



Open your mind. LUT.  
Lappeenranta University of Technology

Jyri Vilko

## **APPROACHES TO SUPPLY CHAIN RISK MANAGEMENT: IDENTIFICATION, ANALYSIS AND CONTROL**

Thesis for the degree of Doctor of Science (Economics and Business Administration) to be presented with due permission for public examination and criticism in the Auditorium 1382 at Lappeenranta University of Technology, Lappeenranta, Finland, on the 12 of April, 2012, at noon.

Acta Universitatis  
Lappeenrantaensis 471

- Supervisors Professor Jukka Hallikas  
School of Business  
Lappeenranta University of Technology  
Finland
- Professor Jouni Koivuniemi  
Faculty of Technology Management  
Lappeenranta University of Technology  
Finland
- Reviewers Associate Professor Ruth Banomyong  
Faculty of Commerce and Accountancy  
Thammasat University  
Thailand
- Professor Hannu Kärkkäinen  
Department of Business Information Management and Logistics  
Tampere University of Technology  
Finland
- Opponent Professor Hannu Kärkkäinen  
Department of Business Information Management and Logistics  
Tampere University of Technology  
Finland

ISBN 978-952-265-219-5

ISBN 978-952-265-220-1 (PDF)

ISSN 1456-4491

Lappeenranta University of Technology

Digipaino 2012

## ABSTRACT

Jyri Vilko

### **Approaches to Supply Chain Risk Management: Identification, Analysis and Control**

Lappeenranta 2012

276 pages, 1 Appendix

Acta Universitatis Lappeenrantaensis 471

Dissertation Lappeenranta University of Technology

ISBN 978-952-265-219-5, ISBN 978-952-265-220-1 (PDF), ISSN 1456-4491

Supply chain risk management has emerged as an increasingly important issue in logistics as disruptions in the supply chain have become critical issues for many companies. The scientific literature on the subject is developing and in many respects the understanding of it is still in its infancy. Thus, there is a need for more information in order for scholars and practitioners to understand the causalities and interrelations that characterise the phenomenon. The aim of this dissertation is to narrow this gap by exploring key aspects of supply chain risk management through two maritime supply chains in the immediate region of the Gulf of Finland.

The study contributes to the field in three different ways. Firstly, it facilitates the identification of risks on different levels of the supply chain through a systematic analysis of the processes and actors, and of the cognitive barriers that limit the actors' visibility and their understanding of the operations and the risks involved. There is a clear need to increase collaboration and information exchange in order to improve visibility in the chain. Risk management should be a collaborative effort among the individual actors, aimed at obtaining a holistic picture. Secondly, the study contributes to the literature on risk analysis through the use of systemic frameworks that illustrate the causalities and linkages in the system, thereby making it easier to perceive the vulnerabilities. Thirdly, the study enhances current knowledge of risk control in identifying actor roles, risk visibility and risk controllability as being among the key factors determining risk-management effectiveness against supply-chain vulnerability.

This dissertation is divided into two parts. The first part gives a general overview of the relevant literature, the research design and the conclusions of the study, and the second part comprises six research publications. Case-study methodology with systematic combining approach is used, where in-depth interviews, questionnaires and expert panel sessions are the main data collection methods. The study illustrates the current state of risk management in multimodal maritime supply chains, and develops frameworks for further analysis. The results imply that there are major differences between organizations in their ability to execute supply chain risk management. Further collaboration should be considered in order to facilitate the development of systematic and effective management processes.

**Keywords:** supply chain risk management, identification, analysis, assessment, control, visibility, information exchange, vulnerability, public, private, maritime, multimodal

UDC 658.7:65.01:656.61:316.776



## ACKNOWLEDGEMENTS

The past three years that I have spent with this research have been the hardest and at the same time the most rewarding of my life. The beginning of this journey was cumbersome and full of obstacles: nevertheless, surmounting the obstacles was an educational experience. I learned to open my mind to new ideas and to discuss them with others. Now that I have reached my goal, I have many people to thank for encouraging and guiding me in my efforts.

I would like to express my gratitude to my supervisors, Professor Jukka Hallikas and Professor Jouni Koivuniemi, whose open-minded guidance and encouragement have supported me every step of the way. I would also like to thank my reviewers, Professor Ruth Banomyong and Professor Hannu Kärkkäinen for their helpful and constructive comments that increased the quality of my work.

I am grateful to have been working in an open and friendly environment such as the Northern Dimension Research Centre and the Technology Business Research Center, where I have been encouraged to come up with new aspects in developing my work. I would like to express my gratitude to Paavo Ritala, Mika Immonen and Ossi Taipale in particular for their helpful suggestions on both the theoretical and practical level. For improving my English communication in this dissertation I would like to express my appreciation to Ms Joan Nordlund and Ms Minna Vierimaa.

I would also like to extend my gratitude to everyone in Thammasat Business School I had the pleasure to work with during my exchange period in Bangkok. The experience I gained during the visit gave me new perspectives on my work.

I am also grateful for the financial support I have received from the following foundations: Lappeenrannan teknillisen yliopiston tukisäätiö, Lauri and Lahja Hotisen rahasto, The Finnish Maritime Foundation, The Dr.h.c. Marcus Wallenberg Foundation, The Auramo Foundation and The Werner Hacklin Foundation.

I would like to thank my family and friends for their support and understanding during these last few years. Most importantly, I would like to express my gratitude to my mother Pirjo: you found the strength to support your son even during your tough battle with cancer.

Finally and especially, I would like to express my most heartfelt gratitude to you, Anna, for being by my side when I needed you the most.

Lappeenranta, April 2012

*Jyri Vilko*



# TABLE OF CONTENTS

## PART I: AN OVERVIEW OF THE DISSERTATION

|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>INTRODUCTION .....</b>                                     | <b>15</b> |
| 1.1      | Background and research gap .....                             | 15        |
| 1.2      | Research objectives and questions .....                       | 20        |
| 1.3      | Positioning the research .....                                | 22        |
| 1.4      | Definitions of the key concepts applied in the research.....  | 24        |
| 1.4.1    | Multimodal supply chains.....                                 | 24        |
| 1.4.2    | Supply chain risk .....                                       | 25        |
| 1.4.3    | Supply chain vulnerability .....                              | 27        |
| 1.4.4    | Supply chain management.....                                  | 27        |
| 1.4.5    | Supply chain risk management.....                             | 28        |
| 1.4.6    | Supply chain visibility .....                                 | 28        |
| 1.4.7    | Supply chain information exchange .....                       | 29        |
| 1.4.8    | Supply chain collaboration .....                              | 29        |
| 1.5      | The structure of the thesis .....                             | 31        |
| <b>2</b> | <b>THEORETICAL BACKGROUND.....</b>                            | <b>33</b> |
| 2.1      | Transaction cost theory in the context of supply chains ..... | 33        |
| 2.2      | The resource-based view in the context of supply chains.....  | 36        |
| 2.3      | Risks related to supply chains .....                          | 38        |
| 2.4      | Supply chain risk management .....                            | 43        |
| 2.4.1    | Risk identification.....                                      | 45        |
| 2.4.2    | Risk analysis .....   | 46        |
| 2.4.3    | Risk control.....   | 47        |
| 2.4.4    | Developments in supply chain risk management .....            | 48        |
| <b>3</b> | <b>RESEARCH DESIGN .....</b>                                  | <b>53</b> |
| 3.1      | The research approach and the theoretical perspective.....    | 53        |
| 3.2      | Case-study research.....                                      | 56        |
| 3.3      | Systematic combining in case research.....                    | 59        |
| 3.4      | The research process and the data collection .....            | 61        |
| 3.5      | The validity and reliability of the study .....               | 65        |

|          |  |           |
|----------|--|-----------|
| <b>4</b> | <b>A REVIEW OF THE RESULTS .....</b>   | <b>69</b> |
| 4.1      | Positioning the publications in the context of supply chain risk management  | 69        |
| 4.2      | Publication 1 – Origin and impact of supply chain risks affecting supply security .....  | 73        |
| 4.2.1    | Main objective .....   | 73        |
| 4.2.2    | Main findings .....  | 73        |
| 4.3      | Publication 2 - Risk assessment in multimodal supply chains.....   | 74        |
| 4.3.1    | Main objective .....   | 74        |
| 4.3.2    | Main findings .....  | 75        |
| 4.4      | Publication 3 - Information-exchange vulnerability in supply chains .....  | 76        |
| 4.4.1    | Main objective .....   | 76        |
| 4.4.2    | Main findings .....  | 76        |
| 4.5      | Publication 4 - An information-exchange perspective on supply chain risk management: systemic organizational motives and cognitive barriers..... | 77        |
| 4.5.1    | Main objective .....   | 77        |
| 4.5.2    | Main findings .....  | 78        |
| 4.6      | Publication 5 - The Nature of risk, visibility and control in supply chains.....   | 79        |
| 4.6.1    | Main objective .....   | 79        |
| 4.6.2    | Main findings .....  | 79        |
| 4.7      | Publication 6 - Supply chain risk management: risks, roles and control in maritime supply chains.....  | 80        |
| 4.7.1    | Main objective .....   | 80        |
| 4.7.2    | Main findings .....  | 80        |
| <b>5</b> | <b>CONCLUSIONS.....</b>  | <b>83</b> |
| 5.1      | Answering the research questions .....   | 83        |
| 5.2      | Contribution to the literature .....   | 85        |
| 5.3      | Methodological contribution.....   | 90        |
| 5.4      | Managerial implications .....  | 91        |
| 5.5      | Limitations and suggestions for further research .....   | 92        |
|          | <b>REFERENCES.....</b>   | <b>95</b> |

**PART II: PUBLICATIONS**

**APPENDIX**



## LIST OF PUBLICATIONS

The publications are listed in non-chronological order in accordance with the particular purposes of the research setting.

1. Vilko, Jyri and Hallikas, Jukka (2012) Origin and impact of supply chain risks affecting supply security, *International Journal of Shipping and Transportation Logistics*, Vol. 4, Accepted manuscript, Article in press.
2. Vilko, Jyri and Hallikas, Jukka (2011) Risk assessment in multimodal supply chains, *International Journal of Production Economics*, Accepted manuscript, available online since 21.9.2011. DOI: 10.1016/j.ijpe.2011.09.010.
3. Vilko, Jyri and Rumpu, Anna (2012) Information-exchange vulnerability in supply chains, *Journal of Business Administration*, Accepted manuscript, article in press.
4. Vilko, Jyri, Rumpu, Anna and Koivuniemi, Jouni (2012) An information-exchange perspective on supply chain risk management: systemic organizational motives and cognitive barriers, *International Journal of Logistics Systems and Management*, Accepted manuscript, Article in press.
5. Vilko, Jyri, Ritala, Paavo and Hallikas, Jukka (2012) The nature of risk, visibility and control in supply chains; a revised version of the paper published in the proceedings of the 17<sup>th</sup> *International Working Seminar on Production Economics*, (Innsbruck, Austria, February, 2012).
6. Vilko, Jyri and Hallikas, Jukka (2011) Supply chain risk management: risks, roles, and control in maritime supply chains; a revised and further submitted version of the paper published in the proceedings of the 16<sup>th</sup> *International Symposium on Logistics*, (Berlin, Germany, June, 2011).

## **THE CONTRIBUTION OF THE AUTHOR TO THE PUBLICATIONS**

### **Publication 1**

Responsibilities in the research: Responsible for the research process and planning.

Data collection and analysis: Responsible for the data collection and analysing the results

Writing the paper: Lead author, wrote most of the paper.

### **Publication 2**

Responsibilities in the research: Responsible for the research process and planning.

Data collection and analysis: Responsible for the data collection and analysing the results.

Writing the paper: Lead author, wrote most of the paper.

### **Publication 3**

Responsibilities in the research: Responsible for the research process and planning.

Data collection and analysis: Responsible for the data collection and analysing the results.

Writing the paper: Lead author, wrote most of the paper.

### **Publication 4**

Responsibilities in the research: Responsible for the research process and planning.

Data collection and analysis: Responsible for data the collection and analysing the results.

Writing the paper: Lead author, wrote most of the paper.

### **Publication 5**

Responsibilities in the research: Responsible for the research process and planning.

Data collection and analysis: Responsible for the data collection and analysing the results.

Writing the paper: Lead author, wrote most of the paper.

### **Publication 6**

Responsibilities in the research: Responsible for the research process and planning.

Data collection and analysis: Responsible for data the collection and analysing the results.

Writing the paper: Lead author, wrote most of the paper.

## Figures

|           |   |    |
|-----------|---|----|
| Figure 1  | Positioning the research.....   | 23 |
| Figure 2  | Outline of the thesis.....  | 31 |
| Figure 3  | From open-market to hierarchical governance in supply chains.....   | 34 |
| Figure 4  | The connections between the various concepts covering risk management in supply chains (Waters, 2007) ..... | 42 |
| Figure 5  | Supply chain risk management.....   | 43 |
| Figure 6  | A framework for managing risks in supply chains (adapted from Waters, 2007).....                            | 45 |
| Figure 7  | The risk matrix (adapted from Norrman and Lindroth, 2002) .....   | 46 |
| Figure 8  | A Framework for assessing and positioning risk in supply chains (Lindroth and Norrman, 2001).....           | 47 |
| Figure 9  | Introducing the research approach .....   | 53 |
| Figure 10 | Research dimensions (Järvensivu and Törnroos, 2010) .....   | 54 |
| Figure 11 | Systematic combining in abductive case research (Dubois and Gadde, 2002).....                               | 60 |
| Figure 12 | The time-line of the research process .....   | 63 |
| Figure 13 | The positioning of the publications .....   | 69 |

## Tables

|          |   |    |
|----------|---|----|
| Table 1  | A summary of the working definitions.....   | 30 |
| Table 2  | Different perceptions of supply chain risk (adapted from Sodhi, Son and Tang, 2012).....                                    | 41 |
| Table 3  | Risk classification (Manuj and Mentzer, 2008b).....   | 42 |
| Table 4  | Studies on supply chain risk management and related fields.....   | 49 |
| Table 5  | Supply chain risk management: research focus and approaches in the literature (adapted from Sodhi, Son and Tang, 2012)..... | 51 |
| Table 6  | Ontological and epistemological worldviews (Järvensivu and Törnroos, 2010).....   | 55 |
| Table 7  | The relative strengths and limitations of a case-study research strategy (adapted from Vissak, 2010).....                   | 58 |
| Table 8  | Research data related to the different publications.....  | 64 |
| Table 9  | Validity Procedures based on the Qualitative Lens and Paradigm Assumptions (Cresswell and Miller, 2000).....                | 65 |
| Table 10 | A summary of the findings and the contributions of the publications.....  | 72 |
| Table 11 | The research questions and the publications.....  | 83 |

**PART I: AN OVERVIEW OF THE DISSERTATION**



# 1 INTRODUCTION

This chapter begins the thesis by describing the research area, and setting out the main objectives and research questions in order to give an indication of the expected contributions. Thereafter the key concepts are introduced, and the relations between them explained.

## 1.1 Background and research gap

Supply chains have become the centre of attention in many firms aiming to improve organizational competitiveness in the twenty-first century. Companies are tending more and more to explore the potential of the concept of supply chain management in order to improve their revenue growth. The chains are becoming more agile with a view to getting the products to the customer more quickly and at a minimum total cost (Gunasekaran, Lai and Cheng, 2006). Global supply chains comprise a multitude of companies acting as part of a long and complex logistics system (Wagner and Neshat, 2010). The length and complexity of supply chains derives from the many parallel physical and information flows in place to ensure that products are delivered in the right quantities, to the right place in a cost-effective manner (Jüttner, 2005). The increasing demands for improved transportation performance, higher on-time delivery rates and reduced damage-in-transit require a high level of flexibility and the ability to adapt to changes.

The increase in length and complexity of global supply chains is attributable to many drivers, including globalization, the development of communications and other technologies, e-business, complex international networks of industrial partners, unpredictable demand, cost pressures, outsourcing, reliance on suppliers, international governmental intervention, and more lean and agile logistics (Waters 2007; Craighead et al., 2007; Harland, Brechley and Walker, 2003; Hult, 2004; Mason-Jones, Naylor and Towill, 2000; Narasimhan and Talluri, 2009; Thun and Hoenig, 2009, 2011; Brindley, 2004). According to some authors, improved infrastructures have also added to the complexity and the length of the chains (e.g.,

Blome and Schoenherr, 2011; Tang, 2006; Aydin, 2012). Moreover, Wagner and Neshan (2010) emphasise the increase in and intensity of disasters in recent decades.

Competition between companies is getting ever tougher. Organizations that previously relied on traditional vertical integration are being forced to re-evaluate their business models, and in order to avoid interruptions in logistic flows they have to increase cooperation with their partners (Edwards, Peters and Sharman, 2001; Svensson, 2001). Companies in search of higher efficiency are being forced to disintegrate their operations and cooperate with each other. Cooperation typically entails more information exchange between partners, thus the development of information systems has had a huge impact (Pereira, 2009). Information systems may make supply chains function more efficiently, but they have become a major source of vulnerability that supply chain risk management has to take into account. There are studies reporting on the increased risk exposure in disintegrated chains relying on complicated systems (e.g., Wagner and Bode, 2006).

The continuing disintegration and the specialization of operations have made the chains vulnerable to disturbances from both inside and outside the system. The visibility of operations outside the companies' own functions has weakened, and with it the ability to identify the risks threatening them and the whole supply chain. As Harland, Brenchley and Walker (2003) note, less than 50 per cent of the risks were visible to the focal company in the supply chains they examined. In most cases the business impact associated with the risk of disruption is much greater than that of operational risks (Tang, 2006).

Previously supply chains were thought to be purely operational activities, and on those grounds were ignored and trivialized by many managers (Gattorna, 1998). Many recent events have shown how vulnerable long and complex supply chains are, however, thus attracting the attention of many academics and resulting in some guidance in the form of research reports and publications. Although awareness of the vulnerability and of risk management is increasing among practitioners, certain related concepts are still in their infancy. There are thus insufficient conceptual



frameworks and empirical findings to provide a clear picture of the phenomenon of supply chain risk management (Jüttner, 2005; Manuj and Mentzer, 2008b). Both academic research and practitioner reports stress its importance and the need to develop different approaches (e.g., Blos et al., 2009; Manuj and Mentzer, 2008b; Shaer and Goedhart, 2009). The focus in recent articles and books has been on the need for the systematic analysis of supply chain vulnerability (e.g., Peck et al., 2003).

