to the cultural values and norms. It means that depending on life situation, the routine, weekly, major shopping activity for groceries can be approached differently (Thomas and Garland, 2004).
Grocery shopping behavior is not only directed by their personal preferences, but also their economic and environmental conditions. Some consumers plan shopping activities beforehand, others do not. The existence of a shopping list is generally considered as an indication of prior planning, as it is a guide for shopping trip (Brunso and Grunert, 1998). Shopping lists and budgeting can be considered as initial part of shopping planning (Thomas and Garland, 2004). The existence of a list may change depending on culture; consumers without tend to be more impulse shoppers. Impulse buying is an unplanned decision to buy a product just before a purchase.

Thomas and Garland (1996) find that non-list users are more likely to purchase products on promotion than list users. Therefore, in store environment may contribute to this additional purchase, and a shopping list plays as a guiding action in grocery shopping behavior. Shopping lists are generally made arranged by the household member with overall responsibilities for shopping activities. Also, shopping planning may differ based on cultural values. While planning is generally realized by parents, children may determine needs in some cultures (Wiig and Smith, 2008).

2.2. Consumer logistics and grocery shopping

Consumers also participate in the logistical processing of goods from a point of acquisition to a point of disposal in the process of consumption. The process of this system is called consumer logistics (CL) system – initially presented by Granzin and Bahn (1989) - and consists of 10 sequential decision areas as shown in Figure 2.1.

CL comprises of both human and non-human objects, which are involved in the logistical processing of goods for the purpose of the consumption by household members (Granzin and Bahn, 1989). CL implies consumers’ participation in the movement and handling of the goods from point of origin to the consumption (Granzin et al., 1997).

Based on Granzin and Bahn (1989), Granzin (1990) suggested specific functions/processes of consumer logistics that are shown in Table 2.1.

Granzin and Bahn (1989), Granzin (1990), Granzin et al. (1997) further examined differences between the patterns of participation of CL and shopping patterns and demographic characteristics. Granzin and Bahn (1989) discussed thereby five functional subsystems referring to location, inventory, transportation, handling and storage and communication in greater detail by examining some of the most outstanding decisions and activities of each subsystem. Their study represents a generalized description of the structure and the process of the CL system. It also offers a conceptual system framework based on five functional components. This framework concentrates on the logistics activities that the households perform

Teller and Kotzab (2004) used the notions of Granzin and Bahn (1989) in order to find out to which extent consumers undertake logistics activities. They also examined how consumers perceive CL, the relevance of CL to the consumers’ choice of a distribution channel. Thereby Teller and Kotzab (2004) found out that consumers do not perceive CL as an important issue. This supports the assumptions of Barth et al. (2007), who claim that consumers do not consider the necessity to plan and calculate their logistical performance, which is contrary to business organisations. This is an interesting finding as Teller et al. (2012) showed in their study that consumers are performing CL very frequently, especially when it comes to grocery shopping. In an earlier study though Teller et al. (2006) could show that consumers evaluate their undertaken CL performance as being efficient.
In conclusion to that, CL seems to be performed habitually in parallel to shopping behavior. Furthermore, the demographics of a household and its shopping habit categorize a CL pattern (Teller and Kotzab, 2004; Granzin et al. 1997). In addition, store formats also affect the intensity of CL (Teller et al. 2006).

In their latest paper, Bahn et al. (2015) examine CL from the perspective of service dominant logic (S-D). Thereby they identified ten end-user logistics functions with associated activities including storage management, transportation management, inventory needs assessment and planning, materials handling, independent transportation operations, contingent inventory operations, location of product acquisition, intra-household communication and information search.

![Generic Model of Consumer Logistics](image)

*Figure 2.1 A generic model of consumer logistics (Granzin and Bahn, 1989)*
### Table 2.1 Identified Consumer Logistic Functions (adapted from Granzin, 1990, pp. 248-251)

<table>
<thead>
<tr>
<th>Function</th>
<th>Activity/Decision</th>
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<tr>
<td>In-home stock management (inventory)</td>
<td>Activities/decisions on where items to store at home, when to buy a product, the</td>
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<td>discard of items, the removal of items from stock, the management of the</td>
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<td>household’s supply, determination of the needs, control of available items at</td>
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<td>home, and the formalization of a shopping list.</td>
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<td>Selection of trip origin (location)</td>
<td>Activities/decision on from where to start the shopping trip.</td>
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<td>Trip management (transportation)</td>
<td>Activities/decisions on which vehicle, means of transport to use, which route to</td>
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<td>follow, when to shop (time), persons who has to shop with whom.</td>
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<td>Trip rescheduling (transportation)</td>
<td>Activities/decisions on how to substitute items if the shopping trip is not</td>
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<td>possible, postponing or canceling the shopping trip.</td>
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<td>Nature of travel (transportation)</td>
<td>Activities/decisions on taking a long trip or a short trip, how much time should</td>
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<td>be spent, how many and which stores are visited, involvement of carrying</td>
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<td>purchased items.</td>
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<td>Store selection and usage (location)</td>
<td>Activities/decisions on the type of store, how many stores to visit in regard to</td>
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<td>time limit, comparison between stores in regard to prices and products.</td>
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<td>In-store information gathering (communication)</td>
<td>Activities/decision on what products to buy due to information from store</td>
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<td>In-store substitution (inventory)</td>
<td>Activities/decision on substitution of the item by another article, product, or</td>
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<td>brand, in regard to Out-of-Stock (OOS), or by switching the store.</td>
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<td>Transport-related materials handling</td>
<td>Activities/decisions on how to manage conveyance of items within the store,</td>
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<td>(handling and storage)</td>
<td>home, and from the mode of transportation.</td>
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<td>In-home customer service communication</td>
<td>Activities/decisions on arrangement of joint needs, discussions about feedback</td>
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<td>(communication)</td>
<td>and satisfaction of the shopping trip.</td>
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<td>External food supply (location)</td>
<td>Activities/decisions on the supply of food, eating in a restaurant, or food</td>
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<td>Household supporting operations (handling and</td>
<td>Activities/decisions on maintenance of equipment (vehicle), disposing of</td>
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<td>storage)</td>
<td>garbage, supporting the household.</td>
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</tbody>
</table>

Unfortunately, Granzin and Bahn’s (1989) process model for consumer logistics has not received great deal of attention from the marketing channels and logistics management researchers (Bahn et al., 2015). The main reason for this is that consumer activities such as checking household inventory levels, determining route to the grocery store and preparing a shopping list based on the household inventory levels are all considered issues of consumer behavior issues rather than logistics management (Krishnamurthi et al., 1992; Block and Morvitz, 1999).

### 3. METHODOLOGY

The aim of this study is to validate the CL scale as suggested by Bahn et al. (2015) in a different country setting. Since Bahn et al.’s (2015) research concentrates on CL functions and their associated activities in grocery shopping, our sample consists of consumers who are actively involved in this type of activity too. We chose grocery shopping as the focal point for
measurement because the food industry is strongly related to daily needs, and such shopping is generally performed in a physical grocery store with great frequency.

The original scale of Bahn et al. (2015) consists of 32 separate tasks and we translated the original formulations from English to Turkish as well as translated the results back in order to ensure validity of our research (Malhotra et al. 1996).

A preliminary version of the self-administered online-questionnaire was reviewed and discussed by peers who led to the elimination of two of the tasks due to inappropriateness for grocery shopping in a Turkish setting. The eliminated two tasks were from location of product acquisition; these were “have part of your meal come from a store ….. meals/week, and have most of your meal purchased for “takeout” ….. meals/week”. These tasks were deleted from the CL activities, while grocery retailers are not mainly involved in meals sales and consumers do not consider “takeout” meal purchase as part of their grocery shopping in Turkey. Shoppers’ participation in logistics was measured with 30 separate tasks/activities under ten different consumer functions and their associated activities. The first part of the questionnaire contained questions to collect descriptive characteristics relating to the sample. In the second part, respondents were asked with the separate tasks to reveal their individual participation in a particular activity on ordinal and metric scale level.

The questionnaire was randomly sent to 650 consumers between March-May 2015. We received 474 answers resulting in a response rate of 73%. After adjustments for missing data, 356 responses from different geographical regions of Turkey were used for the analysis. Regarding this, the effective return rate is 55%.

4. RESULTS

4.1. Background on Turkish retailing and sample characteristics

4.1.1. Retail sector in Turkey

Turkish retailing continued to record a good performance in 2015 due to an ongoing company investment in new outlet openings and improvements in service levels. Also grocery retailers continued to account for by far the highest proportion of value sales in retailing in 2015. Nevertheless, in terms of value growth, non-grocery retailers had a better performance during the year. Thanks to the increasing penetration of modern grocery retail channels such as convenience stores and discounters, grocery stores have the significant growth rates (Euromonitor International, 2016). The increasing urban population, higher levels of employment, the increasing penetration of chained outlets and the high proportion of the Turkish population who are young people are expected to be the main reasons behind the positive performance of retailing during the forecast period, with the industry expected to register higher value growth at constant 2015 prices over the forecast period than it did over the review period (Euromonitor International 2016). On the demand side, for instance, grocery shopping habits have turned out to be largely localized. Emerging-market consumers tend to prepare their own meals and cook more than their peers in developed markets do, and they are used to do shopping at open-air market stands or small neighborhood grocery stores that provide a familiar selection of fresh food and household staples. They don’t necessarily perceive customer service at modern retailers as superior to that of the traditional trade (Child et al., 2015). In an emerging economy such as Turkey, internet users are increasing turning to online shopping. According to Turkish Statistical Institute (2012) reports, 21.8% of the Internet users shop online in Turkey. The results show that, online grocery shopping market is more than US$
2 billion in the whole e-commerce market, which exceeds US$ 6 billion in Turkey (Deloitte, 2014). Although the number of internet users has increased around the world, the majority of the consumers still prefer to use physical grocery stores. Therefore, it means important to examine consumers’ preferences, activities and decisions in physical grocery stores.

4.1.2. Sample characteristics

Our sample consists of 52% female and 48% male. The majority of our respondents prefer to do grocery shopping at the weekends. While Turkish population is young, the sample consists of the respondents mainly young respondents. Most of the sample has high school or bachelor’s degree. Income per month is mostly between 2001-5000 TL. 39% of the sample spends 16-30 minutes for grocery shopping. The grocery shopping is mainly derived from daily needs. Decision on the product changes according to brand, discount rate of the product, unit price and only price. The discount coupons definitely impact grocery shopping decision. Moreover, information search for discounts is obtained mainly from TV and brochures. Personal car and local transportation are preferred for grocery shopping. A more detailed information of our sample is further provided in Appendix 1.

4.2. Scale validation

We performed principal component analysis (PCA) to characterize the factor structure of the 30 items of consumers’ participation in grocery shopping. Factor analysis with varimax rotation was applied to validate the CL scale using SPSS version 22.0. We dropped five items with a factor loadings of less than 0.5 (see Fischer, 1992; Hulland, 1999; Cleff, 2013).

In accordance with Batra and Ahtola (1991), Geyskens and Steenkamp (2000) or Sweeney and Soutar (2001) we performed in a second step confirmatory factor analysis (CFA; with Lisrel 8.80) for the determination of the model fit as PCA considers only the total variance in the data (see also Malhotra, 2007). Content validity is provided through the use of existing CL scale. Reliability is demonstrated by checking the Cronbach’s alpha of the constructs.

Principal Component Analysis and CFA results both provide six components with 25 tasks/activities of CL. These are inventory needs assessment & storage management, transportation management & materials handling, contingent inventory operations & product acquisition, information search, intra household communication and interdependent transportation operations. In Turkey, inventory needs assessment and storage management are interdependent to each other likewise contingent inventory operations and product acquisition; transportation management and materials handling.

Table 4.1 displays the results of principal component analysis results and Cronbach’s alpha values for each construct. Six constructs have Cronbach’s alpha ranging from 0.761 to 0.934. While the principal component analysis explains approximately 75% of the total variance, the divergent validity is also provided. For convergent validity, a scale with NFI of 0.90 or above shows strong convergent validity. NFI value is 0.96, and hence provides strong convergent validity. The Goodness of Fit Measures as displayed in Table 4.2 represent a reasonable model fit.
<table>
<thead>
<tr>
<th><strong>Table 4.1 Results of principal component analysis</strong></th>
<th>α</th>
<th>% of variance</th>
<th>Factor loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Management &amp; Inventory Needs and Assessment (SMINA)</strong></td>
<td>0.934</td>
<td>34.015</td>
<td></td>
</tr>
<tr>
<td>Decide where items will be stored</td>
<td>0.844</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remove items from household stock so they can be used.</td>
<td>0.750</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decide how storage spaces in the home will be used.</td>
<td>0.821</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check to see which items that are needed are already available at home before the shopping trip</td>
<td>0.836</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check the items in household storage prior to the shopping trip to determine what is needed</td>
<td>0.840</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Look in the food storage area(s) to see what is needed</td>
<td>0.827</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transportation Management &amp; Materials Handling (TMMH)</strong></td>
<td>0.904</td>
<td>12.894</td>
<td></td>
</tr>
<tr>
<td>Choose the vehicle to use for transportation</td>
<td>0.791</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choose the transportation route to follow on the trip</td>
<td>0.869</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decide for myself what means I will use to reach the grocery store</td>
<td>0.836</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convey the groceries out of the store myself</td>
<td>0.730</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convey the groceries into my home by myself</td>
<td>0.776</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contingent Inventory Operations &amp; Product Acquisition (CIOA)</strong></td>
<td>0.878</td>
<td>9.680</td>
<td></td>
</tr>
<tr>
<td>When the desired item is not in stock at the store, purchase a substitute item</td>
<td>0.806</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When the desired brand is not in stock at the store, purchase a substitute brand</td>
<td>0.839</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When the desired size is not in stock at the store, purchase a different size.</td>
<td>0.793</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have part of your meal come ready-to-eat from a store</td>
<td>0.736</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have ready-to-eat-food delivered to your home</td>
<td>0.625</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Information Search (IS)</strong></td>
<td>0.903</td>
<td>7.329</td>
<td></td>
</tr>
<tr>
<td>Compare prices between two or more stores</td>
<td>0.885</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compare products between two or more stores</td>
<td>0.867</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Go to more than one store to get the best buys</td>
<td>0.854</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intrahousehold Communications (IHC)</strong></td>
<td>0.806</td>
<td>5.719</td>
<td></td>
</tr>
<tr>
<td>Notify household members whether I was able to purchase the items they wanted</td>
<td>0.825</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask household members what they want from the store</td>
<td>0.802</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask household members whether they are satisfied with the grocery products I buy</td>
<td>0.719</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interdependent transportation operations (ITO)</strong></td>
<td>0.761</td>
<td>4.987</td>
<td></td>
</tr>
<tr>
<td>Have store personnel convey the groceries to my vehicle</td>
<td>0.829</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Table 4.2 Goodness of Fit Measures

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square</td>
<td>565.94</td>
</tr>
<tr>
<td>df</td>
<td>252</td>
</tr>
<tr>
<td>Chi-square/ df</td>
<td>2.245</td>
</tr>
<tr>
<td>Goodness of Fit (GFI)</td>
<td>0.89</td>
</tr>
<tr>
<td>Adjusted Goodness of Fit</td>
<td>0.86</td>
</tr>
<tr>
<td>Normed Fit Index (NFI)</td>
<td>0.96</td>
</tr>
<tr>
<td>Comparative Fit Index (CFI)</td>
<td>0.98</td>
</tr>
<tr>
<td>Non-Normed Fit Index (NNFI)</td>
<td>0.97</td>
</tr>
<tr>
<td>Root Mean Square Error of Approximation (RMSEA)</td>
<td>0.058</td>
</tr>
</tbody>
</table>

## 5. DISCUSSION

The CL scale by Bahn et al. (2015) was first developed and tested in USA and comprised of ten different CL functions. However, in Turkey, only six CL functions were identified which were combined under the three CL functions of storage management & inventory needs and assessment, transportation management & materials handling, and contingent inventory operations & product acquisition. Compared to the Turkish results, the Bahn et al. (2015) scale presents the combined CL functions separately. Inventory needs and assessment drive storage management, materials handling is realized with the support of transportation management and product acquisition leads to contingent inventory operations. The six Bahn et al. (2015) CL functions are considered in our results as three interdependent CL functions within each other. This finding reveals that Turkish consumers do not perceive or perform these six functions separately, rather they perform the six CL functions with three CL functions.

Inventory needs and assessment drives storage management and vice versa. In addition, material handling and transportation management are performed and perceived as a single function. This is mainly due to the choice for the transport mean depending on the amount of grocery shopping to be purchased. Moreover, contingent inventory operations and product acquisition are considered as a single function. When unable to find the desired item at the store, a consumer may prefer to buy a substitute brand, substitute product, or a different size. Based on the out-of-stock situation of a desired item, a consumer is likely to select either another product, brand or different size of the same product.

The three other CL functions are information search, intra-household communication and interdependent transportation operations. When it comes to those, we did not find any differences to the original scale. However, when it comes to intra-store communication, which involves asking store personnel for help in locating items, asking store personnel about products
and complaining to store personnel about the service received, we were unable to identify this function in our study. This can be explained by the reluctance of Turkish consumers to ask questions, and the difficulty they have in making complaints in the physical store. Intra-store communication is the only CL function which was not validated by our results. According to our results, we named six CL functions as compared to the ten functions as identified by Bahn et al. (2015). Among these six CL functions, three functions involve the combination of two CL functions each (storage management & inventory needs and assessment, transportation management & materials handling, and contingent inventory operations & product acquisition), while the other CL functions are separate functions (information search, intra-household communication, interdependent transportation operations).

It should be noted that according to PCA, storage management & inventory needs and assessment explain the highest variance (34.015%) in CL functions followed by storage management & inventory needs assessment, transportation management & materials handling (12.894%), contingent inventory operations & product acquisition (9.680%), information search (7.329%), intra-household communication (5.719%) and interdependent transportation operations (4.987%).

Apart from these, we were not able to identify any significant differences amongst the validated CL functions in terms of gender, education, income and number of shopping days in a week. However, there is one significant difference in regards to those consumers who spend more than 30 minutes shopping time compared to those who that spend less. It is found that, the more time spent searching for information, the more time they spend on grocery shopping.

6. CONCLUSION AND OUTLOOK

The purpose of this paper was to contribute to the research field of CL by examining whether the measurement instrument of Bahn et al. (2015) can be used in a different country setting. We tested and validated the CL-scale in Turkey and revealed some differences as compared to previous studies.

First, not all scale items from Bahn et al. (2015) were relevant in our country setting, which led to a reduction of originally 32 items to 30 items in our research instrument. Second, the empirical results of our study further showed that CL activities were condensed to six CL-groups relevant for grocery shopping in Turkey as compared to ten activity areas suggested by Bahn et al. (2015).

Bahn et al. (2015) discussed based on the premises of Lucsch et al. (2007) implications of S-D logic for consumer logistics. From this point of view, storage management & inventory needs assessment depending on efficient storage space management, location decision and preparing a shopping list and we consider the S-D logic will have a number of implications for retailers’ practice and opportunities particularly with regard to enhancing value co-creation with the end-user not only in a Turkish context. Although consumer behavior seems to be kind of global and have similar manners for shopping, it still remains to be an emerging and interesting research area. Therefore, CL should be examined in different country settings through various retailer types.

This work is a first attempt for the contribution to the consumer engagement literature as another value of services performed by consumers and further research is necessary in order to investigate future sets of functions and/or additional activities.
Limitations refer to the sampling, which was generally conducted based on the close proximity to the authors’ living area. Further research should determine samples from a wide variety of geographic locations including outside of Turkey in order to make more valid generalizations concerning the consumer logistics functions.

Further research may make significant practical contributions to managers and researchers. Managers would benefit from the logistics activities presented in this article and get some insights about how they enhance their retail organization. Moreover, researchers would be encouraged to represent a profile of personal characteristics for consumers who participate in shopping.

