THE CONNECTION BETWEEN SUPPLY CHAIN PRACTICES AND FIRM PERFORMANCE – EVIDENCE FROM MULTIPLE SURVEYS AND FINANCIAL REPORTING DATA

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Evidence from multiple surveys and financial reporting data

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ABSTRACT

This thesis aims to increase knowledge on firm performance with two separate objectives. The first analyzes how the measurement and analysis of supply chain performance could be enhanced. The second examines the connections between firm performance and supply chain practices.

Firm performance is considered to comprise both the financial performance of the firm, and intra-firm supply chain performance, which is further divided into cost performance in the form of logistics costs, service performance and asset utilization, as suggested by the research literature.

Based on extant literature, supply chain practices analyzed here include logistics outsourcing, supply chain collaboration, and information systems support. In addition, the role of firm characteristics such as size, manufacturing strategy and industry orientation is explored.

The thesis consists of four articles and an introductory part, which concludes on the results of the individual articles, presents a synthesis of key findings, and summarizes the managerial, methodological and theoretical implications of this research.

The research questions are addressed by analyzing firm-level empirical data from manufacturing firms operating in Finland. Data gathered from trading firms operating in Finland was used as a reference in one of the articles. The empirical material is derived from two sources: survey-based self-reported data from three national level Finland State of Logistics surveys from 2006, 2009 and 2010, and financial reporting data from responding firms for the corresponding years retrieved from official sources.

The data is analyzed with multiple analysis methods, including basic descriptive statistics, t-tests and analysis of variance and more advanced methods such as generalized linear models and generalized linear mixed models.

The findings concerning the measurement and analysis of firm performance reveal that the performance measures are seldom normally distributed. Rather, skewness and kurtosis are common in the performance data. For instance, logistics costs, measured as share of turnover, consist mainly of small values, whereas also high relative costs occur, causing the distribution of logistics costs to be positively skewed. The data on financial performance, on the other hand, is concentrated close to the mean value, which is visible in the kurtosis of the data. The non-normality of the data should be taken into account when analyzing performance data, either by employing proper transformations of the

data or by choosing analysis methods that are less dependent on assumptions of normality.

Analysis of the connections between chosen supply chain practices and firm performance revealed some interesting findings. First, most of the previous literature assumes a positive relationship between outsourcing and firm performance. That assumption was not supported in this analysis. It would seem that the effects of outsourcing are more dependent on firm level characteristics than on outsourcing itself. Firms are outsourcing their operations for many reasons, of which only some are directly associated with performance. Second, the results also indicate that the connection between outsourcing and performance is not linear, but could instead be curvilinear. In practice, this means that firms with either no outsourcing at all or with heavy outsourcing experience better performance than firms that have not made an equally clear decision in either direction.

A higher level of supply chain collaboration was found to be associated with lower logistics costs and better financial performance in the analyzed population. A higher level of information systems support was found to be associated with lower logistics costs, whereas the connection with financial performance was negative. Combined, the findings on supply chain collaboration and information systems support highlight the importance of collaborative actions within the supply chain. At the same time, they also warn about relying too heavily on the technological capabilities of IT systems used to manage the supply chain.

This thesis provides contributions on: (i) managerial; (ii) theoretical; and (iii) methodological levels.

On the managerial level, the two main messages to practitioners are as follows: First, the connections between supply chain practices and firm performance are dependent on the firm's characteristics, such as firm size, industry and the level of internationalization. With this in mind, rather than trusting readymade recipes for success, management should instead thoroughly analyze what the effects of different practices would be, considering the individual characteristics of their firm. Second, the results emphasize the key role of Supply Chain Management (SCM). Especially for firms that have expanded their supply chains beyond the domestic market, it is important to extend their perspective towards suppliers and customers in addition to service providers. Realizing this seems to be an essential factor in the success of the firm.

On a theoretical level, some of the results of this thesis are in line with the mainstream of existing literature, while at the same time some of the findings challenge the assumptions made in the literature. As anticipated, a higher level of supply chain collaboration was found to be positively associated with firm performance. The results on logistics outsourcing, on the other hand, question

the previous assumptions about the positive connection with firm performance and instead highlight the firm level characteristics.

The thesis also contributes on the methodological level by providing additional information on both the measurement and analysis of firm performance. The experiences of the research process support open-ended questions instead of pre-defined scales with pre-defined intervals as a tool to measure firm performance in a survey setup. Also, the results of the thesis highlight the non-normal nature of the performance data, suggesting tools for a more robust analysis. For example, some of the traditionally used research methods, such as ordinary regression analysis and structured equations modeling, are sensitive to the normality of the data. The findings of this thesis suggest the use of generalized linear models, which allows the use of non-normal distributions.

The empirical material of this thesis was obtained from national level surveys, with the respondent population covering most of the manufacturing industry operating in Finland. In that sense, the generalizability of the findings can be considered good, with certain limitations in mind; while the material covers well the manufacturing firms operating in Finland, the sample is limited to a single country. Internationally, some generalizations could be made, especially to manufacturing firms operating in similar small, export-oriented and developed economies. Micro-sized firms are omitted from the analysis of supply chain practices, which limits the generalizability towards micro-firms while simultaneously increasing it towards larger firms. In addi-tion, the findings concentrate on manufacturing firms and cannot therefore be directly applied to other main industries, such as the trading industry.

Keywords: Supply Chain Management, firm performance, logistics costs, logistics outsourcing, supply chain collaboration

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One of the great minds of the 20th century, Vince Lombardi once said: "*I firmly believe that any man's finest hour, the greatest fulfillment of all that he holds dear, is that moment when he has worked his heart out in a good cause and lies exhausted on the field of battle - victorious.*"

Even though the academic world is different than the world Lombardi was referring to, there is still much to reflect to. The process from the very beginning 'til the end has been a long one, and I've definitely worked my heart out. Now, when I lie exhausted on this academic battlefield, it is time to look back and acknowledge the ones who have aided my path towards this moment of victory.

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At this moment I also want to share some California Love with my homies. The rare moments together have been breathers that have kept me sane amidst all the pressure. Throw up a finger if ya feel the same way.

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Turku, March 17 2014
Tomi Solakivi

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1 INTRODUCTION

1.1 Study background and motivation

In the last few decades the world has experienced serious economic growth combined with a rapid increase in international trade. According to the World Trade Organization (2012), the volume of merchandise exports in 2011 was over 113 times higher than 50 years earlier. The last decade has seen international trade grow almost 200% (World Economic Forum 2012). In addition to increased international trade, domestic commercial activity has also experienced significant growth.

From the perspective of an individual firm, the growth in trade volumes has meant possibilities to seek new business opportunities far from old, traditional markets. In their quest to seek out new business partners from new, distant areas, these firms have become more international both in terms of their customer and supplier base and in relation to production.

These new opportunities have simultaneously exposed firms to new challenges. Global markets, global sourcing and global production have expanded the firms' supply chains, making them increasingly vulnerable and more difficult to master and exposing them to new, global risks.

Longer, more complex supply chains have increased the importance of logistics and Supply Chain Management (SCM) in giving firms an edge in the tightening competition.

As a small, open economy, Finland is especially interesting form the point of view of logistics efficiency and SCM. Finnish merchandise exports exceeded 56 billion euros in 2011, which together with the export of services (22 billion euros) is close to 40% of Finnish Gross Domestic Product (Statistics Finland 2013).

The export-driven economy of Finland is also challenged by geography. From the logistics point of view, Finland has traditionally been called "an island", referring to the fact that it has usable land connections only to a single trade partner, Russia, while all other exports and imports have to be transported by sea or air. This is clearly visible in the modal split of Finnish international trade, of which over 70% is transported by sea (Finnish Customs 2013). Compulsory sea and air transport, combined with the longer distance from main markets such as Sweden and countries in Central Europe highlight the role of functioning logistics and SCM even more.

Despite, or perhaps due to, the challenges to logistics functionality, Finland as a country and Finnish companies have been forced to develop high standards of logistics in order to be successful. From the logistics perspective, Finland is considered one of the best performing countries in the world. In the World Bank's Logistics Performance Index (LPI) 2012, international freight forwarders and other logistics professionals ranked Finland 3rd out of 155 countries on how "easy" or "difficult" countries are in a Trade Logistics respect. Also in LPI 2007 and 2010, Finland was among the top 10% of 150 and 155 countries, respectively (Arvis, Mustra, Ojala, Shepherd, Saslavsky 2012).

The high ranking of Finland, together with the key role of SCM for Finnish firms, is one of the motivators of this thesis. Given their level of success, presumably there is something to be learnt from them.

This thesis has two objectives. The first is to attempt a broad review of firm performance from the supply chain perspective, and to try to gain a better understanding of firm performance by determining how performance is best measured and analyzed. The second is to provide additional information on how firm performance, with its various dimensions, is connected to certain supply chain practices. The dimensions of firm performance are measured either as self-reported survey data or as financial reporting data. The supply chain practices analyzed here include outsourcing of logistics operations, supply chain collaboration, and information systems support.

Some of these practices include other parts of the supply chain beyond the focal firm; thus this thesis straddles the two concepts of logistics and Supply Chain Management. The Council of Logistics Management (1986) defines logistics as "The process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information flow from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements."

Lambert et al. (1998) offer a somewhat wider definition for Supply Chain Management (SCM) as: "The integration of key business processes from end users through original suppliers that provides products, services, and information that add value for customers and other stakeholders," taking the definition closer to the idea of a value chain as defined by Porter (1985). As the Lambert et al. (1998) definition of SCM includes the business processes all the way from the original suppliers to the end users the way the supply chain is understood and considered in this thesis is a bit narrower. Here, a view towards the supply chain is taken from the focal firm's point of view. In addition to the processes within the firm, the interfaces with the suppliers and customers are also included. The tiers further up- and downstream the supply chain are not included in the analyses.

The theoretical contribution of this thesis derives partly from updated analysis of some concepts previously analyzed in the literature. For example, the influence of supply chain collaboration on performance has been widely studied. In part this thesis contributes to the existing literature by taking previously employed concepts into new fields of research.

The empirical material for this research is derived from multiple sources. The bulk was collected as part of the national Finland State of Logistics surveys between 2006 and 2012. This thesis also makes a unique contribution by connecting firm-level survey material with financial data from official sources.

1.2 Research questions and the *a priori* model

The motivation for this thesis can be expressed as two research questions. In the previous literature, firm performance has been analyzed from many perspectives with varying measures, which According to Fabbe-Costes and Jahre (2008) and Akyuz and Erkan (2010) are both numerous and lacking in consensus. This thesis attempts to contribute to the discussion on performance measurement by including a wide range of measures, both operational and financial, and by further attempting to find improved ways of measuring and analyzing the performance data. Thus, the first main research question is:

RQ1. How can the measurement and analysis of intra-firm supply chain performance be improved?

Firm performance has been defined in many ways in the existing literature, including both operational and financial methods. In this thesis, firm performance is defined following the example of Lorentz, Töyli, Solakivi, Hälinen and Ojala (2012) as consisting of intra-firm supply chain performance and financial performance. Intra-firm supply chain performance is further defined to include cost performance through relative logistics costs, service performance and asset utilization, and financial performance.

Financial performance has been widely analyzed using a broad variety of measures. These include return-based measures such as Return on Equity (Capon, Farley & Hoenig 1990), Return on Capital Employed (Wagner 2005), Return on Assets (Henderson, Raynor & Ahmed 2012) or Return on Sales (Vickery, Jayaram, Droge & Calantone 2003). Stock price has been used either directly (Hendricks & Singhal 2005) or in the form of Tobin's q (Wernerfelt & Montgomery 1988). The literature introducing the key concepts of this research is presented in more detail in chapters 2 and 3.

The other research question addresses the possible contributors to firm performance from the supply chain perspective, by bringing into focus some of the supply chain practices and analyzing their connections with the different aspects of firm performance.

RQ2. What are the connections between certain supply chain practices and firm performance?

As such, the question requires clarification. Since the concept of SCM is rather broad, and there are numerous possibilities as to what kind of practices to include and exclude, it is unrealistic to assume that a single thesis could cover them all. A few practices have been selected based on the earlier literature. Figure 1 shows the research framework in greater detail.

Already two decades ago, Bettis, Bradley and Hamel (1992) argued that outsourcing might aid competitiveness. Aertsen (1993) analyzed the benefits of outsourcing on distribution performance, whereas D'Aveni and Ravenscraft (1994) identified outsourcing to have a positive influence on cost performance. Recently, Kotabe and Mol (2009) were able to find a positive connection between outsourcing and financial performance. Thus, outsourcing of logistics operations was included as one of the supply chain practices with a possible connection to firm performance. The first sub-research question is:

SRQ2a. What is the connection between logistics outsourcing and firm performance?

A vast body of literature is addressing the connection of supply chain integration or supply chain collaboration to performance. Fabbe-Costes and Jahre (2008) presented a detailed review of previous literature on supply chain integration or collaboration and performance, concluding that both concepts have been analyzed with various definitions. All in all, the vast amount of literature on supply chain collaboration justifies its place as one of the possible contributors to performance. The second sub-research question is:

SRQ2b. What is the connection between supply chain collaboration and firm performance?