According to Frankel et al. (2008), logistics is undergoing continuous, considerable and rapid change, and supply chain risk management is of growing importance in this context (Trkman and McCormack, 2009). Indeed, disruption in the supply chain has become a critical issue for many companies (Singhal, Hendricks and Zhang, 2009). As the amount of multimodal transportation is growing, so is its importance in international trade. There are more than two billion containers transporting cargo in the world (Hu, 2011). According to Beresford, Pettit and Liu (2011), the choice of transport mode, or combination of modes, may have a direct impact on the efficiency of a multimodal supply chain. The recent rapid rise in container-transport volumes has brought shorter delivery times, but has also exposed actors in the chains to various risks. Complicated and combined transportation has increased inter-organizational dependency. Organizations therefore need to understand the holistic picture in order to ensure proper resilience against the various risks in these multimodal supply chains.

According to Soosay, Hyland and Ferrer (2008), inter-organizational relationships in supply chains have become increasingly important. Integrated and seamless logistics can play a crucial role in facilitating global supply-chain processes (Banomyong 2005). Yet, in practice, greater integration increases the dependency between companies, and exposes them to the risks of other companies (Hallikas et al., 2004). Indeed, increasing risks are a current trend in logistics, and supply chains are more vulnerable than ever before (Wagner and Nethan, 2010; Minahan, 2005). According to Jüttner (2005), any approach to managing risks from a supply-chain perspective must have a broader scope than that of a single organization, and should provide

insights into how the key processes extend to at least three organizations. Hence, in order to assess the vulnerabilities in a supply chain companies must identify the risks not only to their operations but also to all other entities, as well as those caused by the inter-organizational linkages.

Many recent events have signalled how vulnerable long and complex chains are. According to Jüttner (2005), a disruption affecting an entity anywhere in the supply chain can have a direct effect on a corporation's ability to continue operations, get finished goods to the market and provide critical services to customers. In the US a ten-day shutdown of 29 ports costs one billion dollars per day to the US economy, which illustrates the effects that disruptions can have (Park et al., 2008; Jüttner, 2005). Investor reactions have also been significant in that companies admitting to major supply-chain problems have seen their shareholder value drop by 10 per cent on average (Handfield and McCormack, 2008; Hendricks, Singhal and Zhang, 2009). According to Blome and Schoenherr, (2011), the current financial crisis has emphasized the role of supply chain risk management in many companies. Indeed, Jüttner (2005) found that 44 per cent of organisations expected their vulnerabilities to increase within the next five years. More recently, the need for supply chain risk management is evidenced in the results of Snell's (2010) study showing that 90 per cent of the respondent companies feared supply risks, whereas only 60 per cent felt confident or knowledgeable enough about such issues. Moreover, Christopher et al. (2011) found that most companies did not have a structured management and mitigation system covering supply chain risk. It is therefore no surprise that risks are considered the main reason why desired performance is not achieved in supply chains (e.g., Tummala and Schoenherr, 2011; Blackhurst et al., 2005; Swink and Zsidisin, 2006; Craighead et al., 2007; Hendricks, Singhal and Zhang, 2009).

Thus, it is no wonder that the notion of supply chain risk management has been increasingly attracting and receiving attention from academic researchers. The concepts are under development, and many are still without a commonly accepted definition. More research is thus needed and several academics have pointed out clear gaps in current studies. Almost a decade ago Zsidisin (2003) addressed the

need for managerial perceptions of risk from different perspectives in future research. In a more recent article Lavastre, Gunasekaran and Spalanzani (2011) suggest the need for more case studies on how different companies perceive and assess risks in their supply chains. Sodhi, Son and Tang (2012), in turn, found three gaps in the current literature on supply chain risk management: i) there is no clear consensus on the definition, ii) there is a lack of commensurate research on responses to risk incidents, and iii) there is a shortage of empirical research in the area. Furthermore, they gave suggestions for narrowing the gaps: more industry-based case studies, event-study-based research, and the development of conceptual knowledge on which to base empirical investigation (Sodhi, Son and Tang, 2012).

Although there are several studies on supply chain risk management in the current literature, only a few of them concern multimodal maritime supply chains. Given that supply risks and, further, the likelihood of supply disruptions are emerging as a key management challenge, the ability to identify the parts of the chain with greater disruption potential is a critical first step in managing the frequency and impact of the disruptions that endanger the security of supply (Trkman and McCormack, 2009).

The supply chains operating between the Gulf of Finland and mainland Finland are extremely important for the security of Finnish supply, as sea transport comprises over 80 per cent of the country's cargo flows. Moreover, the Gulf of Finland has a special position with the three biggest ports on its shores. Finland as a northern country with small markets and great distances is particularly vulnerable, and here the ports on the Gulf of Finland are in a unique position. If a port is unable to receive cargo, supply chain disruptions, or at least delays, will be likely. Disruptions in the downstream chain can also affect the Gulf of Finland's maritime transportation in the case of a disaster in or near the ports.

This thesis explores supply chain risk management in terms of the effects and the critical management aspects involved in assessing and controlling the risks. The perspective is holistic, meaning that the phenomenon is studied from the viewpoint

of each individual actor and on different levels of the chain in order to reach an understanding of the whole system.

## **1.2 Research objectives and questions**

Given the research gaps discussed above, there is a clear need for more studies on supply chain risk management. Both practitioners and academics agree that there is a need for more case studies on how risks are perceived and managed. The objective of this study is to narrow the gaps by studying the phenomenon from three different perspectives, namely risk identification, risk analysis and risk management. These aspects are addressed in the context of two multimodal maritime supply chains operating in the Gulf of Finland. More precisely, the first supply chain extends from the Gulf of Finland to inland Finland, and the second, in which the examination focuses on information exchange, runs between the Baltic States and Finland.

According to the literature, the risks in the Gulf of Finland mostly concern maritime transportation in terms of environmental effects, security, or the failure of insurance companies to consider the viewpoint of the organizations operating in the area. Cargo flows have grown substantially during the last decade. The financial crisis has resulted in some downturn, but given that economic growth will continue in the EU, and especially in Russia, the traffic volume will also continue to rise in the future. So far there have been fewer accidents in the Baltic Sea Region compared to traffic density than in the world on average (Pelto, 2003): the average frequency of accidents in the Gulf of Finland is about 0.2 per 1,000 transportations, varying between 0.1 and 0.84 during the last ten years (Kujala, Hänninen and Ylitalo, 2009; Finnish Maritime Administration, 2011; SÖKÖ II, 2011). As transport volumes continue to rise, however, the probability of unwanted events increases. Finland as a northern country with small markets and great distances is particularly vulnerable to supply-chain disruptions.

Given the developing state of the theory and the few studies on supply chain risk management that have been conducted in this geographical area, the case-study

method with the systematic combining was adopted in order to bring in new insights from the field. The case study facilitates the logical linking of the exploratory data with the “how” type of research questions in focus (Yin, 1994). In order to enhance understanding of supply chain risk management, the main question addressed this study was broadly formulated as follows.

**Research Question:** *How can the risks in multimodal supply chains be managed?*

This main question is divided into three more specific sub-questions that address the different aspects of the research problem.

**Sub-Question 1:** *How can the risks in a multimodal supply chain be identified?*

As discussed above, the risks in logistics supply chains have increased due to a series of trends. Identifying these risks has become increasingly difficult for the companies involved. Given that supply risks and, further, the likelihood of disruption are emerging as a key challenge in supply chain management, the ability to identify the parts of the chain that are more prone to disruption is a critical first step in managing its frequency and impact (Trkman and McCormack, 2009). The first research question therefore focuses on the first activity of supply chain risk management, risk identification, which is one of the most crucial parts of the process because the subsequent activities have no meaning without it (Waters, 2007). The source and severity of risk and its relationship with business objectives, together with the threat of disruption are considered key concepts in the management of risk in supply chains (Waters, 2007). With that in mind, risk identification is examined in the two above-mentioned case supply chains. The focus in the first is on identifying the sources of risk and the nature of their impact. In the second case, following their identification the risks are analysed in terms of information flows and exposure/vulnerabilities in relation to the business objectives. The next step is to analyse the dimensions of their impact (severity and threat), hence it is natural to ask:

**Sub-Question 2:** *How can the risks in a multimodal supply chain be analysed?*

The second sub-question follows the risk-management process in focusing on risk analysis. Some researchers argue that this is the most important phase (e.g., Blackhurst, Scheibe and Johnson, 2008). In the supply-chain context the nature of the risks is complex, which makes them hard to analyse. However, in order to manage something one must have a holistic understanding of it. This is particularly relevant in complicated supply-chain structures in which the companies involved vary in their analytical skills. The aim in this dissertation is thus to shed light on processes of risk analysis, including the nature of its impact. Different methods are used to analyse and explore the most relevant risks.

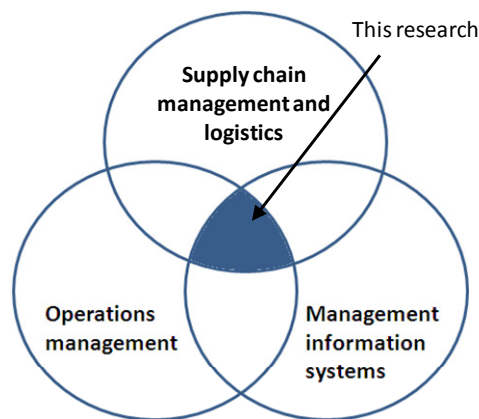
**Sub-Question 3:** *How can the risks in a multimodal supply chain be controlled through risk-management actions?*

Finally, following the risk analysis, the third question concerns the actual management phase. In addition to identifying and analysing the risks, actors in supply chains vary in their ability to influence and prepare for them. Numerous organisations are involved in various positions and operations in multimodal supply chains, and their risk-management abilities and opportunities differ. Even though there are several risk-identification and analysis frameworks available, most companies do not have a structured risk-management system. On the contrary, most of them use a number of informal practices in coping with risk issues. (Christopher et al., 2011) The third question therefore examines how actors can control different kinds of risks in supply chains.

### **1.3 Positioning the research**

Supply chain risk management is a multidisciplinary and very broadly defined concept with many research streams, and in many ways it is still in the process of being defined in the scientific literature (Smith and Buddress, 2005). Some scholars do not even recognise supply chain management as a separate discipline, which complicates the explicit positioning of the research (Smith and Buddress, 2005).

Given the strong emphasis on the management of supply chains in this dissertation, however, and the resulting research overlap with other scientific disciplines, the positioning is defined from three perspectives, as follows. The research contributes at the intersection of three disciplines, namely supply chain management and logistics, operational research, and the management of information systems (Figure 1). The chosen approach links to these disciplines with its emphasis on risk management. Thus combining the three perspectives will allow a holistic view on supply chain risk management to emerge, which takes the processes into account in a broader sense.



**Figure 1 Positioning the research**

This perspective on supply chain management and logistics incorporates logistics activities between organizations. This is important given that many scholars nowadays argue that competition is no longer between organizations, but rather between supply chains. Lambert, García-Dastugue and Croxton, (2008), discussing supply chain management and logistics, criticise researchers for using the terms as synonyms. According to (CSCMP, 2012), the former is a broader concept and takes the processes into account in a wide sense. This interpretation is also applied in this research: the supply chains in question are logistic, multimodal, maritime supply chains.

Operations management has a clear position in this research. Through it and the methods applied it allows analysis of the complex risks in multimodal supply

chains. Understanding the complicated interrelations and uncertainties in this context therefore requires analytical methods such as decision analysis and simulation. Operations management is inextricably linked to both logistics and supply chain management, but it shifts the focus onto the processes, inside and outside the chain.

The management of information systems is closely related to both disciplines, and its position is particularly strong nowadays when supply chains incorporate numerous different information systems that have improved their efficiency, but have also made them vulnerable to various disturbances. Efficient management is therefore essential.

## **1.4 Definitions of the key concepts applied in the research**

This section gives the definitions of the key concepts. The concepts are summarised in Table 1 at the end of the section.

### **1.4.1 Multimodal supply chains**

A supply chain is defined as a system of suppliers, manufacturers, distributors, retailers and customers in which material, financial and information flows connect participants in both directions (Fiala, 2005). According to Lambert, Cooper and Pagh (1998), supply chains consist of networks of structures, processes and management components. They provide the linkage between supply and demand, binding together the producer of the service or product and the customer. Meanwhile, Waters (2007) describes a supply chain as consisting of a series of activities and organisations through which material moves on its journey from initial suppliers to final customers. Material includes everything that an organisation moves—both tangible and intangible. Supply chains have become the centre of attention in many firms aiming to improve organisational competitiveness in the twenty-first century.



Multimodal supply chains are international transport systems combining various modes of transport, such as ship, rail and truck, primarily through the use of containers. Containers ensure the transport of unitised cargo from its origin to its final destination, with efficiency and the least possible risk (UNCTAD, 1993). There are two prominent characteristics in the multimodal transport chain: first, there may be more than one means of transport from one place to another, and second, in order to allow transfer from one means to another the place should have additional facilities for loading/unloading containers to/from transport tools of different means, for example (Hu, 2011). The costs and risks of multimodal transportation have attracted research attention, and various models have been created to enable logistics practitioners to choose the most cost-effective and risk-free mode or combination of modes (Christopher, 2005; Yan, Bernstein and Sheffi, 1995; Barnhart and Ratliff, 1993; Minh, 1991).

#### **1.4.2 Supply chain risk**

There are various conceptualisations of risk, the nature of which is hard to grasp. The literature on risk management offers few clear definitions (Holton, 2004; Chiles and McMackin, 1996). According to Rao and Goldsby (2009), the reason for this may be the tension in the academic literature on the nature of risk.

Waters (2007) defines risk as a threat that something might occur to disrupt normal activities and stop things happening as planned. On the finance side, risk is considered in terms of the probabilities of expected outcomes (Beaver, 1966). This view is probably the oldest one known as it was used for insuring merchant ships hundreds of years ago. In terms of strategy, risk is used to adjust the rates of capital return on investment (Christensen and Montgomery, 1981) and the variability of expected and actual returns (Bettis, 1981). The literature also covers the risk related to strategic actions and relational risks (opportunism, cheating, stealing, for example: Baird and Thomas, 1985; Bettis and Mahajan, 1985; Manuj and Mentzer, 2008b). From a marketing perspective risks concern the nature and importance of buying goals and the failure to meet psychological or performance goals (Cox,

1967; Manuj and Mentzer, 2008b). Typically, the literature on supply chain management defines risk as purely negative and as leading to undesired results or consequences (Harland, Brenchley and Walker, 2003; Manuj and Mentzer, 2008b). Academics and professionals define risk in a multitude of ways depending on the discipline and the context. According to Paulsson (2004), it is an event with negative consequences, or “the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge”. In the context of supply chains, risk is defined in terms of interruption caused by resource unreliability and uncertainty (Tang and Nurmaya Musa, 2010). It is defined in this study as the potential occurrence of an incident or failure that inhibits the free and undisrupted flow of material and information, thereby causing interruption in the supply chain (Tang and Nurmaya Musa, 2010; Waters, 2007; Zsidisin, 2003).

A standard formula for the quantitative definition of supply chain risk is thus:

$$\text{Risk} = P(\text{Loss}) * I(\text{Loss}),$$

where risk is defined as the product of the probability (P) of loss times the significance of its consequences (I) (Mentzer et al., 2001).

Hetland (2003) and Diekmann, Sewester and Tahen (1988) view risks as indicative of an uncertain phenomenon. Waters (2007) explains the difference between the concepts: risk occurs because there is uncertainty about the future. According to him, the key difference is that risk yields some quantifiable measure of future events, whereas uncertainty does not. This uncertainty means that unexpected events may occur: we can list the events that might happen in the future, but we have no idea of what will actually happen or of the relative likelihood. Both concepts concern the lack of knowledge about the future, and events that may or may not happen, but they make no reference to whether the events are harmful or beneficial. Knight (1921) produced what could be regarded as the best known and most used typology of uncertainty for risk management, distinguishing between certainty, risk and uncertainty. In defining risk Knight coined the terms (quantitative) “measurable” uncertainty, and (non-quantitative) “unmeasurable” uncertainty when

only partial knowledge of outcomes, such as beliefs and opinions, is available. Some authors criticise the fact that the literature on supply chain risk management does not always clearly distinguish between risk and uncertainty, which makes the definitions quite vague (Tang and Nurmaya Musa, 2010)

### **1.4.3 Supply chain vulnerability**

Peck (2005) describes supply chain vulnerability as exposure to serious disturbance arising from risks within as well as external to the chain. How sensitive a supply chain is to these disturbances is measured by its vulnerability. Waters (2007) suggests that vulnerability reflects the susceptibility of a supply chain to disruption and is a consequence of the risks it faces. According to Wagner and Bode (2006, p. 304), “supply chain vulnerability is a function of certain supply chain characteristics and that the loss a firm incurs is a result of its supply chain vulnerability to a given supply chain disruption”. Furthermore, Jüttner (2005) describes supply chain vulnerability as the propensity of risk sources and risk drivers to outweigh risk-mitigating strategies, thus causing adverse consequences and jeopardising the supply chain’s ability to effectively serve the end-customer market. How sensitive a supply chain is to these disturbances is measured by its vulnerability, which in turn depends on its structural agility and resilience. This is where risk management plays a crucial role.

### **1.4.4 Supply chain management**

According to Lysons and Farrington (2006), there is no unique definition of supply chain management (SCM). Tan (2001) defines it as a holistic and strategic approach to operations, materials and logistics management, and it has been described as a management philosophy, the implementation of a management philosophy, and the management process. SCM is the function responsible for the transport and storage of materials on their journey from the original suppliers via intermediate operations to the final customers (Waters, 2007). Hence, it controls the flow of materials through the supply chain. According to Chopra and Meindl (2003), there are three main decision-making levels involved: the strategic, the tactical and the operational.