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consumer brand choice and purchase quantity decisions, Journal of Consumer  


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### Appendix 1

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<tr>
<th>Shopping day</th>
<th>N</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Weekday</td>
<td>72</td>
<td>20.2</td>
</tr>
<tr>
<td>Weekend</td>
<td>163</td>
<td>45.8</td>
</tr>
<tr>
<td>Both</td>
<td>121</td>
<td>34.0</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>185</td>
<td>52.0</td>
</tr>
<tr>
<td>Male</td>
<td>171</td>
<td>48.0</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-25</td>
<td>151</td>
<td>42.4</td>
</tr>
<tr>
<td>26-35</td>
<td>98</td>
<td>27.5</td>
</tr>
<tr>
<td>36+</td>
<td>107</td>
<td>30.1</td>
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668
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<tr>
<th>Education Level</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
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<tr>
<td>Primary</td>
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<td>7.9</td>
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<tr>
<td>High school</td>
<td>123</td>
<td>34.6</td>
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<tr>
<td>Bachelor’s degree</td>
<td>170</td>
<td>47.8</td>
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<tr>
<td>Master’s degree</td>
<td>27</td>
<td>7.6</td>
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<tr>
<td>PhD</td>
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<td>2.2</td>
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<th>Income Range</th>
<th>Count</th>
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<tr>
<td>1-2000TL</td>
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<td>13.8</td>
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<td>2001-3000TL</td>
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<td>3001-4000TL</td>
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<td>4001-5000TL</td>
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<td>16.3</td>
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<td>5001-6000TL</td>
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<td>6001-7000TL</td>
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<td>4.8</td>
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<td>7001 + TL</td>
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<table>
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<tr>
<th>Shopping Time</th>
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</tr>
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<tbody>
<tr>
<td>1-15 min</td>
<td>49</td>
<td>13.8</td>
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<tr>
<td>16-30 min</td>
<td>139</td>
<td>39.0</td>
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<tr>
<td>31-45 min</td>
<td>87</td>
<td>24.4</td>
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<tr>
<td>46-60 min</td>
<td>46</td>
<td>12.9</td>
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<tr>
<td>60 min-75 min</td>
<td>21</td>
<td>5.9</td>
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<tr>
<td>75 + min</td>
<td>14</td>
<td>3.9</td>
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<table>
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<th>Shopping Motives</th>
<th>Count</th>
<th>Percentage</th>
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<tr>
<td>Daily need</td>
<td>298</td>
<td>83.7</td>
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<tr>
<td>Meal</td>
<td>77</td>
<td>21.6</td>
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<tr>
<td>Guests</td>
<td>95</td>
<td>26.7</td>
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<tr>
<td>Other</td>
<td>27</td>
<td>7.6</td>
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</table>

<table>
<thead>
<tr>
<th>Impact of Discount Coupons</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>227</td>
<td>63.8</td>
</tr>
<tr>
<td>Yes</td>
<td>129</td>
<td>36.2</td>
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<table>
<thead>
<tr>
<th>Decision on the Product</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit price</td>
<td>130</td>
<td>36.5</td>
</tr>
<tr>
<td>Price only</td>
<td>110</td>
<td>30.9</td>
</tr>
<tr>
<td>Discount</td>
<td>116</td>
<td>32.6</td>
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<tr>
<td>Brand</td>
<td>203</td>
<td>57.0</td>
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<td>Others</td>
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<table>
<thead>
<tr>
<th>Information Search for Discounts</th>
<th>Count</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Newspapers</td>
<td>65</td>
<td>18.3</td>
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<tr>
<td>TV</td>
<td>87</td>
<td>24.4</td>
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<tr>
<td>Radio</td>
<td>27</td>
<td>7.6</td>
</tr>
<tr>
<td>Brochures</td>
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<td>61.2</td>
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<td>Other Media</td>
<td>55</td>
<td>15.4</td>
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<table>
<thead>
<tr>
<th>Transportation Mode to Grocery Shopping</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal car</td>
<td>247</td>
<td>69.4</td>
</tr>
<tr>
<td>Bus</td>
<td>98</td>
<td>27.6</td>
</tr>
<tr>
<td>Underground</td>
<td>27</td>
<td>7.6</td>
</tr>
<tr>
<td>Ferry</td>
<td>6</td>
<td>1.7</td>
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<tr>
<td>Multimodal</td>
<td>4</td>
<td>1.1</td>
</tr>
<tr>
<td>On foot</td>
<td>47</td>
<td>13.2</td>
</tr>
</tbody>
</table>
PART II

ABSTRACTS OF WORK-IN-PROGRESS PAPERS
INCORPORATING THE COST OF TIME TO A LINER SHIP FLEET DEPLOYMENT MODEL: AN APPLICATION TO THE FAR EAST – USA/EUROPE TRADE FLOWS

Per J. Agrell*
Manuel Herrera**
Casiano Manrique***
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ABSTRACT

Purpose
In this paper the operational costs of a set of maritime and railway routes are studied. We apply a liner ship fleet deployment (LSFD) model in order to assign container liner shipping fleets to a network of routes connecting the Far East with the East and West coasts of North/South America and Europe. Consequently, some of these routes will cross the Panama Canal. A different mix of scenarios is considered: before and after the Panama Canal expansion and/or delays due to operational conflicts. Multimodality is included through a set of railway routes connecting the West and East coasts of the United States. The model minimizes an objective function comprising operational and time costs. The value of time is introduced in order to generate a more realistic result. Using existing estimates of time costs for the US foreign trade, delays are simulated in two specific sections of the network (ports in the US West Coast, and the Panama Canal), allowing the analysis of the resulting economic and operational impacts. The model leads to an optimal decision as a tradeoff between operational costs and the cost of time considering the associated effects of delays in US West Coast ports and/or the Panama Canal both before and after the Canal expansion. This formulation would allow us to simulate the impact of circumstances like port strikes, operational problems in the Panama Canal and other disruptive situations. The study may be used as an input to multiple regulatory decision methods based on the same benchmarking results.
Design
The present work, combines two different objectives in order to evaluate the operation of a liner fleet deployed on a set of routes. The first objective minimises the cost of operation of a liner fleet with transhipment operations. The second objective considers the value of time from the importer’s point of view, to determine the selection –regarding import traffic from Asia- of different (alternative) routes between the East and West coasts of the United States.

- The LSFD problem. The deployment of ships of the fleet of a liner shipping company is periodically assessed in order to meet the container shipment demand, matching the characteristics of the fleet to the market requirements. This redeployment rises the liner ship fleet deployment (LSFD) problem, this is, how many ships, of which type and to which routes ships should be deployed in order to minimise the cost meeting the demand (Wang & Meng, 2012). Following Wang and Meng (2012) A mixed-integer programming (MIP) model is proposed in order to solve the LSFD problem. The MIP problem, involves two type of decisions: those linked to the deployment of the ships and those linked to the flow and transhipment of containers. Implicit container flow origin-based variables are used instead of explicit origin-destination container flow variables, allowing a substantial decrease in the number of variables that characterise container transhipment operations. In the present application, we carry out pre-and post- Panama Canal expansion numerical simulations in order to assess the influence of the relaxation of the vessels capacity constraints in the structure of the operations: number of ships deployed, transhipment operations and the amount and structure of operating costs in each case.

- The value of time. The LSFD model relates the number of ships deployed to the length of the routes. Given that the model considers a weekly service, the number of ships deployed must equal the number of weeks required to complete the route. If the time to complete the route is increased, more ships will be needed with the consequential increase in the operating cost. LSFD does not take into account time in any other way. The customer perception of time then, is not captured in LSFD. However, transit time is a powerful sales factor for shipping companies. For certain types of goods (perishable goods, electronic equipment, etc.) time of transport is a crucial factor that determines the selection of the mean of transport. In order to capture the customer perception of time in terms of monetary value we contemplate a method developed by Hummels (2001), subsequently developed by Hummels et al. (2007). This method considers that time acts as a trade barrier in international trade, since the customer perception of the quality of certain goods can change depending on the time required for those goods to reach the market. Thus, what an importer perceives in terms of quality of a product changes depending on the time between manufacture and delivery, especially if the product is subject to a rapid depreciation (as it is the case for perishable goods or certain manufactured goods as smartphones or laptop computers, for instance). Hummels et al. (2007) apply this concept, considering that import delays act as an additional import tariff. In order to express time costs in days, they developed a method for expressing time costs in ad-valorem (“tariff equivalent”) terms. Using trade and shipping data, showing the value that consumers attribute to time delivery of each product, they estimate the value of a day saved in the transit of that product. Thus, they get a “per-day value of time savings” by product category. This, indicates the quality improvement for the consumer of a delay reduction of one day.

Findings
Simulations carried out by these authors (using the LSFD model) replicating the traffic across Panama Canal (before and after the expansion), have shown a decline in the operational cost of the deployed fleet after the Canal expansion. A particular simulation carried out to cover a total demand of 227,808 TEUS/week at different speeds, between the ports of Shanghai (SHA),
Hong Kong (HGK), Los Angeles (LAX), Balboa (BLB), Callao (CLL), Valparaíso (VAP), Miami (MIA), Savannah (SAV), New York (NYC), Manzanillo Panamá (MIT), Cartagena de Indias (CTG), Santos (SSZ), Rotterdam (RTM) and Bremerhaven (BRV), showed that after the Canal expansion, the total cost of operate the (deployed) fleet declines. Table 2 shows the costs before (scen 1) and after (scen 2) the Canal expansion:

Table 1 Cost structure (millions of USD/week). Demand: 227,808 TEUS/week. Speed in knots (kts).

<table>
<thead>
<tr>
<th>Costs</th>
<th>Sub-costs</th>
<th>18 kts scene 1</th>
<th>18 kts scene 2</th>
<th>20 kts scene 1</th>
<th>20 kts scene 2</th>
<th>22 kts scene 1</th>
<th>22 kts scene 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel</td>
<td></td>
<td>143</td>
<td>135</td>
<td>156</td>
<td>147</td>
<td>189</td>
<td>172</td>
</tr>
<tr>
<td>Cargo</td>
<td></td>
<td>112</td>
<td>111</td>
<td>114</td>
<td>114</td>
<td>111</td>
<td>113</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>255</td>
<td>245</td>
<td>270</td>
<td>262</td>
<td>299</td>
<td>284</td>
</tr>
</tbody>
</table>

This simulation was carried out using the fleet characteristics that can be seen in Table 2. It must be highlighted the influence of the bunkering cost in the showed cost structure. Given the current volatility of fuel prices, the results of these simulations can be highly variable.

Table 2 Characteristics of the fleet.

<table>
<thead>
<tr>
<th>Bunker price $b_p$ (USD/Tn): 500</th>
<th>Ship type $v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (TEUs)</td>
<td></td>
</tr>
<tr>
<td>Speed $S$ (knots)</td>
<td>1</td>
</tr>
<tr>
<td>Fuel consumption (Tn/h)</td>
<td>18</td>
</tr>
<tr>
<td>5000</td>
<td>2.3</td>
</tr>
<tr>
<td>7000</td>
<td>2.3</td>
</tr>
<tr>
<td>12000</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Research limitations/implications

The inclusion of the cost of time delays in the objective function of the LSFD2 model gives insights into the importer preferences regarding the route of transport to be followed for imported goods. Incorporating time delays as an additional term in the cost function of the LSFD model provides a better estimate of the supply chain value created by the transport. Historically, the importer has decided only about the mode of transport and not about which routes must be followed. The influence of disruptive situations along the route and the options introduced by intermodal transport, open a wide range of options to the importer regarding modes of transport, time and routes.

Keywords: Container, Fleet deployment, Liner shipping, Transhipment, Mixed-integer linear programming.
EXPLORING “SERVICE” IN SUSTAINABLE SUPPLY CHAIN MANAGEMENT RESEARCH

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ABSTRACT

Purpose
He et al. (2016), among others, argue that service sector is the main GDP contributor that improves the global and local economic performance in the developed countries underlining the importance of managing service sector. However, within supply chain management literature managing service supply chains has rarely been investigated (Goldstein et al., 2002; Roth and Menor, 2003; Ellram et al., 2004; Baltaciouglu et al., 2010). Specifically, sustainability issues in service supply chains is almost neglected (see e.g. He et al., 2016; Hussain et al., 2016). Therefore, the aim of this research is to explore how services have been addressed in sustainable supply chain management literature. Additionally, we define and also conceptualize sustainable service supply chain management.

Design/methodology/approach
A systematic literature review method was used to scrutinize the current body of literature on the topic under study (see e.g. Cooper, 1989: Tranfield et al., 2003, Seuring and Gold, 2012). Google scholar search engine was used to identify the highly cited papers on sustainable supply chain management literature. Initially, a search with keyword “Sustainable supply chain” was carried out. A total of 500 highly cited articles were selected for initial analysis, out of which 210 were found to be relevant for further analysis since these focused on sustainable supply chain management. The search was further refined to include only those articles which included word “service”, resulting a total of 142 articles for the final review.

As a first step, a thorough review of the articles was carried out to see how the word service was mentioned in the literature. A descriptive analysis was conducted as an initial step to get a snapshot of the literature. This was followed by a detailed structured analysis. Finally, a structured content analysis of the selected articles against the constructs derived inductively was taken up.

Findings
The results indicate that there is no comprehensive definition for sustainable service supply chain management in the literature so far. A careful analysis of the existing definitions revealed that the classical definitions of sustainable supply chain management are more often used to describe sustainability of services also. Results show that typically in the sustainable supply chain context there was no clear delineation of product and service; often both these terms were mentioned together. However, important characteristic features of service supply chains were missing (which included emphasis on the human element in service supply chains). This implies
that, managing sustainability in service supply chains also involves managing people apart from managing equipment, facilities, information, processes, products and service (Johnson and Mena, 2008). Therefore, sustainable service supply chain management not only includes environmental but social dimension too.

The findings show that the word “service” was mainly found in introductory and literature review parts of the articles reviewed. This is followed by methods and findings. It was surprising to see that the later parts of the articles (discussion, implications, conclusions/summary, and/or limitations) rarely carried forward the arguments from introductory and literature review parts specifically addressing the service. Further, limitation section seldom addresses arguments pertaining to “service” in sustainable supply chains. On the sustainability side, environmental issues were more integrated into service supply chains whereas socio-economic issues hardly receive attention among the researchers. Findings also indicate that there is no concrete construct development in sustainable service chain management. Based on the findings, we provide initial suggestions to develop the constructs further.

**Research limitations/implications**

This research identifies distinct features of services and intend to develop a conceptual framework for sustainable service supply chain management. Specifically, this study aims to link sustainability and service supply chains and could give fresh insights hereby developing the theory for sustainable service supply chain management.

Firstly, despite the refined evaluation process and criteria the review might still be subjective to the researcher interpretation which could be a limitation. Secondly, this literature review is comprehensive but not exhaustive. Nevertheless, the selection of highly cited articles increases the validity of the research. The conceptual framework of sustainable service supply chain management should open the field for further conceptualisation, empirical testing and construct development.

**Practical implications**

The conceptualisation of sustainable service supply chain management may help both practitioners and researchers in identifying key areas of service development. Further, such a conceptualisation should serve as a step towards theory development at the intersection of service and sustainable supply chains simultaneously.

**Social implications**

There are significant social and environmental issues that needs to be taken into consideration by the firms while dealing with services in their supply chains. Identification of key sustainability issues in service supply chains could improve sustainability performance.

**Original/value**

Firstly, by conducting a literature review, we provide a comprehensive set of issues concerning service supply chains, and therefore contribute to the emerging research field of sustainable service supply chain management. Secondly, by bringing the dispersed constructs in sustainable service supply chain management into a conceptual framework we provide initial insights into sustainable service supply chain management.

*Keywords: Service supply chains, Sustainability, conceptualization*
REFERENCES


THE POTENTIAL OF PRIORITY LANES ON URBAN MOTORWAYS

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ABSTRACT

Purpose
Urban freight transport is essential to the functioning of modern urban economies. Cities are places of consumption relying on frequent deliveries of groceries and retail goods, express deliveries to businesses, and a fast-growing home delivery market. Furthermore, in cities serving as hubs for national and international trade, urban freight transport is essential for wholesaling, distribution, logistics, and intermodal operations (NCFRP 2013). The function of a city as a place of production is also involving significant freight activity related to their role and function in global supply chains. Urban freight transport is therefore an important component of the economic vitality of cities (Rodrigue 2013).

However, the urban environment characterized by scarcity of access, such as congested roads, space constraints and limitations of infrastructure restricts the efficiency and quality of freight operations (Hesse and Rodrigue 2004). Freight transport activity is projected to increase significantly (in the EU by about 40% from 2005 to 2030 and by 80% to 2050) (European Commission 2011), resulting in growing congestion with associated costs of approximately 1% of the EU’s GDP (European Commission 2007). These congestion costs are projected to increase by about 50% by 2050 (European Commission 2011). Traffic congestion also impairs the efficiency and quality of logistics operations due to transit time variability as it deteriorates the reliability of deliveries deteriorates. Transit time variability can also reduce the productivity of operations within factories, warehouses and shops (McKinnon, Edwards et al. 2009).

One potential strategy that has recently emerged to improve the efficiency of goods movement is the segregation of trucks from other users of the road. Studies done mainly in the USA have shown that truck-only lanes, which restrict trucks to certain lanes of the roadway, have the potential to alleviate congestion for both passenger cars and trucks, however, these benefits appear only under quite specific traffic volume, truck percentage and value of time conditions (Rudra and Roorda 2014). Little analysis has done to quantify the potential benefits in European cities. The purpose of this study is to evaluate priority lanes on urban motorways from an European perspective.

Design/methodology/approach

Research design

This paper is based on a theoretical case study. In a scenario analysis, the socio-economic costs of two alternative design of an urban motorway are calculated. Today’s design which has three general purpose lanes (GPL) with an urban speed limit of 90 km/h (Figure 1A), is compared with a solution, where one lane is reserved for priority vehicles, resulting in a design of two GPL and one priority lane (PL) (Figure 1B).
The following system effects are evaluated for both scenarios. A prioritization of traffic leading to better vehicle flow on the PL, leads to shorter journey times and better service quality (less stop-and-go traffic). Better service quality leads to reduced fuel consumption, which leads to both reduced environmental impact (reduced emissions) and more efficient transport (less fuel costs). Shorter travel times leads to less time costs for the vehicles, leading to more efficient transport. Factors affecting the size of these effects are:

1. Order of magnitude of improved service quality. The improvement potential depends on two factors. The first factor is the initial traffic situation. If the traffic is congested, getting access to a priority lane implies high travel time savings. These savings decrease with increasing travel speed in the initial situation. The second factor is the number of priority vehicles allowed access to the PL. If the number is too large, this leads to congestion on the PL and speed advantage compared to the initial situation disappears.

2. The environmental effect of an improved traffic quality depends on two factors. The first factor is the vehicle technology and the fuel used and the second factor is the amount of external costs which issues generate. The values for air pollution varies depending on whether the traffic takes place in areas of high or low population densities.

3. The effect on transport efficiency mainly depends on the valuation of travel times for carriers, i.e. cost of a vehicle hour. This depends on many factors, such as the amount the economic value of the freight transported.

The goal of the case study is twofold:

1. Under which circumstances can the traffic quality be improved on the PL without compromising traffic quality on the GPLs?
2. How many vehicles can be prioritised to guarantee a good traffic quality on the PL?
3. How big is the improvement potential in terms of external cost savings under this circumstances?

Method and data

As an indicator of service quality travel speed on the motorway is used, where high travel speed is a good traffic quality (short travel times, energy efficient driving) and a low speed (congestion) is a poor quality (long travel times, high fuel consumption due. Stop & Go). The travel speed depends on the vehicle flow and the capacity of the motorway. The method for calculating the travel speed is based on the Swedish Traffic Administration's report for the calculation of capacity and accessibility effects of road traffic facilities (Trafikverket 2014).

The vehicle emissions in the various traffic situations are calculated based the Handbook Emission Factors for Road Transport (INFRAS 2014). The external costs of these emissions are calculated based on the EU Commission’s handbook on external costs of transport.
Vehicle and fuel: In order to facilitate the calculations it is assumed that the traffic consists of a generic passenger car (1.4 and 2 liter gasoline engine) and a generic lorry (truck / trailer combination, 34-40 tonne capacity, diesel engine). For both vehicle types it is assumed that they have a Euro 6 engine using of fossil fuels.

External cost values for atmospheric emissions: For climate impact it is assumed that 1kg of CO2 gives rise to a cost of 9 €-ct. For local effects it is assumed that the emissions occur in urban areas (more than 1,500 inhabitants per km2), with the following costs: PM: € 19.8 ct/g; NOx: 0.5 € ct/g; HC: 0.1 € ct/g (RICARDO AEA 2014).

The composition of traffic: The vehicle flow analyzed in this case study is assumed to consist out of 74% passenger cars, 15% of small trucks, large trucks 10% and 1% buses.

Vehicle sizes: the following factors are used to calculate the number of vehicles in the vehicle flow. Passenger: 1 passenger car unit (PCU); small truck 1.9 PCU; large truck 2.9 PCU and bus: 2.5 PCU. Summarizing all heavy vehicles (small trucks, large trucks and buses) into a group results in 2.3 PCU.