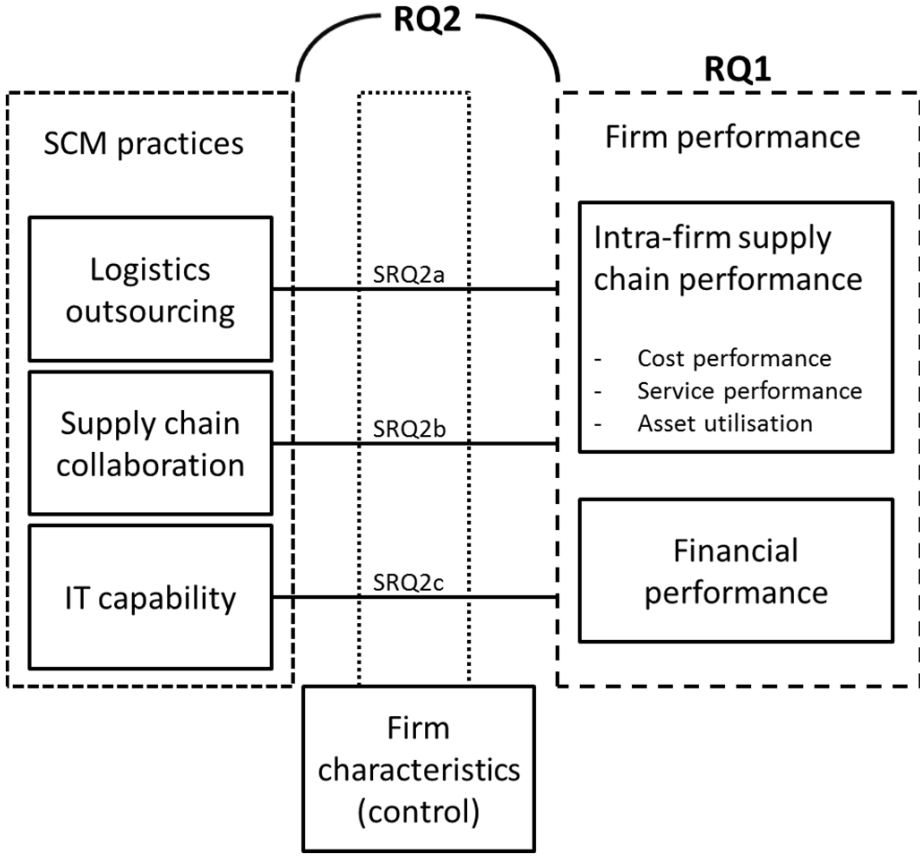

Figure 1 *A priori* research framework

Information technology (IT) has developed rapidly over the past two decades. Sanders and Premus (2005) and Wu, Yeniyurt, Kim and Cavusgil (2006) among others have analyzed IT capability on firm performance. Closs, Swink and Nair (2005) approached information systems from the information connectivity point of view. Following their example, information systems support (Töyli, Häkkinen, Naula & Ojala 2008) was included in this research. Töyli et al. (2008) also list benchmarking capability as a possible contributor to firm performance, which is also associated with information systems support through the resources the firm possesses to collect and analyze information. Thus, the third sub-research question is:

SRQ2c. What is the connection between firm-level information systems support and firm performance?

In addition to the three practices included in the research questions, numerous other supply chain practices possibly contributing to firm performance could be identified. Shang and Marlow (2005) and Shah and Singh (2001) highlight the role of benchmarking capability on performance. The role of logistics capabilities is stressed for example by Zhao, Dröge and Stank (2001) and Richey, Daugherty and Roath (2007), whereas Töyli et al. (2008) add logistics performance evaluation and improvement as possible contributors to supply chain performance. Environmental management of supply chains or Green Supply Chain Management (GSCM) and their effects on firm performance have been a growing topic of interest in recent years. Already in 1996, Klassen and McLaughlin argued that environmental management would have a positive effect on environmental performance, which in turn would have a positive effect on the financial performance of the firm. Later on, Zhu et al. (2008) further refined a measurement model for GSCM, including lower costs and higher operational performance as possible benefit from it.

Undoubtedly other practices could also be identified, but those included here have been chosen with the supply chain perspective in mind. The integrative factor between the selected practices is collaboration, either with suppliers and customers (supply chain collaboration) or with the service providers (outsourcing). Information systems support can be seen as an enabling factor for all the other collaborative actions.

1.3 Contribution of the thesis

This thesis aims to contribute on three levels. On a practical level, it summarizes the results of the thesis articles, providing manufacturing firms with increased knowledge on how their service performance, asset utilization and financial performance are connected with supply chain practices. These results may be used as a guideline on what to do and what to avoid, considering the different dimensions of performance.

On a theoretical level, the thesis contributes in two dimensions. In the thesis articles some of the concepts previously analyzed in the literature are re-examined with a large empirical dataset. Outsourcing and supply chain collaboration, among others, have been widely studied before. The results regarding these concepts partly support earlier assumptions, while some of the results challenge existing knowledge. In part the used concepts are either new or being employed in new fields of research.

The thesis also contributes to the measurement and analysis of firm performance. The majority of previous work analyzes either self-reported data or financial data obtained from financial reporting, whereas in this thesis the two

are combined and analyzed together. As a result, the thesis articles are able to combine both self-reported and "objective" measures of firm performance. Given this unique combination, the variety of measures of firm performance used in the thesis articles is exceptionally large.

In addition to this combination, the empirical data of this thesis is obtained from multiple points in time, which has its own merit. The repeated phases of data collection have enabled comparison and development of the used measures between the different data points. Generally, this thesis provides useful results on how the performance measures should be measured and analyzed. The development of research instruments has been realized especially in relation to logistics costs, for which both the data collection methods and analysis methods were improved during the research process.

In addition, the thesis contributes by using a variety of analysis methods in the thesis articles. The methods are introduced in greater detail in chapter 5.2. Some of them are used regularly in the logistics or supply chain literature, whereas some of the more advanced ones have been adopted from other disciplines. For example, generalized linear mixed models (II) have previously been used in analyzing costs in a hospital setup.

1.4 Structure of the thesis

Dubin's (1978) widely recognized research method for theory building can be presented as a continuous theory-research cycle consisting of two parts. The first is the theory development side and the second a research operation side of the cycle (Figure 2).

This research loosely follows Dubin's method by first introducing the theoretical background through a review of previous research. Based on the literature, research questions are formed and empirical indicators subsequently chosen.

The chosen empirical indicators are then used to study the research questions in order to contribute to the existing theory.

This thesis starts by introducing the background to and motivation for the research, and presenting the research questions in chapter 1

Chapters 2 and 3 introduce the theoretical framework behind the research questions, and chapter 4 introduces in greater detail the origins of the constructs used, such as intra-firm supply chain performance and financial performance.

Chapter 5 introduces the quantitative research approach and the methodologies used, and elaborates on the research process all the way from initial data collection (since the approach is quantitative) to the conclusions.

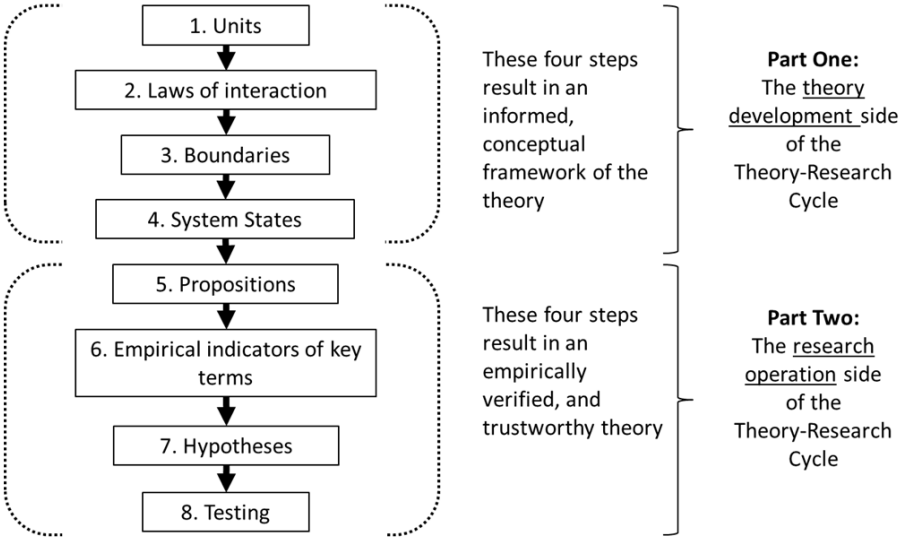

Figure 2 Dubin's theory-building method as an eight-step theory-research cycle, as illustrated by Lynham (2002)

Chapter 6 presents the results of the thesis articles in more detail, together with a discussion weighing the existing literature. Finally, chapter 7 presents the conclusions of the thesis, together with a discussion for further research paths that have arisen during the thesis work.

Referring to Dubin's (1978) methodology, this thesis also attempts to create a theory-research cycle starting with theory development through a detailed review of the existing literature. Based on the literature, the research occurs in the thesis articles, where the theories are tested and verified or invalidated empirically. The empirical results lead the thesis back to the theory development, presented in the concluding section of the thesis.

2 FIRM PERFORMANCE

A respectable amount of research has been conducted addressing the multi-dimensional phenomenon of firm performance. Despite the work done on performance measurement, the existing literature lacks a unified definition of what is included and excluded (Akyuz & Erkan 2010).

Neely, Gregory and Platts (1995) compiled the earlier literature on performance measurement, concluding that performance could be divided into four dimensions of quality, time, cost and flexibility. From the supply chain perspective Beamon (1999) modified these dimensions, dividing supply chain performance into three categories: resource-related, output-related and flexibility-related. Gunasekaran, Patel and McGaughey (2004), on the other hand, classified the performance metrics as strategic, tactical and operational, or according to the supply chain activity (plan, source, make, deliver) they are mainly linked to.

Even though the performance metrics presented by Beamon (1999) and Gunasekaran et al. (2004) included mainly cost-related metrics and measures of operational performance, among the proposed metrics were also sales, profit and Return on Investment (ROI). Sales, profit and ROI may be considered financial measures of performance (see e.g. Capon et al. 1990), which suggests that performance from the supply chain perspective may be measured as costs, operational performance and financial performance. This view is supported by Hofmann and Locker (2009), who conclude that a performance measurement concept should include both financial and non-financial measures in order to be usable at all levels of the firm.

Martin and Patterson (2009) consider performance to include inventory, cycle time and financial, including asset utilization as one of the dimensions of performance. Lai, Ngai, and Cheng (2002) divide performance into two categories, customer-facing and internal-facing performance, concluding that measures like supply chain reliability, flexibility and responsiveness may be considered customer facing, whereas costs and asset utilization are internal facing.

Lorentz et al. (2012) measured performance as intra-firm supply chain performance and financial performance, including cost performance, service performance and asset utilization as dimensions of intra-firm supply chain performance, and measuring financial performance as Return on Assets (ROA), Return on Capital Employed (ROCE) and Earnings Before Interest

and taxes (EBIT-%). A similar definition for performance is used in this thesis. The concepts of intra-firm supply chain performance and financial performance, together with the included and excluded components, are further elaborated in this chapter.

2.1 Intra-firm supply chain performance

2.1.1 Logistics costs

One of the most prominently discussed elements of firm performance is logistics costs. Cost performance is considered a key part of firm performance, for example by Beamon (1999), Morgan (2004), Schramm-Klein and Morschett (2006) and Whicker, Bernon, Templar and Mena (2009). Depending on the source and measurement technique used, the share of logistics costs of the total costs may vary significantly, but is estimated to be around 10% of sales in industrialized countries (see e.g. ELA and AT Kearney 2004 and 2009; Naula, Ojala and Solakivi 2006; Ojala, Solakivi, Hälinen, Lorentz and Hoffmann 2007; Solakivi et al. 2009; Solakivi et al. 2010; Solakivi, Ojala, Lorentz, Laari & Töyli 2012).

Even though logistics costs are widely discussed, no unified definition on what is included and what is excluded exists. One of the earliest definitions of logistics costs is from Heskett, Glaskowsky and Ivie (1973), who divide logistics costs into four categories: transportation costs, warehousing costs, inventory carrying costs and logistics administration costs. A similar classification has since been used for example by ELA and AT Kearney (2004 and 2009). Other, partly overlapping definitions also exist. Beamon (1999) makes a distinction between operating costs and inventory costs. Zeng and Rossetti (2003) include customs risk and damage and handling and packaging as elements of logistics costs. Klaus and Kille (2007) and Klaus et al. (2010) separate order entry costs from administration. Gunasekaran, Patel and Tirtiroglu (2001) define logistics costs to include opportunity cost of capital and costs associated with risk, such as cost of lost sales.

Transportation costs are easier to define, whereas costs related to inventory are more debated. Like Heskett et al. (1973), Lambert and LaLonde (1976) separate warehousing and inventory costs, but define them differently by including some of the elements of warehousing costs such as storage space costs into inventory carrying. Also Stewart (1995), Lee and Billington (1992) and Levy (1997) have provided their own definitions of inventory carrying costs.

In previous research, logistics costs have been measured to serve different goals. Multiple techniques have been used in relation to both the used data and

methodology. In order to provide information for national level decision making, Elger et al. (2008), Wilson (2009) and Havenga (2010) among others have analyzed national accounting statistics, resulting in an estimate of logistics costs as a share of GDP. Boversox, Calantone and Rodrigues (2003) and Rodrigues, Boversox and Calantone (2005) applied econometric modeling to evaluate the logistics costs on a regional level. Estimates at firm level have also been made. Van Damme and vander Zorn (1999) and Baykasoglu and Kaplanoglu (2008) used accounting and activity based methods to evaluate logistics costs at firm level, whereas Huiskonen (1996) applied mission costing.