Strategic-level decisions are long-term, covering five or more years, for example, whereas tactical-level decisions are medium-term (six months to a year) and take into account logistical requirements and the relevant parties or networks. Finally, on the operational level are short-term decisions that are made weekly or daily, and sometimes in the face of sudden changes, which facilitate compliance with the tactical decisions outlined above. An example is detailed scheduling and routing (Chopra and Meindl, 2003)

#### **1.4.5 Supply chain risk management**

Risk management is the function responsible for managing risks in organisations, meaning taking actions that reduce the consequences or probability of an unwanted occurrence or failure. It can also be defined as taking “actions to shift the odds in your favour” (Paulsson, 2004, 79, Ref. The Royal Society, 1992). The aim of supply chain risk management is to identify the potential sources of risk and implement appropriate actions in order to avoid or contain supply chain vulnerability (Narasimhan and Talluri, 2009).

#### **1.4.6 Supply chain visibility**

One of the key factors in supply chain risk management is risk identification, which as many authors acknowledge is closely related to visibility (e.g., Caridi et al., 2010; Al-Mudimigha, Zairib and Ahmedc, 2004). It is generally agreed that visibility in the supply chain provides benefits in terms of efficiency (e.g., Smaros et al., 2003), productivity, and the effective planning of operations (e.g., Petersen, Ragatz and Monczka, 2005). Christopher and Lee (2004) describe visibility as the actors’ knowledge of what goes on in other parts of the chain. The visibility of operations outside the companies’ own functions has decreased, and with it the ability to identify risks threatening the companies and the whole supply chain. Events that affect one supply-chain entity or process may interrupt the operations of other members of the chain, thus the issue is of greater significance in global than in local supply chains (Wagner and Bode, 2006).

#### **1.4.7 Supply chain information exchange**

Information within the supply chain has become a vital element in terms of integration, performance and successful implementation (Chen et al., 2010). Information exchange in this context could be defined as the extent to which information is communicated between the partners in the chain. In facilitating dynamic actions and decision-making, the exchange of information of a sufficiently high quality is vital in the coordination of operations within supply chains (Li and Lin, 2006; Fiala, 2005).

According to Minahan (2005), the success of supply management depends heavily on the ability to access, organise, analyse and utilise data. Information has become a key driver for improving performance in the supply chain by better matching supply with demand (Fu and Zhu, 2009). It can also reduce the incidence of inaccuracy and redundancy. However, the invaluable assistance available from these systems has had yet another consequence: namely, information disruption, which has increased the vulnerability of information-dependent supply chains (Tang et al., 2010).

Managing the information exchange is an important part of supply chain risk management (Gunasekaran, Lai and Cheng, 2008). According to Seal et al. (1999), information exchange is a crucial element of SCM. Despite the recognized threat of information-exchange disruption and its potential damage to the organizations involved and to whole supply chains, there is a clear lack of research in this area (Tang and Nurmaya Musa, 2011; Pereira, 2009). There have been some recent studies, but more are needed.

#### **1.4.8 Supply chain collaboration**

The many definitions of supply chain collaboration fall into two groups in terms of conceptualization: those with a process focus and those with a relationship focus. On the one hand, collaboration is viewed as a business process whereby two or more supply-chain partners work together towards common goals, whereas on the other it is defined as the formation of close, long-term partnerships of supply-chain

members working together and sharing information, resources and risk in order to achieve mutual objectives (Mentzer et al., 2001; Stank, Keller and Daugherty, 2001; Manthou, Vlachopoulou and Folinas, 2004; Sheu, Lee and Niehoff, 2006). As a term, supply chain collaboration has been criticised as an amorphous meta-concept with no clear meaning, which is one of the reasons why it is difficult to implement in organizations (e.g., Barratt, 2004).

**Table 1 A summary of the working definitions**

| <b>Concept</b>  | <b>Working definition</b>   |
|---|---|
| Supply chain  | A system of suppliers, manufacturers, distributors, retailers and customers in which material, financial and information flows connect participants in both directions (Fiala, 2005)  |
| Supply chain management   | The function responsible for the transport and storage of materials on their journey from original suppliers through intermediate operations to final customers (Waters, 2007)  |
| Risk  | A threat that something might happen to disrupt normal activities and stop things happening as planned (Waters, 2007)   |
| Supply chain risk management; the management of risk in supply chains | An umbrella concept incorporating the identification, analysis and control of risk. It refers to the overall function responsible for all aspects of risk to the supply chain; it ensures that the principles established by the senior managers are applied to logistics risk (adapted from Waters, 2007)  |
| Risk identification   | The initial step of supply chain risk management in which potential threats to the chain are identified (Waters, 2007)  |
| Risk analysis   | The second step of supply chain risk management in which the risks are evaluated and assessed (Waters, 2007)  |
| Risk control; risk-management action; risk mitigation; risk response  | The third step of supply chain risk management, referring to actual risk-management actions based on the information produced during the identification and analysis stages (adapted from Waters, 2007)   |
| Multimodal supply chains  | International transport systems combining various modes of transport, such as ship, rail and truck, primarily through the use of containers (Beresford, Pettit and Liu, 2011)   |
| Supply chain visibility   | The actors' knowledge of what goes on in other parts of the chain (Christopher and Lee, 2004)   |
| Supply chain collaboration  | Process-focused or relationship-focused collaboration: the former is viewed as a business process whereby two or more supply-chain partners work together towards common goals, whereas the latter refers to the formation of close, long-term partnerships among supply-chain members working together and sharing information, resources and risk in order to achieve mutual objectives (Mentzer et al., 2001; Stank, Keller and Daugherty, 2001; Manthou, Vlachopoulou and Folinas, 2004; Sheu, Lee and Niehoff, 2006) |
| Supply chain information exchange                                     | The extent to which information is communicated between the partners in the supply chain (Li and Lin, 2006; Fiala, 2005)  |

## 1.5 The structure of the thesis

This thesis consists of two main parts: the overview (Part I) and the publications (Part II: see Figure 2). Part I serves as an introduction to the research, describing the background and motivations, summarising the theoretical background and research approach, and presenting the results and conclusions. Given the practice of systematic combining followed in the study, the research process was iterative. It was redirected according to the findings from each round, which the separate publications in Part II represent here. Part II comprises the six publications that aim to answer the research questions from different points of view. The general conclusions of the research are based on the findings presented in these publications.

| <b>Part I: An Overview of the dissertation</b> |   |
|--|---|
|  | <ul style="list-style-type: none"><li>- Introduction</li><li>- Theoretical background</li><li>- Research design</li><li>- Review of the results</li><li>- Conclusions</li></ul> |
| <b>Part II: Publications</b>                   |   |
| Publication 1                                  | Origin and impact of supply chain risks affecting supply security   |
| Publication 2                                  | Risk assessment in multimodal supply chains   |
| Publication 3                                  | Information-exchange vulnerability in supply chains   |
| Publication 4                                  | An information-exchange perspective on supply chain risk management: systemic organizational motives and cognitive barriers   |
| Publication 5                                  | The nature of risk, visibility and control in supply chains   |
| Publication 6                                  | Supply chain risk management: risks, roles and control in maritime supply chain   |

**Figure 2** Outline of the thesis





## 2 THEORETICAL BACKGROUND

This chapter describes the theoretical background of the study. It also introduces the theories applied, namely transaction cost theory and the resource-based view, and explains how those relate to supply chain management and the management of risk in supply chains.

### 2.1 Transaction cost theory in the context of supply chains

As mentioned above, supply chain management is related on the theoretical level to the transaction-cost theories introduced in the “Nature of The Firm” (Coase, 1937), according to which the organizing of a company’s production is based on minimizing costs at each and every stage. The theory became commonly known through Williamson (1975, 1985) and his analyses. The basic premise is that a transaction occurs whenever the product moves from one production phase to another. A company has two choices in terms of managing this: integrating the phase into its own production line, or purchasing it either on the market or by making a contract with another company. The administration or planning, the implementation and the monitoring incur costs in any case, and thus the solution that minimizes the transaction costs sets the limits for the company (Williamson, 1975). In other words, transaction costs are minimized when the characteristics of the institutional arrangements are in balance with the transaction requirements. The aim in transaction cost analysis, therefore, is to find out why transactions under certain institutional arrangements operate more or less efficiently (Müller, 2002).

The independent variables used in transaction cost theory are *specificity*, *uncertainty* and *frequency*. Uncertainty here refers to the predictability of the number of modifications in terms of *quality*, *time*, *price* or *volume* in a transaction. The level of uncertainty therefore depends on how much these variables vary over time. (Williamson, 1975; Müller, 2002)

Specificity is defined in terms of how high the value difference is between the intended and the second-best use of resources, and frequency measures how often the transaction occurs. (Williamson, 1975, 1981)

Transaction cost theory defines three strategic options for a company in organizing its structure and relations among other actors, *market*, *hybrid* and *hierarchical*. According to Williamson, the best way for an organization to minimize costs is to coordinate these strategies in line with the independent variables using fixed and variable transaction costs as attributes. Fixed transaction costs are those arising from coordination, whereas variable costs are those arising from the transaction and depend on the specificity. (Williamson, 1981; Müller, 2002)

In the supply-chain context, hierarchy refers to vertical integration when the focal company rules the whole supply chain. This entails high fixed costs and requires good mechanisms to reduce uncertainty and specificity. According to Coase (1937), organizations tend to carry out their operations internally until the costs of the hierarchy exceed those on the market. Market refers here to situations in which organizations have no fixed agreements at all. The fixed costs are low, however the mechanisms for controlling uncertainty and specificity are weak. Coase (1937) considers firms and markets the only organizational governance structures, and thus internal operations generate hierarchy costs and operations purchased from the market generate transaction costs (Rindfleisch and Heide, 1997). The hybrid structure Williamson (1991) introduces includes the intervening structures. From the perspective of the supply chain, Williamson's (1985) extreme governance forms can be depicted as a continuum ranging from a perfectly competitive open market to the vertically integrated hierarchy of a focal company (its supply chain) (see Figure 3 below).



**Figure 3 From open-market to hierarchical governance in supply chains (adapted from Spekman, Kamauff and Myhr, 1998)**

A network can be seen as a type of organizational structure falling between the market and the hierarchical forms. The network structure of a supply chain is rather difficult to define precisely, but the basic idea is quite easy to grasp intuitively: the organizations act together on different levels of cooperation and with low levels of vertical integration (Chen and Paulraj, 2004). Harland (1996) defines networks as specific types of relation linking a defined set of persons, objects and events. Supply chain management is the function responsible for managing these arrangements. Its implementation incurs high transaction costs (Müller, 2002), although with long-term relations and information exchange it is possible to maintain lower transaction costs than with market-based competition (Hallikas, 2003).

Transaction cost theory also rests on certain behavioural assumptions, namely opportunism and bounded rationality (Williamson, 1985). Williamson (1985) defines opportunism as the strongest form of self-interest, accounting for circumstances in which individuals seek to exploit the situation to their own advantage. Bounded rationality, on the other hand, refers to the limited cognitive ability and rationality among individuals to make and evaluate decisions (Rindfleisch and Heide, 1997).

Some scholars have criticised the use of the traditional construct of transaction cost theory, mainly because it focuses on static explanations and neglects midrange relationships (see Grover and Malhotra, 2003; Hobbs, 1996 and Blomqvist, Kyläheiko and Virolainen, 2002).

There is scant reference to transaction cost theory in the context of supply-chain management, although the latter theory is rather young and still under development. New institutional economics theories are rarely applied either, however, and transaction cost theory is considered valid in terms of explaining why certain structural arrangements and companies exist in supply chains (Seuring and Müller, 2003). Müller (2002), for example, included the characteristics of transactions costs in his analyses of supply chain management. Moreover, transaction costs are evident in logistics supply chains, especially in the context of outsourcing. It has become

cheaper for companies with lower transaction costs to be less vertically integrated, which means that they become disintegrated and increasingly vulnerable to various risks. Specificity, for example, has been used as an independent variable in the field of logistics and supply chain management to explain vertical integration (Aertsen, 1993; Rindfleisch and Heide, 1997).

## **2.2 The resource-based view in the context of supply chains**

The resource-based view and transaction cost theory constitute the theoretical background of this study. The former originates in the studies of Penrose (1959), in which firms are described as bundles resources – both tangible and intangible (Barney, 1991) - that they use to pursue their competitive strategies (Conner, 1991; Parnell and Hershey, 2005). In other words, how well these resources are exploited determines the growth of the firm.

The goal is thus to create sustainable competitive advantage through the acquisition of Valuable, Rare, Imperfectly imitable and Non-substitutable (VRIN) resources (Barney, 1991; Peteraf, 1993). According to Barney (1991), a resource includes “all assets, capabilities, organisational processes, firm attributes, information, knowledge, etc. controlled by a firm” that enable it to “improve its efficiency and effectiveness.” The resource-based view, according to Kovacs and Tatham (2009), distinguishes various resources, and also attributes differences in efficiency and effectiveness (competitiveness) among firms to differences in resource configurations. These resource configurations are arranged through the use of *organisational capabilities*, defined by Winter (2003) as “a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization’s management a set of decision options for producing significant outputs of a particular type.”

The original model of the resource-based view focused on the firm’s internal resources. Since then, it has been broadened to include resources that can be acquired or complemented through partnerships (Conner, 1991; Harrison et al.

2001). Grant (2005), for example, proposes an extension to the original model through the categorisation of resources as *material*, *immaterial* and *human* based, which could include combining the organisation's internal resources in order to respond to the external environment. Furthermore, according to Teece (1986), the concept of *complementary capability* emphasises the external capabilities needed to perfect the organisation's internal capabilities. As an extension of the original model, the notion of collaboration has assumed significance in the resource-based view through the involvement of organisations that mutually leverage each other's resources and capabilities in order to derive competitive advantage (Min et al. 2005).

The organisation's logistical resources have been categorised as *input factors*, *assets* and *capabilities* (Olavarrieta and Ellinger, 1997). Here, *input factors* refer to materials and skills acquired from the market, *assets* to the stocks or investments that comprise the physical and technological infrastructure, and *capabilities* to the skills and assets required for organising the resources (Olavarrieta and Ellinger, 1997).

The resource-based view has received only limited attention in the context of supply-chain risk, although it has been used in recent studies to complement transaction theory (e.g., Arnold, 2000; Watjatrakul, 2005). Furthermore, it has been found to have strong explanatory power in value supply chains (e.g., Kähkönen, 2010; Lassar et al. 2010; Ketchen and Hult, 2007; Holcomb and Hitt, 2007; Miles and Snow 2007).

The effective management of risks in supply chains requires an understanding not only of the risks themselves but also of the capabilities and resources that can be utilized in the process. The resource-based view is adopted in this study because it clearly compliments the transaction-cost perspective on supply chain risk management in terms of explaining the differences in organizational risk-management capabilities and the mutual complementation of the resources and capabilities in the network of actors. In other words, it sheds light on the differences

between the risk-management capabilities among actors in the supply chain, and therefore can help in identifying the essential elements on which to focus in the development of an effective risk-management strategy.

### **2.3 Risks related to supply chains**

Organisations in a supply chain are in closer relationships than in markets that expose them to risks coming from both inside and outside the chain. It is a fact that risks may bring positive value to the company, and according to Zsidisin et al. (2004), acknowledging their existence is critical. Nowadays organisations tend to prefer a less vertically integrated structure. Since the early 1990s numerous companies have implemented various initiatives in the supply chain to increase revenues and to reduce costs (Sodhi, Son and Tang, 2012). This has increased the complexity, however, and has made the chains more vulnerable to various risks from inside and outside (Minahan, 2005; Craighead et al. 2007).

Risk in a supply chain comprises anything that affects the material or information flow between the original supplier and the end customer (Norrman and Lindroth, 2002). According to Tang and Nurmaya Musa (2011), any material, financial or information risk can disrupt the normal operations.

Even though risk management in supply chains is becoming increasingly popular among researchers, the current literature is still very much under development. The phenomenon of supply chain risk in particular has attracted more attention in recent decades (Tang and Nurmaya Musa, 2010), but there are diverse perceptions among researchers from different fields, who approach it from different perspectives (Sodhi, Son and Tang, 2012). The related concepts are also still rather unclear, and Jüttner, Peck and Christopher (2003), for example, note that the use of the term “risk” is confusing. They argue that risk should be clearly separated from its sources and consequences, and categorise the sources in three different groups: i) environmental risk (those external to the supply chain), ii) network-related risk and

iii) organisational risk (which cannot be predicted with certainty and that affects the supply-chain-outcome variables).

There are various categorisations of supply chain risk. It is suggested in the current literature that the categorisation should be tailored to the supply chain in question. Blackhurst, Scheibe and Johnson (2008) argue that the most important step during the process of risk assessment is the selection and definition of the categories, which then can be weighted, compared and quantified. Some categorisations are industry-specific and others general: in the present study the risks were classified according to the case.

According to Tang (2006), risks may be operational or disruptive. They are operational when their consequences are minor but the probability of their occurrence is high. Such risks can cause disturbances in the supply chain that are not considered serious. However, if they occur simultaneously or cause a snowball effect the consequences may be serious. There is more reference to disruptive risks, which Tang (2006) and Knemeyer, Zinn and Eroglu (2009) describe as low-probability-high-consequence (LP-HC) events. Such risks rarely materialise, but when they do they have a high impact on the chain.

Brindley (2004) describes high-impact risks as follows: the probability of the occurrence of catastrophic events is small but the business impact associated with them can be extremely damaging to the supply chain. This refers to natural hazards (force majeure), socio-political instability, civil unrest, economic disruptions and terrorist attacks (Keindorfer and Saad, 2005; Martha and Subbakrishna, 2002). These events are so rare that they are usually not considered. However, the consequences may be significant, and as such should be acknowledged on some level, at least by supply-chain managers. Knemeyer, Zinn and Eroglu (2009) propose a four-step planning process for proactive protection against such events: i) identification of the key supply-chain locations and threats, ii) estimation of the probabilities and loss for each location, iii) the evaluation of alternative counter-

measures for each location, and iv) the selection of counter-measures for each location.