The values of time: for passenger cars 200 Swedish Crowns (SEK) per hour are assumed, and for heavy vehicles (composition of small trucks, large trucks and buses) 560 SEK per hour.

Findings
The result of the analysis leads to two conclusions. The first conclusion is that it is possible to improve traffic flow for all vehicles, both for vehicles in the PL and vehicles in the GPL, but not under all traffic conditions. In an initial traffic situation where travel speed is only slightly below allowed travel speed, travel time improvements in the PL are only marginal while travel speed in the GPL decreases substantially. In an initial situation with more traffic, and thus lower travel speeds in BAU, a significant improvement on both PL and GPL can be achieved in the scenario. This 'win-win' occurs when approximately 25-35% of the vehicle flow is allocated to the PL. If less than 25% of the vehicle flow is moved to the PL, the vehicle flow on the GPL is still high and hence resulting in a lower travel speed on the GPL than in BAU. It thus results in a 'win-lose situation' where the speed on the GPL is lower than in BAU, while speed on the PL is higher. If more than 35% of the vehicle flow is moved to the PL, travel speed is lower than in BAU.

Research limitations/implications
This case study is a theoretical case study based on many assumptions that imply simplification of reality. The results of the case study therefore show only a theoretical potential, which probably cannot be achieved in full scale in reality. The following simplified assumptions are made:

- Simplified vehicle fleet
- Simplified values for the value of time based on an USA context
- Only new vehicles with emission class Euro 6
- The case study does not take into account the impact of ramps and exits on traffic flow

A complete analysis of the potential benefits therefore requires to take into account several factors that were not included in this study. Suggestions for further research therefore include:

- A higher level of detail on the fleet in terms of vehicle categories and emission classes
- A higher level of detail on the values of times

(RICARDO AEA 2014). Value of time calculations are based on the values used in the analysis of the effects of night deliveries in New York City (Holguín-Veras, Ozbay et al. 2011). The following values are assumed for the calculations:
Several scenarios with other road types, such as highway with two lanes and urban arterials with bus lanes

In addition, this case study is methodologically limited, as it does not take into account the effect ramps and exits, as well as the travel time losses in different states of congestion. One possibility for further research is therefore a microscopic traffic simulation that can take into account these factors.

Keywords: urban freight, city logistics, priority lanes, value of time, external costs.

REFERENCES

A GAME-THEORETIC MODEL FOR ANALYSIS OF INVESTMENT DECISIONS OF PORTS

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Alari Purju**

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ABSTRACT

Purpose
The paper discusses the conditions and interrelationships for investments into infrastructure made by ports. Investments are divided into two groups: investments into common infrastructure (development of road, railway network etc.) and investments into port-specific infrastructure (investments on the territory of the port). The investments to the common infrastructure affect investments to the infrastructure related only to the specific port since ports are subject to budget constraint. Therefore, investments to the common infrastructure reduce the amount of resources available for investments related only to the specific port. At the same time, some investments related to the specific port are meaningful only provided the investments to the common infrastructure (e.g. quality of hinterland-connections) are on a certain level. In the game, two ports have to decide, whether or not to contribute to the investment into common infrastructure which is related to both ports and would benefit both ports. Common infrastructure can be considered as a public good. The paper addresses the following questions: Which are conditions for the cooperation of competing ports? Which are options to overcome the problem of free rider? Which are options to overcome the social traps and achieve the Pareto-efficient outcome? Also the role of public sector is of interest since public sector can influence the marginal utility of investments into the common infrastructure.

Introduction
The formation of competitiveness of ports can be analysed with the help of the framework of game theory. The framework of game theory offers possibilities for the analysis in a dynamic context: as a result of the interaction, competition and cooperation of ports and the strategic decisions of ports having effect on each other.

The strategic decisions of competing ports have been analysed in the framework of game theory in different studies from different perspectives. These studies have considered different strategic decisions (e.g. decisions regarding charges, decisions regarding investments) in case of different players (e.g. the interaction between competing ports, between a port and its terminals, between a port and shipping lines, between container terminals of a port) in different game settings.

**Method**

The game theoretic models elaborated in the current study are related to the concepts of public economics. As important concepts, mechanism design, public good and problem of free rider can be pointed out.

The game is modelled in different settings to analyse how the solution of the game changes if the assumptions of the game change. The following cases are under observation: static game with complete information, static game with incomplete information, dynamic game with complete information, dynamic game with incomplete information. Also, the impact of change in the aim of the players presents interest.

In case of static games, the players make a decision simultaneously. In case of dynamic games, the players make decisions in a sequence meaning that the decisions already made in previous steps of the game are known to the players (the history of the game is known). In the games of complete information the players have information regarding each other’s payoff functions. In case of games with incomplete information the players lack this information.

If the players lack dominant strategies, it is assumed that they will apply mixed strategies in case of which both pure strategies (to contribute or not to contribute to the common infrastructure) are applied with equal probability.

In the elaborated models, the players are two competing ports which have a common hinterland. The general aim of a port is to enhance its competitiveness. In different models the aim of the ports is formulated in different ways:

- The aim of a port is to maximize its throughput.
- The aim of a port is to attain larger level of throughput than that of its competitor.

In the game two ports have to make the decision whether or not to support investment into common infrastructure. The essence of the game is described in the section “Purpose”.

The payoff function of the first port is defined as follows:

\[
y_1 = \alpha_1 + \alpha_2 (C + A_1)^2 + \alpha_3 (I + A_2 + B_2) + \alpha_4 (A_3)
\]

where \(A_1\) is the investment to the infrastructure related only to the first port; \(A_2\) is the contribution of the first port to the common infrastructure; \(B_2\) refers to the contribution of the second port to the common infrastructure; \(A_3\) are other factors affecting the competitiveness of the first port; \(C\) refers to the level of investments already made to the first port’s infrastructure before decisions of the game; \(I\) refers to the level of investments already made to the general infrastructure before decisions of the game; \(\alpha_1, \alpha_2, \alpha_3, \alpha_4\) are parameters of the model.

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The budget constraint of the port is $A_1 + A_2 = 2$. With the substitution $A_1 = 2 - A_2$, the payoff function above can be rewritten $y_1 = a_1 + a_2 (C + 2 - A_2)^2 + a_3 (1 + A_2 + B_2) + a_4 (A_3)$

The assumption of the game is that $A_2$ can obtain values $0$ or $1$. Hence, $A_1$ can obtain values $2$ or $1$. Another assumption is that some investments to the port-specific infrastructure are meaningful only provided that investments to the common infrastructure are at least on the level $1$ ($A_2 + B_2 \geq 1$). Let $A_1 = 2$ be possible only provided that $A_2 + B_2 \geq 1$.

Similarly, the payoff function of the second port is defined as $y_2 = \beta_1 + \beta_2 (D + 2 - B_2)^2 + \beta_3 (1 + A_2 + B_2) + \beta_4 (B_3)$ where $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$ are parameters of the model; $D$ refers to the level of investments already made to the second port’s infrastructure before the start of the game; $B_2$ refers to the contribution of the second port to the common infrastructure whereas $B_1$ is the investment to the infrastructure related only to the second port; $B_3$ are other factors affecting the competitiveness of the second port.

In the following, the normal form of the static game is presented.

<table>
<thead>
<tr>
<th>First port</th>
<th>Contribute</th>
<th>Not to contribute</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$y_1 = a_1 + a_2 (C + 1)^2 + a_3 (1 + 2) + a_4 (A_3)$;</td>
<td>$y_1 = a_1 + a_2 (C + 1)^2 + a_3 (1 + 1) + a_4 (A_3)$;</td>
</tr>
<tr>
<td></td>
<td>$y_2 = \beta_1 + \beta_2 (D + 1)^2 + \beta_3 (1 + 2) + \beta_4 (B_3)$</td>
<td>$y_2 = \beta_1 + \beta_2 (D + 1)^2 + \beta_3 (1 + 1) + \beta_4 (B_3)$</td>
</tr>
<tr>
<td></td>
<td>$y_1 = a_1 + a_2 (C + 2)^2 + a_3 (1 + 1) + a_4 (A_3)$;</td>
<td>$y_1 = a_1 + a_2 (C + 1)^2 + a_3 + a_4 (A_3)$;</td>
</tr>
<tr>
<td></td>
<td>$y_2 = \beta_1 + \beta_2 (D + 1)^2 + \beta_3 (1 + 1) + \beta_4 (B_3)$</td>
<td>$y_2 = \beta_1 + \beta_2 (D + 1)^2 + \beta_3 I + \beta_4 (B_3)$</td>
</tr>
</tbody>
</table>

The equilibrium solutions of the game depend on the values of parameters $\alpha_2$, $\alpha_3$, $\beta_2$, $\beta_3$ and the levels of investments already made to the port-specific infrastructure, $C$ and $D$.

In dynamic games the fact that the second player has information regarding the decisions of the first player has an impact on the solution of the game.

**Findings**

Generally, two solutions of the game are of interest: 1) the solution where both ports contribute to the common infrastructure, i.e. cooperation is the outcome; 2) the solution where neither of the ports contributes to the common infrastructure.

In very general theoretical terms, the cooperation of ports in supporting common infrastructure projects makes headway, if for both ports the marginal utility of the common infrastructure is higher than the marginal utility of the infrastructure related only to one port. The probability for this solution is relatively higher if the level of previous investments to the common infrastructure is low or in case where both the levels of previous investments to common infrastructure as well as to port-specific infrastructure are high but additional investments to enhance the capacity of a port require additional investments to common infrastructure.

In case of static games, both in case of the game with complete information as well as the game with incomplete information, one possible outcome, among others, is the situation where neither of the ports contributes to the common infrastructure. This outcome can be considered as the social trap since the competitiveness of both ports would increase if at least one of the ports would contribute to the common infrastructure. In case of dynamic games, the social trap can be avoided and the Pareto-efficient outcome can be attained.
Contribution of the research
The research provides an analytical theoretical framework to consider the strategic decisions related to infrastructure investments of the ports. In particular, the study addresses the potential cooperation between competing ports and the importance of infrastructure related to hinterland-connections in the formation of competitiveness of ports. Also, on the basis of the results of the model, the role of the public sector in influencing the outcome of the game can be discussed.

Keywords: competitiveness of ports, game-theoretic modelling, infrastructure investments, cooperation of ports, free rider problem
ABSTRACT

Purpose
In an ever faster evolving environment which is increasingly characterized through hyper competition, shorter product life-cycles, and globalization companies need to change and adapt on a constant bases to sustain a competitive advantage (Defee and Fugate, 2010; Richey et al., 2010). According to Defee and Fugate (2010) firms need dynamic capabilities which allow them to respond to environmental changes and generate temporary advantages (Teece, 2014). In addition, the redesign of governance forms plays an important role when responding to environmental dynamics (Richey et al., 2010; Gereffi et al., 2005). Considering however, that the supply chain itself has been referred to as an organization (Ketchen and Giunipero, 2004) and the competition is on the level of supply chain rather than companies nowadays (Henkoff, 1994), these (dynamic) capabilities and governance forms need to be researched on the supply chain level. Therefore, the governance redesigns must focus on “...how the supply chain is managed, who controls it and how direction is set. It extends beyond the firm, to explore firm boundaries, in terms of who does what in the supply chain, including the make-buy decision and the nature of supply chain relationships or collaboration” (Ellram and Cooper, 2014 p. 13-14). Thus, the governance redesign is subject to vertical integration and supply chain integration. While vertical integration explores the boundaries of the firm by using theory from strategic management, industrial organization or organization literature that focuses on hierarchy or market mechanisms (e.g. Helfat, 2015), supply chain management literature on the other side mainly analyses the concept of supply chain integration, using cooperative network governance forms (Bhakoo et al., 2015). Despite the increased interest in both research fields, studies combining these two literature streams are scarce. However, recent papers that consider the outsourcing decision of one company as the integration decision of another company show that a combination of vertical and supply chain integration literature contributes to the advancement of the integration discussion (Guan and Rehme, 2012). This paper aims at integrating these two literature streams and their reasoning on boundary decisions on a strategic level to explain the development of supply chains in regard to the division of tasks between the firms and the ways of integrating them. We develop propositions on how these two literature streams combined can more fully explain the decisions than either one alone.

Design/methodology/approach
First, a structured literature review of the vertical integration and supply chain integration literature is conducted. Theories from the organizational, strategic management and industrial organization literature are used, as they are the main theories when explaining vertical
integration (Helfat, 2015). Specifically the transaction cost economics theory and the resource-based view, with the application of the knowledge-based view, and the evolution theory are used. These theories have already been applied to supply chain management, though only to an individual firm within the supply chain (Chen et al., 2009; Ketchen and Giunipero, 2004; Hitt, 2011). As adapting strategic management theories to supply chain management is thought to be beneficial for the development of the theoretical foundation of supply chains (Defee and Stank, 2005), it is important to include the recent developments from the literature on vertical integration in the model about supply chain governance decisions. Arguments from both literature streams will be combined and conceptualized to theoretically define the factors that influence how the supply chain as an organization “decides” how to split up tasks and coordinate them thereafter.

**Findings**

Much progress on combining the resource-based view and transaction cost economics in order to explain the vertical integration decisions has been made recently – e.g. dividing transaction costs in transient and non-transient costs, combining resource-based and transaction cost theory in order to explain capability development (Jacobides and Winter, 2012; Helfat, 2015). However, this theory development and application is mostly done outside of SCM literature and without taking into account advancements in SCM literature.

The supply chain integration literature departed from the assumption that more integration (of the supply chain) always leads to better performance (van der Vaart and van Donk, 2008). Mixed empirical results have raised questions about such a simplistic view (Fabbe-Costes and Jahre, 2008; Vallet-Bellmunt and Rivera-Torres, 2013). Without a strictly positive relationship between supply chain integration and performance, contextual factors are increasingly used to explain in which cases integration leads to positive performance outcomes (Nakano and Akikawa, 2014; Tsinopoulos, 2015). As there is no “underlying theory describing the contingencies of supply chains” (Stonebraker and Afifi, 2004 p. 1132), we theoretically develop these contextual factors.

By analyzing the vertical and supply chain integration through the theories of the resource-based view, with the application of the knowledge-based view, transaction cost economics and evolution theory we find the following:

One important contingency from the firm boundary decision literature is the occurrence of systemic innovations. From a knowledge-based view the “integrative capabilities” of a company play a major role in the boundary decision when faced with (repeated) systemic innovations (Helfat, 2016). Such “integrative capabilities” can basically be translated as very high levels of internal (or even external) supply chain integration, as both focus on coordination, communication, and sharing knowledge over (internal) boundaries (Kim, 2013). Therefore, we propose:

**Proposition 1:** High levels of internal supply chain integration can lead to vertical integration in the face of systemic innovation.

However, if the relevant complementary knowledge for the systemic innovation can be found in a supplier/customer with whom a very high external integration, with a focus on knowledge sharing, exists, no vertical integration has to follow. The high level of external integration enhances knowledge transfer and knowledge generation between the two firms, giving the necessary access to the knowledge without ownership. Therefore the second proposition is as follows:
Proposition 2: High levels of external supply chain integration can lead to a sustained vertical disintegration in the face of systemic innovation. This gives a contrary argument to the classical literature on vertical integration.

Combining evolutionary theory and the transaction cost view lead to the differentiation between transient and persisting transaction costs (Qian, 2012). While transient costs fall when the industry develops, persistent costs remain (e.g. due to demand fluctuations). However, the possibility of mitigating such persistent transaction costs via external supply chain integration has been very much ignored. Including external supply chain integration reasoning leads to proposition three:

Proposition 3: High levels of external integration can lower “persistent” transaction costs leading to even more vertical disintegation as industries develop.

Research limitations/implications
As this paper is conceptual in nature only a framework for incorporating both literature streams and propositions about their interconnectedness are presented. Empirical testing thereof has to be conducted.

Practical implications
When making decisions about firm boundaries more than just a strict make-or-buy decision must be made. Possibilities and ways of integrating the task, resources or capabilities via supply chain integration practices must already be considered in the initial boundary setting decision.

Original/value
The proposed combination of reasoning from strategic management and organisation literature on vertical integration with SCM based supply chain integration reasoning increases the knowledge on the development of supply chains. To the knowledge of the authors this is the first work including transaction cost economics as well as resource based reasoning when combining vertical and supply chain integration. It also follows the call for research on theoretical foundation of the supply chain management literature and the call for more usage of strategic management advancements in SCM related research.

Keywords: Supply Chain Integration, Vertical Integration, Transaction Cost Economics, Resource Based View, Knowledge Based View
SUPPLY CHAIN RISK MANAGEMENT
– IT’S ALL ABOUT CAPACITY

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ABSTRACT

Purpose of this paper
This paper examines supply chain risk management (SCRM) from a systems perspective by considering the main risk reduction strategies for supply chains suggested in literature. The strategies will be linked to the traditional supply chain management (SCM) problems of effectiveness, efficiency and capacity. The purpose of this paper is to identify if SCRM addresses the same problem of effectiveness, efficiency and capacity, but expressed and utilized in new way.

Design/methodology/approach
The research is based on a system approach, which emphasizes a holistic view instead of the characteristics of the different parts. This research is mainly conceptual, based on a literature review of relevant SCRM-papers in SCM journals.

Findings
Traditional SCM focus more on efficiency (do things right/upstream attention) than on effectiveness (do the right things/downstream attention). The same perspective is found in SCRM strategies. Thus, the main concern in SCRM is linked to capacity problems either as a shortage, potentially lost sales, or a surplus creating high inventory.

Research limitations/implications
This research is primarily based on scientific literature sources, which limits the generalisation possibilities for the finding.

Practical implications
Increase the understanding of how SCRM strategies can be applied to classical SCM problems as well as how the two areas can be combined to target common problems for companies today.

What is original/value of paper
The holistic perspective on SCRM in this paper linked to traditional SCM problems brings clarity to the SCRM area as it identifies what is truly new and what is just “emperors new clothes”.

Keywords: Supply chain risk management, Supply chain management, Capacity, Retrospective analysis, Business strategy, Hazard project

Introduction
The foundation of trade is the ability to move or transport a product from the source to the customer and still make a profit (Landes, 1998). The foundation of businesses can be described with the two fundamental major problems - finding or creating demand and how to supply it. Supply and demand are two sides of the same coin in business; by controlling either supply or
demand, one organisation can increase its ability to affect the price of a certain commodity within a certain geographical area (Mankiw, 1997). Normally the supply side is considered easier to control than demand. The supply side can be described as the question of how to produce or acquire parts for the complete product.

In their proposal for a comprehensive risk management and mitigation model for global supply chains, Manuj and Mentzer (2008a) argue that the risk of any particular type of loss should be conceptualized as the probability of the loss multiplied by the impact of the loss. Similar definitions of risk can be found in much of the contemporary supply chain risk management (SCRM) research (e.g., Khan and Burnes, 2007; Norrman and Jansson, 2004; Tummala and Schoenherr, 2011; Wagner and Bode, 2008). Thus, according to this view, risk should be seen as the combination of probability or frequency of occurrence of a certain hazard and the value or impact of its occurrence. In SCRM practice, however, the distinction between probability and impact is usually overlooked, as risks are often measured or discussed on the aggregate level.

**Background**

Ghison et al. (2005) defines supply chain management (SCM) as “the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies.” The different building blocks integrated in a supply chain can be located throughout the world and connected through a transport network. The transport network only physically integrates the supply chain with the fulfillment of its transport demands (Bowersox et al., 2002). Current economic trends suggest the necessity of specialization rather than vertical integration (e.g., economies of scale). This trend forces large organizations to rely on partners, suppliers, consultants, and other types of external firms to deliver customer value to their marketplaces. Different risks are attached to all these SCM activities; one of these is the risk of products being stolen during transport, primarily during road transport. According to Souter (2000), companies should focus on risks from links in their supply chain, rather than just their own risks. Sharing both risks and rewards among the members of the supply chain is a key component of SCM (Lambert and Cooper, 2000; Mentzer et al., 2001). This reinforces the need to both understand and manage risks from a supply chain perspective to reduce ripple effects of all magnitudes. The usage of risk management tools and processes within the scope of logistics and SCM is described by Normran and Lindroth (2002) as follows: “Supply chain risk management is to [collaborate] with partners in a supply chain applying risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources.” This description stresses the need for interdisciplinary research, as risk management practice is included in SCM (Sanders and Wagner, 2011).