Logistics costs were analyzed in all four thesis articles. The logistics costs data used in this thesis is collected using the example of ELA/AT Kearney (2004 and 2009), who have used the Heskett et al. (1973) definition of logistics costs including transportation costs, warehousing costs, inventory carrying costs and logistics administration costs in a survey setting, targeting European manufacturing and trading companies. Like ELA and AT Kearney, logistics costs were measured as a share of firm turnover, providing estimates of costs in relation to the volume of operations. For the purposes of Finland State of Logistics surveys and this thesis, the Heskett et al. (1973) definition was expanded to include transport packing costs (Zeng & Rossetti 2003). Arguably costs outside the five previously mentioned ones also exist; thus a sixth category, other logistics costs, was also included.

2.1.2 Service performance

In addition to the frequently discussed cost performance, different measures of service performance are also considered to be a crucial part of firm performance. Beamon (1999) lists fill rate, on-time deliveries, stockout, customer response time, manufacturing lead time, shipping errors and customer complaints as measures of output performance. Gunasekaran et al. (2004) include similar types of measures as part of operational level performance in source and deliver activities. Fawcett and Cooper (1998) consider perfect order fulfillment, order fulfillment cycle time and supply chain response time as measures of supply chain performance.

On a general level, most of the previous literature balances between two or more different approaches to service performance. Chow, Heaver and Henriksson (1994) and Stank, Keller and Daugherty (2001) approach performance from a service quality point of view, whereas the approach of Morgan (2004) is more oriented towards customer service but includes time-related factors. Whicker et al. (2009) measure supply chain performance as time, but

end up overlapping with cost measures by calculating monetary values including costs for time.

In total, the measures of service performance are many, depending on the various motives of performance measures (see e.g. Gunasekaran and Kobu, 2007). Some of the authors approach performance from the more traditional logistics perspective (Chow et al. 1994; Fawcett and Cooper 1998), whereas especially recently, the discussion has been increasingly from the supply chain perspective (Neely et al. 1995; Beamon 1999; Morgan 2004; Whicker et al. 2009). Even though the approach has been towards supply chain performance, Fabbe-Costes and Jahre (2008) conclude that supply chain performance has still been analyzed from the focal firm point of view, considering mainly the performance of the focal firm, not the entire supply chain. The approach of this thesis on operational performance is the focal firm in the supply chain, including operational performance measures from the source and deliver phases of the supply chain (Gunasekaran et al. 2004). Following the example of Lorentz et al. (2012), this kind of performance is classified as "intra-firm supply chain performance" and is addressed in articles I, III and IV of this thesis. During the research process, some additional measures were added to the original measures of operational performance. In article I, service performance (referred to as "absolute logistics performance") includes share of deliveries with errors in documentation, perfect order fulfillment and average delivery time.

2.1.3 Asset utilization

In addition to service performance, asset utilization in some form or another is often mentioned among the important performance metrics to the firm (Stewart 1995; Gunasekaran et al. 2001; Johnson & Templar 2011).

Some authors consider asset utilization to be a part of financial performance (Capon et al. 1990; Brewer & Speh 2000). Lambert and Pohlen (2001) depict them as being "key numbers expressing operational performance in financial terms." In this thesis, asset utilization is considered to be a measure of supply chain performance, following the example of Gunasekaran et al. (2001) and Johnson and Templar (2011).

One of the possible ways to approach asset utilization is the cash to cash cycle time, sometimes called the cash conversion cycle. The basic idea of the cash to cash cycle time defined by Stewart (1995) is "the length of time between cash payment for purchase of resalable goods and collection of accounts receivable generated by sales of these goods." Lancaster, Stevens and Jennings (1998) define the cash to cash cycle time as "the number of days

between paying for raw materials and getting paid for product, as calculated by inventory days of supply plus days of sales outstanding minus average payment period for material."

Brewer and Speh (2000) consider cash to cash cycle time to be a critical financial measure, tying together several important processes in the supply chain. Hofmann and Kotzab (2010) classify it as a working capital measure, and a common indicator for measuring the performance of a supply chain. Further, Johnson and Templar (2011) argue that reducing the cash to cash cycle time is indicative of good SCM. According to Brewer and Speh (2000), successful SCM in the form of increased product and information flow and deeper integration with suppliers and customers can be seen in form of faster cash to cash cycle times, compared to firms that have been less successful in managing their flows and integrating their supply chain.

Christopher and Ryals (1999) highlight the significance of cash to cash cycle time from the viewpoint of working capital, arguing that by eliminating non-value adding time in the supply chain, the firm will be able to lower its needs for working capital. As an anecdote, Christopher and Ryals (1999) compare oil pipelines with the cash to cash cycle. The longer the pipeline, the more oil it contains, indicating a higher need for working capital due to a longer cash to cash cycle. Also, the shorter the pipeline, the faster the firm will be able to adjust, and the more responsive it can be.

In the SCOR framework (Supply Chain Council, SCC), cash to cash cycle time is one of the internal measures of supply chain performance. This makes sense from the supply chain perspective, given that the argument of the SCC is that the definition of "internal" in the SCOR framework is linked to the efficiency of the supply chain. With regard to an individual firm, the classification of Christopher and Ryals (1999) seems more logical. Christopher and Ryals (1999) divide the cash to cash cycle time into three elements of the "pipeline": inbound, internal and outbound, with each element linking to one or multiple parts of the supply chain. Cash to cash cycle time is analyzed in articles I, III and IV of this thesis. The definition used here closely resembles the one provided by Lancaster et al. (1998) as "calculated by inventory days of supply plus days of sales outstanding minus average payment period for material."

2.2 Financial performance

The definition of financial performance in the literature is just as confusing as that of operational performance. It would seem that many of the authors analyzing financial performance or the factors affecting it refer to "tradition-

ally used" measures of financial performance, without properly referring to the previous literature (see e.g. Vickery et al. 2003; Shang & Marlow 2005).

One of the broadest definitions is presented by Gunasekaran et al. (2001), who include not only rate of return and net profit, but also logistics costs and delivery performance as measures of financial performance, whereas most of the literature consider logistics costs to be mainly an operational performance measure, as presented in chapter 2.1.1. On the other hand, D'Avanzo, Von Lewinski and Van Wassenhove (2003) surveyed the key drivers of financial performance in North American and European firms, concluding that cost reductions are the most important. This again would imply that even though costs in general or logistics costs in particular are not by themselves a financial measure, their contribution to financial performance is evident.

Different types of return-based measures of financial performance seem to be widely accepted. Wagner, Grosse-Ruyken and Erhun (2012) justify the financial ratio of ROA as being a measure of how effective the firm is in utilizing its assets in order to generate profits. Henderson, Raynor and Ahmed (2012) use ROA as a measure of financial performance in a longitudinal setting. In connection with SCM, ROA has been previously used, for example, by Tan, Kannan, Handfield and Ghosh (1999), Vickery et al. (2003) and Brewer and Speh (2000). Some variations based on ROA have also been used. For example, Hansen and Wernerfelt (1989) used ROA deducted by the T-bill rate as a measure of financial performance. Other return-based measures have been widely used. Lynch, Keller and Ozment (2000), Vickery et al. (2003), Shang and Marlow (2005) and Yu, Jacobs, Salisbury and Enns (2013) have used ROI, whereas Tobin and Brainard (1968) question its validity as a comparable measure of performance, based on an argument that a firm might be able to affect ROI with its financial leverage, thus making it incomparable between firms.

Of the other return-based measures, Vickery et al. (2003) and Dehning, Richardson and Zmud (2007) include Return on Sales (ROS), whereas Töyli et al. (2008) include EBIT-% to check whether profitability behaved differently compared to asset-based measures. Gotzamani, Longinidis and Vouzas (2010) also use EBIT, Depreciation and Amortization (EBITDA) together with EBIT-% in their analysis, without justifying why both should be included. In their meta-analysis of determinants of financial performance, Capon et al. (1990) include Return on Equity and Return on Capital as measures of financial performance.

In addition to return-based measures, also others have been used. Tan et al. (1999) mention growth of sales and market share as valid measures of financial performance, whereas Brewer and Speh (2000) and Rai, Patnayakuni and Nainika (2006) use revenue growth. Stock price has also been used either

directly (Hendricks & Singhal 2005) or in the form of Tobin's q (Tobin 1969) (Wernerfelt & Montgomery 1988).

From other measures of financial performance Greer and Theuri (2012) compiled a measure of multifaceted financial performance, including cost ratios such as cost to sales, activity ratios such as trading cycle, or liquidity ratios in the form of current ratio and cash turnover ratio.

In this thesis, financial performance is analyzed in articles I, III and IV, using different return-based measures such as ROA, ROCE, and EBIT-%. Selling and Stickney (1989) consider ROA to be a useful measure for evaluating the operating and investing performance of a firm. Similarly, Wagner et al. (2012) argue for the use of ROA as a valid measure of financial performance for how effectively the firm utilizes its assets in generating profits. ROCE is included as a financial measure that according to Kaplan and Norton (1996) is linked to SCM through operational performance and asset utilization. EBIT-% is included as recommended by Töyli et al. (2008) to check whether profitability has behaved differently compared to asset-based measures. Growth of sales and market share are not included in the analysis based on the judgment that they are more connected with other functions of the firm such as sales and marketing. Stock price with its various forms is excluded because the chosen sample included firms that were not publicly listed.

3 ANALYSIS OF SUPPLY CHAIN PRACTICES CONNECTED WITH FIRM PERFORMANCE

As with firm performance, the supply chain practices connected to it have been analyzed from various perspectives, with multiple outcomes. In this thesis, the analyzed practices include outsourcing of logistics operations, supply chain collaboration, and information systems support. This chapter summarizes the previous literature on these practices.

3.1 Logistics outsourcing

Although the phenomenon of outsourcing is not new (see e.g. Greif 1993), the possible benefits and downsides of outsourcing have been discussed more during the past 20–30 years. Traditionally, outsourcing has been seen as one of the possible ways to increase flexibility, enhance performance and cut the costs of operations. One of the first authors to present motives for and against outsourcing were Bettis et al. (1992), who argued that outsourcing could aid competitiveness providing it was managed properly. Among other early contributors to the discussion was Aertsen (1994), one of the first to discuss it from the logistics perspective and to analyze the outsourcing of physical distribution. Also, D'Aveni and Ravenscraft (1994) and Gilley and Rasheed (2000) argue that one of the core motives for outsourcing is the firm's need to concentrate on its core competencies, thereby achieving higher performance. Kremic, Tukel and Rom (2006) have conducted a comprehensive literature review on the motives for outsourcing.

The relationship between outsourcing and firm performance has also been studied increasingly over the last few years. Kotabe and Mol (2009) identified a curvilinear relationship between the level of outsourcing and firm performance, suggesting that there would be an optimal level of outsourcing, and distractions from it would be costly. Hsiao, Kemp, van der Vorst and Omta (2010) analyzed the effects of logistics outsourcing on service performance, being unable to find any significant effects.

Wallenburg (2009) and Brewer, Ashenbaum and Ogden (2013) have recently analyzed the effect of logistics outsourcing on firm performance, both concluding that the motives, and thus the focus, of outsourcing is crucial to the performance outcomes. Both Wallenburg (2009) and Brewer et al. (2013)

argue that cost-driven outsourcing is dominant from the performance perspective. Wallenburg takes the idea further, suggesting that also more strategic motives for outsourcing could be beneficial on a long term basis.

Although the list is compressed rather than complete, the dimensions of logistics outsourcing used in the questionnaire originate from previous research by Langley, van Dort, Ang and Sykes (2005). The link between logistics outsourcing and firm performance is analyzed in thesis article I.

3.2 Supply chain collaboration

One of the most discussed factors to affect firm performance is definitely supply chain integration. Numerous researchers report positive effects of collaboration on performance. For example Bagchi, Ha, Skjoett-Larsen and Soerensen (2005) report these positive effects on logistics costs and operational performance metrics such as perfect order fulfillment rate. Sanders and Premus 2005 report positive effects on a composite measure of firm performance consisting of cost, quality, delivery and new product introduction time. Cao and Zhang (2010 and 2011) identify positive effects between supply chain collaboration and growth of sales, ROI, growth of ROI and profit margin.

Despite the vast amount of research already done on supply chain collaboration, the discipline has been unable to determine a unified definition for it. Stank et al. (2001) and Giménez and Ventura (2005), for example, consider supply chain integration to consist of internal and external integration, whereas Flynn, Huo and Zhao (2010) divide it into three dimensions: customer, supplier and internal. Barratt (2004) provides a detailed description on which activities are considered to be intra-organizational and which are inter-organizational.

Other classifications also exist. Simatupang and Sridharan (2005) divide supply chain integration into three dimensions: information sharing, decision synchronization and incentive alignment. Recently, Leuschner, Rogers and Charvet (2012) compiled a meta-analysis on the relationship between supply chain integration and performance, concluding that based on previous literature supply chain integration has three dimensions: 1) information integration, 2) operational integration and 3) relational integration. According to Vereecke and Muylle (2006), firms engage in two forms of collaboration: exchange of information on forecasts, planning, inventory etc. or alternatively structural collaboration such as installing Kanban systems or co-locating plants.

Most of the previous research assumes a straightforward relationship between supply chain integration and supply chain performance: the more integration, the better the performance (see e.g. Fabbe-Costes & Jahre 2008)

but this consensus has also been questioned. For example Das, Narasimhan and Talluri (2006) argue that once a certain threshold level of integration has been reached, increasing integration does not necessarily increase performance. Kampstra, Ashayeri and Gattorna (2006) on the other hand are more concerned about "sub-optimization", in other words the failure of firms to commit enough to collaboration within a single supply chain. In their meta-analysis, Leuschner, Rogers and Charvet (2013) review 86 articles analyzing the connection of supply chain integration and firm performance, concluding that while supply chain integration would seem to have a positive impact on firm performance, the effects depend on the nature of the collaboration. Interestingly, they were unable to find support for the connection between operational integration and firm performance.