Wagner and Bode (2006) describe a framework identifying three sources of risk: supply-side, demand-side and catastrophic. In one of the most recent articles, Christopher et al. (2011) classify global supply chain risks in four categories: supply risk, process and control risks, environmental and sustainability risks, and demand risks.

Mason-Jones and Towill (1998) and Jüttner, Peck and Christopher (2003) identify three risk groups: i) internal risks arising from the organisation, ii) supply chain risks that are external to the organisation but within the supply chain, and iii) external risks that are external to the supply chain and arise from the partners or the environment. Risks are significant if their realisation would disturb the free flow of materials or information in the supply chain.

Waters (2007) categorises risks in the same way, but offers other options as well. One interesting possibility is to distinguish between physical risks associated with the movement and storage of materials, financial risks associated with the flow of money, information risks associated with the systems and the flow of information, and organisational risks arising from the links between the members of the supply chain.

In the context of risks in logistics supply chains, Yang (2010) identifies three risk types in maritime supply chains from the security perspective, namely operational risk, physical risk and financial risk.

Although the literature on supply chain risk management is expanding, there is still a lack of consensus on the sources of the risk (Rao and Goldsby, 2009): Sodhi, Son and Tang (2012) review the main risk areas in their recent article. Table 2 shows the diversity of perceptions of supply chain risk in different studies, and gives a clear indication of the missing consensus on its definition.



**Table 2 Different perceptions of supply chain risk (adapted from Sodhi, Son and Tang, 2012)**

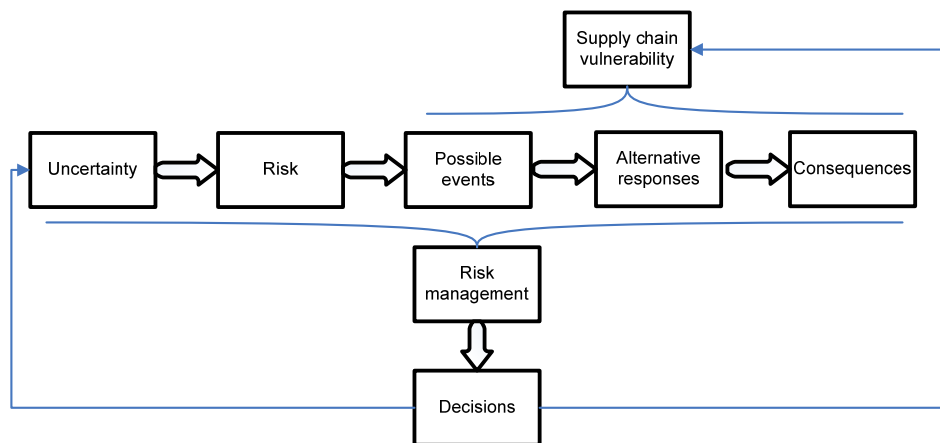
| Author                               | Scope of risks  |
|--------------------------------------|---|
| Jüttner, Peck and Christopher (2003) | Environmental sources, network sources, and organizational sources  |
| Spekman and Davis (2004)             | (1) inbound supply, (2) information flow, (3) financial flow, (4) the security of a firm's internal information system, (5) relationship with partners, and (6) corporate social responsibility         |
| Cavinato (2004)                      | (1) physical, (2) financial, (3) informational, (4) relational, and (5) innovational sources  |
| Chopra and Sodhi (2004)              | Categorise supply chain risks at a high level as disruptions or delays. These risks pertain to (1) systems, (2) forecasts, (3) intellectual property, (4) receivables, (5) inventories and (6) capacity |
| Christopher and Peck (2004)          | (1) process, (2) control, (3) demand, (4) supply, and (5) the environmental   |
| Kleindorfer and Saad (2005)          | Risks sources and vulnerabilities from (1) operational contingencies, (2) natural hazards, and (3) terrorism and political instability  |
| Bogataj and Bogataj (2007)           | (1) supply risks, (2) process risks, (3) demand risks, and (4) control risks  |
| Sodhi and Lee (2007)                 | (1) supply, (2) demand, and (3) contextual risks requiring both strategic and operational decisions   |
| Tang and Tomlin (2008)               | (1) supply, (2) process, and (3) demand risks, (4) intellectual property risks, (5) behavioural risks and (6) political/social risks  |
| Manuj and Mentzer (2008a)            | (1) supply, (2) operations, (3) demand, and (4) other risks including security and those related to currency  |
| Manuj and Mentzer (2008b)            | (1) supply, (2) operational, (3) demand, (4) security, (5) macro, (6) policy, (7) competitive, and (8) resource risks   |
| Oke and Gopalakrishnan (2009)        | Consider low-impact-high-frequency and high-impact-low-frequency risks in three major categories: (1) supply, (2) demand, and (3) miscellaneous   |
| Rao and Goldsby (2009)               | (1) framework, (2) problem-specific and (3) decision-making risk  |

Xia and Chen (2011) identify four different forms of risk impact, related to quantity, cost, quality and time. The risk analysis in the present study included the three latter forms as identified by the actors in the field. Furthermore, Manuj and Mentzer's (2008) risk classification presented in Table 3 was used as a starting point in determining the source categories.

**Table 3 Risk classification (Manuj and Mentzer, 2008b)**

| Type of risk             | Source  |
|--------------------------|---|
| <b>Supply Risks</b>      | Disruption of supply, inventory, schedules, and technology access; price escalation; quality issues; technology uncertainty; product complexity; frequency of material design changes               |
| <b>Operational Risks</b> | Breakdown of operations; inadequate manufacturing or processing capability; high levels of process variations; changes in technology; changes in operating exposure                                 |
| <b>Demand Risks</b>      | New product introductions; variations in demand (fads, seasonality, and new product introductions by competitors); chaos in the system (the Bullwhip Effect on demand distortion and amplification) |
| <b>Security Risks</b>    | Information systems security; infrastructure security; freight breaches from terrorism, vandalism, crime, and sabotage  |
| <b>Macro Risks</b>       | Economic shifts in wage rates, interest rates, exchange rates, and prices   |
| <b>Policy Risks</b>      | Actions of national governments such as quota restrictions or sanctions   |
| <b>Competitive Risks</b> | Lack of history about competitor activities and moves   |
| <b>Resource Risks</b>    | Unanticipated resource requirements   |

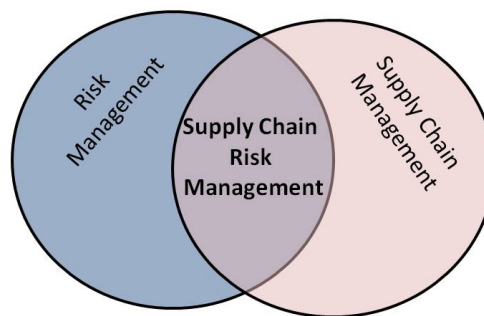
This research reflects the notion of conceptual causality introduced by Waters (2007). The following figure illustrates the focal position of risk management in the holistic management of the uncertainty-driven risks confronting the supply chain.



**Figure 4 The connections between the various concepts covering risk management in supply chains (Waters, 2007)**

## 2.4 Supply chain risk management

Intensifying competition since the 1990s has forced companies to improve efficiency in many aspects of their business. While getting rid of the ‘slack’ in their supply chains they expose themselves to greater uncertainty, and this is what supply chain risk management aims to control. As a concept it is at the intersection of supply chain management and risk management (see Figure 5). The term “supply chain management” is still relatively new, first appearing in the literature in 1982 (Keith and Webber, 1982). It was originally used in the context of logistics, and emphasised a reduction in inventories within and across organisations (Cooper, Lampert and Pagh, 1997). The concept, in general, is still new, and in many companies it is unknown (Blos et al. 2009).



**Figure 5** Supply chain risk management

Lavastre, Gunasekaran and Spalanzani (2011, p. 8) define supply chain risk management as “the management of risk that implies both strategic and operational horizons for long-term and short-term assessment”. According to Brindley (2004), it means “the management of supply chain risk through coordination or collaboration among supply chain partners so as to ensure profitability and continuity”. The aim therefore is to control the risks and uncertainties caused by, or impacted on, logistics-related activities or resources (Waters, 2007). It is executed collaboratively with partners in a supply chain by applying risk-management-process tools (Norman and Lindroth, 2002). According to Christopher et al. (2011), companies managing risks in a global economy should adopt a multidisciplinary approach.

Supply chain risk management starts from the identification and computation of probable risks and their possible impact on operations in the supply process. The first stage is to identify the direct risks to its operations, and then to consider the potential causes of risk at every significant link in every step of the chain. (Lysons and Farrington, 2006) A further aim is to identify the potential sources of risk and implement appropriate actions to avoid or contain vulnerability.

According to Tang (2006), there are two forms of governance in supply chain risk management, namely coordination and collaboration. Along the continuum of supply-chain relationships presented above in Figure 3 it is positioned between cooperation and hierarchy, depending on the depth of relations and information exchange and the form of governance with respect to the focal company.

According to Jüttner, Peck and Christopher (2003), supply chain risk management comprises four main elements: (1) assessing the risk sources, (2) identifying the concepts, (3) tracking the drivers, and (4) mitigating the risks. Kleindorfer and Saad (2005), in turn, propose three process elements, namely (1) specifying the sources of risk and vulnerability, (2) assessment and (3) mitigation, which is fairly close to what Waters (2007) proposes (see Figure 6). Sodhi, Son and Tang (2012) identify similar elements from the literature, differentiating between (1) risk identification, (2) risk assessment, (3) risk mitigation and (4) responsiveness to risk (either operational or catastrophic). Hallikas et al. (2004) propose a similar model: (1) risk identification, (2) risk assessment, (3) risk-management action and (4) risk monitoring.

Supply chain risk management could thus be viewed as a strategic-management activity given that it can affect the operational, market and financial performance of firms (Narasimhan and Talluri, 2009). Figure 6 presents a framework for risk management in supply chains.



**Figure 6** A framework for managing risks in supply chains (adapted from Waters, 2007)

### 2.4.1 Risk identification

It is generally agreed that identification is the initial step in the process of supply chain risk management. According to Waters (2007), identifying the risks is a key activity on which all other aspects of the process are based. However, in reality it is virtually impossible to list every conceivable risk, and identification will only cover the most significant in terms of their effect on the supply chain. Inter-organisational actors usually have the most intimate knowledge of the organisation and its conditions, but do not necessarily have the capability to identify risks. Organisations cannot rely on personal knowledge and informal procedures, but need some formal arrangements (Waters, 2007).

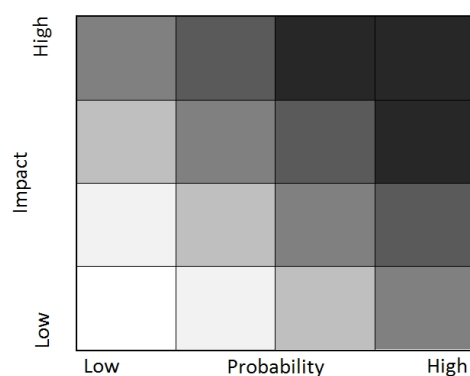
There are numerous techniques covering the management of risk in supply chains (see e.g., Peck et al., 2003). According to Lavastre, Gunasekaran and Spalanzani (2011), the tools tend to be used more in the risk-identification and assessment phases. One of the most popular, Failure Mode and Effects Analysis (FMEA), is introduced in this study. A proactive tool for risk identification and analysis, FMEA was developed by NASA in 1963 to identify, evaluate and prevent product and/or process failures (Hu et al., 2009). It is considered a powerful and effective analytical tool for examining possible failure modes in a system (Chen, 2007). According to Van Leeuwen et al. (2009), FMEA can be used to prioritise risks and monitor the effectiveness of risk-control activities, and therefore is valuable in terms of identifying risks, including those related to human factors. The conventional FMEA procedure suffers from inadequate definition of some steps, high uncertainty, and even decision-making failures throughout the procedure (Bluvband and Grabov, 2009). Further disadvantages include the assumption that the failure modes are all single events and level in nature, the fact that it requires a lot of time, resources and

cooperation to achieve the required detail, that it takes limited account of human error, and that it may give an identical risk-priority value to different events even though the implication may be totally different (e.g., Rhee and Ishii, 2003; Pillay and Wang, 2003; Xiao et al. 2011; Hsu, Tan and Cross, 2011). Scholars acknowledge the limitations of FMEA, and there have been attempts to overcome some of the drawbacks (see e.g., Franceschini and Galetto, 2001; Sankar and Prabhu, 2001; Arunachalam and Jegadheesan, 2006; Chen, 2007; Wang et al. 2009).

### 2.4.2 Risk analysis

Analyses of risks affecting the supply chain should also take into account where the risks derive from so that contingencies can be built in to mitigate their effects or prevent their realisation. Handfield and McCormack (2008) define the severity of disruption as the number of nodes within a supply network whose ability to ship and/or receive goods and materials has been affected by an unplanned, unanticipated event. All supply chains carry some risk, but the extent depends on multiple factors including the density, criticality and node density of the network.

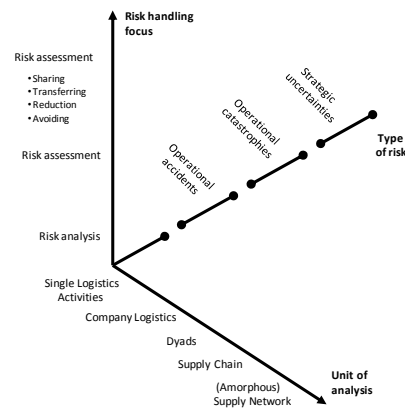
Norrman and Lindroth (2002) developed a two-dimensional risk matrix based on measures of impact and probability. The matrix can be used to assess the severity of risk, as illustrated in Figure 7.



**Figure 7 The risk matrix (adapted from Norrman and Lindroth, 2002)**

Lindroth and Norrman, (2001) further propose a three-dimensional framework (see Figure 8 below) comprising the risk-handling focus, the type of risk and the unit of

analysis. The framework is useful for examining the multi-dimensional construct of risk, which many authors recognise (e.g., Zsidisin, 2003; Peck et al., 2004).



**Figure 8 A Framework for assessing and positioning risk in supply chains (Lindroth and Norrman, 2001)**

### 2.4.3 Risk control

Consequent to their analysis, the risks have to be properly managed (Gerber and von Solms, 2005). According to Scarff, Carty and Charette (1993, p. 2), the management of risk refers to the “overall process by which risks are analysed and managed”, whereas risk management entails “planning, monitoring and controlling activities which are based on information produced by risk analysis activity”. In order to avoid confusion among these two terms, the concept of supply chain risk management is assumed in this study to include the overall process in which risks are identified, analysed and controlled, whereas the concept of risk control refers to the actual risk-management actions based on the information produced from risk identification and analysis.

Waters, (2007) defines the activity of supply chain risk management following risk analysis as “designing an appropriate response”, in other words determining the most appropriate way of dealing with the risks. Once they have been identified and prioritised, and the amount of attention each risk deserves has been assessed, careful consideration should be given to the amount of resources required to deal with them.

Waters (2007) suggests the following range of responses to risk: ignore or accept it, reduce the probability, reduce or limit the consequences, transfer, share or deflect the risk, make contingency plans, adapt to it, oppose a change, or move to another environment. Tummala and Schoenherr (2011) present a list of ‘risk triggers’, and like many other authors divide the risks according to their ‘consequence severity level’ and ‘risk probability’, which finally determines the severity.

#### **2.4.4 Developments in supply chain risk management**

Numerous studies have been published on supply chain risk management and in related fields in the last decade (see Table 4). Tang (2006), for example, reviewed the quantitative models, and realised that they were designed to cope with operational rather than disruption risks. He also discovered that the use of risk-management strategies could improve supply-chain efficiency in terms of operational risks, and make the chain more resilient in managing disruption risks. Manuj and Mentzer (2008b) also studied risk-management strategies, as well as their antecedents. On the basis of their findings they suggested certain categories of risk, thereby enhancing knowledge of risk interactions in the supply-chain context.

Tang (2001), in defining the concept of supply chain management, added the need for genuine cooperation, which Hallikas et al. (2004) also advocate.

Yu, Zheng and Zhao (2009) studied the impacts of disruption risks and came to the conclusion that the interdependency in supply chains has increased, and that this makes them vulnerable to such risks.

Christopher and Lee (2004) assessed the importance of supply-chain visibility, noting its relation with information exchange, and further that supply chains were increasingly vulnerable. Xu, Dong and Evers (2001) and Fiala (2005), in turn, studied coordination in supply chains and came to the conclusion that information exchange between the actors was one of the keys to successful management. In another study related to information, Pereira (2009) found evidence of the benefits information technology has brought to supply chains, but also warned about the



vulnerabilities. More recently, Tang and Nurmaya Musa (2010) discovered a lack of attention to information flows in the literature on supply chain risk management. Their study included cash, materials and information, which appear to comprise supply-chain flows.