According to Colicchia and Strozzi (2012), current research in SCRM has received increasing interest from both the practitioners’ perspective and as a research area. This area is relatively new and began with research on risks and purchase (Khan and Burnes, 2007). The current research in this area is based, both in the literature and in practice, on a wide consensus that it is critical to manage risks within supply chain capability (Colicchia and Strozzi, 2012). Studies of supply chain risk seldom address the causes of risk (Christopher and Lee, 2004, Christopher and Peck 2004; Cousins et al., 2004; Juttner, 2005; Sheffi, 2001); they simply mention sources of risk without discussing causes such as theft, smuggling, sabotage, and criminal activity other than terrorism. Notwithstanding the reasons for excluding criminal activity (except terrorism)
from general threats against the supply chain, crime exists and needs to be understood. The research has focused mainly on identifying research gaps (Khan and Burnes, 2007; Manuj and Mentzer, 2008b; Tang, 2006) and thereby pointing out future research directions for SCRM. Some authors have focused on strategies related to SCRM (Chopra and Sodhi, 2004; Huchzermeier and Cohen, 1996; Juttner and Maklan, 2011; Tang, 2006; Wieland and Wallenburg, 2012), whereas others have classified risk according to relative supply chain position (Christopher and Peck, 2004; Svensson, 2002, Zsidisin et al., 2000) or risk type (Barry 2004; Chapman et al., 2002, Juttner, 2005, Sheffi, 2001). Furthermore, some authors have focused on the effects of a played-out risk, mainly disruptions in the material flow (Craighead et al., 2007; Giunipero and Eltantawy, 2004; Kern et al., 2012).

Research purpose

This paper examines supply chain risk management (SCRM) from a systems perspective by considering the main risk reduction strategies for supply chains suggested in literature. The purpose of this paper is to identify if SCRM addresses the same problem of effectiveness, efficiency and capacity, but expressed and utilized in new way.

Risk and uncertainty

Scientific study of the term risk began in the seventeenth century and was/is associated with probability theory and gambling (Frosdick, 1997). The concept of risk combines the probability and consequence of a certain event (Hubbard, 2008). Risk and uncertainty are often seen as synonymous (Helliar et al., 2001), but risk can also be seen as the consequence of uncertainty (Lalwani et al., 2006). According to Waters (2007), the key difference between risk and uncertainty is that risk has some quantifiable measure for future events and uncertainty does not. Therefore, risks can be defined as quantifiable uncertainties. The definition of risk evolves over time, and the meaning changes depending on an individual’s perception of the world (Frosdick, 1997). Therefore, risk can be said to hold both the possibility of loss and the hope of gain (Moore, 1983). Moore (1983) marks the importance of context in the perception of risk, stating, “when terms like high risk or low risk are used, the meaning commonly depends on the starting asset base and the consequences that the occurrence of the risk would have for the asset base of the individual or organisation concerned.” Mitchell (1999) takes a similar standpoint: “Risk is, therefore, defined as a subjectively-determined expectation of loss; the greater the probability of this loss, the greater the risk thought to exist for an individual.” Both authors stress the perception of risk in relationship to its surroundings as the key to understanding the meaning of the term risk. Furthermore, it is possible to state that both authors are supporting the common understanding that risk is the combination of possibility and negative impact. This paper follows this understanding and utilizes cargo theft statistics to demonstrate how this works with real-life data about an unwanted effect.

The importance of global SCRM from both academic and practitioner points of view suggests that SCRM needs to be a top priority (Manuj and Mentzer, 2008b). As a risk matrix is commonly used to evaluate the relative riskiness of different identified risks (Frosdick, 1997, Manuj and Mentzer, 2008b), we translate the yearly quantified risk (possibility × negative impact) based on cargo theft statistics into a risk matrix setup. This type of risk assessment is how practitioners address and compare different risks. The different risks presented in this paper are classified on a risk scale of one to four (one means low and four means high) for both the possibility (incident frequency) of occurrence and the impact of the risks. The combined possibility and impact factors are then the de facto quantified risk value for each combined incident category and location type. The result from this step is that all identified risks can have a quantified risk value between 1 and 16, where a risk value of 16 (4 × 4) means both high possibility (incident frequency) and high impact (cost/value) for the focal organization. The
relative riskiness makes it possible to identify which risks must be addressed and which risks to live with (accept). Normally higher impact is more serious than higher possibility (Aggarwal and Bohinc, 2012; Bernstein, 1996). The outcome from a risk matrix gives the priority list for risk management activities, as the highest quantified risk is also the most critical to address. In this paper, the impact from a cargo theft incident is simplified as the value of the stolen products; in real life, indirect costs would also be included in the impact side of risk.
SEDUCTIVE REASONING
– CONFUSED RATIONALITY IN LOGISTIC RESEARCH

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ABSTRACT

Purpose
The purpose of this paper is to develop a conceptual model for logistics research reasoning which can be used in order to better analyze supply chains as they really are instead of the oversimplified and rational model which is normally used in research. This paper aims to divulge the intrinsic bounded/context depended rationality in logistics and supply chain management research.

Design/methodology/approach
The research is based on a system approach, which emphasizes a holistic view instead of the characteristics of the different parts. The research method used in this paper is deductive desk research. Explicit content analysis is applied in the research, looking at articles published in IJLM, IJPDL and JBL in the period of 2012-2015. Furthermore, this paper presents a conceptual theoretical model for SCM research which includes theories from the field of behaviour economics.

Findings
The implicit usage of full system (ultimate supply chain) rationality in order to stipulate the system behaviour without including the, often, contradictive incentives (component/element rationality) among supply chain actors leads to a theoretical conclusion which never can be practical implemented in real supply chains. This theoretical self-seduction leads to that the findings, from a systems perspective, is not of the ideal system rationality but to be guided by a confused or bounded rationality.

Research limitations/implications
Explicit content analysis limits the findings to the rare discussion of generalisation implications.

Practical implications
The research will provide one new viewpoint in logistics research that includes behavioural economic theories into SCM modelling

Originality/value
This paper uses complexity theory based in behavioral economic theories in order to point out the seductive theoretical reasoning in SCM research.

Keywords: Logistics knowledge, Generalisation, Research reliability

Paper type: Conceptual paper
The term logistics comes from the Greek logos meaning "speech, reason, ratio, rationality, language, phrase, furthermore specifically from the Greek word logistiki meaning accounting and financial organization. This origin of the term makes it possible to state the logistics in essence is the rational financial organization with focus on financial and supply distribution matters. The military interpretation of the term is related to procuring, maintaining and transporting material, personnel and facilities. In modern companies is logistics considered to be a main competent to their success. Business logistics can be defined as "having the right item in the right quantity at the right time at the right place for the right price in the right condition to the right customer. To be successful, all aspects of operations and information need to work together (Christopher, 1998). The main targets of logistics can be divided into performance related and cost related. This may utterly leads to a trade-off effect between performance and cost for logistics. Christopher’s definition of logistics (2005) captures and explains the interaction between actors, stakeholders, and authorities within the market. According to Christopher (2005), logistics is, “the process of strategically managing the procurement, movement and storage of material, parts and finished inventory (and the related information flow) through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfilment of orders”. Christopher’s definition of logistics works well within the fifth and sixth of principles of microeconomics (Mankiw, 1997) which explain the marketplace function for economic transactions. Striving for better business deals is the practical way to maximize profitability.

A more recent term than logistics is the term supply chain (SC) and supply chain management (SCM). Christopher (2005) defines the supply chain as follows: “The network of organisations that are involved through upstream and downstream relationships in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer”. The goal for all involved organisations is to provide the ultimate customer with the right product at the right time and place (cf. Christopher, 1998). The place for the transaction is in generally referred to as the market. The description and understanding of the market has been, since the days of Adam Smith, the centre for all economic research. The classic description of the market as governed by the invisible hand and the theory of supply and demand are as valid today as they were in the 18th century. The market as a concept can be used as a description for all business transactions, which includes everything from the cradle to the grave (and again, with the recycling) in a product’s life. In essence, both terms are strongly linked to rational behaviour/accounting and a profitable supply of demanded products as a certain market.

The question of who really should have unified views and common goals is never asked. Furthermore, who should cooperate is never addressed. In addition, how should the unifying goal be set and achieved? In the literature available, it is said that the firms leave the interpretation space wide open for subjective interpretation. In this regard, Johannessen (2003) declares: “The everyday conflicts and unpredictability of human relating is not examined and explored, leaving the recommendations seemingly easy and straightforward to adopt and implement in any organization.” This leads to the conclusion that the simplified world of logistics literature is a vision and ultimate goal for organisations whereas the reality of business includes problems that the logistics literature does not try to answer. This is the big paradox in logistics research.

**Research purpose**

Divulge the intrinsic bounded/context depended rationality in logistics and supply chain management research in order to advocate the more research linked to complexity theory within the logistics research community.
Method
The research method used in this paper is desk-top reasoning. This paper utilizes different theoretical viewpoints from both logistics/SCM and behaviour economics research with focus on the complex interaction around actor’s rational behaviour. The perception of supply networks and logistics as complex is emphasized by several authors (Bowersox et al., 2002; Christopher, 2005; Cox, 1999; Tan, 2001; Gallagher and Tim, 1999). This paper follows this tradition and utilizes the complexity theory in order to capture the interaction between actors (Nilsson, 2006). Insights from complexity theory guide the search for guiding principles that describe the behaviour of the system (Gault et al., 1996; Gallagher and Tim, 1999; cf. Keynes, 1936). The conceptual framework in this paper aims to provide description on the different relationships between theoretical viewpoints and their complex system behaviour which in all can be described as a self-seduction of the research if not the complex reality is taken into account, which contemporary SCM research tries to avoid.

Frame of reference

Complexity theory
The principles of complexity theory suggest that physical, social, and mental worlds are nonlinear and complex. The perception of supply networks and logistics as complex is emphasized by several authors (Bowersox et al., 2002; Christopher, 1998; Cox, 1999; Lambert et al., 1998; Lumsdén et al., 1998; Tan, 2001; Borodzicz, 2005 Gallagher et al., 1999; Mainzer, 1997). Milgate (2001) observes that, “complexity should be viewed as a deterministic component more related to the numerousness and variety in the system” i.e., logistics systems could and should be reduced heavily and simplified. There are several others proclaiming the same simple approach to deal with logistics complexity (Childerhouse and Towill, 2003a, 2003b; Narasimhan and Jayaram, 1998; Towill, 1999; Towill, Childerhouse and Disney, 2000; and Wilding, 1998). However, Choi, Dooley and Rungtusanatham (2001), Johannessen & Solem (2002), and Nilsson (2005) question these simplified and reductionist approaches. They believe, instead, that “logistics processes, where human beings are involved, are not simply a sequence of mechanical devices which can be assumed to work along positivistic beliefs, but instead a complex network of living, innovative, creative, and evolving creatures which react and adapt dynamically to their perceived environment, and try to proactively create what they themselves, or collectively with others, find to be beneficial for their own interests” (Nilsson, 2005). With such a perspective on logistics, the reality of transport issues can be examined and empirically identifiable actions such as minimizing personal losses, wishes for blurry borders, keeping out of trouble, etc., can be better understood.

Complexity is closely related to uncertainty, because the underlying principles of determinism and predictability are desired for business. Certainty in business means that every factor is fully deterministic and the outcome will be fulfilled in a precise manner. However, uncertainty is simply a key characteristic of any economic activity (von Oetinger, 2004) and with uncertainty comes risks. A major consequence of uncertainty in business is that each actor, as rationally as it can from its subjective perspective, tries to control and reduce its uncertainties.

While knowing and predicting what customers want often involves a great amount of uncertainty, it is only one of many questions to be answered. Also, each manager needs to answer the question as to when, how, and why the customer wants a certain product and how it is possible to get it to the customer; i.e., logistics uncertainties. According to Nilsson (2006), logistics uncertainty can be grouped into four different dimensions:

1. Customer’s demand and expectations
2. Internal processes

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3. Human factors
4. General trends

All four dimensions of logistics uncertainty will, to varying degrees, occur throughout the transport network. This indicates that the complexity within the transport network increases due to uncertainty in different dimensions. According to Nilsson (2006), the message in logistics literature is that the treatment for uncertainty is to reduce it as much as possible. This is also, as mentioned above, the valid view on complexity. The actors within the transport network handle its complexity in similar ways - the actors are, to varying degrees, involved in activities that aim to reduce or limit their own complexity and that of the transport network. The more complexity in the transport network, the more complexity is transformed through it. This increases the need for handling strategies that reduce the effects of complexity.
VALUE CREATION IN RETURNS MANAGEMENT
– AN EMPIRICAL ANALYSIS

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ABSTRACT

Purpose
While the phenomenal growth and potential for electronic commerce in retail is undeniable, there are numerous challenges related to this channel that remain largely unexplored and unresolved. One of these issues involves returns management. Although returns management has received attention in the literature, it is commonly acknowledged that there is a limited understating of the topic. In particular, returns are often seen as a necessary cost of doing business. In contrast to this dominating view, returns can be seen as customer value and a differentiation strategy for achieving competitive advantage. Yet, the understanding of how product returns can facilitate value creation is limited. This research poses the following questions: How do customer return practices affect their purchase patterns? What impact will this have on revenue? The study explores customers’ returns experiences to capture variations in purchase patterns. The study explicitly integrates returns management and consumption processes, building on the interactions between the online retailers and customers. Whether the consumption is appreciated or not is observed through the market exchange mechanism as customers will either buy or not buy again. This study also emphasises the value interaction mechanism, which is defined here as returns service provision intertwined with consumer consumption.

Design/methodology/approach
The topic is approached by an empirical analysis using a dual case study design. Case based research provides an appropriate methodology, not only due to customer returns in on-line retailing is an emerging empirical topic, of which comparatively little is known, but also for exploring emergent practices, especially in dynamic fields where new practices are continually developed. The nature of this research goes beyond being exploratory, to also be confirmatory with the intent to assess a customer value creation framework with regards to returns management within online retail context. Two Swedish online fashion retailers are carefully selected as cases in order to offer both replication logic and contrasting situations. Since we focus on actual customer return and purchase practice to understand the value creation in returns management, archival data is primarily utilised, while interviews with operations and marketing managers and site visits functioned more of complementing, interpreting and validating the archival data. The final archival data set represents a two-year selling period containing 142,659
customers and 93,643 customers in respective case. In total, these customers encompass 585,246 transactions, representing more than 1.5 million order rows.

Findings
We provide evidence that returns management processes facilitate customer value creation (and significantly influence repurchase behaviour), resulting in revenues that is higher than the associated customer servicing cost, i.e. returns management is a value driver. Additionally, we provide evidence that returns create value for certain customers. Case findings demonstrate that 35% and 30% of the customers in respective case have actually returned products and for a majority of these customers the returns service go beyond product value recovery and support their purchasing practices, so that value is created in these practices, and ultimately increases sales. In both cases the repeat customers that returns products represent more than 50% of the total revenue and have a significant higher contribution margins than repeat customers that do not return products, even though associated with the additional cost of returns. This finding confirms marketing wisdom that based on perceived service quality, customers acquire value influencing customer satisfaction that in turn lead to repurchase behaviour. Our results also suggest that mode of payment and return policy impact how customers create value through the returns management process. With regard to returns management, our results illustrate the complex relations between customer value, servicing cost, and firm revenue. In overall, our result suggest that returns management can be a matter of competitiveness and need to be recognised as one of the key services in online retailing.

Research limitations/implications
The analysis extends previous research addressing the operations and marketing interface of returns management and provides a foundation for further development using service logic and well as discussion of adopting such business logic to returns management. The previous research primarily focuses on the recovery of products, i.e. value recovery, while our evidence explicitly emphasis the value creation in returns and its impact on customer retention and revenue. In the context of e-commerce two main directions for future research are proposed in order to critically comprehend customer returns in returns management.

Practical implications
Marketing and operational practioners will find new perspectives of understanding customers values in returns and of developing return policy and processes. To unlock the value of customer returns, managers are encouraged to go beyond developing a better understanding of the total cost of returns, and extend their horizon to include the revenue of returns. Our findings challenge the view that firms should try to prevent customer’s product returns when they can, either through gatekeeping, avoidance or by a zero-return policy. If so they may miss out on value co-creation opportunities. To design powerful, cohesive return processes that facilitate customer value creation may not only impact revenue but also raise customers’ expectations beyond the competitor’s reach. Thus, the research provide strategic implications for operations management investments in return processing.

Original/value
For a scholarly audience, the research provides an extended and novel understanding of customer value creation in returns management. For a practioners audience, it offers new perspectives and means of aligning return policy and processes for value co-creation with customer practices.

Keywords: Returns management, reverse logistics, product returns, value creation, value co-creation, return policy, e-commerce, service management, service marketing
ABSTRACT

Purpose

Sea transportation is of major significance for the European economy. Today, over 31% of the transport volume is forwarded by sea which makes it after road transport (approx. 49%) the second most important mode (Statista, 2013). Due to its geographical particularities, shipping of cargo and passengers especially for the Baltic Sea Region (BSR) is of high economical and ecological relevance. For many neighbouring countries of the Baltic Sea, sea transportation presents a vital channel for import and export of various economic commodities and therefore marks the economic base. In this logistic network, ports are essential as they ensure a fast and smooth transport operation, in particular in the modal shift of goods and people.

In this context, the purpose of this abstract is to outline the current state of activities in the project “HAZARD”. The project is co-funded by the Interreg Baltic Sea Region Programme and addresses the issue of sustainable transport with the specific objective of increasing the interoperability of transport modes. Therefore, HAZARD aims at mitigating emergencies in major seaports and at improving related safety and security preparedness in the BSR. The partners in the project consortium are rescue services, port authorities/operators, universities as knowledge partners and one municipality. As a result, the project combines all relevant stakeholders of safe and secure transport in port and sea shore areas.

In particular, our abstract focuses on work package 4 “Risk Assessment and Analysis” (WP4) of the project. This work package helps the project partners as well as their non-partner peers to better understand and apply risk analysis and assessment methods in order to mitigate risks in seaports and areas adjacent to these. Risk analysis in ports is important for ensuring reliability, supply chain resilience, and transport safety and security in logistics operations. As a result, proper activities in this field provide the bases for a stable economic environment.

Design/methodology/approach

A supply chain is best described as a group of independent companies that are interconnected through flows of goods, information and cash in either up- or downstream processes (Mentzer et al., 2001). An important element of managing supply chains is the concept of supply chain risk management (SCRM). It is dedicated to identifying possible risk sources and to determining proper mitigation strategies. For this purpose, a systematic risk management relies on a process that is divided into five steps: identification, analysis, assessment, handling and control.
In the first step (identification), potential risks within the company and its supply chain are identified. The results obtained are then compiled in risk portfolios for each company. In the second step (analysis), all risks on company level are aggregated and assessed in a qualitative manner. Thus, a first estimation in view of different priorities of risks is created. In the third step (assessment), a quantitative evaluation in terms of probability and extent of damage is performed giving a sufficiently detailed picture of the current situation. In case an intervention is required, suitable strategies and tools are selected and applied in the fourth step (handling). Then, in the fifth step (control), a successful mitigation is examined and potential risk changes are monitored. The SCRM process is executed iteratively and thereby provides the basis for a successful risk management in supply chains (Kersten, 2008).

To apply methods and tools of SCRM in seaports the following steps are planned:

- Identification of risks in “port systems” considering the specifics of the BSR,
- Literature research (e.g. database and review of accidents),
- Case study research in different ports (Interviews and workshops with rescue services and port authorities/operators),
- Identification of the current status of risk management in port systems,
- Literature research (e.g. standards, methodologies, tools),
- Case study research in different ports (Interviews and workshops with rescue services and port authorities/operators),
- Development of a comprehensive framework for risk management in seaports contributing to an improved coordination of risk management activities.

**Findings**

We will report on the findings as they are achieved. As a result of our literature and empirical analysis, we hope to gain in depth insides in regional and trans-regional risk management activities of the respective actors in BSR seaports. By this approach, we strive to disclose any deficits and to develop an integrated approach to overcome these.

**Practical implications**

At the end of the HAZARD project, proposals for improved risk management procedures in seaports in the BSR will be provided.

**Social implications**

As a result, safety and security in seaports in the BSR can be enhanced and disruption risks for supply chains will be reduced.

**Original/value**

As an innovative measure, our approach combines the theoretical application of (supply chain) risk management methods and tools with empirical data from case studies of seaports. In order to obtain a comprehensive picture of the field, we focus on different ports in the BSR and strive to develop an integrated framework. We build our work on previous Interreg projects such as DAGOB and CASH.

**Keywords:** Risk management, seaports, case study research, Baltic sea region, framework.
ABSTRACT

Purpose
The paper intention is to present the Polish Safety and Reliability Association (PSRA) research team involved in the HAZARD project proposed methodology and approaches to fulfil the main aims of the project research focused on the mitigating the effects of emergencies in Baltic Sea region ports.

Methodology and approaches
The following approaches to the project task “Risk Assessment and Analysis” are proposed.