The measures of supply chain collaboration used in articles III and IV were originally derived from Sanders and Premus (2005), with some modifications based on experiences and feedback from the testing phase, after which the questions were given their final form.

3.3 Information systems support

The development of information and communications technology (ICT) has created new possibilities for improving firm performance. For example Brynjolf and Hitt (2000) review the evidence on how investments in (and thus the increased use of) IT influences performance.

As part of their definition, Simatupang and Sridharan (2005) include information sharing as one of the dimensions of supply chain collaboration. Assuming that supply chain collaboration has a positive effect on firm performance, the Simatupang and Sridharan (2005) framework can be interpreted such that increased information systems support is linked to better performance by enabling deeper supply chain collaboration.

Most of the previous literature seems to assume an indirect rather than direct impact of IT on performance. Byrd and Davidson (2003) assume that the technical quality of IT and the utilization plan for it, and support by top management for IT development influence its impact on the supply chain, which in turn affects firm performance. Kent and Mentzer (2003) identify investment in inter-organizational IT as having an effect on logistics efficiency through relationship commitment. For their part, Wu et al. (2006) consider that the alignment and advancement of IT are positively connected to supply chain capabilities, which in turn are tied to both the firm's marketing and financial performance.

Also direct relationships between IT and performance have been identified. Bayraktar, Demirbag, Koh, Tatoglu and Zaim (2009) detect a significant positive connection between information systems practices and operational performance of small and medium enterprises (SMEs), whereas Dehning et al. (2007) pinpoint a positive relationship between a firm's investment in IT-based SCM systems and performance.

Some of the research (see e.g. Vijayasarathy 2010) has also been unsuccessful in identifying connections between information technology and IT use and performance.

Sanders and Premus (2005) executed a survey-based study measuring IT capabilities and supply chain collaboration and their effects on firm performance. Their results suggest that IT capabilities positively affect firm performance. Closs, Swink and Nair (2005) argue that information systems would have a mediating role between the flexibility of logistics and performance, in the form of information connectivity.

In this thesis, IT is analyzed through information systems support, as suggested by Töyli et al. (2008). The structure of the questions on IT capabilities used in articles III and IV resemble those used by Sanders and Premus (2005) and Closs et al. (2005), with some modifications.

3.4 Research framework

As presented before, the relationships between the supply chain practices and the measures of firm performance have been widely studied. Töyli et al. (2008) have presented a three layer research framework describing the linkages between supply chain practices and performance, including a layer of "logistics profile elements", which in this research are referred as "supply chain practices", a layer of "logistics performance" which in this research are considered as "intra-firm supply chain performance, following the example of Lorentz et al. (2012). The third layer, as in this research is considered to consist of financial performance. Figure 3 illustrates the refined framework after Töyli et al. (2008) used in this research.

The major distinction between the proposed research framework by Töyli et al. (2008) and this research is that while Töyli et al. (2008) suggest that logistics performance would be addressed together with its antecedents and consequences in a holistic manner, this research is addressing the framework through the individual links.

Moreover, as the research focuses on individual links, one has to consider the limits of the research considering the possible moderating effect of intra-firm supply chain performance. Even though previous research suggests that

certain supply chain practices might affect the financial performance of the firm through intra-firm supply chain performance, in this research the relationships between the supply chain practices and financial performance are analyzed directly.

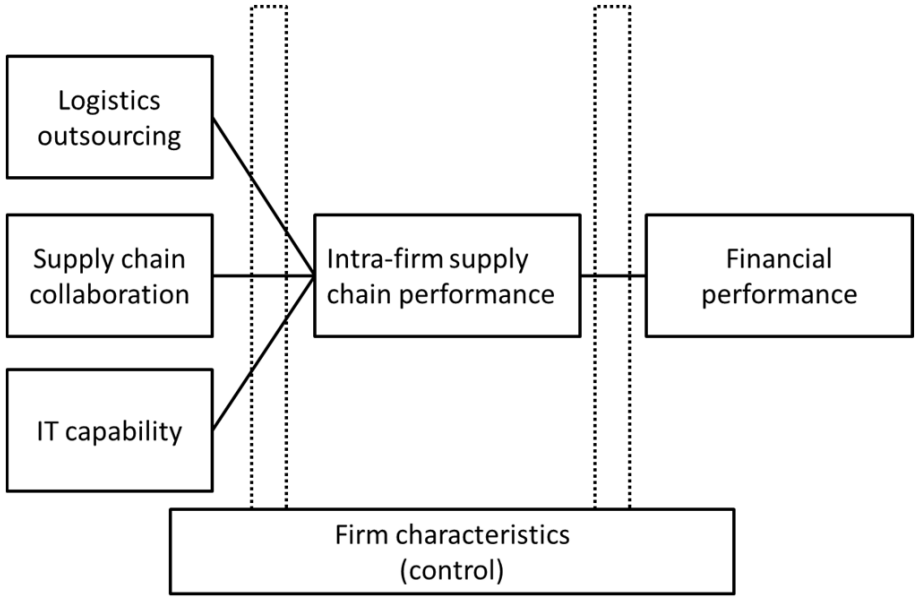

Figure 3 Research framework (modified after Töyli et al. 2008)

Finally, Töyli et al. (2008) suggest that the effects of supply chain practices on firm performance are dependent on firm and context-related factors. Even though it is not mentioned in the initial framework, this suggestion takes the research framework towards the contingency approach, in which the underlying assumption is that the "fit" of organizational structure, or in this case the applied supply chain practices and performance depends on the environment the firm operates in (see for example Drazin and Van de Ven 1985).

In this research, the contingency approach is taken into account by following the examples of Swamidass and Newell (1987), Venkatraman and Prescott (1990) and Ketchen and Hult (2007) by using a selection of control variables such as firm size, manufacturing strategy and industry orientation, illustrating the environment the firms operate in. As the firm size may also be considered to be connected with the resources the firm possesses, also the resource based view could have been considered as an approach. In this research the size of the firm, together with the level of internationalization of the firm is considered more as an indicator of the complexity of the supply chain, rather than a measure resources available for the firm, the contingency approach is considered more suitable.

4 RESEARCH CONSTRUCTS

In the thesis articles, numerous constructs with various measurement scales were employed to analyze their connections to firm performance. Some measures of firm performance were obtained as survey data. This chapter presents the constructs in detail, along with the measurement scales listed in Table 1.

Firm performance was considered to consist of logistics costs, service performance, asset utilization and financial performance. The data on logistics costs was obtained as self-reported survey data, in which the respondents were requested to provide estimates on the logistics costs of their firm, as a share of the firm turnover. In three of the first surveys, the respondents were asked to provide their estimates using a scale from 1 to 100 with one percentage point intervals. Previously, for example Stewart (1995) has argued the scale to be sufficiently robust for the analysis. In the last survey, cost data was requested, providing respondents with an open response field allowing an accuracy of one decimal. The division of total logistics costs into multiple components (transportation, warehousing, inventory carrying, logistics administration, transport packing and other logistics costs) was derived from multiple sources, including Heskett et al. (1973), ELA and AT Kearney (2004 and 2009) and Zeng and Rossetti (2003).

Service performance was measured using 2–4 different measures, depending on the article. In article I, service performance was measured as perfect order fulfillment (as % of all orders) and order fulfillment cycle time, measured in days. Similar measures had been previously employed for example by Fawcett and Cooper (1998).

In addition to logistics costs and service performance, intra-firm supply chain performance was considered to include also asset utilization. Following the example of Stewart (1995) and Brewer and Speh (2000), the survey respondents were requested to provide estimates of the elements of their cash to cash cycle time, including inventory days of supply, days of sales outstanding and days of payables outstanding, as full days. The measures of asset utilization were analyzed in a similar manner in articles I, III and IV.

Based on previous work, for example by Capon et al. (1990), Tan et al. (1990) and Töyli et al. (2008), financial performance was measured as ROA, ROCE and EBIT-%. Unlike other measures of firm performance, the financial

measures were not obtained as survey responses, but from the financial reporting of the firms through official sources.

Table 1 Measures of intra-firm supply chain performance and financial performance used in the thesis articles

Constructs	Measured as	Data source	Included in thesis article	From
Logistics costs				
Transportation costs	% of sales	*	I,II,III,IV	
Warehousing costs	% of sales	*	I,II,III,IV	Heskett et al.
Inventory carrying costs	% of sales	*	I,II,III,IV	(1973), ELA and AT
Logistics administration costs	% of sales	*	I,II,III,IV	Kearney (2004 and
Transport packing costs	% of sales	*	I,II,III,IV	2009), Zeng and
Other logistics costs	% of sales	*	I,II,III,IV	Rossetti (2003)
Total logistics costs	% of sales	*	I,II,III,IV	
Service performance				
Perfect order fulfillment	% of orders	*	I,III,IV	Fawcett and Cooper
Order fulfillment cycle time	In days	*	I,III,IV	(1998)
Asset utilisation				
Inventory days of supply	In days	*	I,III,IV	Stewart (1995),
Days of sales outstanding	In days	*	I,III,IV	Brewer and Speh
Days of payables outstanding	In days	*	I,III,IV	(2000)
Financial performance				
Return on Assets	%	#	I,III,IV	Capon et al. (1990),
Return on Capital Employed	%	#	I,III,IV	Tan et al. (1990),
EBIT-%	%	#	I,III,IV	Töyli et al. (2008)

* self-reported survey data
# data from financial reporting

The supply chain practices analyzed in the thesis articles are listed in Table 2. Article I analyses the connections between logistics outsourcing and firm performance. Estimates of the level of outsourcing were self-reported by the survey respondents in answer to questions previously employed by Langley et al. (2005). The original Langley et al. (2005) questionnaire includes a long and detailed list of logistics operations, for which respondents are requested to provide estimates of the extent of outsourcing. For the purposes of article I, a more compressed list was created. The article analyzes logistics outsourcing in three dimensions: outsourcing of transportation, outsourcing of information processing and outsourcing of materials management & value-added services. Outsourcing of transportation is a combination of (outsourcing of) domestic transportation, international transportation, reverse logistics and freight forwarding, whereas information processing is a combination of order processing, invoicing and logistics IT systems. Finally, materials management and value-added services are considered to consist of warehousing, inventory

management and product customization. In the questionnaire, the respondents were asked to provide estimates on the level of outsourcing of each dimension using a five-point scale (0%, 1–25%, 26–50%, 51–75%, 76–100%), which were further combined into three groups (1=0%, 2=1–50%, 3= 51–100%). Logistics outsourcing and the other constructs are presented in Table 2.

Table 2 Supply chain practices connected with firm performance

Constructs	Measured as	Data source	Included in thesis article	From
Outsourcing of transportation	% of service	*	I	
Outsourcing of information processing	% of service	*	I	Langley et al. (2005)
Outsourcing of materials management & value added services	% of service	*	I	
Internal collaboration in the supply chain	Items on 5-point Likert scale	*	III,IV	
External collaboration in the supply chain	Items on 5-point Likert scale	*	III,IV	Sanders and Premus (2005), Closs et al. (2005)
Information systems support	Items on 5-point Likert scale	*	III,IV	

* self-reported survey data
# data from financial reporting

Articles III and IV analyze, among other things, supply chain collaboration, information systems support and benchmarking and monitoring. The constructs of internal and external collaboration and information systems support were originally based on the earlier work of Sanders and Premus (2005) and Closs et al. (2005). These constructs were initially included in the Finland State of Logistics 2009 survey, but failed to function as anticipated. After the first survey, the questions concerning these constructs were partly reorganized and rephrased in order to gain better validity of the constructs. Modifications were made especially to some of the items originally measuring information systems support. Based on the feedback received from the first survey, some of the items were found to measure dimensions of supply chain collaboration rather than information systems support, and were thus relocated and reformulated. The constructs mentioned above were asked as 5-point Likert scale items (1 = totally disagree, 5 = totally agree).

In the thesis articles, multiple firm characteristics have been used as control variables. All firm characteristics were obtained from survey data as self-reported categorical values. The characteristics are presented in Table 3.

Firm size was measured both as turnover and number of employees, and used in separate ways to control the size of the firms in the data. In article I, firm size was controlled by limiting the sample to small and medium-sized

firms, based on the European Commission's definition of SMEs (European Commission 2005). In article II, the firms were divided into four groups: micro, small, medium-sized and large, based on both the turnover and number of employees. In article III, only turnover was used to make a similar division. In article IV, firms were divided into two groups: those with a turnover of 2-50 million euros and those with a turnover exceeding 50 million euros.