**Table 4 Studies on supply chain risk management and related fields**

| Author                                 | Focus  | Findings  |
|--|--|---|
| Tang, C. (2006)                        | Quantitative risk models and SCRM strategies | - Quantitative models are designed primarily for managing operational risks, not disruption risks.<br>- SCRM strategies can make a supply chain more efficient in terms operational risks and more resilient in terms of managing disruption risks. |
| Manuj and Mentzer (2008b)              | Risks and SCRM strategies                    | - Definitions of different supply chain risks<br>- Interaction among the different risks<br>- SCRM strategies<br>- Antecedents of strategy selection  |
| Tang and Nurmaya Musa (2011)           | Research developments in the SCRM literature | - Quantitative models and supply-chain information-flow risk have received less attention<br>- Risks in material, cash and information flows.   |
| Xu, Dong and Evers (2001)              | Coordination, information exchange           | - Effective information exchange is one of the keys to the success of supply-chain coordination.  |
| Yu, Zheng and Zhao (2009)              | The impacts of supply disruption             | - Organizational relationships have developed to become integrated, interdependent supply-chain networks<br>- The change has caused problems in the form of the risk of disruption in the supply chain  |
| Tan (2001)                             | Supply chain management strategies           | - Genuinely integrated supply chain management requires a massive commitment by all members.  |
| Giannakis and Louis (2011)             | Framework for a SCRM decision-support system | - The use of IT decision-support systems is becoming an indispensable tool for designing and managing complex supply-chain systems.   |
| Blackhurst, Scheibe and Johnson (2008) | Supplier risk-assessment methodology         | - A framework of risk factors<br>- A multi-criteria-scoring risk-assessment and monitoring system   |
| Christopher and Lee (2004)             | Supply-chain visibility and confidence       | - Vulnerability of supply chains to disturbance or disruption has increased<br>- Visibility is a key element of SCRM<br>- Visibility will increase in proportion to the quality of information in the supply chain.                                 |
| Fiala (2005)                           | Information sharing in supply chains         | - SCM is affected by network and dynamic business environments and by information and communication technologies<br>- Information exchange is very important in coordinating the actions of units   |
| Pereira (2009)                         | Information management                       | - IT supports information management, but is also a source of vulnerability in the supply chain.  |

As mentioned above, the increase in risk reported by company executives has made supply chain risk management an attractive proposition to researchers wishing to have an impact on business. However, as researchers with different kinds of expertise approach this emerging field in which the terms and concepts are still under development, a discussion about the various perceptions of the tools and their appropriateness has arisen (Sodhi, Son and Tang, 2012). According to Zsidisin (2008, p. 2), the problem is that “many authors choose to highlight particular dimensions or perspectives appropriate to their focus of attention”. From the beginning the terms used in this field have been broad, which illustrates the complexity. As new perspectives come to light, some researchers have started looking for the common ground.

Sodhi, Son and Tang (2012) adopted a multi-method approach in their study of supply chain risk management, reviewing articles, interviewing researchers, posting surveys and distributing questionnaires. With a view to finding a holistic understanding of the field they analysed how researchers have defined supply chain risk and its management, how they have addressed the whole process, and what methods they have used. Table 5 illustrates how the different steps in the process have contributed to the scientific literature. It also shows how the studies are distributed quite evenly among conceptual, quantitative empirical and qualitative empirical research approaches.

Vanany, Zailani and Pujawan (2009) identify four categories of supply chain risk management, which vary in terms of contributions: Risk identification (9 articles), Risk assessment (18), Risk management (24) and Business continuity (7). What is noticeable in both of these studies is that risk identification is somewhat neglected in comparison to assessment and management actions. This is surprising given the evidence that companies typically struggle to identify supply-related risks.

**Table 5 Supply chain risk management: research focus and approaches in the literature (adapted from Sodhi, Son and Tang, 2012)**

| Articles                           | Research focus on SCRM |          |            | Research approach        |                             |                            |
|------------------------------------|------------------------|----------|------------|--------------------------|-----------------------------|----------------------------|
|                                    | Identification         | Analysis | Mitigation | Conceptual/<br>Framework | Empirical<br>(quantitative) | Empirical<br>(qualitative) |
| Treleven and Schweikhart (1988)    | x                      | x        |            | x                        |                             | x                          |
| Johnson (2001)                     |                        |          | x          |                          |                             | x                          |
| Hendricks and Singhal (2003)       |                        | x        |            |                          | x                           |                            |
| Chopra and Sodhi (2004)            | x                      | x        | x          | x                        |                             |                            |
| Christopher and Lee (2004)         |                        |          | x          | x                        |                             |                            |
| Giunipero and Eltantawy (2004)     |                        | x        | x          | x                        |                             |                            |
| Norrman and Jansson (2004)         | x                      | x        | x          |                          |                             | x                          |
| Spekman and Davis (2004)           | x                      |          | x          | x                        |                             |                            |
| Zsidisin et al. (2004)             | x                      | x        | x          |                          |                             | x                          |
| Blackhurst et al. (2005)           |                        |          | x          |                          |                             | x                          |
| Hendricks and Singhal (2005a)      |                        | x        |            |                          | x                           |                            |
| Hendricks and Singhal (2005b)      |                        | x        |            |                          | x                           |                            |
| Kleindorfer and Saad (2005)        | x                      | x        | x          | x                        | x                           |                            |
| Brun et al. (2006)                 |                        | x        |            | x                        |                             | x                          |
| Choi and Krause (2006)             |                        |          | x          | x                        |                             |                            |
| Cucchiella and Gastaldi (2006)     |                        |          | x          | x                        |                             |                            |
| Gaudenzi and Borghesi (2006)       |                        | x        |            |                          |                             | x                          |
| Bogataj and Bogataj (2007)         |                        | x        |            |                          |                             |                            |
| Sodhi and Lee (2007)               | x                      |          | x          | x                        |                             | x                          |
| Cheng and Kam (2008)               | x                      | x        | x          | x                        |                             |                            |
| Manuj and Mentzer (2008a)          | x                      | x        | x          | x                        |                             | x                          |
| Tang and Tomlin (2008)             |                        |          | x          | x                        |                             |                            |
| Wagner and Bode (2008)             |                        | x        |            |                          | x                           |                            |
| Braunscheidel and Suresh (2009)    |                        |          | x          |                          | x                           |                            |
| Jiang, Baker and Frazier (2009)    |                        |          | x          |                          | x                           |                            |
| Knemeyer et al. (2009)             | x                      | x        | x          | x                        |                             |                            |
| Neiger, Rotaru and Churilov (2009) | x                      |          |            | x                        |                             |                            |
| Oke and Gopalakrishnan (2009)      | x                      |          | x          | x                        |                             | x                          |
| Rao, Goldsby and Iyengar (2009)    | x                      |          |            | x                        |                             |                            |
| Trkman and McCormack (2009)        | x                      | x        |            | x                        |                             |                            |
| Ellis, Henry and Shockley (2010)   |                        | x        |            |                          | x                           |                            |
| TOTAL                              | 14                     | 18       | 19         | 19                       | 19                          | 19                         |

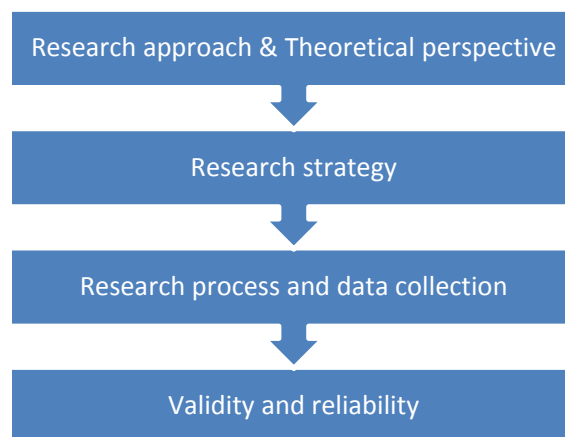
Table 4 and Table 5 give a good picture of the recent contributions and their focus in the field of supply chain risk management. The literature reviews presented (Vanany, Zailani and Pujawan, 2009 and Sodhi, Son and Tang, 2012) above illustrate where the focus of the research has been and the number of contributions

dealing with the different aspects. They do not take into account the depth of the research conducted nor its quality, however. Supply chain risk management is linked with many fields in science, and therefore the contributions typically present a solution to a specific problem and lack generalizability. There is thus a need for new information in order to form a critical mass through which the concepts can be defined.

Finally, it is clear from the available literature that, as a scientific discipline, supply chain risk management is still in its infancy. A number of the concepts lack a commonly agreed definition, and in many ways awareness of the risks related to supply chains is still poor. It is also clear that there has been less emphasis on the strategic level than on the operational level. Nevertheless, research on the subject has been accumulating during the last decade or so, and several studies address the phenomenon from the perspectives of risk identification, analysis and control. It is clearly difficult to find common solutions given the vastness of the field and the contributions from different domains of science with their different terminologies.

### 3 RESEARCH DESIGN

This chapter describes how the research was conducted. The first section presents the research approach and the theoretical perspective, sections 2 and 3 cover the research strategy, section 4 describes the process and methods of data collection with respect to the six publications presented, and finally, section 5 discusses the validity and reliability of the study in the light of previous findings (see Figure 9 below).



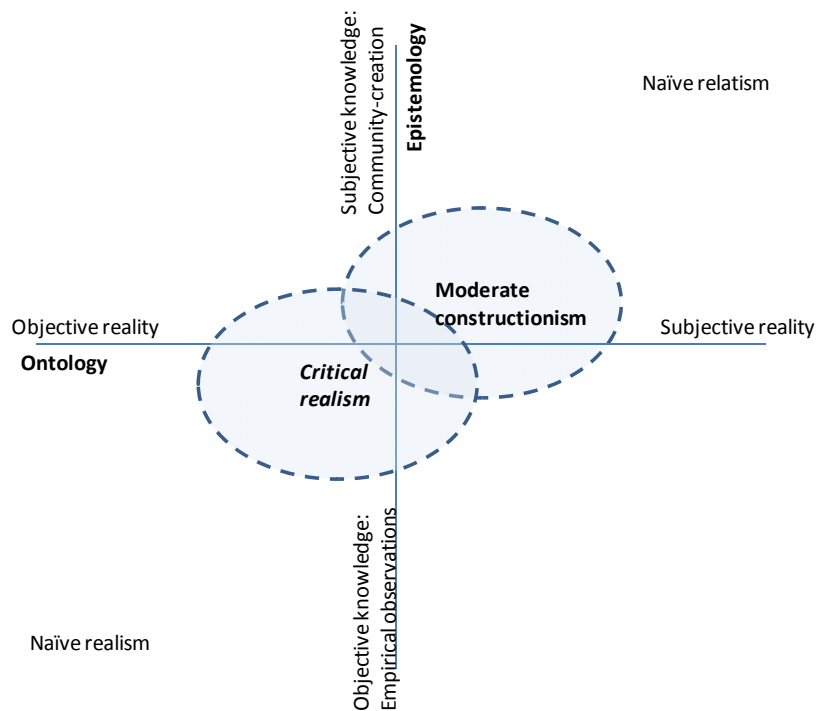
**Figure 9** Introducing the research approach

#### 3.1 The research approach and the theoretical perspective

The interdisciplinary nature of supply chain management must influence the choice of research approach. The issues are typically multidimensional and questions are generally asked both ontologically and epistemologically (Chen and Paulraj, 2003). Ontology and epistemology are focal concepts in the philosophy of science. Angeles (1981) defines ontology as “that branch of philosophy which deals with the order and structure of reality in the broadest sense possible”. In the social sciences it refers to the claims or assumptions that a particular approach to social enquiry makes about the nature of social reality – the fundamental assumptions about what reality is (Blaikie, 1993). Epistemology, on the other hand, embodies assumptions about the ways in which it is possible to attain knowledge of this reality: “How we know

what we know” (Crotty, 2003). It is basically a theory of knowledge, and is concerned with the view and justification of what knowledge is (Blaikie, 1993).

The nature of the approach is not unidimensional in the present research setting. A group of methods was used in the case studies, reflecting both critical realism and moderate constructionism. The classification could also be based on the analytical assumptions in the social sciences reflecting subjective and objective realism (see Figure 10 below). Table 6 explains the concepts and their positioning along the different research dimensions (Järvensivu and Törnroos, 2010).



**Figure 10 Research dimensions (Järvensivu and Törnroos, 2010)**

**Table 6      Ontological and epistemological worldviews (Järvensivu and Törnroos, 2010)**

|                         | <b>Naive realism</b>   | <b>Critical realism</b>  | <b>Moderate Constructionism</b>  | <b>Naive relativism</b>  |
|-------------------------|--|--|--|--|
| <b>Ontology</b>         | Only one, true reality exists; universal truth claims apply                                  | There is a reality; specific local, contingent truth claims apply  | There may be a reality; specific local, contingent truth claims apply  | There is no reality beyond subjects  |
| <b>Epistemology</b>     | It is possible to know exactly what this reality is through objective, empirical observation | It is possible to move closer to local truths through empirical observation, bounded by community-based critique/consensus | It is possible to understand local truths through community-based knowledge creation and empirical observation bounded by subjectivity | It is possible to form an understanding of subjective reality through the analysis of the subject's account of knowledge |
| <b>Methodology</b>      | Direct empirical observations  | Empirical observation bounded by subjectivity and community-based critique/consensus                                       | Community-based knowledge creation through empirical observation bounded by subjectivity   | Analysis of knowledge structures and processes by observing texts  |
| <b>Research Process</b> | Deductive, theory testing  | Abductive; theory generating and testing   | Abductive; theory generating and testing   | Inductive; theory generating   |

Two opposing philosophies are traditionally used to define the approach to management research: positivism and phenomenology (e.g., Moran 2000). Positivist and phenomenologist theories of knowledge divide the generalization process into deductive and inductive reasoning. Whereas Positivism relies on hypothesis testing from large congruent data sets, the phenomenological approach involves interpreting and understanding the phenomenon. Abductive reasoning is a mixture of these two methods. According to Kovács and Spens (2005), the inductive and abductive approaches aim at theory development, whereas the deductive approach aims at testing or evaluating the theory. The difference between the two is that induction traditionally involves generalizing findings from empirical data, whereas abduction focuses on understanding and interpreting a new phenomenon (Kovács and Spens, 2005).

Both critical realism and moderate constructionism are grounded in the abductive approach, which is a so-called mixed-method approach incorporating characteristics of both deductive and inductive reasoning. Theories found from the scientific

literature were used as a framework in this study, which is characteristic of the deductive approach. The framework was then developed in accordance with the qualitative data collected, which in turn was used to study the local phenomena as is distinctive of the moderate constructionist approach. The aim was to increase general understanding of the research subject from the stakeholder perspective and to reach a community consensus via expert group sessions. This approach resulted in a good understanding of complex business networks and facilitated theoretical abstraction with limited sample sizes. All the publications were based on qualitative, so-called soft data, the aim of which is to understand and explain the phenomenon.

### **3.2 Case-study research**

The chosen strategy for this research was the instrumental case-study method. According to Yin (1994), the case-study method is useful when the aim is to gain theoretical and empirical insight into topics that have not received much previous research attention. Case studies facilitate in-depth research into dynamic, experiential and complex processes and areas, and the construction of interesting and easily readable descriptions and rich understandings (Eisenhardt and Graebner, 2007; Gummesson, 2003; Ghauri, 2004; Halinen and Törnroos, 2005). According to Voss et al. (2002), the qualitative approach typically involves no hypothesis setting beforehand, and the researcher should have no pre-conceived assumptions concerning the subject. Eisenhardt (1989), in turn, describes the strategic focus of case research as understanding the dynamics present within single settings.

An information-oriented critical-case-selection strategy was thus adopted. The aim is to maximise the utility of information, and the case selection is based on the researcher's expectations of the information content (Flyvbjerg, 2011). More specifically, the purpose in critical case the selection is to arrive at logical deduction. According to Flyvbjerg (2011), a critical case could be defined as "having strategic importance in relation to the general problem".



A case strategy is particularly suitable for studying business and information networks (Halinen and Törnroos, 2005; Bensabat, Goldstein, and Mead, 1987). Given the complexities of these systems one of the benefits of case research in this study was that it allowed the data to be gathered over a long period and from multiple levels, perspectives and sources (Yin, 1994; Ghauri, 2004; Leonard-Barton, 1990; Dubois and Gadde, 2002; Vissak, 2010; Patton and Applebaum, 2003). This made it possible to collect a large amount of data in numerous interviews with people in different positions within the international, multimodal supply chain.

The chosen research approach allowed in-depth studying of the processes in the supply chain and the related risk-management activities in the companies. Case research is usually suitable when “how” or “why” questions are addressed, and when the research subject is studied in its natural real life setting (Yin, 1994). There are various ways of conducting a case study. In general, the strategy is considered especially well suited when the aim is to discover the causal relationships of a phenomenon and the focus is on contemporary phenomena in a real-life context (Jensen and Rodgers, 2001; Yin, 1994). According to Eisenhardt (1989), it is also appropriate when the phenomena and the context do not have defined boundaries. Neither the phenomenon nor the context was evident in this research, and the approach was chosen in order to make sense of both through interpretation of the meanings people bring to them (Yin, 1994). It was also assumed that the qualitative approach would better serve the purpose because it facilitates in-depth detailed study of the subject (Alasuutari, 1999) from the perspective of those under investigation.

Case-study research has attracted a lot of criticism, however. For example, it is said to be too situation-specific, and not open to generalization (Weick, 1969). The limitations also include the extensive consumption of time and resources. With regard to generalizability, the results derived from single cases in which the sampling is small are not significant in terms of statistical value, and the data use may be mainly explanatory (Ellram, 1996; Johnston, Leach and Liu, 1999; Alasuutari, 1999). If there are large numbers of interviews the people involved may

experience and describe the complex issues differently, which might make it difficult to interpret the phenomenon correctly (Vissak, 2010). A further criticism is that the results of case research are not extendable to different settings or beyond a specific phenomenon (Eisenhardt, 1989; Hurmerinta-Peltomäki and Nummela, 2006; Gummesson, 2005). Indeed, as Stake (1995) suggests, the objective of a case study is to create a detailed picture of the phenomenon in question, and the term particularisation should be used instead of generalisation. Moreover, given the vast amount of data generated, there may be a risk to researchers of being overwhelmed by it and of losing sight of the issues in question (Halinen and Törnroos, 2005). The data could be also considered subjective, and the respondents might present delicate issues in a more favourable light (Vissak, 2010).