1. Constructing stochastic models for investigation of dangerous events and accidents number in Baltic Sea region ports

The stochastic processes theory provides concepts and theorems that allow to build probabilistic models concerning incidents and accidents. The counting processes can be applied for modelling number of the dangerous events and accidents in Baltic Sea region ports during the fixed time intervals. A crucial role in construction of the models plays a Poisson process and its generalizations. Three models for determination of the incidents and accidents number in the seaports are going to be constructed. Moreover, some procedures of the models’ parameters identification and the computer procedures for anticipation of the dangerous events number will be proposed as well.

2. Investigating and mitigating accident consequences of maritime ferry operating at the Baltic Sea waters.

The approach is concerned with the prevention of a maritime ferry collision with static and dynamic installations at the Baltic Sea waters. Investigation of a ferry real collision with the oil terminal infrastructure inside the port will be carried out. Safety management and emergency preparedness procedures of maritime ferries will be reviewed. Direct causes like human error, fire on board, technical failure, lack of obey of safe operation procedures (or not adequate procedures) and heavy hydro-meteorological conditions will be analyzed on the basis of data coming from exemplary real scenarios of maritime ferry accidents. The collisions avoidance procedures and their consequences mitigation will be proposed as decision support for captains of ferries operating at Baltic Sea waters.

3. Mitigating consequences of oil spills at sea restricted areas based on their dynamic domains modelling, identification and prediction

Methods of oil spill domains determination will be reviewed and a new method based on a probabilistic approach to the solution of this problem will be proposed. To describe the oil spill central point position a two-dimensional stochastic process will be used and parametric equations of its drift trend curve will be determined. The oil spill domain motion general model for various hydro-meteorological conditions will be constructed and the methods of its parameters estimation will be proposed. The proposed methods will be presented in the form
of procedures giving successive steps which should be done to estimate the unknown model parameters on the base of statistical data coming from experiments/exercises performed at sea to predict the spill domain movement and to prevent and mitigate the oil spill consequences.

4. Procedure based proactive functional safety management for the risk mitigation of hazardous events in the oil port installations including insurance aspects

The approach addresses selected technical and organization aspects of risk mitigation in the oil port installations with regard to functional safety and security requirements specified in standards IEC 61508, IEC 61511 and IEC 62443. The procedure for functional safety management will includes the hazard identification, risk analysis and assessment, specification of overall safety requirements and definition of safety functions. Based on the risk evaluation results the safety integrity level (SIL) and security assurance level (SAL) will be determined for consecutive safety functions. The proposed approach will be composed of the following items: process and procedure based safety and security management, example of procedure based safety management including insurance, integrated safety and security assessment of industrial control system (ICS) of the oil port pipelines, tanks and critical infrastructure.

5. Modeling hazard related interactions between various processes in and around the Baltic Sea ports

The aim of this approach is to construct a model of hazard-related interdependence of the individual processes interacting in and around one of the ports located in the Baltic Sea area. This model should describe, in a formalized way, the impact of hazardous events involved in one process (caused by the operations carried out within this process alone) on the risks of events adversely affecting the other processes. The developed model will constitute a basis for the analysis of inter-process dependencies, including the feedback and cascading effects that can result from the dependencies between the hazardous events occurring in different processes, as well as the assessment and mitigation of their adverse effects. It will be applied to modelling, predicting, quantifying and mitigating the possible adverse effects of hazard-related mutual impacts between the oil terminal and the container terminal operation processes.

6. Mitigating potential major accidents and emergencies close to the Swinoujscie harbour based on LNG carrier emergency towing exercise

The exercise aims at mitigating potential major accidents and emergencies close to the harbour in Swinoujscie located at the Southern part of the Baltic Sea and the very sensitive coasts of Germany and Poland. The main goals of the exercise are as follows:

- to test the emergency towing capability including national and international resources,
- to test procedures connected to the Maritime Assistance Service (MAS procedures) rendered to the vessel in a need of assistance and connected to the emergency towing and use of the place of refuge,
- to check equipment and communication,
- to improve safety of LNG tankers emergency towing.

7. Trajectory planning during emergency ship to ship cargo transfer to mitigate oil spill at the Baltic Sea

One of the most important task during Ship to Ship (STS) lightering operations include manoeuvring in close proximity during different weather conditions in order to come in position for operation alongside to commence cargo transfer. A STS lightering operation as a result of emergency situations at sea can be carried out when both ships are side by side and constant heading and drift velocity can be maintained. Collisions between the two ships typically occur
as a result of incorrect approach angle between the maneuvering vessel and constant heading ship. To mitigate this risk of incidents, guidelines will be prepared for the navigator, which include information about reference trajectory in meaning references position, heading and velocity at each stage of the ship maneuvering.

8. Developing procedures for hazard identification

The reliable operation of the Baltic Sea area critical infrastructures have direct impact on the safety of this region and the whole country as well. Due to the complexity and vastness of such complex systems it is exposed to various types of events that could lead to failure. These risks may result directly from the operation and also be the result of external factors. Especially dangerous are the undesirable events with incidental character or unlikely events that constitute a serious threat to people and the environment and resulting in significant loss. The primary objective of risk management is to increase the safety of the considered complex technical system. The proposed approach will be composed of the following items: hazard identification methods, strategies for safety management, registration of undesirable hazard events at the Baltic Sea area.

9. Conception of decision support system for resilience management of seaport supply chains

The project is aimed at improvement of safety level of logistic support processes carried out in the corridor to the seaport and in the seaport in the context of proper performance of supply chain. Following this, the approach is aimed at development of decision support system for seaports supply chain risk management in the aspect of vulnerability and resilience engineering. There will be done a literature review connected with resilience engineering of seaport infrastructure systems and their supply chains. Next, the decision support system conception will be proposed. The developed decision support system is to be based on the What if? approach and Bow-Tie method. The proposed approach will be applied to a selected seaport supply chain vulnerability and resilience assessment.

10. Prevention of oil spills during oil transfer between tankers and port oil terminal

Considering the operation process of port oil terminals, the approach will be focused on processes related to the cargo movement inside the pipeline system. Processes of crude oil loading and discharging and process of internal recirculation of crude oil will be described and their statistical identification will be given. Various types of accidents that have the potential to occur during oil transfer will be considered and subsequently classified. Analysis of potential threats that can cause oil spill during oil transfer in the terminal and their classification with distinction of internal and external causes will be performed. Further, a particular attention will be addressed to the pressure upsurge inside the pipelines caused by sudden valve closure on the oil reloading installation in port terminal. The main aim of this approach will be to find the uniform legal requirements in order to prevent such kind of accidents.

Keywords: Port accident, Maritime collision, Port operation safety, Port oil terminal, Oil transfer, Oil spill, Ship operation safety, Ship safe trajectory planning, Contingency prediction, Threats and hazards assessment, Threats and hazards response, Emergency prevention, Accident consequences mitigation, Resilience engineering, Inter-process dependence, Hazardous event, Risk analysis, Probabilistic models, Probabilistic anticipation, Statistical identification, Probabilistic prediction.
ABSTRACT

Purpose
The focus of this work-in-progress is to develop a general traceability framework for the textile supply chain. Traceability is of a significant importance for the textile industry, firstly due to multiple actors’ involvement in the production and distribution, and secondly the heterogeneous nature of actors, dealing with diverse materials, including fibre spinning mills, yarn spinning mills, weaving industry and garment manufacturers. Moreover, the textile industry has seen a global shift towards recently industrialized countries; consequently, the offshore buyers have become more dependent on complex supply chains and created more information asymmetry as offshore buyers cannot directly observe the production activities of a distant manufacturer. Resulting consequences of information asymmetry can be seen in terms of counterfeit products, malpractices in production and other social and environmental issues. Moreover, textile market is a volatile market because of rapidly changing trends and consumers’ preferences, therefore inter-actor visibility of production activities is required for synchronous production to meet the market demands. Considering the above-mentioned characteristics and challenges in textile industry, this work targets to develop a traceability framework for improving supply chain visibility and integrate various actors in the textile production supply chain.

Design/methodology/approach
The traceability framework development has been divided into four steps, namely, identification of user requirement of different stakeholders in the textile supply chain, identification of different information points, traceability data modelling, and information exchange model to develop traceability among various stakeholders in the textile production supply chain. In-depth analysis was conducted for the need of traceability from various stakeholders’ perspectives in textile sectors, which include various actors in textile production and distribution, consumers and surveillance/certification authorities. An UML case diagram approach has been followed to define the traceability requirements and UML class diagram approach has been adopted for modelling traceability data.

Findings
The present traceability framework is proposed to handle traceability information and information exchange between various stakeholders in the textile production supply chain, which can not only disseminate the traceability information in the supply chain, but also helpful
in case of recall crisis (such as product design fault, harmful chemicals or other related issues) where surveillance authorities can track (forward traceability) and trace (for identifying the source error which resulted recall) the products in the textile supply chain for recalling. Moreover, the traceability information can be used by consumers in order to about the product and raw materials’ history.

**Practical implications**

Traceability works on the credibility of the organizations, which handle the traceability data. Therefore, in the real implementation, either organizations need to be transparent in terms of traceability data or third party certification/audit is required for ensuring that the traceability information provided by an organization is correct/authentic. Secondly the semantics for information exchange are required to be unified across various actors involved in traceability information storage and exchange.

**Original/value**

The traceability framework covers perspectives from traceability not only from various actors involved in textile supply chain, but also includes consumers therefore, traceability information is collected by this framework can be utilized from industrial as well as consumer and surveillance perspectives.

*Keywords: Traceability, Textile supply chain, UML*
Delphi Method Application

– Mitigating the Impacts of Emergencies in Baltic Sea Region

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Abstract

Seaports are essential nodes for seamless passenger and cargo transport in the Baltic Sea Region (BSR) and across the EU. Thus their ability to provide well-functioning traffic services also in case of major accidents and/or emergencies is important for the public, businesses and the environment within the BSR and beyond. The ongoing HAZARD project aims at mitigating major accidents in major multimodal seaports in the BSR and deals with a range of relevant safety and security concerns in relation to port activities. The paper describes the planned Delphi study, which will bring together representatives of the relevant authorities (public sector actors), businesses (private sector actors) and research bodies to deal with communication practices in emergencies and address the complex regulatory safety and security framework within the seaport context.

Keywords: Planning, Preparedness, Disaster Management, Mitigation, Seaport, Delphi method, Foresight.

Introduction

The Baltic Sea is one of the most heavily trafficked seas in the world. The countries of the Baltic Sea Region (BSR) are heavily dependent on shipping for imports and exports, as well as for internal trade. Passenger transport and cruise tourism is also considerable. The current high level and expected growth in vessel traffic increases the risk that there will be more accidents in the future, unless improved safety and security procedures are set in place. Therefore, the EU’s vision is that the Baltic Sea should become a leading region in maritime safety and security. (CEC 2015.)

Emergencies can be caused e.g. by fire, explosion, leakage of hazardous substances, or by natural causes such as flooding. Also security issues can pose a serious problem to supply chains through criminal activities related to cargo and/or vehicles, and to the mobility of people as evidenced by the rapidly changing situation with immigrants and asylum seekers. Subsequently, mitigating the adverse effects of such safety and security incidents is very much in the interest of seaports (see e.g. on safety DfT - Department for Transport 2015, and Haveman and Shatz 2006, Bichou 2008, Helmick 2008 on security). It is also the responsibility of competent authorities - notably rescue services or their equivalent - to deal with such incidents both before, during and after they might occur.

The joint research project HAZARD aims at mitigating major accidents in major multimodal seaports in the BSR, and deals with a range of relevant safety and security concerns in relation to port activities. HAZARD brings together rescue services, port authorities, logistics operators
and universities from Estonia, Finland, Germany, Lithuania, Poland and Sweden. Totally fifteen partners and ten associated organizations are involved in the project. In order to get experts’ views and development ideas on the topics especially related to WP2 and WP3 of the project, the method chosen is Delphi, because it is widely applied for structuring a group communication process so that it is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Gordon 2011, Linstone and Turoff 1975).

Delphi Method Application

Authorities or companies specialized in their own fields act and communicate differently or use different concepts and terms for the same issue, although the object domain is the same. Some of this may be explained by cultural differences or differences in organization cultures (Carver and Turoff 2007, Hofstede et al. 2010, Lewis 2006). Thus, a Delphi study will be carried out at an early stage of the HAZARD project. In addition to its problem solving and future orientation, there are other advantages of the Delphi method for finding solutions to research questions: for example, its ability to take into account tacit knowledge and experiences of the experts. Furthermore, Delphi offers the experts the possibility to learn from other experts during the iterative process. (Linstone and Turoff 1975, Laakso and Palomäki 2013.)

An important aspect when applying the Delphi approach in HAZARD is to find ways of improving the communication between actors and towards the general public both during and after emergencies. Hence, the objective of the HAZARD Delphi study is to produce new knowledge on:

- Better communication practices in emergencies, which are also tested in several large joint emergency exercises, and
- How to cope with the complex regulatory framework on safety and security in a seaport context.

The aim is to study emergency situations using Delphi and to identify circumstances where different actors have recognized potential problems or risk situations related to emergencies in seaports, allowing us to create an overall picture of these challenges.

The Delphi study is a two-round process. Execution of the Delphi rounds is done by online questionnaires. Questions and claims for the rounds will be formulated based on the desk study and the analysis of material from the first round. The experts will be asked to answer not only as a representative of their own organization but also as a representative of their branch.

In a Delphi study, experts are selected from among the experts of a field of study, and the aim is to cover all the relevant aspects of the study subject (Okoli and Pawlowski 2004). Therefore, successful realization of Delphi requires the design of an expert group structure allowing for many knowledgeable individuals from different disciplines or specialties, who have a different working background and experience, and who contribute information or assessments that are broader in scope than is possible for any single individual. (Gordon 2011, Kuusi 1999, Laakso et al. 2012, Linstone and Turoff 1975.)

In this Delphi application the panel of experts will be selected from the organizations of the fifteen project partners and ten associated organizations, i.e. rescue authorities, seaports and logistics companies, and universities. Three competence areas for experts were identified during the planning phase of HAZARD: experts are expected to have knowledge on (1) preparedness for major incidents (2) responding to major incidents, and (3) regulations related to major incidents. The organizations will be asked to nominate one to three experts for the panel. The total number of experts is expected to be fifty.
Conclusions

The Baltic Sea is one of the most heavily trafficked seas in the world, and a very high share of Baltic Sea Region (BSR) trade, as well as domestic transport within these countries, depends on shipping. Therefore, mitigating the adverse effects of safety and security incidents is very much in the interest of seaports. Effective collaboration and communication in emergencies require making sense of what has happened and what is going to happen; placing things in the right frameworks, comprehending, constructing meaning, interacting in pursuit of mutual understanding, and patterning.

The HAZARD project focuses on better coordination and communication, preparedness, helping reduce damage and loss of life in emergencies, and facilitating post-emergency actions in the BSR. In order to get an overall picture on challenges in joint exercises, communication, and regulatory framework, a two-round Delphi study will be carried out at the start of the HAZARD project. The results of the Delphi study will form one step for the project group towards their further work, and are anticipated to bring new information for seaport and logistics personnel and the authorities. The immediate beneficiaries of the findings include the seaport and rescue service partners in the project, but the results will also be effectively disseminated to relevant port community professionals and civil protection agencies within the EU and beyond.

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SUPPLIER PARTICIPATION IN STRATEGY WORKSHOPS

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ABSTRACT

Purpose
The purpose of this article is to describe and analyze how strategic work between a buyer and a seller can be improved and deepened using strategy workshops linked to the framework of strategy as practice.

Design/methodology/approach
Building upon Whittington’s early work strategy as practice has emerged as an important theoretical field aiming at answering questions on who develops strategy, what they focus on and with which help and how they do (Whittington, 1996). A significant part of this field is strategy workshops. Several scholars have concluded that more research on workshops is needed but see clear evidence of successfully managed workshops as being an important part of the strategic work in the involved organizations (e.g. Hodgkinson, Whittington, Johnson & Schwarz, 2006). It has also been noted that there is a need for more research with plurality in terms of level of analysis, plurality of actors, plurality of dependent variables and as well as plurality of theories (Johnson, Langley, Melin, & Whittington, 2007). The research is based upon the study of three strategic workshops held between a seller and two buying organizations. The research also include a pre-study with interviews as well as follow-up interviews.

Findings
The paper illustrates that within a buyer-seller relationship a lot of strategic discussion can take place and there is indeed important practitioners (Jarzabkovski & Spee, 2009) to be found also among external parties, such as suppliers. Contrary to the claims of Hodgkinson et al, (2006) we see the in this case involvement of both external stakeholders as well as internal stakeholder representing a variety of functions and level as a success factor in the workshop thus making a contribution to the strategy as practice field as well as to supplier development.

Research limitations/implications
The research is based upon a case from the nuclear industry which in some aspects is a very rigours industry and also is highly regulated.

Practical implications
The case studied here clearly illustrate that strategy workshops is a well-functioning tool for strategic discussions and supplier development. The strategy workshops need to include both participators from the buying firm as well as from the selling firms since the success of any strategic decisions will rely upon the actions from both parties.

Social implications
The research presented highlights the importance of new ways of cooperation between buyers and sellers also on the in the top management levels and is therefore also of interest to different trade and industry organizations working with help and advice to their members.
Original/value
In the article the strategy of practice field is linked to the purchasing and supply management field adding to both knowledge about strategy workshops and supplier development. The case is from a very interesting sector, namely the nuclear industry.

Keywords: purchasing, supply management, strategy as practice, strategy workshops, supplier development

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ALIGNING OUTSOURCING RELATIONSHIPS IN LOGISTICS: A RESOURCE PORTFOLIO APPROACH

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ABSTRACT

Purpose
The purpose of this research is to explore how alignment in outsourcing relationships is achieved between a logistics service provider and service user in Finland. Both Finnish companies exploit their resource portfolios as a source of aligning logistics outsourcing relationship for business growth.

Design/methodology/approach
Using a theoretical framework based on the resource-based view of the firm, this research builds on resource portfolio approach and elaborates on the successful alignment of logistics outsourcing relationships. The empirical material is gathered through semi-structured interviews for this case study-based research.

Findings
The initial findings highlight that logistics service provider maintains a certain level of resources (assets, people, technology and processes) in its portfolio of resources and the successful alignment of logistics outsourcing relationships is achieved by coordination, control, incentives and organizational culture.

Research limitations/implications
The data for this study was gathered from Finland; additional comparative studies can use a different geographical location.

Practical implications
The proposed framework provides guidance to practitioners with respect to arrangement and allocation of resources in resource portfolio and highlights the importance of alignment for successful outsourcing relationship.

Original/value
The presented construct provides a new perspective to view firm’s resources thereby adding knowledge to the current literature on outsourcing relationship in logistics.

Keywords: Resource Portfolio Alignment, Outsourcing, Dynamic Capabilities, Logistics Service Provider, Resource Based View.
ABSTRACT

Purpose
Maritime Intermodal door-2-door supply chains are complex as many different actors are involved. Beside legal supply chain actors also criminals use logistics transport networks for their operations. For example, illicit narcotics, weapons and counterfeited products are smuggled in these supply chains generating significant social-economic damages.

Customs authorities focus on these illicit activities in order to detect and to limit damage to the society. Therefore, customs authorities use risk targeting systems which are based on customs declaration data and intelligence systems to detect high risk trade flows. High quality data has to be used to detect these illicit trade flows. However, today the quality of data is lacking. The CASSANDRA project and its follow-up project CORE aim on improving the supply chain visibility. The CASSANDRA project developed a data pipeline approach to improve the data quality by sharing data between all legal supply chain actors, including businesses and authorities. If the data is available in IT systems customs should be able to “piggy-back” on the data which is used in the supply chain.

The data pipeline principle enables customs to improve their risk assessment and to detect high risk trade flows. Sharing data by using the data pipeline showed various benefits for businesses. Consequently, a socio-economic cost benefit analysis was executed in order to evaluate the benefits of the data pipeline in the field of socio-economic risks.

Methodology
A socio-economic cost benefit analysis was carried out in order to qualify the benefit, which is generated for the socio-economy through the CASSANDRA approach. Therefore, the damage for each modus operandi for the socio-economy, which is already prevented by customs (as-is
situation), and the possible changes through the data pipeline approach, were compared (to-be situation). The difference of both values (actual prevented damage and possible prevented damage because of data pipeline approach) is the benefit for the socio-economy through the CASSANDRA approach.