Table 3 Firm characteristics used as control variables in the thesis articles

Constructs	Measured as	Operationalisation	Included in thesis article	From
Firm size (turnover)	Categorical, self-reported	SME:s included	I	
		4 categories, micro, small, medium and large	II,III	European Commission (2005)
		0= 2-50 million, 1= over 50 million	IV	
Firm size (number of employees)	Categorical, self-reported	4 categories, 1-9, 10-49, 50-249, 250-	II	European Commission (2005)
Manufacturing strategy	Categorical, self-reported	5 categories, MTS, MTO, ATO, ETO, CS	III	Wemmerlöw (1984), Lorentz et al. (2012)
		2 categories, 0=Push, 1= Pull	IV	
Level of internationalisation	Categorical, self-reported	3 categories, Domestic, Export, International	II,III	Lorentz et al. (2012)
Industry orientation	Categorical, self-reported	0=Technology industry, 1= Other industries	III,IV	Author, The Federation of Finnish Technology Industries
Value added percentage	Categorical, self-reported	0=High, 1=Low	III,IV	Lorentz et al. (2012)

Manufacturing strategy was asked as a categorical variable with 5 categories: Make to Stock (MTS), Make to Order (MTO), Assembly to Order (ATO), Engineer to Order (ETO) and Capacity Selling (CS), based on the strategy the firm primarily follows. These manufacturing strategies have previously been discussed by for example Wemmerlöv (1984) In article III, the firms were divided into these 5 categories, whereas in article IV they were divided into two groups, Push and Pull, following the example of Lorentz et al. (2012). Push included all the firms with Make to Order as the primary strategy, whereas Pull included those employing primarily other manufacturing strategies.

In some of the articles, firms were also divided into three categories according to the level of internationalization of their operations, following the

example of Lorentz et al. (2012). Domestic firms were considered to have more than 90% of their sales originating from home markets and to have no production capacity abroad. Export firms were considered to have more than 10% of sales from abroad, and international firms were also considered to have production capacity outside home markets.

In addition, in articles III and IV the firms were also divided according to their "industry orientation" and value-added percentage. In this context, industry orientation meant dividing the firms into two groups, based on whether or not they belonged to a Finnish industry interest group "technology industry". The firms were also divided into two categories "high" and "low", based on whether the value-added percentage of the industry was below or above the median of the Finnish manufacturing industry, as has previously been done for example by Lorentz et al. (2012).

5 METHODS OF ANALYSIS

5.1 Research approach

Since the research presented here is quantitative in nature, the research process and the structure of this thesis are closely connected to the quantitative approach presented by Creswell (2003) (Table 4).

According to Creswell (2003), a quantitative approach is based on post-positivistic philosophical assumptions. The post-positivistic approach differs from the traditional positivistic approach in that the latter judges theory through factual evidence showing whether the theory is right or wrong (Friedman 1953), whereas the post-positivistic approach highlights the probabilistic nature of these relationships (Popper 1962). The assumption is well in line with the statistical probability included in traditional quantitative analysis, and is visible in the testing of statistical significance and confidence intervals.

As a strategy of enquiry for the quantitative approach, Creswell (2003) suggests surveys and experiments. Thus a survey methodology was chosen for the data collection of this thesis.

Creswell (2003) suggests that the correct methods to be employed in quantitative research are the use of closed-ended questions and pre-determined approaches. Creswell also suggests the use of numeric data. The questions used in the data collection of this thesis are closed-ended and based on constructs previously determined in the literature. Numeric data in form of financial reporting is used in addition.

Table 4 Definition of the research process (Creswell 2003)

Tend to or Typically	Qualitative approaches	Quantitative approaches	Mixed Methods Approaches
Use these philosophical assumptions	Constructivist/Advocacy/Participatory knowledge claims	Postpositivism knowledge claims	Pragmatic knowledge claims
Employ these strategies of enquiry	Phenomenology, grounded theory, ethnography, case study, and narrative	Surveys and experiments	Sequential, concurrent and transformative
Employ these methods	Open-ended questions, emerging approaches, text or image data	Closed-ended questions, predetermined approaches, numeric data	Both open- and closed-ended questions, both emerging and pre-determined approaches, and both quantitative and qualitative data and
Use these practices of research as the researcher	Positions himself or herself Collects participant meanings Focuses on a single concept or phenomenon Brings personal values into the study Studies the context or setting of participants Validates the accuracy of findings Makes interpretations of the data Creates an agenda for change or reform Collaborates with the participants	Tests or verifies theories or explanations Identifies variables to study Relates variables in questions or hypotheses Uses standards of validity and reliability Observes and measures information numerically Uses unbiased approaches Employs statististical procedures	Collects both quantitative and qualitative data Develops a rationale for mixing Integrates the data at different stages of inquiry Presents visual pictures of the procedures in the study Employs the practices of both qualitative and quantitative research

In the thesis articles, statistical research methods are used to analyze the numerical survey data. The validity and reliability of the constructs and the data are discussed in the thesis articles, as suggested by Creswell (2003).

In the following sections, the research process is elaborated in more detail. First, the used statistical procedures are introduced, followed by a detailed description of the dialogue between literature review, data collection and analysis. The phases of data collection are also described.

5.2 Used research models

In the thesis articles, numerous analysis methods were employed. In articles I and II, different models were used to analyze the sample and population distributions. Analysis of Variance (ANOVA) and t-test were used in articles I and III. In addition, Pearson's Chi-square test was used in article I to analyze the connections between two categorical variables. In articles I and IV, the independent variables were constructs consisting of multiple items. In these cases factor analysis was employed, either exploratory or confirmatory.

In article IV, generalized linear models were used, whereas in article II the analysis of panel data (i.e. multiple data points in time) required the use of generalized linear mixed models. This chapter presents in detail the research methods used.

5.2.1 Models analyzing sample and population distributions

The one-way ANOVA assumes a single independent variable with three or more categories to investigate the possibility of differential impact on the dependent variable (integer/ratio measure). There are three basic assumptions which underlie the F-test, similar to those for the t-test.

- The dependent variable generates interval/ratio data and the data for each treatment group or sample are normally distributed
- There is homogeneity of variance across groups (which can be compensated)
- There is independence of observations

Assuming these are met, the test focuses on differences in means (μ). It is assumed that the sample means ($\mu_A \ldots \mu_n$)are indicators of potential population means, thus H_0 is really saying that these are all the same:

$$\mu_A = \mu_B = \mu_C = \cdots = \mu_0 \qquad (1)$$

The basis of the ANOVA is the F-test, which in practice is based on the ratio of population variances (s^2), the variance based upon variance between means and variance within the groups:

$$s^2_{between} = n\frac{\sum_{j=1}^{k}(\bar{x}_j - \bar{X})^2}{k-1} \quad (2)$$

$$s^2_{within} = \frac{\sum_{j=1}^{k} s_j^2}{k} \quad (3)$$

As estimates of the population mean, these two should be approximately equal if all the samples were to belong to same population. Thus,

$$F \equiv \frac{s^2_{between}}{s^2_{within}} \quad (4)$$

is expected to be 1.0 if all samples belong to one population.

In articles I and III, comparisons between two groups were made based on the mean values of the groups. In order to compare the mean values, Student's t-test was employed. In the case of two samples, the t-test is based on the assumption that if all the possible independent sample pairs were taken from a single population and differences in their means were found, they would also form a normal distribution. Theoretically the mean should be 0, since there should not be any differences in the means. Based on this it is able to calculate the t-score, which tells how far the observed means are compared to the distribution. The t-score is calculated as:

$$t(\bar{x}_A - \bar{x}_{B)} = \frac{\bar{x}_A - \bar{x}_B}{s_{diff}} \quad (5)$$

The s_{diff} in the denominator is further calculated as:

$$s_{diff} = \sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}} \quad (6)$$

Based on the t-value, the test then compares the above-presented ratio to the appropriate t-distribution to check for the likelihood of the two samples originating from a single population that would tolerate a difference of this magnitude.

In article I, part of the analysis was performed using Pearson's Chi-square test. In this particular case, the test is an extension of the one used for two independent groups, which compares the observed frequencies to the expected frequencies. The expected frequencies are based on the combined distribution

of frequencies. In the Chi-square test the null hypothesis is that all the samples could have come from one population, based upon whether the differences in proportions would be greater than expected by chance. The equation for the Chi-square statistic is:

$$\chi^2 = \sum_{i=1}^{m} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \quad (7)$$

where O_{ij} are the observed frequencies for each category from 1 to m, of all groups from 1 to k; E_{ij} are the expected frequencies, determined by combining the expected frequencies for all the groups; I represents variable categories, ranging from 1 to m, where m is at least 2; and j stands for the treatment groups ranging from 1 to k, where k is at least 3.

5.2.2 Factor analysis

The purpose of factor analysis is to describe the structure of variability among observed, correlated variables through unobserved variables called factors. In practice this reflects that variations in multiple observed variables in reality reflect variations in unobserved, latent variables.
The common variation of the observed variables is described by the covariance matrix. Factor analysis attempts to describe the covariance structure of the observed variables. The factor model in matrix form is:

$$\boldsymbol{x} - \boldsymbol{\mu} = \boldsymbol{Af} + u \quad (8)$$

where x denotes the original values of the observed variables, μ are the averages of the observed variables, f is a q-dimensional vector with uncorrelated components forming the set of common factors, and A is a p*q matrix, in which the elements are unknown factor loadings. The factor structure is described by matrix A, in which the elements are the covariances between the variables and the factors.

In exploratory factor analysis the number of factors is not determined in advance, but decided based on a chosen criterion, whereas in confirmatory factor analysis the number and structure of the factors is pre-determined and the analysis is testing the goodness of fit of the model.

In this thesis, factor analysis was used to reduce the number of research variables by grouping individual items into research constructs, based on theory. In this way the constructs were validated and could be used in further analysis.

5.2.3 Generalized linear models and generalized linear mixed models

In articles II and IV, some of the dependent variables were identified to be non-normal. This was especially true with the variables measuring logistics costs, which were measured as share of firm turnover and thus varied between 0 and 100. Because of the non-normal distribution of these dependent variables, generalized linear models were used in the analysis of article IV. According to McCulloch, Searle and Neuhaus (2008), Generalized linear models are a generalization of ordinary regression that also allows distributions other than normal distribution. These models are all linear models, where

$$\boldsymbol{Y} = \boldsymbol{\mu} + \boldsymbol{\varepsilon}. \tag{9}$$

in which Y is a matrix for dependent variables, μ the mean vector and ε the residuals of the model. Linear dependency between the dependent and independent variables is assumed through a link function (η) where

$$\eta(\boldsymbol{\mu}) = \boldsymbol{X\beta} \tag{10}$$

and vector X stands for the independent variables and the β slope estimates of the model. The starting model is (in scalar form):

$$\eta = \alpha_1 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n \tag{11}$$

where η represents the link function used in the analysis and is model-dependent. (McCulloch et al. 2008)

In article II, the logistics costs were analyzed in a panel setup, between two time points, which further complicated the analysis. The inclusion of multiple time points led to the use of an even more sophisticated analysis method, the generalized linear mixed model. A general matrix from of a linear mixed model is:

$$\boldsymbol{Y} = \boldsymbol{\mu} + \boldsymbol{\varepsilon} = \boldsymbol{X\beta} + \boldsymbol{Zb} + \boldsymbol{\varepsilon} \tag{12}$$

where Y is a matrix for dependent variables, μ the mean vector and X and β fixed effects, similar to regression analysis. Linear dependency between the variables is assumed through a link function, which in the case of this equation is identity. Z is a known matrix for the random effects in the model, and b is a vector containing the coefficients of random variables. ε is a matrix describing the residuals of the model. Usually, matrices b and ε are assumed to be normally distributed, and independent. (McCulloch et al. 2008)

As with the generalized linear model, linear dependency is assumed through a link function. In the case of beta-distributed cost data analyzed in the thesis articles, a logarithmic link function was used (see for example Dodd et al. 2006). As a result, the generalized linear mixed model used in the analysis was:

$$\boldsymbol{Y} = g^{-1}(\boldsymbol{X\beta} + \boldsymbol{Zb}) + \boldsymbol{\varepsilon} = e^{\boldsymbol{X\beta}+\boldsymbol{Zb}} + \boldsymbol{\varepsilon} \quad (13)$$

Because some of the independent variables in the analysis were categorical, a number of binary variables were used in the models (k-1, where k is the number of categories), meaning that the final models for the logistics costs were:

$$\frac{COST_{ij}}{TURNOV_{ij}} = e^{\alpha+b_i+\sum_{k=1}^{n}\beta_k X_1+\cdots\sum_{k=1}^{n}\beta_k X_n} + \varepsilon_{ij} \quad (14)$$

In the model, b denotes the assumption that each firm has its own baseline of logistics costs, whereas i refers to the firms in the sample and j to the different points of time.

Even though applying the generalized linear model and generalized linear mixed model eases the assumption of normality and could in that sense be considered a superior method for analyzing non-normally distributed data, one should critically consider the weaknesses of the method. As McCullagh and Nelder (1999) point out, the data will often point towards several possible models and it is important for the researcher to acknowledge this.

Finding the right fit is essential, and the methods for that purpose are imperfect. In the analysis of articles II and IV, fitting the data to identify the right distributions was done by using Schwarz –information criteria. Also other criteria could have been used and in that sense a possibility remains that with other criteria, some of the analysis could have ended up being done by using other distributions. The previous findings of Dodd et al. (2006) on the other hand support the choices made in articles II and IV. The other thing to consider when interpreting the results is the absence of R^2, the traditional measure of goodness of fit of the model, when generalized linear models are used. In that sense, the overall goodness of fit cannot be weighted as traditionally, but instead more emphasis has been put to the significance of individual coefficients. As the reported coefficients are statistically significant, there is strong support for the identified connections, but at the same time, the overall explanatory power of the final models cannot be evaluated with similar precision.

5.3 Research process

This section describes the research process of the thesis and elaborates on the process behind each of the thesis articles.