**Table 7 The relative strengths and limitations of a case-study research strategy (adapted from Vissak, 2010)**

| Strengths  | Limitations  |
|--|--|
| <ul style="list-style-type: none"> <li>• Commonly used in many scientific disciplines.</li> <li>• A higher response rate than in surveys.</li> <li>• Useful for generating new theory or specifying (and, if necessary, criticising) already researched topics.</li> <li>• Can explain new, complex and/or dynamic issues.</li> <li>• Suitable for asking “how” and “why” (not) questions about a set of events and studying a firm from multiple perspectives.</li> <li>• Provides a holistic perspective on real-life events and the processes leading to certain results.</li> <li>• Theoretical reading and empirical research can be done at the same time. The data can be collected from a large number of different qualitative and quantitative sources.</li> <li>• Flexible in terms of sequencing, reformulating and adding questions.</li> </ul> | <ul style="list-style-type: none"> <li>• Unappreciated and underutilized as a methodology.</li> <li>• Sometimes considered to be soft, weak, “feminine,” and unscientific.</li> <li>• Harder to publish in certain journals.</li> <li>• Hard to conduct and interpret the results.</li> <li>• Time- and labour-consuming.</li> <li>• Cannot handle large data sets. Hard to make statistical generalizations.</li> <li>• Difficult to access confidential data. The interviewee may not be totally honest.</li> <li>• Potential researcher bias, bias from the use of key informants and selecting certain firms.</li> <li>• The possibility of ending up with a weak theory or partial support for particular theories or frameworks.</li> <li>• Hard to find a balance between depth and breadth: a single case increases the former but decreases the latter, whereas a multiple case study increases the latter but decreases the former.</li> </ul> |

Table 7 lists some of the strong points and weaknesses that should be taken into consideration in case research. One way of overcoming some of the weaknesses, according to Vissak (2010), is to adopt a multi-method approach. Gilmore and Carson (2006) describe such an approach as particularly useful when the phenomenon is complex, processual and interactive. In this research, the questionnaires sent to the interviewed companies helped to validate the data.

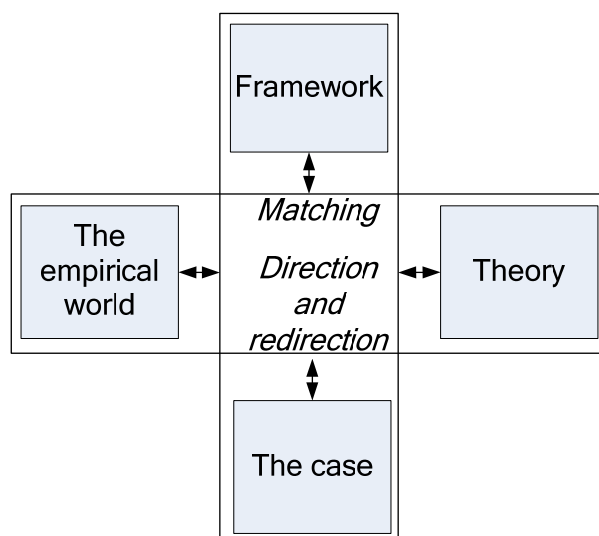
Moreover, the use of a multi-method research strategy improved the quality of the data in allowing triangulation, minimising respondent bias and providing additional information (Eisenhardt and Graebner, 2007; Ghauri, 2004; Hurmerinta-Peltomäki and Nummela, 2006; Vissak, 2010). This allowed the researcher to go deeper into the issues and to obtain more explicit results by quantifying the data and raising some questions for further research.

### **3.3 Systematic combining in case research**

Interpretive research has been criticised for lacking valid processes, which is considered a major weakness (e.g., Modell, 2010). The abductive process is commonly used in case-based research for building explanations because it allows iteration (Dubois and Gadde, 2002). Still, most textbooks on research methodology fail to take account of the opportunities an intertwined research process offers. According to Dubois and Gadde (2002), the problem lies in handling the interrelatedness of the various elements in research work, whereas understanding the characteristics and consequences of abduction-based case studies requires an integrated approach.

Systematic combining is an approach to case research advocated by Dupois and Gadde (2002). It is a process in which the theoretical framework, the empirical fieldwork and the case analysis evolve simultaneously. The framework builds on the abduction approach, the main characteristic of which is “a continuous movement between an empirical world and a model world” (Dubois and Gadde, 2002, p.554).

The approach is based on four cornerstones (Figure 11): *the empirical world*, *the framework*, *the theory* and *the case*. The iterative activities of the framework include *Matching*, and *Direction and redirection*, and the process could be described as “a nonlinear, path-dependent process of combining efforts with the ultimate objective of matching theory and reality”. (Dubois and Gadde, 2002)



**Figure 11 Systematic combining in abductive case research (Dubois and Gadde, 2002)**

*The empirical world* is the ‘real life’ in which the practical problems (or phenomena) reside. *Theory* refers to the current level of scientific knowledge of the phenomenon. The objective is to develop and enrich this knowledge through *the framework*, which acts as a lens through which it is analysed. *Matching* is an activity that involves moving between the data and the analysis in order eventually to create theory through the evolved and refined frameworks. The *case* in the framework acts as a ‘tool’ and a ‘product’. It evolves and is evaluated during the research process as empirical data is added to it. The goal is to enable the researcher to understand in-depth the real-life events from bounded and justifiably selected descriptions of the empirical world, and thus to increase the validity of the research in terms of theoretical preconceptions. Direction and redirection are important in order to achieve the matching. Direction happens at the beginning of the research process and includes the initial perspective on the phenomenon and the main research approach. Re-direction activity includes finding multiple perspectives, and through the revealed dimensions re-directing the research approach. (Dubois and Gadde, 2002)

In this research the iterations are represented through different publications. In other words, as new information about the focal supply chain came to light it was reported in the form of publications and the research was re-directed accordingly.

### **3.4 The research process and the data collection**

The study was conducted in several overlapping phases, which primarily involved identifying the phases in the chain governing supply chains in the Gulf of Finland, and the risks affecting them. The field research was conducted as part of the larger STOCA (Study of Cargo Flows in the Gulf of Finland) project. The first phase of the research process started with a preliminary literature review. Scientific literature from the field of supply chain risk management provided a basis for the empirical part, and the review also included a White Paper and research report about the study area. The literature review continued along with the empirical data collection in the subsequent phases. When enough background information had been gathered the case supply chain was selected. The selection was based on its significance to the study area, and was made in cooperation with the National Supply Emergency Agency, which has extensive knowledge of the issue. Following the selection of the target supply chain two explorative test interviews were conducted with a view to determining the structure of the research interviews. It was concluded from the test interviews that a relaxed and semi-structured yet discursive approach would serve the data collection best as the interviewees would be able to speak freely about the issues, thus producing more data about the events and their background and enhancing the researcher's understanding about the subject.

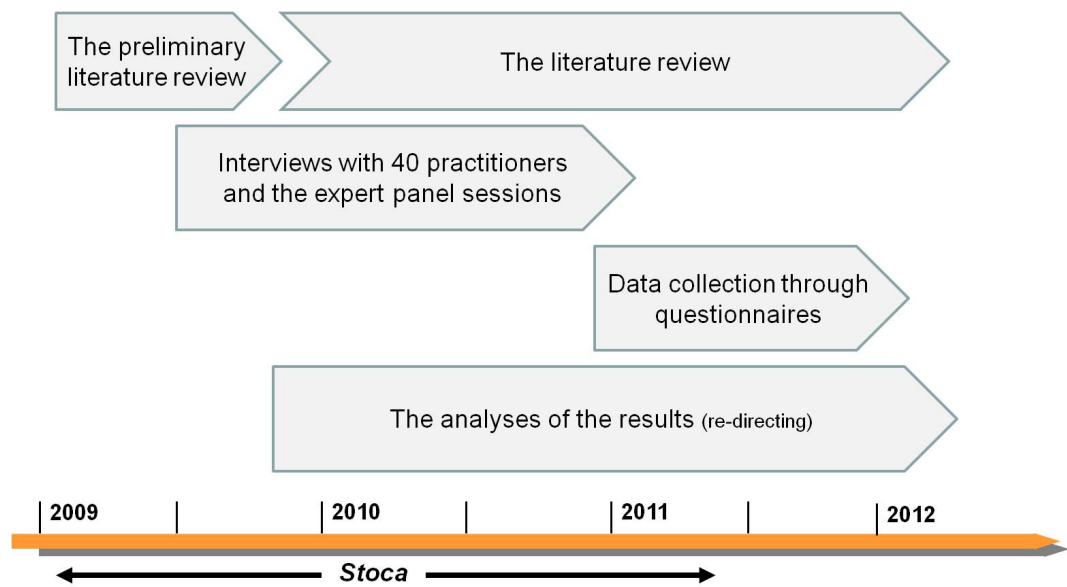
The uncertainties in the multimodal supply chain were identified in the interviews conducted during the second phase. The empirical data collection for the case study concentrated on the practitioners in the supply chain operating between the Gulf of Finland and inland Finland. Three different data-collection methods were used: themed interviews, expert panel workshops and mail questionnaires. The use of multiple methods improved the validity of the study and helped to overcome the limitations of case research (Dubois and Gadde, 2002; Vissak, 2010).

The data-collection process was iterative, and overall involved forty practitioners. All of the interviewed companies belonged to the supply chain under investigation and were active in different parts of it. A discovery-oriented approach was adopted in order to tap into the supply-chain professionals' experience and knowledge.

The interview process started in mid-2009 and continued until late in 2010, thus lasting over a year. During this time expert panel workshops were held in order to confirm and refine the interview results. An expert panel comprising some of the interviewees assisted in testing the created frameworks, and as new findings about the phenomenon emerged the research direction changed accordingly. Each phase of the iteration process resulted in one publication.

The literature review revealed the increasing importance of information issues in supply chain risk management, and this was confirmed in the interviews. A parallel case study was therefore conducted targeting a focal pulp and paper company in the chain that governed an international supply chain. The same research approach was adopted in both studies, the second one focusing on risk issues from a holistic security-of-supply perspective.

Following the completion of the interviews in 2010 two different questionnaires were sent to different groups of respondents in the two supply chains. The first group represented a multimodal maritime supply chain operating between the Gulf of Finland and inland Finland, and the other one a multimodal maritime wood-supply chain. The focus in the latter case was on information-exchange-related risk, whereas the former concerned supply-chain risk from a more holistic perspective. The questionnaires were built on the basis of the interview findings, and helped to quantify, verify and deepen the data. Figure 12 illustrates the process time line.



**Figure 12 The time-line of the research process**

The publications give limited results related to different aspects of supply chain risk management, and they also represent different groups of respondents given that the data was collected during different time periods in the course of the case study (see Table 8 on the next page). Table 8 also lists the analytical methods used for the different publications. Risk identification and analysis in a supply network is a complex and holistic phenomenon, and the comprehensive coverage in some of the publications required the simultaneous use of a variety of methods (see Harland et al., 2004).

**Table 8 Research data related to the different publications**

|                         | <b>Publication 1</b>   | <b>Publication 2</b>  | <b>Publication 3</b>  | <b>Publication 4</b>  | <b>Publication 5</b>  | <b>Publication 6</b>  |
|-------------------------|--|---|---|---|---|---|
| <b>Case</b>             | Multimodal maritime supply chain between the Gulf of Finland and mainland Finland          | Multimodal maritime supply chain between the Gulf of Finland and mainland Finland | International multimodal maritime supply chain between the Baltic States and Finland  | International multimodal maritime supply chain between the Baltic States and Finland  | Multimodal maritime supply chain between the Gulf of Finland and mainland Finland | Multimodal maritime supply chain between the Gulf of Finland and mainland Finland |
| <b>Sample</b>           | 20 supply chain actors   | 22 supply chain companies<br>Three to six expert panelists                        | 12 supply chain actors  | 9 supply chain actors   | 40 supply chain actors<br>5 respondents   | 27 supply chain actors<br>7 expert panelists                                      |
| <b>Data collection</b>  | Explorative and semi-structured interviews, review of research reports and SCRM literature | Explorative and semi-structured interviews<br>Expert panel                        | In-depth and semi-structured interviews<br>Questionnaire                              | In-depth and structured interviews  | Interviews<br>Questionnaire<br>expert panel                                       | Semi-structured interviews<br>Expert panel  |
| <b>Data</b>             | Opinions and experiences of the supply chain actors, Process and practice information      | Opinions and experiences of the supply chain actors, expert opinions              | Opinions and experiences of the supply chain actors, Process and practice information | Opinions and experiences of the supply chain actors, Process and practice information | Opinions and experiences of the supply chain actors, questionnaire results        | Opinions and experiences of the supply chain actors, expert panel opinions        |
| <b>Analysis Methods</b> | FMEA framework, Risk score card, Descriptive analysis                                      | Expert group session<br>FMEA framework, Monte Carlo-simulation                    | Interviews, questionnaire, risk matrix, Data triangulation                            | Descriptive analysis  | Questionnaire analysis  | Expert group session, Group decision software and Social network analysis         |



### 3.5 The validity and reliability of the study

Validity, reliability and generalizability are considered in modern, positivist philosophies of science the most important hallmarks of credible scientific research (Kvale, 1995). These concepts are approached from different standpoints in qualitative and quantitative studies, however. In terms of qualitative research, various authors have constructed a number of typologies of validity (e.g., Maxwell, 1992; Lather, 1993 and Schwandt, 1997). Yin (2003), for example, claims that in case research methodology validity comprises internal validity, external validity, construct validity and the research design. According to Winter (2000, p.1), in turn, validity is not a single universal concept, but “rather a contingent construct, inescapably grounded in the processes and intentions of particular research methodologies and projects”. Creswell and Miller (2000) suggest procedures for establishing validity through two perspectives: the lens through which the researchers choose to validate their studies, and their paradigm assumptions. The framework they put forward is based on the procedures identified by several authors for establishing validity (e.g., Lincoln and Guba, 1985; Maxwell, 1996; Merriam, 1998), and comprises two dimensions within which to locate nine different types of validity procedure. This study considers validity and reliability through this framework (see Table 9 below).

**Table 9 Validity Procedures based on the Qualitative Lens and Paradigm Assumptions (Cresswell and Miller, 2000)**

| <b>Paradigm assumption/Lens</b>                                      | <b>Postpositivist or Systematic Paradigm</b> | <b>Constructive Paradigm</b>      | <b>Critical Paradigm</b> |
|--|--|-----------------------------------|--------------------------|
| <b>Lens of the researcher</b>  | <b>Triangulation</b>                         | Disconfirm evidence               | Researcher reflexivity   |
| <b>Lens of the Study Participants</b>                                | <b>Member checking</b>                       | Prolonged engagement in the field | <b>Collaboration</b>     |
| <b>Lens of the People External to the Study (Reviewers, Readers)</b> | The audit trail                              | Thick, rich Description           | <b>Peer debriefing</b>   |

Four different procedures were chosen in order to ensure the validity of the study: *Triangulation* (through the lens of the researcher), *Member checking* and *Collaboration* (through the lens of the participants), and *Peer debriefing* (through the lens of people external to the study).

Triangulation entails the search for convergence among multiple and different sources of data in order to form themes or categories (Cresswell and Miller, 2000). Denzin (1978) identified four different types of triangulation: data sources, theories, methods and different investigators. In the context of this study, data-source triangulation was achieved through interviewing a variety of informants and obtaining data from different sources (interviews, presentations, documents and the Internet). Secondly, method triangulation derived from the use of interviews, questionnaires, expert panels and observations, and finally investigator triangulation came from the use of researchers with different backgrounds in the interviews.

According to Lincoln and Guba (1985), member checking is the most crucial technique in terms of establishing research credibility. It involves taking back the data and interpretations to the participants so that they can confirm the credibility of the information and the narrative account (Cresswell and Miller, 2000). In this case the interview data was carefully recorded and transcribed, after which it was sent to the informants for checking. The informants could thereby comment on its accuracy, thereby enhancing the credibility of the study (Cresswell and Miller, 2000).

Secondly through the participants' lens, the critical paradigm was used to confirm the validity and reliability of the study. This involved collaboration, meaning incorporating the participants' views. As a critical paradigm it respects and supports the study participants (Cresswell and Miller, 2000). In this case the collaboration procedure entailed involving the participants in the expert panel sessions in which they could, firstly, review and comment on the research data and secondly, further analyse it. Thus the informants were closely involved in the research work and in the production of more data through the analyses.

Checking validity through the lens of external actors involved Peer debriefing. This means asking someone who is familiar with the study or the phenomenon to review the data and the research process (Cresswell and Miller, 2000). According to Lincoln and Guba (1985), an outside peer debriefer provides support, plays devil's advocate, challenges the researcher's assumptions and pushes him or her towards the next step methodologically, and asks hard questions about methods and interpretations. This process strengthens the credibility of the study.

The publications included in the dissertation represent single iterations during the research process, leading to a description of the presented risk-management aspects in supply chains.

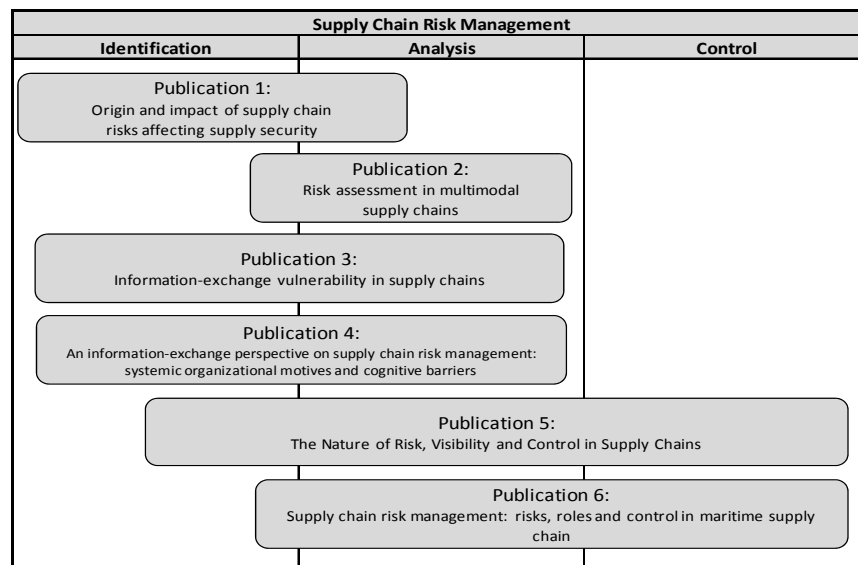


## 4 A REVIEW OF THE RESULTS

This part of the dissertation presents the main results reported in the different publications. The first section shows their positioning in terms of the research questions and summarises the results (Table 10), whereas the remaining sections describe the objectives and main findings in more detail.