On the basis of a cost-utility analysis a methodology was developed for performing a qualitative socio-economic cost benefit analysis. For the adapted benefit analysis of the CASSANDRA approach, the following steps have been accomplished: (i) Definition of the scenarios, (ii) Definition of the modi operandi, (iii) weighting of the modi operandi and (iv) rating the ability of customs authorities to mitigate each damage for both scenarios.

In detail, the scenarios (i) which have been compared were the as-is (without) and to-be situation (with CASSANDRA approach). The modi operandi (ii) describes criminal activities which lead to losses in governmental revenues; increases in law enforcement, health care and social security costs plus increases in reversible and irreversible damages to the nature. The following lists describe these modi operandi:

- Smuggling for fiscal fraud
- Trafficking in counterfeit products
- Trafficking in narcotics
- Trafficking in counterfeit pharmaceuticals
- Trafficking in polluting substances
- Trafficking in quota-restricted commodities
- Trafficking in stolen goods
- Trafficking in stolen cultural property
- Trafficking in small arms and light weapons
- Trafficking in endangered wildlife
- Human trafficking

Later each operandi was weighted (iii) using literal constants according to the priority of customs authorities to fight against these criminal activities in order to minimize the damage for each operandi. These constants range from “is not relevant (0)” to “is very important (4)”. Finally customs’ ability to mitigate each of these damages were rated (iv): Here, for each scenario customs were interviewed to assess their efficiency of limiting the damages by usage of available data. The literal constants for the rating range from “Very poor (1)” to “Very good (5)”.

The required information on the damage of each modus operandi was determined by literature review. The required data on the weight and rating on efficiency of detecting a criminal action of the two scenarios was determined by interviews of UK and Dutch Customs. The literal constants on weight and rating given by customs were translated into integer values by defuzzification in order to process the values later.

Finally a third customs authority (German Customs) was asked to validate the results.

**Findings**

The evaluation methodology for assessing the qualitative statement was successfully executed.

During the interviews the weighting factors for each modus operandi were rated from “is more relevant (2)” up to “very important (4)” on a scale from “is not relevant (0)” to “is very important (4)” The most important modus operandi customs is looking for are “Smuggling for fiscal fraud”, “Trafficking in narcotics”, “Trafficking in counterfeit pharmaceuticals”,

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“Trafficking in stolen goods” and “Trafficking in small arms and light weapons”. Each of these operandi got the weight “is very important (4)”.

Starting with the rating on the current efficiency of detection of each modus operandi for the as-is-situation customs rated nearly every benefit with an “ok”, which equals a rating of 3, on a scale from 1 to 5. Only “Trafficking in counterfeit products”, “Trafficking in polluting substances”, “Trafficking in quota-restricted commodities” and “Trafficking in endangered wildlife”, were rated a bit lower with “poor”, which equals 2.5 or 2 respectively.

By multiplying the weighting factors with the ratings and adding up these products the benefit value for each scenario was calculated. In sum the benefit value of the as-is-situation is 105.25.

Concerning the to-be-situation with a fully implemented CASSANDRA approach customs expected to increase the detection rate and consequently increasing the benefit value. The detection of nearly every operandi could be improved up to the level “good”, which equals a rating of 4. Only human trafficking would be slightly lower with 3.5. Combined with the weighting factor the biggest impact of the CASSANDRA approach would be on the detection of the damages “Trafficking in quota-restricted commodities” and “Trafficking in endangered wildlife”. The rating, i.e. improvement in finding these damages, would increase from poor (2) up to good (4).

Overall by usage of the data pipeline approach the detection rate for all modus operandi would increase significantly. Taking the weighting factor into account the overall benefit value would increase from 105.25 by 41.6% to 149.

After the interviews with the UK and Dutch Customs officers the results had been presented to a German Customs officer who confirmed the expected impact of the data pipeline approach unto the socio-economic related modus operandi.

Research limitations/implications
It was originally planned to conduct a quantitative assessment of the socio-economic benefits by usage of the data-pipeline. But due to legal regulations it was likely, that customs could not provide a full set of quantitative data for an assessment of the social-economic costs and benefits. Consequently, a qualitative assessment was carried out. Future research should be carried out in order to (i) develop a quantitative methodology and (ii) to conduct the quantitative assessment if possible.

Practical implications
During the CASSANDRA project the data pipeline approach was implemented in three different Living Labs in order to demonstrate the feasibility and to assess the benefits for businesses and governmental authorities. The follow-up project CORE continues this work in the field of supply chain visibility.

Social implications
Results of the socio-economic cost benefit analysis show clearly that damages to the social community can be lowered by usage of the data pipeline approach. Policy makers should take the data-pipeline approach for future regulations into account, because of its higher data quality instead of declaration data.

Originality/value
By now very limited research has been carried out in the field of socio-economic benefits through supply chain visibility. This paper describes the methodology, execution and findings of the assessment of the socio-economic benefits of the data pipeline approach.
Keywords: Supply Chain Visibility, Customs, Maritime logistics, Security, Socio-economic benefits
ABSTRACT

Purpose
The HAZARD project aims at mitigating the effects of emergencies in major seaports in the Baltic Sea Region (BSR).

Design/methodology/approach
HAZARD is a regional cooperation project which deals with safety and security issues by bringing together rescue services, other authorities, logistics operators and established knowledge partners.

Findings
The status quo in the target field is that stakeholders, such as Rescue Services and seaport actors, have identified a need to further develop cross-border cooperation regarding the safety and security issues.

Research limitations/implications
The project is a regional and cross-sectoral cooperation project, which limits the scope of research activities.

Practical implications
HAZARD helps seaports and Rescue Services to i) better mitigate accidents and emergencies; ii) comply more efficiently regulation; iii) cope with accidents and emergencies iv) manage communication; v) better understand and apply risk assessment methods and vi) increase the use of state-of-the-art technologies.

Social implications
HAZARD contributes to the Policy Area Secure of the Action Plan to the EU Strategy for the BSR. The core issue for this priority area is civil protection cooperation in a macro-regional context where countries are linked to each other. The project will contribute to achieving the objectives of the strategy by improving cross-border and cross-sectoral cooperation in civil protection.

Original/value
An effective sharing of experiences across all themes in the project ensures that HAZARD reaches its results in a transnational setting.

Keywords: Baltic Sea Region, TEN-T ports, Rescue Services, safety and security, HAZARD project, risk assessment
**Project HAZARD and its Knowledge Partners**

HAZARD project aims at mitigating the effects of major accidents and emergencies in major multimodal seaports in the Baltic Sea Region. Ports, terminals and storage facilities are often located close to residential areas, thus potentially exposing a large number of people to the consequences of accidents. The 4.3 M€ project will be executed in Spring 2016-Spring 2019.

HAZARD brings together Rescue Services, other authorities, logistics operators and established knowledge partners, and provides a unique transnational learning platform, where Partners can evaluate and improve their procedures and practices in emergencies supported by strong knowledge partners.

The knowledge partners in HAZARD (i) provide knowledge support the seaports and rescue services to improve their performance; (ii) enhance the use of analytical work on e.g. risk assessment methods; (iii) support joint exercises\(^1\); and (iv) provide overall analysis and reporting work for the project.

HAZARD knowledge partners are 1) University of Turku (FI); 2) Hamburg University of Technology (DE); 3) Vilnius Gedimino Technical University (LT); 4) Euroacademy (EE); 5) University of Borås (SE); and 6) Polish Safety and Reliability Association (PL).

**Regulatory framework on safety and security**

Core TEN-T seaports are essential nodes for seamless passenger and cargo transports in the EU. Their ability to provide well-functioning traffic services also in case of major accidents and/or emergencies is important for the people and businesses.

The body safety & security regulation in ports is comprehensive and complicated. Much of it is multilateral (e.g. UN or EC based), but there is large variation on national level enforcement of and national/local level additions to this regulatory framework. HAZARD aims at better compliance and implementation of existing and future regulation on safety and security, where progress is monitored to verify the achieved improvements.

**Risk assessment and analysis in HAZARD**

HAZARD helps Project Partners and their peers to better understand and apply risk analysis and assessment methods in mitigating accident risks in seaports and areas adjacent to these.

In addition to mitigating the effects of emergencies to people and the environment, risk analysis in ports is important for ensuring reliability, supply chain resilience, and transport safety & security in logistics both for commercial actors and relevant Competent Authorities.

Within the framework of HAZARD it is possible to make better use of risk analysis and assessment methods. Steps to be taken in order to develop the main output:

i. Determine target group-specific requirements for the application of risk methods;
ii. Evaluate theoretical approaches for their suitability in the present context;
iii. Use of requirements and theoretical foundation to develop a guideline to improve the use of risk analysis and assessment methods; and
iv. Validation of guideline with selected representatives of the target group.

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\(^1\) Over 12 large joint exercises dealing with, for example, leakage of hazardous materials, fire on a passenger ship at a port, oil spill in port areas as well as explosion of gases or chemicals.

\(^2\) The two-round Delphi study on Communication needs in emergencies; see Laakso and Ahokas (2016).
Table 1 The role of the knowledge partners in HAZARD.

<table>
<thead>
<tr>
<th>Project objectives in HAZARD</th>
<th>Activities in HAZARD</th>
<th>The role of knowledge partners in HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAZARD helps major seaports, Rescue Services and related Competent Authorities to:</td>
<td>Organizing Emergency Exercises in Seaports.</td>
<td>Knowledge partners support with suitable risk analysis and assessment methods, and they provide the background information needed to target the joint exercises. Knowledge partners are essential in analyzing the results and experiences gained through joint exercises.</td>
</tr>
<tr>
<td>1) better mitigate accidents and emergencies in seaports and areas adjacent to these;</td>
<td>Communication Practices in Emergencies.</td>
<td>The Delphi study will be conducted during Autumn 2016–Spring 2017. It creates an overall picture of the communicational and regulatory challenges among Project Partners and beyond.</td>
</tr>
<tr>
<td>2) manage communication in emergencies between key actors, and towards the general public;</td>
<td>Regulatory Framework on Seaport Safety &amp; Security</td>
<td>Collecting and analyzing data on the regulatory framework; a comprehensive structure of the relevant regulatory. Identifying how these are followed and/or enforced among Project Partners and beyond; an empirical investigation as to how well the stakeholders are a) following the changes in the relevant regulatory frameworks; and b) to identify and analyse the challenges to comply with the current regulatory framework in their operations. Dissemination of the findings and verification of how to deal with upcoming changes in the regulatory framework is done in close cooperation with other Project Partners.</td>
</tr>
<tr>
<td>3) enforce current and future safety &amp; security regulation/comply with them more efficiently.</td>
<td>Compliance with Safety &amp; Security Regulation</td>
<td>Collecting and analyzing data on the risk analysis and assessment methods especially applied to the issues related to seaport safety and security.</td>
</tr>
<tr>
<td>HAZARD helps project partners to:</td>
<td>Risk Assessment Methods &amp; Models</td>
<td>Identifying how risk assessment/analysis methods are used among project partners and beyond.</td>
</tr>
<tr>
<td>1) better understand and apply risk analysis and assessment methods in mitigating accident risks in seaports and areas adjacent to these;</td>
<td>The Use of Risk Assessment Methods</td>
<td></td>
</tr>
<tr>
<td>2) increase use of state-of-the-art technologies and accelerated adoption of these.</td>
<td>Rescue Service Equipment</td>
<td>Knowledge partners will have a supporting role in the equipment testing. They provide input to help HAZARD Rescue Service and seaport partners assess and disseminate the findings including some verification and reporting activities. The knowledge partners are important in increasing and sharing knowledge of available technologies and equipment to improve safety and security levels among all Project Partners.</td>
</tr>
<tr>
<td></td>
<td>Seaport safety &amp; security equipment and IT systems</td>
<td></td>
</tr>
</tbody>
</table>
ABSTRACT

Purpose
Today’s competitive business landscape requires addressing changes in market and customer requirements promptly and properly. As a result, responsiveness, in this paper defined as the ability to react in order to meet changes in customer demands, has become a major research topic in the logistics and supply chain management (SCM) literature.

Although it is widely accepted that sources of supply chain responsiveness could be found in the entire supply chain, existing research on responsiveness (and related concepts such as flexibility) have had a strong focus on manufacturing activities as a major mean to facilitate responsiveness in the supply chain. This can be to a great extent linked to the overall developments in the flexibility literature, in which historically, manufacturing flexibility has been regarded as a major contributor to the overall supply chain flexibility, and performance. Thus, we argue that there should be much room for studying the concept in other industries such as retail, wholesale and services.

As the focus in the literature has so far been given to responsiveness in manufacturing companies, we argue that more research on retailers’ responsiveness is needed. The “general” literature on supply chain responsiveness that is geared towards a manufacturing context, gives little guidance and structure to retailers’ specific involvement in supply chain responsiveness. Thus, as a starting point for this paper, we question the comprehensiveness of the established models in responsiveness, as they are not necessarily applicable to non-manufacturing contexts. We also assume that there are specific characteristics of retail supply chain responsiveness – compared to general supply chain responsiveness – that call for examining the relevance of the existing frameworks in retailing. Specifically, the absence of manufacturing calls for an understanding of alternative means of the retailer to achieve responsiveness.

The purpose of this paper is to, through a systematic literature review, explore the existing research on retail supply chain responsiveness, and to propose a future research agenda in this area.

Design/Methodology/Approach
This study has adopted a systematic literature review approach. Given the relatively sparse existence of research and our exploratory purpose, the review can be described as inductive, aiming at improved understanding of existing research. The following five steps, in accordance with the existing literature on systematic literature review approach, can describe the review process:
1. Question formulation  
2. Locating studies  
3. Study selection and evaluation  
4. Analysis and synthesis  
5. Reporting and using the results

Search strings with “retail” combined with “responsiveness”, “flexibility” or “agil*” were used in two different databases. Figure 1 shows the selection process from 657 hits to the 42 articles that were read in full.

**Figure 1 The article selection process**

**Findings**

The reviewed articles can be grouped into 6 loosely defined categories, see Figure 2.

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1. Supply chain strategy *(supply chain structure; supply chain concepts, enablers and inhibitors)*  
Chaudhuri, 2008; Bourlakis et al., 2014; Mason et al., 2007; Randall et al., 2011; Barnes & Lea Greenwood, 2010; Christopher et al., 2004; D’Avolio et al., 2015; Rana et al., 2015; Bhardwaj, 2010; Barnes & Lea Greenwood, 2006; Bowersox et al., 2009; Adjei et al., 2009; Seth & Panigrahi, 2015

2. Marketing strategy *(positioning, cultural differences)*  
Okongwu & Santosa, 2008; Yu et al., 2012; Shi & Au-Yeung, 2015; Swoboda et al., 2014; Lau, 2012

3. Market-oriented capabilities of the retailer *(managerial commitment, market sensing, innovation)*  
Atapattu et al., 2014; Combe et al., 2012; Heo & Lummala, 2011; Storey et al., 2005; Griffith et al., 2006

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5. Global sourcing *(total costs, proximity sourcing)*  
Lowson, 2001a; 2001b; Abernathy et al., 2006; Bygballe et al., 2012; Lowson, 2002; Kumar, 2010

6 Supplier relationships *(Coordination, relationships)*  
Wong & Johansen, 2006; Richy et al., 2012; Doyle et al., 2004; Wong & Hvolby, 2007

4. Supply chain operations *(inventory management, distribution, information sharing, RFID)*  
Leung et al., 2003; Gong & De Koster, 2008; Jain et al., 2009; Ganeshan et al., 2007; Yu et al., 2011; Goebel & Gunther, 2009; Azevedo & Carvalho, 2012; Selig et al., 2007; Azevedo & Ferreira, 2009

---

**Figure 2 Reviewed articles grouped into 6 themes**

**Research limitations/implications**

The findings presented in this paper reinforce a number of future research areas to be addressed. First, a future research area that deserves more attention from a retail research perspective is the integration of information and capacities among supply chain members so that the overall responsiveness of the entire supply chain could be improved. The supply chain-wide orchestration of capacities and information is in the very heart of the traditional SCM philosophy and retailers are in pole position to take the initiative for increased supply chain-
wide responsiveness. Of particular importance from the retail perspective is how retailers can leverage their position close to the end customers, being the “match-makers” between supply and customer demand.

A second future research area is how cross-sector learnings on retail supply chain responsiveness can be achieved. Although all retail sectors are different from each other, and “one size doesn’t fit all”, there seem to be an exaggeration of the differences among retailers, which may hamper learning and development in the research field. For instance, literature targeting the fashion sector often presents the peculiarities of this sector, but fails (or avoid) to explain why the research is not generalizable to other sectors.

As a third promising future research area, the findings reveal that relatively few articles are anchored in more rigid theory. Here opportunities for improved sharpness and further development are still open. Promising combinations that are briefly suggested in literature are dynamic capabilities and coordination theory. Another interesting theoretical ground would be power. Both in articles on general supply chain strategy but also in articles discussing supplier-retailer relationships the question of power emerges. More research is needed from a power perspective. In addition to the lack of grounding in more rigid theory, a number of more common retail research topics are not related to research on retail supply chain responsiveness. For instance, juxtaposing research on retail responsiveness with retail research themes such as forecasting and in-store logistics could help to anchor existing research on retail responsiveness.

Original/value
The systematic literature review presented in this paper has explored the relatively sparse research done on retail supply chain responsiveness. From a theoretical standpoint, this paper contributes by analysing the existing literature on retail supply chain responsiveness, specifically in terms of theoretical bases and major research themes. Two major differences between general literature on supply chain responsiveness and retail supply chain responsiveness have emerged during the research. First, as retailers normally do not own or control manufacturing capacity, this capacity cannot be used (by the retailer) as a tool for responsiveness creation. As a result of this, retailers become highly dependent on manufacturers for creating this type of responsiveness. The absence of manufacturing gives that the very core of retail supply chain responsiveness tends to be geared towards marketing-related issues such as customer segmentation and knowledge and adaptation to local culture and customers. Second, retailers have a unique position close to the end customers, which means a potential for rich information and in-depth understanding of end customer needs and requirements. The ability to sense and capture end customer demand, i.e., “being close to the customers” is often discussed as a core competence for the retailers. As the power of the end customer is expected to increase, the role of the retailers is likely to be even more important in the future.

Keywords: retail, responsiveness, flexibility, agility, market-orientation
ABSTRACT

Purpose
Sustainability is one of the major key terms in our modern globalized world affected by such
different but nevertheless closely interrelated issues like prosperity of worldwide trade,
globally-spanning supply chains, the growing social gap and the threatening effects of climate
change. The paper shows how responsible citizenship and reflective critical thinking as well as
a deeper understanding of these complex interdependencies can be conveyed in a systematic
way to a group of international business students in form of a one-week block seminar course
in the CEMS Master-in-International-Management (MIM) program.

Design/methodology/approach
The paper includes a discussion of proven course design, general key skills fostered, didactic
approaches and methods employed along with feedback mechanisms and evaluation results
demonstrating clearly its impact on student’s mind sets afterwards.

Findings
Based on the discussions with our students and post-course reflective reports it turned out, that
for many of them their perception of sustainability issues and of their own behaviour has
changed during this single week because of the topics dealt with in our course.

Practical implications
A well thought-out didactic approach and extraordinary commitment and dedication by the
instructors is inevitable to ensure the success of such a course.

Original/value
This paper explains in a compact way, how sustainability issues in global supply chain
management can be tackled successfully even in such time restricted one-week block seminar.

Keywords: Sustainability, global supply chains, course design, triple bottom line, feedback

In the framework of the CEMS MIM program, our course about sustainable supply chain
management is offered right at the start of winter semester where students from a wide range
of different CEMS partner universities (see http://www.cems.org/mim) with different
background come together for not more than one week. The course was announced to cover
economic / environmental / social sustainability aspects in global supply chains (full course layout can be provided by the authors upon request), which is a truly emotional topic. Hence, from the start we tried to play with student emotions - rather than just providing some slides with hard facts - relying on intellectual awareness building. Accordingly, right at the beginning we showed “The Forgotten Space” by Allan Sekula and Noël Burch (http://www.theforgottenspace.net/) at a small cinema outside the university campus. It is a very provoking film showing clearly the impact of globalization to ‘People, Planet and Profit’ and the role of maritime transport in containers therein, the ‘forgotten space’ of our modernity. After a lively discussion about the participants’ first impressions concerning the film, a first lecture in the afternoon provided a brief course outline (especially about the concepts of sustainability and the Triple Bottom Line (TBL) by Elkington, 1997) and introduced the participants to their group work project challenge for the rest of the week, which topic was shortly pronounced as follows:

“Please make a sustainability report for a product / company / industry of your choice including 5-6 economic / environmental / social aspects according to Global Reporting Initiative Guidelines (GRI). Expected deliverables are a Management Summary (max. 10 pages) and Presentation (max. 20 min) to be submitted before the final presentations in class at the end of the course.”