Generally, the research process can be described as waves of different phases of literature review, data collection and analysis. Here this means that a research question, or an idea in a broader sense, would arise from the existing literature, leading to a more detailed literature review in the search for proper constructs to measure the phenomenon. Once the proper constructs were identified, data collection would follow as part of the national level surveys. Next, possible duplicate responses from the same firm were removed, always keeping the first response received. Responses that had clearly fallen into the wrong part of the questionnaire (for example, the main industry provided by the respondent did not correspond to the real industry of the firm) and thus answered questions meant for other industries were also omitted from the sample. As in most of the thesis articles, the survey data was linked to the data from financial reporting. During the analysis phase the literature was again thoroughly scrutinized in order to tie the analysis and the results into the latest discussion on the topic. Figure 3 illustrates the overlapping processes during the thesis work.

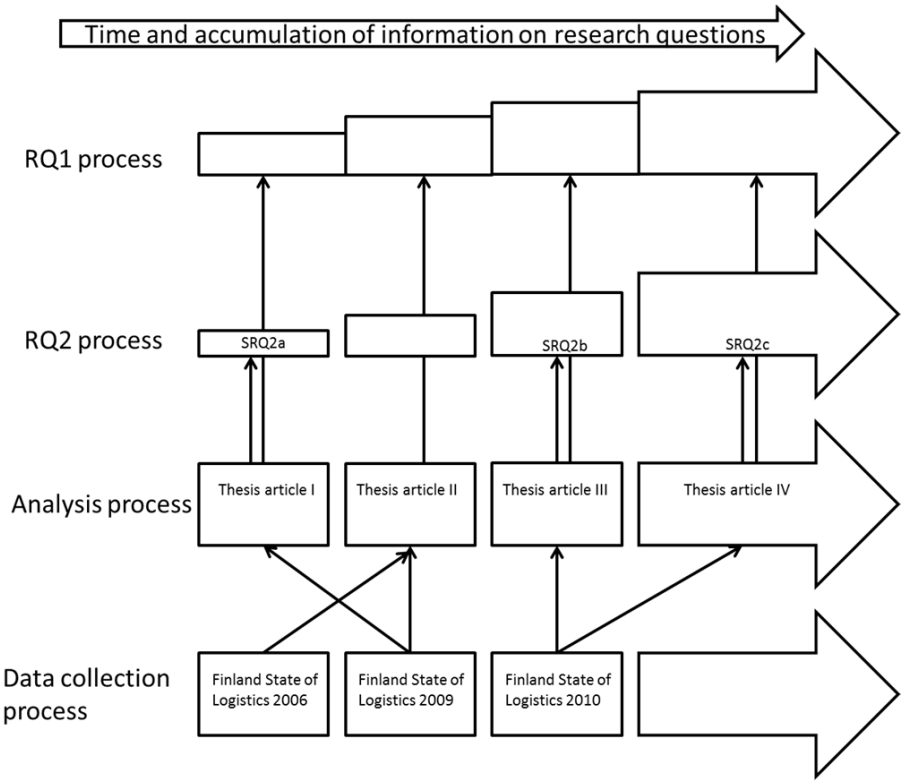

Figure 4 Overlapping processes of the thesis work. Horizontal arrows illustrate time and accumulation of information; vertical arrows illustrate the flows of information.

The initial starting point of the research was the commission by the Finland State of Logistics 2006 survey, after which the author, as part of the research team commissioned to do the work, started to review the literature in order to come up with proper constructs and questions for the questionnaire. During that phase, several possible research questions for the thesis were identified. The constructs analyzed in two of the chronologically first articles of the thesis, articles I and II, were initially included in the national survey of 2006. From the beginning, logistics costs were considered to be a key indicator for the performance of Finnish firms, and were included in the questionnaire from the start. Although the previous literature was not unanimous on the different measures of firm performance, measures of service performance and asset utilization were included. The first variable to possibly have a connection with firm performance, the outsourcing of logistics operations, was also included.

Although the data collection of 2006 provided a large dataset of high quality, the need for additional data arose during the initial analysis. Analysis of changes in logistics costs required another data point, and especially

following an article by Töyli et al. (2008) on the constructs possibly connected to firm performance using the data from 2006, a wide range of new research questions emerged. Based on the work of Töyli et al. (2008) and a thorough literature review, a list of new questionnaire items was formulated to include questions regarding supply chain collaboration, information systems support and benchmarking and monitoring of logistics in the survey. At this point the author was acting as the head of the project, responsible for the data collection and reporting of the survey results.

The material for articles I and II were collected as part of the Finland State of Logistics 2006 and 2009 surveys. Article I uses empirical material collected as part of the Finland State of Logistics 2009 survey (Solakivi et al. 2009), and financial reporting data connected to it. The purpose of the article is to analyze the effects of logistics outsourcing on firm performance. The level of outsourcing was measured by asking the respondents of the survey to estimate the proportion of outsourcing in their logistics operations. Performance was considered to consist of self-reported logistics costs, self-reported operational performance and measures of financial performance, obtained from financial reporting.

Article II is based on survey data from 2006 and 2009. Panel data was formed from respondents to both Finland State of Logistics surveys, including manufacturing and trading firms. The panel setting was chosen to analyze the changes in self-reported logistics costs between the two points in time. In addition, the effects of firm characteristics on logistics costs and the interactions between firm characteristics and time were analyzed. The analysis of article II provided new and interesting information on both the used survey instrument and the data. Originally, data on logistics costs was obtained by asking the respondents to estimate the logistics costs (or individual cost components) as a relative share of their turnover on a scale of 0% to 100% using single percentage intervals. Although the previous literature (see e.g. Stewart 1995) considers this to be a robust way of obtaining cost estimates, some problems were identified in the analysis. The data on logistics costs was found to be skewed towards small values, creating bias in a regular regression analysis. And notably, data concerning some of the minor cost components was found to contain a large number of 0s. Given the precision of the question to 1 percentage point, the 0s presumably contained true values between 0 and 0.5, which could not be excluded from the analysis.

These findings influenced both future data collection and the choice of analysis methods. In the survey instrument, the question concerning logistics costs was reformulated as an open-ended question, allowing answers with a precision of one decimal rather than a whole percentage point. In view of the

skewed distributions of cost data, new, more robust analysis methods were also sought and employed.

The initial analysis of the 2009 survey results revealed problems with the data, especially from questions on supply chain collaboration and information systems support; although these questions were based on previous literature, the constructs failed to work as anticipated. Fortunately the possibility to repeat the questions emerged already the following year, 2010, as part of the next Finland State of Logistics survey. Before running the survey, the questions on supply chain collaboration and information systems support were tested on a peer group and subsequently partially rephrased or relocated within the questionnaire.

As with the previous survey, the author was responsible for coordination of both the data collection and the reporting phase of the survey.

The data collection of 2010 led to two of the articles included in this thesis. Article III analyses the connections between company characteristics such as size, level of internationalization, manufacturing strategy and industry orientation on logistics costs and firm performance. In addition, the article attempts to identify in which ways supply chain collaboration and information systems support, among other things, are dependent on firm characteristics.

Article IV continues from the initial analysis of article III by including also financial performance in the analysis. The goal of the article is to identify the connections between supply chain collaboration, information systems support and firm performance. Firm characteristics that were the focus in article III are employed as control variables in the analysis.

The introduction part of the thesis sums up the findings of the articles and presents the general conclusions of the research. The role of the author has been central in all the phases of the research, from initial planning to final reporting of the results. The same is true with all four articles, which justifies their inclusion as part of the thesis.

5.4 The data

The empirical data used in this thesis was obtained from two sources. Part of the data was collected in connection with the national level Finland State of Logistics surveys between 2006 and 2010.

The Finnish Ministry of Transport and Communications has for over 20 years commissioned research institutions to survey the current level and future developments of logistics in Finland. The first three surveys were conducted in 1990, 1996 and 2000 as mail surveys by PricewaterhouseCoopers. The four

latest were conducted by Turku School of Economics in 2006, 2009, 2010 and 2012 as web-based surveys, as summarized in Table 5.

The Finland State of Logistics 2006 (Naula et al. 2006) and 2009 (Solakivi et al. 2009) surveys were targeted at three groups: manufacturing firms, trading firms and logistics service providers operating in Finland. The two latest surveys, Finland State of Logistics 2010 (Solakivi et al. 2010) and 2012 (Solakivi et al. 2012) also included separate questionnaires for logistics consultants and academia in the field of logistics research. The main sample frame of the Finland State of Logistics surveys has remained similar through the four web surveys, including all non-student members of the Finnish Association of Purchasing and Logistics (LOGY), members of the Finnish Transport and Logistics association (SKAL), and members of the Federation of Finnish Enterprises, active in the industries covered in the survey. In addition, the Finland State of Logistics 2009 survey (Solakivi et al. 2009) included members of regional chambers of commerce active in the targeted industries.

As the response rates of the surveys have remained on a relatively low level, one has to be careful with the possible existence of non-response bias. Wagner and Kemmerling (2010) analyzed over 200 surveys conducted in the field of logistics, concluding that the decline in response rates with the sample size of the survey is expected. Compared to the surveys reviewed by Wagner and Kemmerling (2010), the response rates of Finland State of Logistics –surveys presented in Table 5 may be considered normal for surveys of similar scale.

Moreover, the low response rate, and the generalizability of the survey results can be discussed in more detail. The response rates of 13.9% for the Finland State of Logistics 2006 –survey, and the corresponding rates of the latter surveys strongly underestimate the share of the Finnish manufacturing industry the survey is able to cover. Measured as a share of turnover of the industry, Finland State of Logistics 2006 –survey covers around 55% of the manufacturing industry, as the corresponding shares for the 2009 survey and 2010 survey are 84% and 43%, respectively.

Table 5 Data collection periods and respondent data of Finland State of Logistics surveys 2006–2012.

Survey	Data collection period	Sent to	Respondents	Response rate
Finland State of Logistics 2006	March-April 2006	16 231	2 255	13.9 %
Finland State of Logistics 2009	November-December 2008	26 311	2 705	10.3 %
Finland State of Logistics 2010	April-May 2010	25 218	1 813	7.2 %
Finland State of Logistics 2012	January-February 2012	38 834	2 732	7.0 %

The Finnish Ministry of Transport gave the researchers freedom to formulate the questions used in the surveys. This allowed the surveys to be used also for research purposes, with constructs and research questions previously tested by other authors.

In this thesis, data from financial reporting was used in addition to survey data. The survey respondents were identified and assigned a business identity code based on their contact information. The code was then used to connect the respondents to their financial reporting data from corresponding years. The financial data was obtained from the Orbis database of Bureau van Dijck. This is a commercial database containing administrative information on 55 million companies worldwide, of which 99% are private companies (Pinto, Menghinello and Backer 2010).

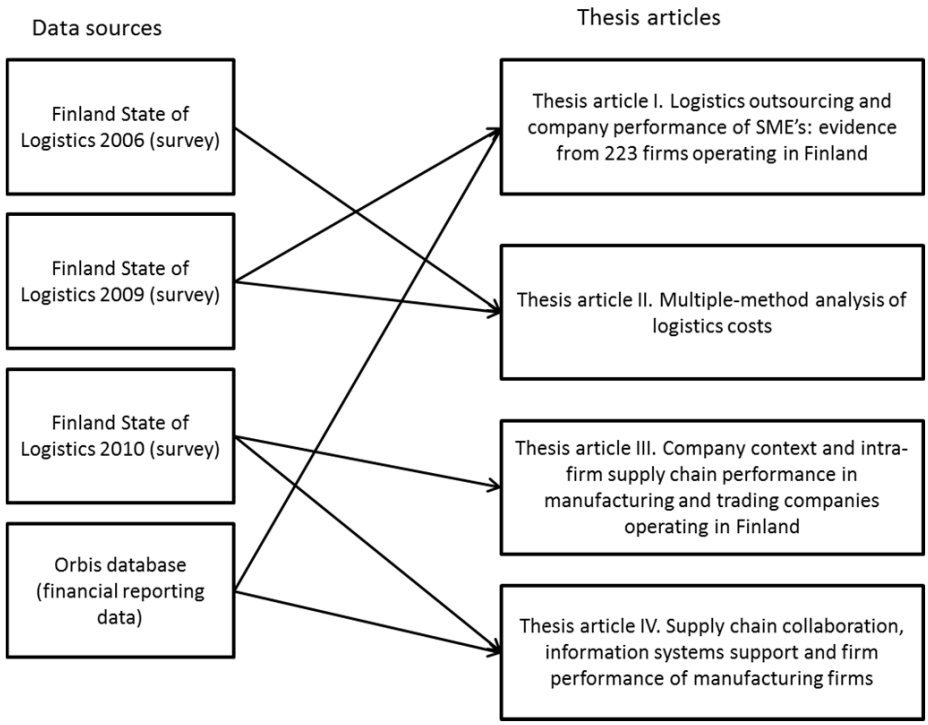

Figure 5 Key references for data collection and data sources for articles I–IV

The data sources for the thesis articles are illustrated in Figure 4. Article I uses the survey data collected as part of the Finland State of Logistics 2009 survey (Solakivi et al. 2009). The variables included in the survey consist of self-reported estimates of the current level and future development of logistics

outsourcing, logistics costs, service performance, and asset utilization. Financial reporting data from the Orbis database was linked to the self-reported survey data using the business identity code of the respondent firms. The financial data used in article I consists of ROA, ROCE, and EBIT-% for the 2008 fiscal year.