### 4.1 Positioning the publications in the context of supply chain risk management

The main aim of this research was to contribute new general knowledge to the current literature on supply chain risk management. The study was conducted through the systematic combining of research approaches in which the iterative process included re-directing the strategy according to the findings from each round. These findings are presented as six publications, which cover the three main categories of risk management in supply chains (Figure 13).



**Figure 13** The positioning of the publications

Overall, the publications (in other words the iterative rounds in the research process) provide a holistic view of risk management in the supply chains under investigation, following the traditional steps: identification, analysis and management activities.

The first publication presents the results of the first round in the iterative research process. It is positioned in the identification phase, analysing the risks discovered in the interviews with practitioners in the supply chain operating between the Gulf of Finland and inland Finland. It focuses on the first step of the process, namely the state of risk identification in the studied supply chains and the key factors that enable identification of the risks to which they are exposed. All the publications cover this aspect to some extent, although publications 1, 3 and 4 contribute the most in describing how the different actors understood the risks and risk management. Publication 1 focuses on the business practitioners' perceptions of the risks, which varied a lot among the companies and individuals in the supply chain. Furthermore, many smaller organisations did not have a conceptual understanding of risk management, or a proper risk-management structure to support their business.

Publications 3 and 4 identify and analyse the risks associated with information exchange in a multimodal maritime supply chain operating between the Baltic States and Finland. The third publication considers information exchange in terms of its effects on risk identification, and the fourth further takes cognitive abilities and systemic motives into account, in particular how they affect the visibility of the risk and facilitate its identification.

The focus in the second phase of supply chain risk management is on analysing the risks, and this is dealt with in publications 2, 3 and 5. The aim in the second publication is to enhance analytical knowledge on the level of actor capability, and furthermore to build risk-analysis frameworks in order to study the case supply chain from different perspectives. The risk-management levels varied widely among the practitioners, and whereas some used risk-identification and analysis tools that enabled them to develop more resilient processes, others ignored the existence of

risks and responded to them as they arose. Various specially developed tools were used to analyse the risks: a risk table and simulation in publication 2, triangulation involving vulnerability analysis, risk analysis and importance analysis in publication 3, and risk and controllability analysis in publication 5.

Finally, the control phase is considered in the fifth and sixth publications, which concentrate more on holistic management abilities in terms of identifying and controlling risks. Thus, the aim was to assess the potential and capabilities of different actors involved in supply chain risk management. This is addressed in publication 5 by linking the nature of the risk impact with the visibility (as a factor enabling identification) and control (i.e. risk management) of different actors. Publication 6, on the other hand, addresses the complicated phenomena of risk-management roles and risk control as examined in an expert group session involving public and private actors.

**Table 10 A summary of the findings and the contributions of the publications**

|                            | <b>Publication 1</b>  | <b>Publication 2</b>   | <b>Publication 3</b>  | <b>Publication 4</b>   | <b>Publication 5</b>  | <b>Publication 6</b>  |
|----------------------------|---|--|---|--|---|---|
| <b>Objective and scope</b> | Presents the risks, their possible impacts and vulnerabilities in supply chains operating between the Gulf of Finland and mainland Finland, as seen by the practitioners.   | Systematically analyses the risks affecting cargo flows in the Gulf of Finland in terms of the nature of their impact, and assesses the time-delay effect of risk realisation.   | Illustrates the vulnerabilities exposed by information-exchange disruptions in a wood supply chain operating between the Baltic States and Finland.   | Assesses risks in a forest-industry raw-material supply chain operating between the Baltic States and Finland from the perspective of visibility and collaboration: the focus is on the cognitive barriers and systemic motives that affect the information exchange.  | Identifies and assesses how risk visibility and control mechanisms in supply chains affect risk-management capabilities in the different organisations involved.  | Assesses the ability of private and public actors in the supply chain to identify and control the risks, and analyses the role of these actors from the risk-management perspective.  |
| <b>Findings</b>            | The most significant impact of risks affecting Gulf of Finland cargo flows from the business point of view is time delay. The port infrastructure and the land routes in the vicinity are the most important parts of the chain in this respect. Managing the risks facing the focal supply chain requires co-operation between the partners. | Risk management requires a holistic understanding of the risks and co-operation involved in multimodal supply chains. Time-sensitive cargo flows are the most sensitive to risks. A simulation tool may be used to assess the business and performance impacts of the risk events. | Risk-causing disruptions and distortions in information exchange can have severe impacts on the supply chain's ability to transfer goods. In the case of risk realisation the usage priorities in the information-exchange systems may change, and resilience and flexibility assume an important role. Even though the logistics systems have the key role in normal supply-chain operations, telephone, email and social networking are also essential, and surpass more vulnerable information systems in risk situations. | Information exchange is essential in proper supply chain risk management. The lack of cognitive inabilities hinders the information exchange and therefore the risk management. There is a need for a better understanding of the causalities of the operations and for the creation of systemic motives on multiple levels in the supply chain in order to ensure effective information exchange. | Many of the smaller companies failed to recognise the risks in the supply chain, and the global logistics operators clearly seemed to benefit from the visibility. Collaboration is important because the visibility of the risks and their control mechanisms do not necessarily reside in the same company. | Management roles and abilities vary considerably between public and private actors. In the case of risk realisation the roles and levels of activity may change. The different actors in the supply chain differ in their ability to control risk, and therefore need to collaborate in order to ensure proper risk control in the whole chain. |



## **4.2 Publication 1 – Origin and impact of supply chain risks affecting supply security**

### **4.2.1 Main objective**

The Gulf of Finland is the most important transport route accommodating Finnish cargo flows. Finland's major ports are on its shores, and are in a key position as far as security of supply is concerned. The risks affecting the supply chains could have a devastating effect on the downstream organizations, and furthermore endanger Finnish business life and the livelihood of the people. The vulnerability of the cargo flows in the face of these risks should therefore be studied, and this is precisely where this publication's contribution lies. Typically the risks in a supply chain are visible only to some of the practitioners, and thus the processes involved were studied separately in order to give a holistic view. The main objective of this paper was to identify the risks affecting the supply chains operating between the Gulf of Finland and inland Finland as seen by the practitioners. The study was based on the literature covering the risks facing maritime transportation in the Gulf of Finland and supply chain risk management, and the findings from the interviews conducted. In terms of this thesis, the contribution lies in identifying and assessing the risks to which the case supply chain is exposed, and finding the most vulnerable parts.

### **4.2.2 Main findings**

This publication enhances understanding of risk, the vulnerable parts of the supply chain and the risk-management capabilities of the different actors. The results shed light on the sources of risk and the nature of its impact based on the performance indicators of time, cost and quality. The analysis also illustrates the substantial variation in risk-management capabilities among organizations in the same supply chain.

The most vital part of the supply chains operating from the Gulf of Finland in the eyes of the interviewed companies comprise the port infrastructure and the land routes in the vicinity. Ports are typically specialised in handling certain

transportation modes and are therefore not easily replaced in case of disruption. The routes in and out of them were seen as the most vulnerable part of the infrastructure after electricity and IT outage. From the export industry's viewpoint the available empty containers also posed a risk because of its dependence on transit traffic.

The risks facing the different supply chains depend on numerous factors, and many of the practitioners saw their company's business as differing somewhat from that of the other members. There were significant differences in risk-management knowledge between the companies and the persons behind them. Perceptions of the risks varied in each one, even if many of the same concerns were shared. Cooperation and information sharing in order to mitigate the risks was hindered by the lack of trust between the partners in the chain.

The risks identified as the most severe included the slippery conditions in winter, strikes and fire. Thus the major source of risks facing the supply chain seemed to arise from the operational environment, and the heaviest impact from time delay. This implies that time-sensitive cargo would be most badly affected.

### **4.3 Publication 2 - Risk assessment in multimodal supply chains**

#### **4.3.1 Main objective**

The purpose of this paper was to continue the research process based on the findings reported in Publication 1: the port sector was identified as the most vital part of the supply-chain system and time delay as the most severe risk impact. This was therefore the research focus and the main objective was twofold: first, to systematically identify and assess the risks affecting the cargo flows in the case multimodal maritime supply chain from the perspective of risk management, and secondly to analyse the impact of the risks in terms of delay. The research was carried out in the following three overlapping phases: the interviewees were identified and the interviews conducted in the first phase; the risk analysis comprising the second phase involved an expert group of researchers and practitioners in the field; and in the final phase the impact of time delay was

evaluated by means of simulation in order to obtain a more in-depth perspective on the possible consequences.

#### **4.3.2 Main findings**

The risks imposed on different parts of a multimodal supply chain depend on numerous factors, and many of the practitioners thought their company's business differed somewhat from that of the other companies. Given the background of the interviewees, neither the conceptual clarity of the risk nor the sources and drivers were taken into consideration; they rather responded with tales of cause and effect. In this respect the findings reflect those reported by Peck (2005) and Zsidisin (2003), who note that practitioners perceive risk as a multi-dimensional construct. The low-hierarchy trucking companies seemed only to have some idea about their functions in the supply chain, and of how any disruption would affect it. Their perspectives were typically narrow, single-functioned and logistics-based, although there were significant individual differences (Larson, Poist and Halldórsson, 2007). The risk-management know-how seemed to be on a relatively better level in that part of the chain. The informants from the port sector were selected to join the expert group session through which the risk-analysis framework was applied.

The risks identified as the most severe were related to time delay, and were therefore selected for closer examination. A simulation approach was used to study the effect on performance of the delay-risk impact. The expected outcomes of the vulnerability analysis were a top-down analysis of supply-chain risk drivers and their impact, and a more in depth investigation into the connection between risk exposure and supply-chain performance measures such as time. This paper connects both of these in exploring risks in a multimodal supply chain. Risk drivers and uncertainty are often analysed separately in this context, but this study presents an integrated framework. Exposure in terms of likelihood and impact provides a solid structure on which to explore risks in different parts of the chain. Simulation with its inherent sensitivities sheds light on the drivers and their impact on performance. The delay impact was used to model risk exposure on the case supply chain in this study.

The study broadens the perspective on risk management in multimodal maritime supply chains in considering both the needs of the chain and the security of supply to the end customers. The findings provide valuable information for practitioners and researchers alike. They illustrate the value of a holistic view to actors in the supply chain attempting to assess the risks facing them. On the national or regional level the findings enhance understanding of such risks, their likelihood and consequences, which gives a good basis on which to prepare for and respond to them in order to ensure the security of supply.

#### **4.4 Publication 3 - Information-exchange vulnerability in supply chains**

##### **4.4.1 Main objective**

The forest industry has an important position in Finland, accounting for approximately 19 per cent of export trade values. In terms of logistics, every third large or medium-sized truck serves the forest industry (Rumpunen, 2010). The supply chains serving the industry belong to complicated international supply networks, and there is a need for constant information exchange to ensure the uninterrupted flow of materials. Information exchange between supply-chain members was identified as among the most relevant in the previous papers, and it is indirectly affected by numerous other risks as well. Therefore, the main objective in this paper was to contribute to the current literature on supply-chain risk management by illustrating the vulnerabilities inherent in the methods of information exchange used in wood supply chains. Triangulation was used in the vulnerability analysis in order to enhance reliability.

##### **4.4.2 Main findings**

The study gives a holistic view of the risks related to information exchange in a wood supply chain. It strengthens some of the findings from earlier research, but also brings out new aspects of risk management in supply chains, particularly with regard to disruptions in information exchange, which still lacks empirical

investigation. The study identified a number of information-exchange methods, to which the many actors with their different perspectives on the supply chain have different levels of access.

The use of different information systems may be of value in risk management in determining what kind of functions can be affected by disruption in certain information-exchange systems. Some of the methods identified covered multiple functions and seemed to have a strong position in the supply chain. In risk situations the most flexible systems were considered the best ones.

The case analysis revealed that the risks attached to the information-exchange methods varied. The highest risk arose from the Internet-based sea logistics system, which holds a huge store of information. Email connections were also considered highly risk-prone in that disruption would clearly hinder the operations. The telephone was used extensively in order to exchange information and to ensure its arrival, maintain good personal connections with the other actors in the supply chain, and most importantly as a solution in extenuating circumstances. Apart from the technical risks attached to several of the information-exchange methods, human-related factors played a significant role in terms of inputting the information and the level of accuracy. Furthermore, the tacit knowledge required to manage the logistic flows was considered a risk at certain stages.

## **4.5 Publication 4 - An information-exchange perspective on supply chain risk management: systemic organizational motives and cognitive barriers**

### **4.5.1 Main objective**

The nature and depth of the relationships actors have in the supply chain directly affect the information shared among the partners (Hong, Youn and Nahm, 2008). This seemed to have an effect on the information exchange in the previous studies as well. On that subject, some of the interviewees raised questions about motivational issues and how different actors understood the big picture and causalities of

different operations. This is precisely where the contribution of this publication lies. The main objective was twofold: firstly, to identify and assess the information exchange in the chain and the associated risks, and secondly to assess the hindrance factors with regard to information exchange and visibility by means of cognitive and motivational interpretation.

#### **4.5.2 Main findings**

Effective information exchange is a cornerstone of risk management in the context of the supply chain. It also provides the means for extending visibility throughout the chain. The role of visibility is emphasised through the need to recognise risks and their respective influences outside the firm's visibility zone. Supply-chain risks are systemic in nature, which calls for a more comprehensive approach. This study broadens the risk-management perspective in considering how cognitive and motivational factors affect information exchange and visibility in the chain.

Human-related factors played a significant role in the information exchange throughout the supply chain. The limited cognitive abilities of even a single actor could cause severe consequences: not understanding the "big picture" and not sharing essential information resulted in losses in terms of time, quality and money.

One of the most obvious motivational aspects concerned the perspectives of the operators on different levels. The higher-level organisations with logistics managers who collaborated vertically and shared information clearly had higher visibility and could therefore identify risks and anticipate changes better, whereas organisations operating on lower levels did not have the same visibility and rather had to plan their responses to possible risks and changes by means of horizontal collaboration. The benefits of collaboration were clearly understood, as were its inhibitors. Some of the lower-level organisations had attempted to collaborate and share information vertically, but a lack of trust and fierce competition seemed to prevent it.

There is clearly an increasing need to develop a holistic view of the supply chain, to which this paper contributes through the adoption of a systemic perspective. An

organisation's ability to deliver and interpret supply-chain information is bounded by organisational cognition and the cognitive processes within. In this regard, the aim was to initiate a systemic cognitive analysis of supply chain risk management, which is somewhat lacking in earlier research.

## **4.6 Publication 5 - The Nature of risk, visibility and control in supply chains**

### **4.6.1 Main objective**

According to the interviews and data analysis conducted for this research, risk-management issues added to the challenges in the supply chain – affecting some organisations more than others. The previous publications identified visibility as one of the key factors in supply chain risk management. However, the current literature lacks studies that systematically analyse risks, visibility and control – and the related collaboration requirements – in the same research framework. Therefore, the main objective of this study was to present an analysis of supply-chain risk, visibility and control that the actors concerned could use in order to increase the competitiveness of the chain.

### **4.6.2 Main findings**

The study shows why and how collaboration is important in the supply-chain context because the visibility of the risks and their control mechanisms do not necessarily reside in the same company. In such cases applying a holistic risk-management strategy would benefit the focal firm and the whole network in that the visibility of the supply chain could enable effective management on the process level as well.

The traditional categorisation of risks in supply chains is sourced-based. However, the findings of this study reveal interesting aspects of the nature of the impacts in terms of the ability of management to control the risks. The uni-dimensional risks causing time delay seemed to be easier for some of the actors to manage, whereas

the multidimensional risks seemed to be more difficult to mitigate. Therefore the nature of the impact of the risk should be taken into consideration. Furthermore, the benefits of increasing collaboration and coordination in order to improve risk visibility and control on the management level should be explored.

## **4.7 Publication 6 - Supply chain risk management: risks, roles and control in maritime supply chains**

### **4.7.1 Main objective**

Studies on supply-chain collaboration in the recent scientific literature are typically limited to business partners, in other words private firms. However, the public sector has an important role to play in terms of safeguarding the fluent and uninterrupted flow of goods and information in supply chains. Effective management of the risks requires identification of the members with the most control over them. In addressing this gap in the literature, the main objective of the study was twofold: firstly to illustrate the ability of private and public actors in the chain to identify and control the risks, and secondly to analyse the roles of these actors from a risk-management perspective. On the basis of the information acquired during the research process so far, an expert group session was organised involving both public and private actors who had both active and passive roles in the process. The session was facilitated by means of an Internet-based decision-support system, although the participants were in the same place in order to facilitate natural discussion.

### **4.7.2 Main findings**

The level of risk management varied greatly among the organisations concerned. Many of the smaller companies did not recognise the risks to the supply chain, whereas the global logistics operators clearly seemed to benefit from the visibility.

The risk-identification differences between private supply-chain actors and state authorities seemed to be fairly small, and only some risks such as ice conditions in winter seemed to be unfamiliar to the latter. Overall, the viewpoints of private and



state actors seemed to be complementary, implying that common risk management would bring benefits.

The study reveals how both private companies acting in the supply chain and public actors have their own strong points in managing the risks, and differ considerably in terms of controlling the different types. The analysis of risks from the perspective of the actors' control capabilities and collaboration in the network could give valuable insights into risk management in the context of supply chains. Social network analysis is a useful visual modelling method for identifying the structure of the risk-management network, and the actors' power positions in it based on the structure and strength of their ties. In terms of practical application, it facilitates the planning of information flows between actors and the allocation of risk-management resources. Above all, network analysis promotes holistic inquiry into actors' roles in a collaborative supply-chain network, and strengthens the joint risk-management plan.



## 5 CONCLUSIONS

This final chapter presents the conclusions of the study. There are many methods available for assessing its general value and contribution, but the aim here is to introduce the key ways in which it adds to current knowledge in theoretical, methodological and managerial terms. The limitations are discussed and suggestions for further research given.