As a guideline how to make sustainability reporting in a structured way we employed the GRI Reporting Framework (https://www.globalreporting.org/). As it provides a coherent framework how to assess sustainability in a global supply chain context it allowed the working groups to concentrate on the exploration of the various challenges that may encounter when assessing products / companies / industries along economic / environmental / social aspects and try to quantify their findings by hard facts. Finally, the first day ended with an expert dialog with a country director of Fairtrade (http://www.fairtrade.net/) who gave a short introduction in the main challenges non-profit companies are confronted with in establishing such fair trade concepts. This provided a basis for students’ questions and for an inspiring discussion on this topic in the following. In the other three days each morning, one of the three pillars of the TBL was subsequently discussed in lectures by resident staff. This was complemented by another expert dialog with a representative of a globally present logistics service provider on his challenges in this respect and a field trip to a recycling centre including a guided tour showing how ecological and social performance can coincide in reverse logistics. Furthermore, on two days coaching sessions of three hours length were organized which allowed the students to progress on their group work project guided by the instructors. Finally, on the last day, all groups presented and discussed the results of their group work project in class.

By this mix of didactic approaches and methods, we tried to ensure that students participating in this seminar (1) develop a greater understanding about typical structures of global supply chains, (2) gain an awareness of environmental and social footprints of global supply chains, (3) learn how to assess environmental and social impacts of products and/or supply chains and (4) get experience in team work. From a didactic point of view, lectures, expert dialogues as well as a field trip were used to teach the relevant stuff in a diversified way including cognitive (thinking), affective (feelings) as well as psychomotor (physical) activities (Anderson and Krathwohl, 2001). Furthermore, the group work project experience in form of a student-written, instructor-facilitated (SWIF) case study helped the students to deepen their insights in this multi-faceted field of sustainability even within the given heavily restricted time frame. Apart from working on the group work project (50% of overall grading) as the main objective in the course, students were required to pass in a written examination about pre-readings distributed before the start of the class (25%), which consisted of a selection of topical articles or book
chapters that allowed the students to enhance their knowledge about sustainability issues. Another part of the grading was about actively engaging in class dialogue and discussion (10%) and submitting a post-course reflective report (15%) to get a mandatory feedback afterwards (as suggested by Rosier, 2003). Concerning adequate feedback as a precondition for effective learning with lasting impact, we placed great emphasis on reflective approaches and attitudes and the added value created through feedback, which can be done in different ways like ad-hoc feedback, systematic feedback methods, or mandatory feedback given through specific channels (Brookhart, 2008). As the course program was a mix of lectures, expert dialogs, field trips, group discussions and work on their projects, students got each day of the course feedback in different ways. First, in all lectures and expert dialogs as well as the field trip always a significant amount of time was spent on discussing upcoming issues from the class. This enabled an ad-hoc feedback not only for the students, who could ask questions and express their opinion, but also for us as instructors, to see whether we presented interesting stuff in the right way. For the group work project highly interactive coaching sessions were organized where the instructors wandered around to give ad-hoc feedback on their advancements and to answer upcoming questions. This approach ensured that the groups made rapid progress in (1) finding a suitable product / company / industry of their choice, (2) exploiting suitable sources for their inquiry and (3) finalizing the project work in the very short time given. During the coaching sessions, it always turned out to be that financial aspects are easy to retrieve but environmental and social aspect are always very hard to quantify due to exact data publicly available.

As the time limitations of this course did not allow a full peer-review process of projects works by students, we used instead a simple voting sheet where they assessed quality of content and the way the works were presented in class. This systematic feedback approach raised attention for the students during presentations and allowed the instructors to complement their impressions about the overall quality of group works to avoid inter-subjective judging. Moreover, the students voted for their overall favourite group work and each member of the most popular group presentation got a present at the closing ceremony. Finally, mandatory feedback in form of post-course reflective reports to be submitted by all students two weeks after the course at latest was demanded as follows:

"Please write a brief report (max. 2 pages) about the block seminar from your point of view and keep in mind the three pillars of sustainability when answering the three questions below:

1. What were topics or facts that you found interesting during the week?
2. What was good about the outline, schedule, and content etc. of the course? What could be improved?
3. In which way did this block seminar inspire you to think about sustainability issues in the future?

Subsequent student feedback in the course framework and our post-course reflective reports demonstrate clearly the overall students’ satisfaction with the course outline which is definitely no fishing for compliments, but provides an invaluable source of improvement ideas as well as hints, which parts of the course already work in a good way and what can be improved next time. Especially the mixed content as well as the diversified teaching methods combined with a film at the beginning, and the field trip to the recycling centre was highly appreciated by the students. Although the workload in this block seminar was felt rather high in comparison to other such block seminar courses, the vast majority of the students did a great job and worked out their projects in an excellent way. Finally, most of the students clearly expressed that the
course forced them e.g. to think over their consumer behaviour which is a clear evidence that the course may have a lasting impact to their lives – at least for some of them.

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DEFINING SECURITY OF SUPPLY
– IN A DEFENCE CONTEXT

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ABSTRACT

Purpose
Security of Supply (SoS) is a growing issue in the defence area. The SoS-concept seems to
differ between contexts and it also seems to be more stable in some areas than others. In the
business area, SoS deals with risk management and interruptions in the supply chains. In the
humanitarian area, SoS deals mainly with ways of having supply chains able to deliver the
needed goods into the affected area. In the defence areas the meaning of the term SoS seems to
have changed over the last 20 years, the authors are of the opinion that the baseline for the term
have matured and can be expected to be more stable in the future.

The European Defence Agency has a working group active trying to create agreement among
the EU countries on some aspects of SoS. In the US the defence budget for materiel is today
spent much more internationally compared to 20 years ago, and therefore the US Department
of Defense has put great effort on identifying and securing their supply chains. But even if there
are many ongoing activities, there seem to be no consensus among practitioners in governments
or industry on what SoS is. What can be identified is that there seems to be more aspects about
the term in the defence area, than in many other business contexts.

The authors have identified a number of research themes that require a defined baseline for the
term SoS, and that the term itself is too complex to be just shortly defined in a research paper
with another purpose than trying to define the term. The purpose of this paper is to define SoS
in a defence context.

Design/methodology/approach
The study is mainly conceptual, with an empirical research element which is used as secondary
data to test and guide the analysis. The study builds on the combination of three methods; a
literature review of SoS in different contexts, a review of the development of the concepts
supporting SoS during the last 50 years, and an action research activity, where one of the
authors work with ongoing multilateral governmental cooperation concerning SoS
arrangements.

Findings
SoS during the Cold War (-1991)
The cold war planning did build on the strategic hypothesis to create a trust worthy threshold that the armed forces had enough of resources to fight until the last soldier standing. On strategic level the plan was to stock keep everything that might be needed in different operational war scenarios including a longer period of closed borders. The operational planning did build on the hypothesis that the forces needed to have supplies prepositioned in the directions where the war was going to be. That had the effect that for several types of goods the national capacity was larger than the needs in one operational direction. The SoS thinking on operational planning was to have more than enough just in case. On tactical level the focus was to have enough transportation capacity to move critical goods from warehouses to the military units. I was expected that the civil society had overcapacity during times of war and that these resources could be used by the armed forces.

SoS during the Cold War was mainly a national interest, both for non-allied countries as Sweden and Finland and for NATO countries.

SoS during the Post-Cold War (1992-2008)

The Post-Cold War period in Europe was by the western European politicians believed to start a new era with no real threats on the European nations. The doctrinal planning on EU level supported by the member states, was that EU should be able to act with military resources 3000 km from Brussels, based on member states contributions. EU posed an ambition to take the leadership for European defence policy, where important activities were managed as; the restructuring of the defence industry, pooling and sharing of military capabilities, and development of SoS agreements.

Nationally most countries reduced the number of military units and much materiel were either sold out or destructed. SoS was something that the market should manage and the political level did not consider SoS as a strategic issue.

In operations participation international operations was the focus for the national forces in Europe. These operations where strongly dependent on the supply chain performance, with civil contractors operating in both to support the rear supply base in the home country of the forces and to give direct support in the operational area, and thereby the focus SoS at operational level concerned this handling. New business models were developed with an operational thinking as Public Private Partnership and Performance Based Logistics/Contracting.

On tactical level much of the planning from the Cold War period stayed unchanged. To some degree higher requirements were applied within the armed forces, resulting in better planning and force protection on logistics transportations, in other words some practical risk management planning, similar to the SoS-thinking in Humanitarian and Business sectors.

SoS during the Rearmament period (2009-)

The war in Georgia 2008 and the Arabian Spring was a turning point in European security policy, slowly the European politicians started to see a change in the military threat just outside the EU borders, with assumed threats directly towards EU-member states, the national defence capability must be given a stronger focus. Within Europe, it have been discussed that both a national and multinational perspectives are needed and where solidarity builds on national capabilities and international collaboration. Both the political leadership and the military specialists in defence logistics have argued the need for an upgraded focus on SoS issues since it is no longer only about the ability to participate in peace support operations but also about national sovereignty. EU through EDA has established working groups to establish common rules for handling different aspects of SoS.
There seems to be a consensus among political and military leadership that the Cold War solution for SoS would not be an option for the future. The globalised supply chains and the civil engagement as a logistic supplier on the battle field, in combination with smaller and more technology advanced forces puts other requirements on the SoS than it did during the Cold War. Future SoS seems to build on the combination of the Cold War aspects, the post-Cold War aspects, and the globalised defence industry. SoS arrangements can be supported by government to company SoS-contracts and in parallel government to government agreements supporting the acknowledging. Another factor that plays a crucial role on operational and tactical level is the government funding available for the defence sector, which delimits the just in case solution of the Cold War.

**Research limitations/implications**
The study has not yet reached a maturity where a definition of SoS can be proposed. The next step of the study is to elaborate around different suggestions that organisations and nations have proposed. This study will constitute a baseline for several other studies concerning parts of the SoS area.

**Practical implications**
The fact that there is no agreed definition and large confusion about SoS, this study will help practitioners in the defence sector worldwide with a framework to base discussions, development and implementation around.

**Original/value**
The most important contribution of this paper will be the creation of a common understanding of SoS. Today several different definitions exist which either are unclear or delimits the scope in one or another direction.

*Keywords: Security of Supply; SoS; Defence logistics; Definition, Defence supply chains*
ABSTRACT

Purpose
The notion of innovation has been overlooked by logistics research (Flint et al., 2005; Busse, 2010). Moreover, patent data (as an established measure for innovative activity) has scarcely been used in previous studies to analyze technological innovativeness or intellectual property (IP) strategies in logistics (Wu, 2006; Niemann et al., 2013). Future research avenues for investigating IP in logistics refer to e.g. the classification of technological areas in logistics (Wu, 2006) or potential new challenges for LSPs in terms of coping with competition and developing strategies for certain types of patents (see Niemann et al., 2013). The purpose of this paper is limited to investigating global 3PL providers’ patenting trends and to identify the main technologies that 3PL providers rely upon. The purpose is further illustrated into the following research questions:

RQ1: Which of the leading global 3PL providers have (active) patent portfolios and how have their patenting trends developed over time?

RQ2: What are the most frequently assigned IPC classes in the 3PL providers’ patent portfolios?

Design/methodology/approach
The objectives of the paper are achieved by analyzing patent data from the Thomson Innovation (TI) international patent database and the public international patent database of the World Intellectual Property Organization (WIPO). In the first step, an official ranking of global 3PLs is identified, in order to pinpoint the assignees’ (applicants) names. The second step entails establishing which of the top ranked global 3PLs have patents and how a new ranking based on patent portfolio size looks like. Third, the development of the patent portfolios over the last 10-15 years will be illustrated for the different 3PLs in question. Subsequently, the main technologies used by the 3PLs will be identified by defining the most frequently encountered international patent classification (IPC) classes. Based on a 3PLs ranking by Armstrong and Associates, Inc. (2015), Table 1 shows global 3PL providers’ ranking according to revenues for the year 2014.

Findings
After completing a search for the assignees in the TI patent database, it appears that only five of the 20 companies in the afore-mentioned ranking have larger patent portfolios (ranging from
47 to 419 patent families), while eight other have small patent portfolios, between 1 and 11 patent families.

Table 1 Top Global 3PL Providers (according to revenues* and patent portfolios**)  

<table>
<thead>
<tr>
<th>Ranking no.</th>
<th>3PL Provider</th>
<th>Gross revenues ($ mil)</th>
<th>Patent portfolio size no. of patent families</th>
<th>No. of patent documents</th>
<th>New ranking based on patent portfolio size</th>
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<td>3</td>
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</table>


**source: Thomson Innovation patent database (data collected Nov-Dec. 2015)

According to the new ranking based on patent portfolio size in the last column of Table 1, the top five 3PL providers were selected to compare the patenting trends over the past fifteen years (Figure 1) and the most frequently assigned IPC classes (Figure 2). For these two analyses complementary data from WIPO’s Patentscope was used in order to provide a more general overview. Figure 1 shows that three of the considered Agility, Nippon Express and Deutsche Bahn (DB) have maintained rather constant patenting trends over time, with DB even decreasing the number of annual patent applications in the last five years. Deutsche Post DHL
and UPS present rapidly increasing annual patent applications in the early 2000s, but more sinuous trends after 2006-2007.

Figure 1 Patenting trends over time for selected 3PLs

Figure 2 shows the IPC classes that are more frequently assigned to patents of the five selected 3PL providers. Here UPS and Deutsche Post DHL dominate most IPCs with some exceptions for B60 (Vehicles in general) and G06 (Computing; calculating; counting) where DB is also quite strong. The top IPC class G06 contains subclasses such as G06F – Electric digital data processing or G06Q - Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes.
**Research implications**

The present study contributes to filling theoretical gaps concerning the lack of studies about innovation in logistics (Flint et al., 2005; Busse, 2010), classifying technologies used by LSPs (Wu, 2006) with the help of the IPC, and possibly even suggesting IP strategies that are applied in logistics (Niemann et al., 2013).

The study is however limited, on one hand by the initial choice of 3PLs and a specific ranking thereof, on the other hand by the descriptive nature of the findings, only meant to provide a glimpse into patenting trends in logistics. More in depth investigation of patent data is likely to reveal fresh insights into this rather unexplored field, as well as unravel possible reasons for the increasing patenting activity in logistics.

**Practical implications**

The awareness about IP strategies and technologies used by potential competitors should be regarded as highly valuable by managers and/or decision makers in LSPs. For instance, the breakdown in technological areas with the help of IPC classes, subclasses, etc. would aid other LSPs identify technological areas of future interest or technologies for which they require IP protection. Furthermore, the IP strategies of LSPs that already patent could provide further indications about their overall innovation strategies and even their business models.

**Keywords:** Patents in logistics, 3PLs, Logistics service providers, International patent classification, patenting trends

**REFERENCES**


HUMANS IN MANAGING SUPPLIER-SUPPLIER RELATIONSHIPS: THE CASE OF THE RUSSIAN ARCTIC WHERE THE SEA MEETS THE RAILWAYS.

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ABSTRACT

Over the past decade, there has happened a shift in both researchers’ and practitioners’ thinking and attention towards how humans interconnect, managing supply chain activities (Kamal & Irani, 2014). An increasing number of earlier studies has highlighted both the strategic and operational significance of collaboration and integration as inherent prerequisites for building long-term relationships between partners, facilitating information sharing and reducing coordination costs (Holweg et al., 2005; Das et al., 2006; Cousins & Menguc, 2006; Gruat La Forme et al., 2007; Horn et al., 2014). Supply chain relationship can be viewed as a network of social ties, which determine behavioral norms between the partners. Mutual trust, commitment, reciprocity, team working, reciprocal information sharing and others are those values, which extend interaction and collaboration between people and groups of individuals like organizations and companies. These social values in supply chain relationship are embedded in the structure of many institutions, which in turn are designed to regulate and maintain the social interaction between the partners to expand long-term collaboration. A number of earlier SCM research has recognized human involvement as an inherent antecedent of integrated supply chain relationship and important for many other aspects of SCM development (Storey et al., 2006; Fawcett et al., 2008; Tokar, 2010). However, the effect that humans and their social ties produce on supply chain relationship and institutions, by which they are regulated, has remained still largely unexplored (Sweeney, 2013).

To date, the academic literature reveals a number of gaps in our understanding of the supply chain relationship. First, there is an increasing number of earlier studies, which has emphasized the importance of considering supply chain relationships through the triads: buyer-supplier-supplier (Choi et al., 2002; Wu & Choi, 2005; Choi & Wu, 2009; Choi & Wu, 2009b; Bastl et al., 2013; Touboulac et al., 2014). At the same time, some studies have recognized that relationships between suppliers (i.e. supplier-supplier relationships) are more complex and dynamic than vertical buyer-supplier relationships (Choi et al., 2002; Wu & Choi, 2005; Wilhelm, 2011). They present a link between what the focal company is able to control, like supplier selection making the supply chain design visible, and the more emergent, invisible part of the supply chain, when a supplier arranges its relations (Choi & Dooley, 2009). That makes supplier-supplier relationships difficult to manage than other kinds of supply chain relationships (Choi et al., 2002) as well as to set up interaction between them (Wilhelm, 2011). According to Wu & Choi’s findings (2005), supplier-supplier relationships have strong strategic implications for the focal company because they affect the process and outcomes of buyer-supplier relationships. However, these dyadic relationships between suppliers and their implications for SCM practice have received scarce attention in the academic literature, reflecting fragmented transport planning through hypotheses mostly. This is generally driven by the relative lack of empirical evidence of how suppliers develop their relationships and interactions.
Second, some earlier studies have suggested that supplier-supplier relationships can be affected by other partners within the supply chain. Wu & Choi (2005) have illustrated how buying companies can play a strategic role in creating various forms of supplier-supplier relationships, encouraging suppliers to work closely together, while other times keeping them apart. Thus, this group of earlier studies has indicated that one of salient characteristics of supplier-supplier relationships is that suppliers compete and collaborate at the same time (Wu et al., 2010). According to Wilhelm (2011), this inherent characteristic indicates that if the buying company is able to exert influence on direct and indirect supplier-supplier relationships, suppliers in turn can affect the way of how power is allocated and redistributed within the supply chain. It refers us to some studies, being critical to positive assessments of gaining mutually beneficial effects of tighter supplier relationships, which have pointed out exploitative nature of supply chain relationships due to unequal level of power between partners (Turnbull et al., 1993). According to Hoejmose et al. (2013), relational power asymmetries can play a constraining role in shaping supply chain relationships to extend mutual interaction and collaboration between the partners. However, the academic literature has provided insufficient understanding of how power asymmetries affect behaviors and communications of partner relationships (Michalski et al., 2013).

Third, another group of emerging SCM studies has recognized human involvement as an inherent antecedent of keeping supply chain relationships and important for many other aspects of SCM development (Storey et al., 2006; Fawcett et al., 2008; Tokar, 2010). These earlier studies have suggested that supply chain relationships can be viewed as a network of social ties, which determine behavioral norms and values to extend interaction between the supply chain partners. However, the effect that social dimension and social ties produce on supply chain relationship and institutions, by which they are regulated, have remained still largely unexplored (Sweeney, 2013).

At the same time, the academic literature has acknowledged that companies choose to work with those suppliers, which provide value to their operational activity. However, some earlier studies has indicated that companies can have a limited choice of their suppliers due to the lack of competencies and capacities (Größler et al., 2013), remote locations with sparse transportation networks (Plaizier et al., 2012) as well as unstable, insufficient environments with high level of uncertainty and complexity (Wong & Boon-it, 2008; Cho & Ha, 2009; Jia & Zsidisin, 2014). These companies are often found as operating in the natural-resources-based industry or low-value-added manufacturing in emerging economies (Größler et al., 2013). Such contextual features are inherent to the Russian Arctic. On the one hand, the Russian regulation of navigation and sailing in Arctic waters has been quite unstable, as well as still lacks some legislative norms and procedures (ref.). On the other hand, the Russian Arctic is full of challenges to organizing the regular flow of goods and materials and integrated supply chain relationship due to harsh natural conditions. In addition, such an unfavourable location can bring to unplanned events like disruptions within the supply chain (Kleindorfer & Saad, 2005) and, as a consequence, expose supply chain partners to operational and financial risks (Stauffer, 2003). In the Russian Arctic, water transportation provides major industrial flows, bringing out output from the industries, located in the northern remote areas, and bringing in input to the industries and consumer goods to the local inhabitants (Høifødt et al., 1995). It is crucial for the “survival” of the northern remote areas, ensuring supply of necessary goods, first of all food and fuel (Granberg, 1997). Transshipment of cargoes destined for domestic customers is carried out mainly in the ports of Murmansk and Arkhangelsk to be sent by railways towards the European central and southern parts of Russia. At the same time, the ports of Murmansk and Arkhangelsk accumulates supplies and industrial cargoes, delivered by railways, to be shipped out then to the eastern northern regions along the Northern Sea Route. Therefore, two modes
of transportation, namely sea shipping and railway delivery, meet in the Russian Arctic. Interaction between suppliers using these both modes of transportation appears to be essential for providing a cargo circulation in the Russian Arctic that makes this case interesting to be explored. The academic literature suggests just a few studies, which have presented implications of the case studies regarding the evolution of the railway industry (Dobbin, 1994; Esposito & Passaro, 2009), railway connections between the seaports and the interports (Thore & Iannone, 2012) and collaboration between haulier and shipper (Fugate et al., 2009). However, the relationships between maritime transportation and railway deliveries have received insufficient attention in the academic literature.