For thesis article II, data was collected as part of two surveys, Finland State of Logistics 2006 (Naula et al. 2006) and Finland State of Logistics 2009 (Solakivi et al. 2009). The article analyses the development of self-reported logistics costs between the 2 years in a panel setup, including a set of control variables. The control variables, firm size (measured as turnover and number of employees) and the level of internationalization, were also obtained as survey data. The data for thesis article III was collected as part of the Finland State of Logistics 2010 survey (Solakivi et al. 2010). The measures of intra-firm supply chain performance (logistics costs, service performance and asset utilization) were sought in a similar fashion as in the previous surveys. In addition, an extensive set of questions was formulated and included on supply chain collaboration and information systems support, but also on other parts of the "logistics profile" previously defined by Töyli et al. (2008).

In article IV, the dataset is mostly the same as in article III. Again, financial reporting data from official sources is included in addition to the survey data. The variables include ROA, ROCE and EBIT-% for the 2009 fiscal year.

6 SUMMARY OF THE RESULTS

This chapter addresses the research questions through the results of the thesis articles. The sub-research questions are addressed first based on individual articles, followed by the main research questions from the summary of the results.

6.1 Developing the measurement and analysis of firm performance

The inclusion of multiple data sources and time points has provided a unique opportunity for learning in regard to both measurement and analysis, and for exploiting lessons learned from previous data collections. There has also been a steep learning curve in relation to the models used for analyzing the performance data in its multiple forms. The following section sums up the findings concerning research question 1.

RQ1. How can the measurement and analysis of intra-firm supply chain performance be improved?

Article II analyzes logistics costs in a panel setup between 2005 and 2008. The article uses a sample of 241 manufacturing and trading firms that answered the Finland State of Logistics 2006 (Naula et al. 2006) and 2009 (Solakivi et al. 2009) surveys.

One key finding of the article is that the distribution of logistics costs, measured either as individual cost components or as total logistics costs, was skewed towards smaller values and thus not normal. Further analysis of the cost data revealed that this non-normal distribution might be at least partly attributable to the way the survey data was collected.

Since the cost estimates were collected as relative measures, as a share of firm turnover, the responses ranged between 0 and 100% of turnover. For example, transportation costs of Finnish firms average around 5% of turnover. Most of the responses clustered around this average but some firms reported transportation costs substantially above it, both of these factors leading to skewed distributions of the cost variables.

Also, as suggested by Stewart (1995), the logistics cost data was initially measured with one-percentage point intervals from 0 to 100. Descriptive

analysis showed that especially smaller logistics cost components (such as logistics administration and transport packing costs) came in at 0. Theoretically, this would include any true values between 0 and 0.5, indicating that a more precise scale should be used. In the later phases of this thesis, the survey questions on logistics costs were therefore updated to include open-ended questions allowing a precision of one decimal. The result was interesting; most of the respondents still provided their estimates as full percentages despite the opportunity to be more precise. In this sense, the results support Stewart's (1995) view that a response scale of full percentage points is sufficient.

The data on other measures of firm performance was also checked for normality. As with logistics costs, either positive or negative skewness and some kurtosis was detected particularly in regard to service performance. Unlike the cost data, other performance data could be transformed to meet the assumption of normality.

The non-normality of the cost data led to a search for the right distribution for cost analysis. Review of the literature showed that previously Dodd, Bassi, Bodger and Williamson (2006) had analyzed cost data in a hospital setting using multivariate regression models. Also Kilian, Matschinger, Löeffler, Roick and Angermeyer (2002) and Thomson (2005) leaned towards a similar methodology. Following their example, analysis of the data showed that the distribution best suitable for the analysis of logistics costs is the beta distribution. Since traditional regression analysis assumes normality of the data, and two points of time were included in the analysis in the form of panel data, traditional regression analysis was dropped in favor of Generalized Linear Mixed Models (GLMM). In article IV the distribution of cost data was found to resemble the beta distribution; thus generalized linear models were employed in the analysis there. The first findings concerning the measurement and analysis of performance data suggest that its non-normal nature should be taken into account already during the measurement phase. The data gathered in multiple surveys indicates that open-ended questions might be the best option when obtaining survey-based performance data. The non-normality of the data should be taken into account in the analysis phase as well. The normality of the data should be analyzed carefully, and in the case of non-normal data proper transformations should be employed and the analysis methods chosen accordingly. For example, traditional regression analysis and structured equations modeling are sensitive to the assumption of the normality of the data.

6.2 Connections between supply chain practices and firm performance

The first of the sub-research questions, SRQ2a, looks at the role of logistics outsourcing practices in firm performance.

SRQ2a What is the connection between logistics outsourcing and firm performance?

Article I describes the current state of logistics outsourcing by manufacturing and trading firms, and examines their expectations of its development. In the analysis, outsourcing is considered to consist of three bundles of logistics operations, each including types of operations that are closely related to each other. Outsourcing of transportation services is considered to consist of domestic transportation, international transportation, reverse logistics and freight forwarding. Outsourcing of information processing is considered to consist of order processing, invoicing and logistics IT systems, and outsourcing of materials management and value-added services includes (outsourcing of) warehousing, inventory management and product customization.

Descriptive analysis shows that transportation services are already widely outsourced among Finnish firms, whereas information processing and materials management are mainly handled in-house. In the analysis, the firms are divided into three groups based on how widely they have outsourced different logistics operations. The group "no outsourcing" handles the respective logistics operation entirely within the firm. "Moderate outsourcing" includes firms that have outsourced 1–50% of the operation, and "heavy outsourcing" includes firms that have outsourced the majority of the logistics operation.

Although article I could not identify statistically significant connections between logistics outsourcing and firm performance, some interesting patterns emerged from the descriptive analysis. The relationship between logistics outsourcing and operational performance, especially logistics costs, seems to be curvilinear rather than linear. In other words, firms with a moderate rate of outsourcing are experiencing higher logistics costs than firms that have either outsourced none of their operations or outsourced the majority. The relationship between outsourcing of information processing and financial performance can be described as negative. Firms with no outsourcing had the highest means of all three measures of financial performance (ROA, ROCE and EBIT-%), whereas the financial performance of firms with heavy outsourcing was the lowest.

SRQ2b. What is the connection between supply chain collaboration and firm performance?

SRQ2c. What is the connection between firm-level information systems support and firm performance?

SRQ2b and SRQ2c are analyzed together in articles III and IV. Article III examines the connections between different firm characteristics and intra-firm supply chain performance, and between the firm characteristics and supply chain collaboration and information systems support. Article IV uses the firm characteristics as control variables, while concentrating more on the connections between supply chain collaboration, information systems support and firm performance.

Some of the characteristics are traditional and are used also in article II (main industry, firm size and level of internationalization), whereas others are less used. In addition to these, some characteristics were introduced that are especially suitable to manufacturing firms. Manufacturing firms were divided based on their main production mode, including Make to Stock, Make to Order, Assembly to Order, Engineer to Order and Capacity Selling. In addition, they were classified in two separate ways based on the industry they represent, according to the average value-added percentage of the industry. Further, a feature special to Finland was introduced, firms being classified according to whether or not they operated in industries belonging to the interest group "technology industry".

The results of article III indicate that supply chain collaboration and information systems support are mainly linked to firm size and the level of internationalization, whereas operational performance is more widely linked to certain characteristics. Larger, more international firms also collaborate more in the supply chain, especially externally, with their suppliers and customers.

Of operational performance, size seems to have a negative effect on some measures of asset utilization (days of sales outstanding, inventory days of supply), whereas some of them (days of payables outstanding) are positively affected. Overall it seems that the explanation for longer payment times and expanded inventory is in the scale of operations. In the analysis a positive connection emerged between the level of internationalization and all of the time-based measures of performance (in addition to order-delivery cycle time), which further supports this notion.

The division between technology industries and other industries turned out to be significant, especially from the standpoint of intra-firm supply chain performance. Technology industries were found to have longer order-delivery

cycle times and longer cash to cash cycle times than other manufacturing industries.

The connections between firm characteristics and logistics costs were found to be moderate. The only statistically significant connection was the lower transportation costs of technology industries compared to other industries.

In article IV, supply chain collaboration and information systems support are studied against firm performance. Firm characteristics such as size, manufacturing strategy (production mode in article III), value-added and industry orientation were used as control variables.

The analysis revealed a negative connection between supply chain collaboration and logistics costs. It seems that both internal and external collaboration have a negative effect on transportation costs. Higher internal collaboration is also associated with lower logistics administration costs and transport packing costs. In addition to transportation costs, a higher level of external collaboration in the supply chain also has negative effects on warehousing costs, inventory carrying costs and total logistics costs.

The role of logistics information systems support on logistics costs was found to be minor. Only logistics administration costs are (negatively) connected with the level of IT systems.

Supply chain collaboration, especially external collaboration, was found to have a positive effect on two measures of financial performance, ROCE and EBIT-%. The level of information systems support, on the other hand, was found to be negatively related to all three measures of financial performance.

RQ2. What are the connections between certain supply chain practices and firm performance?

The results of the thesis articles indicate that different dimensions of firm performance are connected to and affected by different supply chain practices. Some of the results are in line with the findings of previous literature, whereas others bring new insight on the relationships between logistics and performance. Table 6 summarizes the results of the thesis articles.

Table 6 Summary of the results of the research articles

	Independent variable	Dependent variable			
		Logistics costs	Service performance	Asset utilization	Financial performance
Article I. Solakivi et al. (2011)	Logistics outsourcing	-	-	-	-
Article II. Engblom et al. (2012) Article III. Solakivi (2013)	Firm characteristics	*	*	*	*
Article IV. Solakivi et al. (Submitted to a journal)	Supply chain collaboration	Positive	Positive	-	Positive
	Information systems support	Positive	-	-	Negative

- no connection identified

* identified connection

As the definition of firm performance includes multiple dimensions, and the effects of the supply chain practices on these dimensions vary, it is hard to make simple judgments as to whether a certain practice is "good" or "bad" for the firm.

Article I analyzes logistics outsourcing and its effects on firm performance. No statistically significant connections between logistics outsourcing and firm performance were observed; nevertheless, some interesting tendencies emerged that are worth mentioning. It would seem that where outsourcing is concerned, firms should consider strategies from two opposite ends of the scale. They should either concentrate their efforts and resources on handling their logistics (or individual operations) by themselves, or choose a strategy of outsourcing heavily. Being caught in the middle seems to be the hardest way ahead in relation to performance.

Article I makes no judgment as to the motives for outsourcing. Previous literature has pinpointed the cost motive as central to the outsourcing decision. If the motives for outsourcing are not mainly cost related, or otherwise directly connected to performance, the true effects of outsourcing may have gone unnoticed in analyses focusing on performance.

The results indicate that supply chain collaboration has a positive effect on both the logistics costs and financial performance of manufacturing firms. This is especially true of external collaboration. The positive effects of external collaboration can be considered to be an indicator of successful orientation in the supply chain. Instead of operating from a "frog perspective", successful collaboration with customers and suppliers encourages firms to see the supply chain from a "bird's-eye view", enhancing performance.

The connections between logistics IT systems and firm performance was found to be mixed. A higher level of logistics IT systems was found to be associated with lower logistics costs (logistics administration costs in particular), whereas the effect on financial performance was found to be negative.

7 DISCUSSION AND SUGGESTIONS FOR FURTHER RESEARCH

The results of this thesis contribute on three different levels. First of all, the analysis of connections between certain supply chain practices and firm performance provides additional information to practitioners. Many preconceptions exist as to the relationship between the constructs analyzed and various aspects of firm performance, and firms have made and will continue to make decisions based on those assumptions. Some of the results of this thesis further confirm these preconceptions, whereas others bring them into question.

Contrary to what most of the previous literature assumes, the analysis in article I could not confirm the positive connection between logistics outsourcing and firm performance. On the other hand, no statistically significant negative connection between the two was found either. To turn things around, one could conclude that logistics was found to be handled equally efficiently, regardless of whether it had remained in-house or been outsourced. It would seem that logistics outsourcing is more of a firm level question. The potential and real benefits are many, and most likely depend on the firm level characteristics. The firms planning to outsource their logistics operations should not expect any automatic gains, but should instead thoroughly analyze what are the potential benefits, and what are the possible negative consequences in their case.

Articles II and III identify connections between firm characteristics and performance. Whereas firm size, measured both as turnover or number of employees, has been widely analyzed and found to be linked to performance, the analyses in articles II and III were able to identify also other characteristics that seem to matter. It seems that the level of internationalization is linked to logistics costs as well as to service performance and asset utilization. The identified connection acts as a warning especially to practitioners who are planning to expand their operations from domestic to international markets. Expanding operations abroad seems to lead to higher transportation costs and total logistics costs than the firm has been experiencing in domestic markets. The results indicate that once the firm has reached the capability to also manufacture abroad, this cost burden would vanish.

Firms aiming for international markets are also recommended to take into account the changes in their operational performance. The results of article III indicate that firms operating internationally should expect their order-delivery

cycle times to expand significantly. Moreover, correlation analysis in article III identified high correlations between order-delivery cycle time and other measures of performance, such as inventory days of supply, cash to cash cycle time and the used measures of financial performance. The effect of internationalization can also be seen on asset utilization, where there is a clear difference in payment times and inventory levels between domestic and international firms, which would indicate an increased need for management of working capital. Taking these results into account, firms aiming for international markets should be prepared for new challenges in managing their supply chain and maintaining the desired level of performance. The challenges are many and include both operational and financial questions to be solved.

The contribution of thesis article IV for practitioners is mainly that it supports some previous assumptions. As shown by a large number of previous studies, also Finnish manufacturing firms seem to enjoy the benefits of improved cost efficiency and higher financial performance with supply chain collaboration. For practitioners, the results further emphasize the importance of focusing on the entire supply chain rather than solely on internal operations.