Addressing the gaps in the current body of literature, the present study aims to explore how humans participate and interact when managing supplier-supplier relationship in the Russian Arctic in the case of maritime and railway transportation.

In doing so, the present study illustrates the strategic role of horizontal supply chain relationships between two suppliers (engaged in maritime and railway deliveries respectively) when managing the supply chain in the Russian Arctic. The term “horizontal supply chain relationships” is applied to detach the investigated relationships from vertical relationships between the supplier and its sub-suppliers. The present study also explores the managerial implications of supplier-supplier relationships to make them more integrated in order to eliminate the hazard of supply chain disruptions.

The research question is addressed through adopting a qualitative case study of a company, which is a maritime supplier. The empirical data is presented as five narratives of how key managers have interacted within the maritime supplier and their external communication with the employees from the railway carrier. Therefore, the analysis of the empirical data collected was constructed from several scattered stories, told by my respondents, and pictures, watched by my own eyes during personal observations. Through their stories, the respondent managers defined what events, actors and actions were most relevant and central at a certain point of time in the process of nickel matte delivery to make this process regular and exclude any possible disruptions within the supply chain. Thereby, the stories were viewed as a means by which the managers created the social reality of how they were involved in nickel matte transportation and with whom they had to interact.

In order to analyze the data presented through narratives, the study applies institutional logics and social capital theory as theoretical lenses through which to contribute to our understanding of interpersonal (formal and informal) ties and values participate in managing the relationships between two suppliers. This theoretical approach highlights social connections between supply chain partners, which are critical in achieving mutual activity in cargo transportation within the same supply chain. That is helpful to reveal informal mechanisms of communication between managers of both suppliers.

Preliminary empirical findings

1. The maritime supplier has managed to organize its cargo transportation in such a way that now this transportation system functions Just-in-time strategic practice. In the history of cargo transportation in the Arctic waters, such an organization of transportation process, which could be interpreted as Just-in-time, has never been employed and noticed before. This was, first of all, due to the Arctic harsh natural conditions.

2. Human dimension and social ties between the top managers inside the maritime supplier can be interpreted as quite powerful. These social ties and resources work as daily routines. The top managers routinely use them in their interaction and decision making
process in order to influence the employees’ behavior of the railway carrier. The data received during my interviews and my personal observations have revealed that social ties play a special role in SCM practice shared by the maritime supplier and prevail over the formal mechanisms (mostly contractual commitments). They allow organizing such an interaction with the employees of the railway carrier in order to eliminate any possible disruptions in the supply chain.
CUSTOMER VALUES IN SELF-SERVICE TECHNOLOGIES
– A SYSTEMATIC REVIEW

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ABSTRACT

Purpose
The rapid development of the E-commerce has led to the emergence of a new retail channel and delivery mechanisms within the last mile distribution. In logistics, this shift has led to rapid increase in volume of the parcel flow and challenges for the retailers and logistics service providers. Thus, along with growing market competition and consumer expectations, E-commerce expansion has resulted in issues within the last mile distribution. Existing and newly emerging last mile distribution issues have been addressed by some retailers and logistic service providers with the implementation of parcel lockers. This form of self-service kiosks has been successfully implemented in countries like Germany, Australia and Denmark, while other markets have struggled to adopt this form of self-service technology. Despite a widely spread distribution network, parcel lockers appear understudied.

The paper aims to identify consumer values and value attributes in self-service kiosk. This study is triggered by growing attention in research and industries to self-service technology and self-service kiosks in particular. Self-service kiosks appear in form of various technologies, such as ATMs, self check-out and ticket machines. As a form of self-service kiosks, parcel lockers involve consumers in the process of the service conducting. Thereby, the consumer is seen as a value co-creator. At the same time, customer’s values in self-service technology and self-service kiosks appear vague in the wide body of available research. The study aims to provide customer values and value attributes in self-service kiosk by summarizing the findings from the available research.

Design/methodology/approach
The study is designed as a systematic literature review. The method is chosen in order to increase the study rigoroussness and replicability (Tranfield, Denyer, & Smart, 2003). Systematic search in six major databases has provided 1287 articles. Title and abstract filtering, application of predefined inclusion criteria and manual search have allowed to accept 73 articles for this review. The inclusion criteria consisted of peer reviewing, end user perspective, investigation on customer values and value attributes in self-service kiosks. The analysis of customer values and their attributes is conducted with help of the customer value creation framework provided by Smith and Colgate (2007).

Findings
The study is still in the analysis stage. No detailed results can be provided at the moment of the abstract submission.
In alignment with the established framework, the identified values are described as functional/instrumental, experimental/hedonic, symbolic/expressive and cost/sacrifice. The extracted attributes are assigned to the value aspects, which form the customer value, according to Smith and Colgate (2007).

**Research limitations/implications**
The study findings rely on the chosen methodology and methodology application. Furthermore, extracted values do not necessarily apply to all types of self-service kiosks in practice. The research gap in parcel locker studies have resulted in the absence of articles dedicated to this technology in the scope of this review. Thus, it can be expected that customer value creation goes beyond the provided framework in case of parcel lockers.

The findings enable further investigation of self-service technology, self-service kiosks and, most importantly, parcel lockers. The customer value framework provides ground for future empirical studies.

**Practical implications**
The findings are to be taken into account when implementing self-service kiosks or improving performance of existing networks. The knowledge on customer values can serve as a source of service quality improvement. In other words, the findings provide knowledge for various service industries that involve the customer in the service conducting process. One of the examples is providers of parcel locker services within the last mile distribution.

**Original/value**
The article provides a summary and analysis of the research on customer values and value attributes in self-service kiosks. The technology is studied from the customer value creation perspective. The systematic review summarizes the knowledge that has been provided in a wide body of research, but has not been approached with the systematic review method. The findings provide ground for future self-service technology research, as well as enable service improvements for retailers and logistic service providers that use self-service kiosks for deliveries.

*Keywords:* self-service technology, self-service kiosks, customer, value, systematic review.

**REFERENCES**


LOGISTICS PERFORMANCE MEASUREMENT
– CONCEPTUAL STUDY ON THE ROLE OF RISK

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ABSTRACT

Purpose
Logistics and supply chain management has substantially gained researchers’ attention throughout the past decade. Many companies are focused on enriching supply chain strategies and streamlining their logistics operations to increase business competitiveness. It is evident that opportunities for logistics cost reduction and rapid market responsiveness rely heavily on appropriate implementation of logistics improvement process. However, without proper performance measurement, logistics improvement cannot be well achieved as a course of improvement action must be justified through some pertinent performance measures.

A host of researchers have addressed the problem of measuring the performance of transportation, logistics and supply chain. Specifically, a variety of measurements of logistics performance have been proposed in the literature. The role of performance measurement is even more essential when coping with a more complicated supply chain structure. Hence, identifying proper indicators to assess the performance of logistics becomes a crucial step of logistics performance measurement. While most of the developed logistics performance indicators are based on cost and time with consideration of dynamic business environment, the critical problem all researchers still encountered lies in selecting adequate and relevant indicators.

There are numerous ways of defining performance, depending largely upon the company’s business goals, i.e. profits, customer satisfaction or increased sales. This makes some other vital but business inexplicitly related dimensions always overlooked. For example, while they are correlated with business, risk and environmental effects are not well recognized in the logistics performance measurement. Failure in explicitly addressing risk in the measurement of logistics performance is also the case for Logistics Performance Index (LPI) developed by the World Bank. LPI is designed to evaluate the performance of trade logistics and supply chains in response to public policies. This every two year set of indicators has been widely accepted by both logistics researchers and practitioners around the world due to its simplicity. While there are some elements of risk in the LPI indicators, none of them is clearly analyzed and interpreted. To the best of our knowledge, logistics performance with respect to risk, which demands its own particular performance measures is inadequately studied in the literature. Lack of risk dimensions in logistics performance measurement is considered one of the major factors many companies cannot achieve logistics improvement.
The purpose of this research is to examine the possibility of integrating risk with logistics performance measurement. Brief review of the literature from certain reliable sources is carried out to outline how the past works have dealt with logistics performance measurement in terms of risk. In lieu of developing a new set of logistics performance indicators, the framework of the well-known LPI is investigated and enhanced to take into account risk. Future research directions are recommended based on the findings.

**Design/methodology/approach**

In order to link logistics performance measurement with the concept of risk we apply a conceptual research approach. By doing so, the World Bank published Logistics Performance Index (LPI), which is one of the most well-known performance measuring instrument for trade logistics, is specifically studied. Furthermore, we conduct an integrated literature review, which allows to gain a holistic perspective on how widely risk is applied in the logistics performance measurement in the academic literature. In addition to the LPI, the literature review relies on the databases of Elsevier Sciencedirect® and Emeraldsight® from which two terms “logistics performance” and “risk” were sought. Thereafter, the found articles were analyzed by the authors to evaluate how logistics performance measurement considering risk has been studied in international level.

**Findings**

The findings of this study illustrate how risk is addressed in the current logistics performance measurement studies. From the conducted literature review and the analysis to the LPI it becomes obvious that the current logistics performance measurements do not address the role of risk properly. While the inbuilt characteristics of risk can be found from the performance measurements, risk is not explicitly taken into account. It is important to notice that based on our search, while the role of risk has grown in logistics performance during the last decades, the measurement tools have not developed accordingly.

**Research limitations/implications**

As this is an exploratory research attempting to explore what has been done in the literature, rigid conclusions have yet to be drawn. Moreover, the most critical issue arisen in this work is the search for two terms through the limited number of databases in the process of eliciting the findings. Consequently, some relevant works that do not contain those terms nor are not in the sought databases, may be excluded, and thus generalizing the research results is somewhat limited.

**Practical implications**

The findings affirm that the importance of risk has not been well recognized in measuring the performance of logistics. This sparks the necessity of developing logistics performance measurement taking into consideration risk. A great deal of future research based on the findings can be expanded. Particularly, a set of proper performance indicators should be constructed for assessing risk in logistics management, and investigating its relationship with business performance. In this work, LPI is purposively extended to account for risk in trade logistics. It would also be of importance to comprehend how one action can increase risk under one circumstance/criteria and reduce risk under another.

**Original/value**

This research aims to instigate a scientific and managerial discussion on how logistics performance measurement takes into account risk. Specifically, the study explores how risk has been integrated within LPI and other logistics performance indicators we found from the state-of-the-art literature. The value of this discussion lies in the findings, which reveal that the logistics performance measurement tools and risk have been sparsely applied together. This is
an important step in the development of logistics performance indicators that take properly into account the challenges faced by the international supply chains.

Keywords: Risk, logistics, performance measurement, indicators, conceptual study
ABSTRACT

Purpose
Extensive use of fossil fuel to power logistics operations has direct impact on greenhouse gas emissions. Energy-consuming operations in the logistics system need further investigation in order to reduce this negative impact. One promising pathway is over-capacity in the logistics system which has to be identified and ways of how this excessive capacity can be used have to be developed (Wehner et al., 2015). Further, a behavioural change from customers as well as logistics service providers is needed because technical innovations alone are not sufficient to reach this level of energy efficiency (Chapman, 2007). By focusing on freight transport as a key of ‘supply chain execution’, the purpose of this empirical study is twofold: (1) To identify unused potential in road freight transportation; (2) To present ways by which over-capacity in the supply chain can be utilised in order to release this potential.

Design/methodology/approach
Semi-structured interviews were conducted, complemented by secondary evidence and a literature review. The sample consists of customers and providers of logistics services, as well as providers for information and communications technology (ICT) in logistics and consultants in energy. The interviews addressed categories developed from the literature review. The categories used are: Energy consumption, energy efficiency, over-capacity, collaboration, the logistics system, consumer influence, e-commerce as well as new and shared economy. The interview guide was adapted to the particular interviewee, his or her work task, the company’s sector and challenges.

The analysis of the interviews was twofold: (1) Studying what perception of over-capacity the actors and experts within the field have; (2) Identifying the cause of over-capacity together with the experts in regard to road freight transportation chains into and in the urban area.

The secondary evidence included public accessible information from websites in regard to transportation and other supply chain activities. Furthermore, a comparison of e-commerce delivery and return services of eleven different retailers was conducted.

The literature review focused on the logistics-energy domain. The review followed three search strategies: Keywords, journals, as well as snowballing and recommendations.
Findings
Over-capacity is an indicator for inefficiency and describes the operational underutilisation of resources (Kalantari, 2012). The identification of the potential of energy efficiency must take place at different system levels with particular focus on a) capacity that is not fully utilised, and b) root causes of over-capacity. The root causes have been extracted from the interviews, the secondary evidence and literature. This paper develops a framework presenting these different system levels (1 to 4).

Capacity in transportation (1a) depends on the physical ability of a vehicle to carry freight during a certain time (Konings et al., 2008). It is directly influenced by the size and shape of the packaging because reduced packaging requires fewer vehicles (Wu and Dunn, 1995, Kalenoja et al., 2011). Capacity in warehousing (1b) is affected by e.g. the filling of boxes, their arrangement on pallets, the ability of loading and receiving goods and the adaption to time slots.

At the actors level, capacity is influenced by the intensity of collaboration with suppliers (2a) but also with other actors in the supply chain by sharing know-how and expertise (Plambeck, 2012). At the same time, customers (2b) who purchase logistics services, set demands for the logistics service providers in regard to e.g. delivery as well as lead times. These demands often lead to an increased energy consumption and create over-capacity in the logistics system. Improvements in energy efficiency can be achieved when applying a holistic view onto the whole supply chain (3a) (Bottani et al., 2014) and managing the whole chain simultaneously. A further potential is seen in slowing down logistics operations (McKinnon, 2016). This stands in direct contrast with the just-in-time principles which are applied today. E-commerce (3b) is a rather new channel to purchase products online and opens up new opportunities for delivering the product to the end consumer’s household, e.g. via milk runs (Brown and Guiffrida, 2014). The system level point of consumption (4) addresses the importance of the last mile (Browne et al., 2005, Browne et al., 2006) and deals with over-capacity created by requirements which are set by the end consumer.

Research limitations/implications
The objective of the road freight transportation sector is to operate with the lowest costs possible, but to utilize over-capacity and to save energy, does not always match this objective because energy is not the only cost driver in transportation. To exploit the potential of energy efficiency in road freight transportation can be challenging. Future research should study different cost drivers and evaluate the economic component of energy efficiency in freight transportation closer.

Practical implications
To utilise identified over-capacity in the supply chains in the future, helps not only logistics companies to decrease their energy consumption, but also to decrease greenhouse gas emissions which have a negative impact on the environment. Companies are trying to become greener and by operating energy-efficiently, resources are preserved and the companies’ images in regard to sustainability are strengthened.

Original/value
By identifying the causes of over-capacity and utilizing this potential, supply chains can be operated more energy efficiently. The analysis shows that a main issue is originated within the collaboration and communication process of logistics service providers to down-stream actors in the supply chain and that requirements of consumers have a strong influence on all upstream logistics activities. Furthermore, a high energy consumption arises in the reverse logistics.

Keywords: Energy efficiency, Road freight transportation, Over-capacity.
REFERENCES


FINLAND'S TARGETS FOR SECURITY OF SEABORNE SUPPLY AND THEIR ACHIEVEMENT

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ABSTRACT

Purpose of this paper
The research aims at creating a realistic description of Finland's security of seaborne supply situation based on the structure of current fleet and dependency on maritime trade. The research question is formulated as: “Does the Finnish merchant fleet meet the targets set for security of seaborne supply.”

The sufficient and necessary merchant fleet capacity mentioned in recent state budget proposals (SBP 2008, 2009–2016) can be seen as a target level and desired state of affairs. According to the budget proposals, Finland needs to have domestic tonnage for carrying out the necessary and at the very least the essential foreign freight traffic, also during disruptions in normal conditions and during exceptional circumstances.

During years 2002-2014, the number of merchant vessels sailing under the Finnish flag has varied between 129 (2002) and 108 (2014), while the gross tonnage (GT) of the vessels is growing. The share of trade carried by Finnish vessels has decreased from some 40% in 1980 to 33% in 2014 seems to indicate a weakened security of supply in transport performance.

One of the challenges is determining whether it is possible to define a sufficient level for the Finnish merchant fleet in a scientific manner, for instance in the form of the number of vessels, the total deadweight tonnage, the performance of the vessels or the tonne-nautical miles covered by the vessels.

The research problem is formulated as follows: “Does the Finnish merchant fleet meet the targets set for security of seaborne supply.”, and it is broken down into the following sub-questions:

1. What are the constituents of security of seaborne supply?
2. Are the economic decisions being made to form and maintain a sufficient merchant fleet based on the correct figures?
3. What is the transport capacity and performance level of our merchant fleet?
4. Is the composition of our merchant fleet suitable for the different types, amounts and batches of cargo being transported?
5. Does Finland have a suitable and sufficient tonnage for its seaborne export and import activities?

Design/methodology/approach
This study aims at making the security of seaborne supply concept more concrete through qualitative interviews. The dissertation will include elements of both creating new scientific information and applied research producing practical results for public and private sector stakeholders.
In an abductive research strategy the analysis of data is not directly based on theories, but researcher turns to theories to find support for their interpretations or to confirm their ideas. The abductive approach follows the rule-result-case pattern (Danermark & Kirkeby, op. cit. Kovács and Spens 2005).

The main data consists of shipping statistics provided by the Finnish Maritime Administration, Finnish Transport Agency, Finnish Customs, Statistics Finland, Finnish Port Association and Finnish Shipowners’ Association and of government acts, decrees, guidelines, decisions and strategies.

The 35 qualitative interviews will be carried out as expert interviews including structured questions about four different themes. The majority of the empirical data used in the thesis will be collected through these interviews. For the interviews, I have divided the subject into the following themes:

1. How the authorities see the security of supply concept and its requirements.
2. What is a sufficient merchant fleet and a suitable composition for it.
3. The port network required for seaborne import and export activities and its flexibility.
4. Safeguarding sea connections, managing sea traffic, maintaining suitable conditions for sea traffic and protecting sea traffic.

Findings
According to the state budget proposal for 2016 (SBP 2015), the Finnish merchant fleet is estimated to include 114 vessels participating in foreign shipping traffic, of which 96 are cargo vessels and 18 passenger vessels. In the budget proposal, the gross tonnage of these vessels is estimated to be 1,635,000 tonnes. However, new tonnage regulations adopted by the International Maritime Organization (IMO) in 1969 entered into force in 1982. Since then, the tonnage of merchant ships has been presented using a logarithmic function that provides a unitless numerical value. Gross tonnage should therefore not be given in tonnes. Finland approved the International Convention on Tonnage Measurement of Ships with a decree in 1982 (A 31/1982). It seems that the use of a unitless tonnage system has impacted the lay assessment of the transport capacity of our merchant fleet.

One of the basic questions and a starting point to be examined is “whether the economic decisions being made to form and maintain a sufficient merchant fleet are based on the correct figures, Gross or Net tonnage or the dead weight of the merchant fleet”.

Research limitations/implications
This empirical analysis of this research is limited to Finland, and it covers mainly the period 2002-2014.

Practical implications
The aim of the research is to create a realistic description of Finland’s current security of seaborne supply situation while taking the requirements set for it into account. The sufficiency of the Finnish merchant fleet is examined in relation to the current level of foreign sea transport.

Originality/value of the study
Finland’s security of seaborne supply situation has not been systematically studied despite Finland’s high degree of dependency on maritime transport. Therefore, the research provides valuable new information both for policymaking and for practitioners dealing with Finnish trade logistics.

The Finnish security of supply is also arranged in a rather unique way, analysis of which is also valuable in its own right.
Keywords: Security of seaborne supply, Finland’s maritime trade, Sea transport capacity