Overall, there are two main messages for practitioners. First of all, the connections between supply chain practices and firm performance are dependent on the firm characteristics. Instead of relying on ready-made recipes, each firm should analyze carefully what the effects are, considering their individual and unique characteristics. Second, the results would in a broader sense seem to emphasize the key role of SCM. The larger and more international the supply chain, the bigger the challenges, and the more important a supply chain perspective is.

From the theoretical point of view, the empirical results of this thesis support some previously made and analyzed assumptions while questioning some of the others. The majority of previous literature on outsourcing assumes that the connection between firm performance and outsourcing is positive, independent if performance is measured as cost performance, service performance or even financial performance. The results of article I question earlier theoretical assumptions, indicating that the connection between outsourcing and performance is more complex than previously assumed.

Articles II and III broaden our understanding of the role of firm characteristics. The majority of the literature analyzing firm performance simplifies the firm characteristics by controlling firm size while neglecting other, potentially relevant characteristics. Both articles II and III reveal that the role of firm characteristics is wider than that. Especially in the era of globalization, the level of internationalization has become a significant factor in determining the firms and their performance. The results of articles II and III suggest that

future research should extend its scope of possible characteristics that should be taken into account.

Article IV mainly confirms previous understanding of the positive relationship between supply chain collaboration and firm performance with the Finnish dataset. At the same time, the results of article IV question previous assumptions of the role of information systems on firm performance. It would seem that the key to success is on the collaborative, rather than technological, side of information systems. Technological capabilities are not the solution by themselves, unless there is true motivation to use them in a collaborative way.

In addition to the results of the individual articles, one of the novelties of this thesis is the use of data. Most research analyzes firm performance either from the financial reporting point of view, or from the perspective of self-reported data. In articles I and IV, the two approaches are combined through the use of both self-reported survey data and financial reporting data from the respondent firms. This approach, the ability to use both datasets together, brings novelty to the thesis and expands the view of the previous literature on the analyzed topics.

In the thesis articles, several different analysis methods are used. While some of the methods (t-tests, Chi2-tests and ANOVA) are commonly used in this field of research, the research methods used in some of the articles are not that common. Especially the data concerning logistics costs was found to be skewed to such an extent that the more widely used research methods that assume normality of distribution had to be abandoned. The use of a generalized linear model enabled the use of beta distribution, which was found to be best for cost data. A generalized linear model was employed in article IV. In article II, the analysis contained more than one point of time, which required the inclusion of interactions in the model. This further complicated the analysis, which was performed with GLMM. This thesis contributes by presenting arguments for the use of non-normal distributions in cost analysis and the generalized linear models that enable the use of non-normal distributions.

As with any research, the research process has raised questions, leaving doors open for further research. Since the analysis was unable to reveal any significant relationships between logistics outsourcing and firm performance, the topic needs further attention. If the potential and real benefits of outsourcing depend on firm characteristics, it would seem logical to analyze what are the characteristics that make firms successful in outsourcing.

In thesis article II, intertemporal changes in logistics costs are analyzed. The use of multiple data points would further validate the methodology used and the results obtained. In addition, GLMM with beta distribution is just one of the options for modeling costs. This method should be studied against other

ones in order to compare which method is most suitable considering for both scientific and practical use.

Another research path can be seen regarding practices not included in this thesis. While collaborative practices are covered in the thesis articles, other possible practices connected with performance await to be studied. The connection between environmental management and performance, both operational and financial, is one of the future directions for research efforts.

TIIVISTELMÄ

Tämä tutkimus pyrkii lisäämään tietämystä yritysten suorituskyvystä kahden tavoitteen kautta. Tutkimuksen ensimmäisenä tavoitteena on analysoida kuinka yrityksen toimitusketjun suorituskyvyn mittaamista ja analysointia olisi mahdollista kehittää. Tutkimuksen toisena tavoitteena on selvittää yrityksen suorituskyvyn ja yrityksen toimitusketjun johtamisessa tekemien valintojen (supply chain practices) välistä yhteyttä.

Yrityksen suorituskyky käsittää tässä työssä yrityksen taloudellisen suorituskyvyn, sekä toimitusketjun suorituskyvyn yksittäisen yrityksen näkökulmasta. Toimitusketjun suorituskyky on tässä tutkimuksessa jaettu kirjallisuuden perusteella edelleen kustannustehokkuuteen (logistiikkakustannukset), palvelutasoon sekä käyttöpääoman tehokkuuteen. Kirjallisuuden perusteella lähemmän tarkastelun kohteeksi on toimitusketjun johtamisessa tehtyjen valintojen osalta otettu logistiikkatoimintojen ulkoistaminen (logistics outsourcing), toimitusketjuyhteistyö (supply chain collaboration), sekä tietojärjestelmien rooli toimitusketjun johtamisessa (information systems support). Lisäksi on tarkasteltu yritystason erityispiirteiden kuten yrityskoon, tuotantostrategian ja toimialan vaikutuksia toimitusketjuratkaisujen ja yrityksen suorituskyvyn väliseen suhteeseen. Tämä väitöskirja koostuu neljästä artikkelista, ja artikkelit yhteen kokoavasta yhteenveto-osasta, jossa esitetään kootusti artikkelien keskeiset tulokset liikkeenjohdon, tutkimusmetodien ja teorian näkökulmasta.

Tutkimuskysymyksiä on tässä väitöskirjassa tarkasteltu analysoimalla yritystason empiiristä aineistoa Suomessa toimivista valmistavan teollisuuden yrityksestä. Yhdessä artikkelissa aineistoa Suomessa toimivista kaupan alan yrityksistä on käytetty vertailuaineistona. Väitöskirjan empiirinen aineisto on kerätty kahdesta lähteestä. Keskeisenä aineistolähteenä on käytetty kolmen kansallisen Logistiikkaselvityksen aineistoa vuosilta 2006, 2009 ja 2010. Taloudellisen suorituskyvyn mittarit on kerätty kyselyyn vastanneiden yritysten osalta virallisista lähteistä

Tutkimusaineiston analysoinnissa on käytetty useita eri analyysimenetelmiä mukaan lukien kuvailevat tunnusluvut, t-testisuureet ja varianssianalyysi. Myös edistyneempiä analyysimenetelmiä kuten yleistetty lineaarinen malli ja lineaarinen sekamalli on käytetty työssä. Analyysin tulokset paljastivat, että yrityksen suorituskyvyn mittarit noudattavat harvoin normaalijakaumaa. Normaalijakauman sijaan suorituskykyä mittaavassa aineistossa esiintyy sekä vinoutta että huipukkuutta. Esimerkiksi logistiikkakustannukset mitattuna

suhteessa liikevaihtoon koostuvat pääosin pienistä arvoista, kuitenkin siten että myös suuret arvot (korkeat logistiikkakustannukset) ovat mahdollisia. Näin ollen logistiikkakustannusten tilastollinen jakauma on tyypillisesti positiivisesti vino. Taloudellisen suorituskyvyn mittarit puolestaan keskittyvät voimakkaasti lähelle aineiston keskiarvoa, jonka seurauksena niiden tilastolliset jakaumat ovat huipukkaita.

Suorituskykymittareita analysoitaessa tulisi ottaa huomioon aineiston ei-normaalisuus joko soveltamalla aineistoon sopivia muunnoksia, tai vaihtoehtoisesti valitsemalla analyysimenetelmiä, jotka eivät ole sensitiivisiä oletukselle aineiston normaalijakaumaolettamukselle.

Toimitusketjuratkaisujen ja yrityksen suorituskyvyn välisten yhteyksien tarkastelu paljasti mielenkiintoisia tuloksia. Ensinnäkin, aiempi kirjallisuus olettaa logistiikan ulkoistamisella ja yrityksen suorituskyvyn välillä vallitsevan positiivisen yhteyden. Olettamukselle ei löytynyt tukea analysoidussa aineistossa. Sen sijaan aineiston perusteella näyttäisi siltä, että logistiikan ulkoistamisen vaikutukset riippuvat enemmän yritystason erityispiirteistä, kuin ulkoistamisesta. Yritykset ulkoistavat toimintojaan monista syistä, ja vain osa motiiveista liittyy suoraan yrityksen suorituskykyyn. Toiseksi, tulosten perusteella näyttäisi siltä, että logistiikan ulkoistamisen ja yrityksen suorituskyvyn välinen yhteys ei ole lineaarinen vaan epälineaarinen. Käytännössä tämä tarkoittaisi sitä, että yrityksillä jotka ovat joko ulkoistaneet logistiikkansa suurelta osin, tai ovat tehneet ratkaisun hoitaa logistiikkansa itse on parempi suorituskyky kuin yrityksillä jotka eivät ole tehneet selkeää ratkaisua kumpaankaan suuntaan.

Toimitusketjuyhteistyön lisäämisen havaittiin olevan yhteydessä alhaisempiin logistiikkakustannuksiin ja parempaan taloudelliseen suorituskykyyn. Tietojärjestelmien suurempi rooli toimitusketjun johtamisessa havaittiin olevan yhteydessä alhaisempiin logistiikkakustannuksiin. Toisaalta, tietojärjestelmien suuremman roolin havaittiin olevan yhteydessä alhaisempaan taloudelliseen suorituskykyyn. Yhdistettynä nämä tulokset korostavat yhteistyön roolia toimitusketjun johtamisessa, samanaikaisesti varoittaen korostamasta liikaa tietojärjestelmien roolia.

Tällä väitöskirjalla on (i) liikkeenjohdollista; (ii) teoreettista; ja (iii) metodologista kontribuutiota.

Liikkeenjohdon näkökulmasta tutkimuksen tuloksissa on kaksi pääviestiä: Ensinnäkin, toimitusketjun johtamisen ja yrityksen suorituskyvyn väliset yhteydet riippuvat yrityksen erityispiirteistä, kuten yrityskoosta, toimialasta ja yrityksen toiminnan kansainvälisyydestä. Yrityksen erityispiirteiden keskeisen merkityksen takia yritysten tulisi tarkkaan analysoida toimitusketjun johtamisessa tehtävien ratkaisujen vaikutuksia oman yrityksensä kannalta, sen sijaan että luottaisivat em. suhteista tehtyihin yleistyksiin. Toiseksi tulokset

korostavat toimitusketjun johtamisen merkitystä. Toimitusketjun johtamisen ja toimitusketjuyhteistyön merkitys korostuu erityisesti niillä yrityksillä, jotka ovat laajentaneet toimintaansa kotimarkkinoiden ulkopuolelle. Osa empiirisen analyysin tuloksista on linjassa alan kirjallisuuden valtavirran kanssa. Osittain tulokset haastavat alan kirjallisuudessa esitettyjä olettamuksia, tarjoten siten uusia näkökulmia teoreettiseen keskusteluun. Kuten aiempi kirjallisuus olettaa, kiinteämmällä toimitusketjuyhteistyöllä on tilastollisesti merkitsevä yhteys yrityksen suorituskykyyn. Logistiikan ulkoistamista koskevat tulokset sen sijaan kyseenalaistavat olemassa olevan kirjallisuuden valtavirran osoittamalla ulkoistamisen ja suorituskyvyn välisen suhteen olevan epälineaarinen, ja lisäksi korostamalla yritystason erityispiirteiden merkitystä em. suhteissa.

Tämän väitöskirjan metodologinen kontribuutio on yrityksen suorituskyvyn mittaamisen ja analyysin kehittämisessä. Tutkimusprosessin kuluessa saatu kokemus ja numeerisen analyysin tulokset viittaavat siihen, että avoimet kysymykset toimivat ennalta määrättyjä skaaloja paremmin, kun suorituskykyä pyritään arvioimaan kyselytutkimuksen keinoin. Lisäksi tulokset korostavat sitä, että suorituskykyä mittaavat muuttujat eivät noudata tilastollisesti normaalijakaumaa. Koska suorituskyvyn mittarit noudattavat muuta kuin normaalijakaumaa, myös analyysimenetelmät tulisi valita sellaisten menetelmien joukosta, jotka eivät ole herkkiä normaalijakaumaolettamukselle, tai jotka toimivat myös muiden tilastollisten jakaumien kanssa. Käytännössä esimerkiksi tavallisen regressioanalyysin sijaan tulisi käyttää yleistettyä lineaarista mallia tai lineaarisia sekamalleja. Myös rakenneyhtälömallien käytössä tulisi pitää mielessä niiden herkkyys normaalijakaumaolettamuksen osalta.

Tässä väitöskirjatyössä käytetty empiirinen materiaali on kerätty osana kansallisen tason kyselytutkimusta. Kyselyiden aineisto kattaa suurimman osan Suomessa toimivasta valmistavasta teollisuudesta. Tästä näkökulmasta työn tulosten yleistettävyyttä voi pitää varsin hyvänä. Samalla täytyy kuitenkin pitää mielessä, että aineisto on rajoittunut yhteen maahan, Kansainvälisesti vertailuja voidaan tehdä samankaltaisissa, pienissä avoimissa kansantalouksissa toimiviin valmistavan teollisuuden yrityksiin. Pienimmät, mikrokokoiset yritykset on jätetty analyysin ulkopuolelle, mikä toisaalta rajoittaa tulosten yleistettävyyttä kaikkein pienimpiin yrityksiin, samanaikaisesti parantamalla yleistettävyyttä suurempien yritysten osalta. Analyysi keskittyy erityisesti valmistavan teollisuuden yrityksiin, jonka seurauksena tulokset eivät ole sellaisenaan yleistettävissä muille toimialoille, kuten kaupan alan yrityksiin.

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