### 5.1 Answering the research questions

The main research aim in this study was to analyse supply chain risk management and the three steps in the process in order to produce new knowledge about the phenomenon and how it is perceived among practitioners. Although the previous chapter discusses the connection of the publications with the different risk-management steps, it does not explicitly point out which specific research questions each one addresses. The aim in this section is to fill this gap. Table 11 shows how the publications align with the research questions in terms of primary and secondary focus.

**Table 11** The research questions and the publications

| Research questions   | Publications |   |   |   |   |   |
|--|--------------|---|---|---|---|---|
|  | 1            | 2 | 3 | 4 | 5 | 6 |
| Q1: <i>How can the risks in a multimodal supply chain be identified?</i>                           | X            |   | x | X | x |   |
| Q2: <i>How can the risks in a multimodal supply chain be analysed?</i>                             | x            | X | X | x | X | x |
| Q3: <i>How can the risks in a multimodal supply chain be controlled through management action?</i> |              |   |   |   | x | X |

Question 1: *How can the risks in a multimodal supply chain be identified?*

One way of identifying risks in the supply chain is to analyse the perspectives of the individual actors with regard to the sources, and thereby obtain a holistic picture. The identification should include the different levels (i.e. managerial, process and information) in order to shed light on the causalities in the operations and to take account of the cognitive barriers. Mapping the overall processes and the actors in them enhances understanding of the causalities, and therefore of the sources of risk and the parts of the supply chain that are exposed to the perceived impacts.

The first and fourth publications focus primarily on this question. Publication 1 deals with risk identification in the existing literature and in the studied supply chain. In-depth interviews allowed examination of risk perception in both the individual actors and the whole chain. The fourth publication, on the other hand, concentrates on the cognitive and systematic motivational aspects of risk identification. As secondary contributions, the third publication concerns the identification of information-exchange-related risks and the fifth one examines the role of visibility in risk identification. All six publications illustrate the major differences between the actors' capabilities of identifying risks and how the narrow perspectives of single organisations prevent identification of many of the risks they are exposed to.

Question 2: *How can the risks in a multimodal supply chain be analysed?*

The analytical methods include evaluating and assessing, first of all, the likelihood and impact of the risks as well as the nature of their impact. The analysis should be conducted in collaboration with the actors, taking into account the different perceptions in different parts of the chain (e.g., the expert panel). The methods should be systematic in order to enhance understanding about the risks and, further, their impact on the whole system.

The second, third and fifth publications present different analysis methods, and categorise the risks according to the nature of their impact. The expert panel give a

holistic view of risk analysis in the second and fifth publications, and triangulation of analytical methods is used in publication 3. In addition, the first, fourth and sixth publications illustrate how the different perspectives complement each other.

Question 3: *How can the risks in a multimodal supply chain be controlled through management action?*

Management action to control risks should be collaborative, involving the actors who are best able to perceive and control them. It should take into account the risk-management abilities of the actors in different roles (i.e. public/private, active/passive, part of the supply-chain process) because they affect their risk-controlling capabilities. It is essential to be aware of the visibility and controllability, and where they reside in the supply chain in relation to different risks.

The fifth and sixth publications concentrate on risk control among supply-chain actors, and adopt a network perspective to illustrate differences in the capability to control different risks. They also synthesise the notions of visibility and control in terms of the actors' overall influence on supply chain risk management.

## **5.2 Contribution to the literature**

Of the several studies of supply chains that have been conducted, only a few of them concern maritime supply chains, which many authors acknowledge (e.g., Yang, 2011; Berle, Asbjørnslett and Rice, 2011). Indeed, many scholars point to the gaps in the literature, and have called for more case studies in order to enhance understanding of the practitioner's perspective (e.g., Lavastre, Gunasekaran and Spalanzani, 2011; Sodhi, Son and Tang, 2012). This study responds to this call in several ways, as explained below. The viewpoints adopted and the methods used will enhance current research and arouse more discussion.

In general, this research contributes to the current literature in providing new information about the identification, analysis and management phases of supply chain risk management. Its more specific contributions are discussed below.

Firstly, according to recent reviews on supply chain risk management, risks that are taken into consideration are typically related to disruption, or are some type of business risk (Tang and Nurmaya Musa, 2010). This study *broadens the perspective* in considering both the needs of the supply chain and the security of supply to end customers. The chosen holistic approach gives a wider view than typical studies on supply chain management, which tend to concentrate on the focal company (e.g., Giannakis and Louis, 2011; Christopher et al., 2011). A holistic view requires consideration of the perspectives of the different actors: this is especially the case with multimodal supply chains because the operational environment and the nature of the logistics activities differ significantly in different parts of the chain.

Supply chain risks are traditionally analysed in terms of sources, which are then categorised and weighted according to their probability and impact (e.g., Guinipero and Eltantawy, 2004; Blackhurst, Scheibe and Johnson, 2008). However, *this study also considers the nature of the impact*. The extent to which the risk of delay was heightened by the nature of its impact, for example, seemed to affect the organisation's ability to manage it. Thus, future studies on risk assessment should also take this into account. If the actors understand the risk they are better able to focus their risk-management efforts. In terms of the resource-based view, this implies the need to understand the capabilities of the different actors in the supply chain in order to divide the responsibilities accordingly in responding to the threats.

This study shows the *considerable variation in the capability to identify supply-chain risks among organisations in the logistics sector*, which is also acknowledged in previous studies (e.g., Soosay, Hyland and Ferrer, 2008). The risks identified in the different parts of the present study differ in terms of how important the individuals in various parts of the chain perceived them to be. However, the same risks were mentioned in most of the interviews. The conceptual clarity of risk, its

sources and drivers was typically on quite a low level, and the interviewees rather responded with tales of cause and effect. In this respect the findings concur with those reported by Peck (2005) and Zsidisin (2003), who observed that practitioners perceived risk as a multi-dimensional construct. This should be taken into account in the implementation of a collaborative risk-management strategy. Awareness of the risks in the supply chain through visibility and the capability to control them can only enhance the level of risk management in the organisation.

The findings also take the discussion on risk sources further, one of the most relevant factors relating to the *cognitive abilities of actors in the chain and the potential serious challenges and cost implications*. The current literature on supply chain management is somewhat focused on structural issues (governance, processes and networks, for example) and rarely incorporates people issues, even if it is acknowledged that companies, and indeed supply chains, are highly dependent on the motivation and preferences of individuals (Samuel et al., 2011; Kogut and Zander, 1996). Managers in a complex environment such as an international supply chain may lack the cognitive capacity to understand the consequences of a particular decision (Heiner, 1983; Senge, 1990). Furthermore, when deciding “how to decide”, decision makers define the criteria for a “good” decision, which vary according to the extent of available information, cognitive capability and risk-taking behaviour during the decision-making process. In an inter-organisational context such as a supply chain it is important to understand the causality of actions and the true motivations, which have a direct impact on how well or how poorly the operations are carried out. It is noteworthy that all the actors in the case supply chain had their organisational-level cognitive barriers, which nevertheless differed in scope and locus. Another focal issue is how human-level cognitive abilities and processes can be extracted and operationalized at the firm level in support of organisational cognitive processes. Moreover, the tacit knowledge acquired by the logistics managers was found to be substantial.

Various *forms of collaboration* in which different organisations in the supply chain engage were identified. By definition, supply chain risk management is a

collaborative venture, and the nature of the collaboration has attracted research interest in recent years. Mason, Lalwani and Boughton (2007), for example, suggest combining vertical and horizontal collaboration in order to optimise transport solutions, and more broadly confirm the importance of both in various types of supply chains and value networks (Möller and Rajala, 2007; Van Veen-Dirks, 2006). It has also been suggested that lowering the risks in the supply chain would facilitate inter-organisational trust, and thus further increase the benefits of collaboration (Laequddin et al., 2009). Companies that understand the nature of the collaboration and how it affects visibility in the supply chain are better placed to identify risks and anticipate changes

The study also sheds light on *collaboration and its drivers in the context of supply chains in terms of visibility*. Enslow (2006) found that the lack of visibility in the supply-chain process was a major concern in about 79 per cent of the 150 large companies comprising their global survey. In fact, the visibility aspect has received more attention recently (e.g., Christopher and Lee, 2004; Caridi et al., 2010), and given that disintegration has made organisations unaware of what goes on in their chains, there is a clear need for it. This study takes both the visibility and the risk-management-control aspects into account in this context.

The results of the study also reveal why and how collaboration is important in the supply-chain context given that *visibility in terms of risks and their control mechanisms does not necessarily reside in the same company*. In such cases, applying a holistic risk-management strategy would benefit the focal firm and the whole network in that visibility could enable effective management on the process level as well. Organisations that understand their risk-control capabilities can enhance the level of their supply chain risk management.

A further contribution of the dissertation is to highlight the *public-private collaboration in supply chains*: taking account of both public and private actors in commercial supply chains, and categorising them as either passive or active allowed a holistic picture of their roles in risk management to emerge. The analysis of risks



from the perspective of the actors' control capabilities and collaboration in the network could give valuable insights into risk management in the context of supply chains. Social network analysis is a useful visual modelling method for identifying the structure of the risk-management network, and the actors' power positions in it based on the structure and strength of their ties. In terms of practical application, it facilitates the planning of information flows between actors and the allocation of risk-management resources. Above all, network analysis promotes holistic inquiry into actors' roles in a collaborative supply-chain network, and strengthens the joint risk-management plan.

Finally, this study contributes to the current literature on supply chain risk management in focusing on the vulnerabilities of information systems, the benefits of which are often highlighted in logistics (e.g., Fiala, 2005). Only recently have the vulnerabilities to which supply chains are exposed received attention (Pereira, 2009), and the contribution of the study lies in the vulnerability analysis of the case supply chain and the systematic analysis of the affected activities in the case of disruption in any of the information-exchange systems. Closer integration and the wider availability of information were seen as beneficial, and deficiencies in this respect were criticised. However, the related vulnerabilities should be considered carefully: if all the systems were to go down, "putting all one's eggs into the same basket" would constitute a serious risk.

The perspectives of the theories applied (transaction cost theory and the resource-based view) facilitate a deeper understanding of both risk and risk management in supply chains. The problems and costs (in other words risks) involved in transactions are numerous in this context, and their management requires identification of the resources and capabilities of the different actors. This, in turn, highlights the roles of the individual actors, thereby fostering effective and efficient collaborative supply chain risk management and competitive advantage.

### **5.3 Methodological contribution**

This study illustrates how risks imposed on different parts of a multimodal maritime supply chain depend on numerous factors. Moreover, many of the practitioners thought their company's business was somewhat different with regard to the other members of the chain. It also illustrates the interdependence in supply chains that should help managers to realise that effective risk management clearly requires in-depth understanding. Increasing visibility and co-operation in the supply chain would make the risks easier to identify and thus to manage. Some of the logistics operators who were interviewed had taken steps in this direction, but a lack of trust seemed to prevent more extensive collaboration and information sharing. In an international actor network involving different kinds of people with varying conceptual understanding and backgrounds this does not constitute an easy environment in which to engender trust. Therefore, systemic organisational motives should be taken into account in the development of collaboration in supply chain risk management. For example, introducing incentives that motivate the actors concerned to align their processes so as to improve the collaboration and the performance of the whole supply chain would make the benefits visible.

The frameworks developed in this study should help managers to understand and structure the complicated phenomenon and concept of supply chain risk management. Understanding both the causalities and the vulnerabilities that risk exposure entails should enhance the cognitive capacity among members of the chain. Indeed, a surprising finding from the interviews was the poor state of preparedness among the companies for any disruption, no matter how insignificant, and the lack of cooperation between the organisations operating in the same supply chain. Collaboration and communication between the parties were usually only on the level that was compulsory or necessary in order to conduct business. A deeper understanding of the roles, dynamics and benefits in actor collaboration would greatly benefit risk management in this context.

## **5.4 Managerial implications**

Managers should benefit from the knowledge that the risk potential in different parts of multimodal maritime supply chains depends on numerous factors, and from the insight that the perspectives of different actors on the risks are complementary on the holistic level. A surprising finding was the poor state of preparedness for any disruptions and the lack of co-operation among the organizations operating in the same supply chain: collaboration and communication were minimal. A deeper understanding of the roles, dynamics and benefits of actor collaboration would enhance supply chain risk management. Even though some actors emphasised the different nature of their business in the chain, they may be in a unique position and possess unique risk-management capabilities that would enable them to identify and analyse risk in a new way. Furthermore, an enhanced understanding of the interdependence in the chain would facilitate more effective risk management. Increasing the levels of collaboration would also make the risks more visible and thus easier to identify. A better focusing of collaborative efforts according to the capabilities of the different organisations would also improve management efficiency and effectiveness.

One factor that had a detrimental effect on collaboration was the lack of trust. There is thus a need to increase the levels of trust in the international actor network, which would require a better understanding of the underlying organisational motives. One way of bringing this about would be to introduce incentives that motivate the actors to align the processes so as to improve collaboration and the performance of the whole supply chain: this would also illustrate the benefits of collaboration.

Finally, with the help of the developed frameworks managers should be able to better conceptualise the complicated phenomenon of supply chain risk management. Understanding the causalities and vulnerabilities in risk exposure should significantly strengthen the cognitive abilities of those who deal with it.

## **5.5 Limitations and suggestions for further research**

The choice of a qualitative and explorative case study as the research approach was appropriate given the lack of previous knowledge about the phenomenon of supply chain risk management, which is still a developing scientific field in many ways. However, inherent in explorative research are numerous limitations that should be taken into account.

Case-study research is not always recognised as a proper scientific method mainly due to the fact that it provides little basis for scientific generalization (Yin, 1994). In the present study the number of case companies was significant given Eisenhardt's (1989) recommendation to include between four and ten cases in order to allow knowledge generation. Increasing the number of cases is believed to improve generalizability (e.g., Gummesson, 2003), but it would still be very limited. There is thus a need for further empirical research employing a more extensive data set, or a comparative study set in some other geographical location.

The methodological limitations of case studies are related to the subjective focus of the analysis. For example, the risk analysis conducted within the expert panel relied on the knowledge of a few people and on subjective assessment. Furthermore, the researcher's suppositions and subjective interpretations of the interviews potentially influence the results, and this applies particularly to descriptive analysis. Therefore further research should be conducted in a similar setting in order to confirm the evidence gathered. Moreover, the risk-analysis methods developed in this study require further validation. Of those used, social-network analysis and Monte-Carlo simulation yielded only weak empirical evidence, but seemed to work well in the analyses. Overall, the methods require further testing in order to verify the mechanisms on which they are based.

The theoretical limitations of the study are related to the scope of the research. Even though the aim was to cover all the steps in the process of supply chain risk management, the focus is limited to a few factors. There is thus a need for further

investigation of the inter-relations between the factors before definite conclusions can be drawn. Moreover, given that the study is based on individual research papers and limited data on two cases in two countries at a particular time, representing only a small proportion of their overall economies, the picture depicting the roles of the examined concepts remains incomplete.

The individual papers presented in this study are, as such, inefficient in terms of showing an explicit chain of evidence of the conceptual relationships. As a way of enhancing the reliability and credibility of the case studies the results were published in peer-reviewed scientific forums. Exposing the findings to the scientific community at an early stage in the form of blind review processes and conference audiences produced valuable feedback that sharpened the focus of the research.

The identified risks did not, as such, add much to the current literature as they were mostly the same as those identified in many other case studies, although there were also limitations and biases. The time dimension obviously affected the data collection in that the risks associated with the economic downturn were considered higher when it was broadcast in the news. Furthermore, the ice conditions and winter-related risks were considered more significant during the interviews in 2009-2010, when the winter in Finland was colder than usual. On the other hand, risks related to the price of fuel gained in significance in the data collected in late 2011 and early 2012, with the imminent increase in Finnish fuel tax. This clearly illustrates how time- and location-dependent risks in supply chains are. Therefore, risk identification in longer chains should be carried out from the broader perspective of a single operation, a single company, or even a single country. The noted variations depending on when the interviewing was done nevertheless gives good reason to conduct longitudinal case studies in the future in order to shed more light on the dynamic nature of the risks, and thereby improve their management.



## REFERENCES

Aertsen, F. (1993) Contracting out the physical distribution function: A trade-off between asset specificity and performance measurement, *International Journal of Physical Distribution and Logistics Management*, Vol. 23, No. 1, pp. 23–29.

Alasuutari, P. (1999) *Laadullinen tutkimus* (Free translation in English: Qualitative research), Vaajakoski, Finland: Gummerus kirjapaino Oy.

Al-Mudimigha, A.S., Zairib, M. and Ahmedc, A.M.M. (2004) Extending the concept of supply chain: The effective management of value chains, *International Journal of Production Economics*, Vol. 87, No. 3, pp. 309–320.

Angeles, P.A. (1981) *Dictionary of Philosophy*, Harper Perennial, New York.

Arnold, U. (2000) New dimensions of outsourcing: a combination of transaction cost economics and the core competencies concept, *European Journal of Purchasing and Supply Management*, Vol. 6, No. 1, pp. 23–29.

Arunachalam, V. and Jegadheesan, C. (2006) Modified failure mode and effects analysis: a reliability and cost-based approach, *The ICFAI Journal of Operations Management*, Vol. 5 No. 1, pp. 7-20.

Aydin G., Babich, V., Beil, D. and Yang, Z. (2012) Decentralized Supply Risk Management, in *Handbook of Integrated Risk Management in Global Supply Chains*, editors: P. Kouvelis, O. Boyabatli, L. Dong, and R. Li, John Wiley and Sons Inc., pp. 389–424.

Banomyong, R. (2005) The impact of port and trade security initiatives on maritime supply chain management, *Maritime Policy and Management*, Vol. 32, No. 1, pp. 3–13.

Barney, J. (1991) Firm Resources and Sustained Competitive Advantage, *Journal of Management*, Vol. 17, No. 1, pp. 99–120.

Barnhart, C. and Ratliff, D.H. (1993) Modeling intermodal routing, *Journal of Business Logistics*, Vol. 14, No. 1, pp. 205–223.

Blaikie, N. (1993) *Approaches to Social Enquiry*, Cambridge: Polity Press

Baird, I.S. and Thomas, H. (1985) Toward a Contingency Model of Strategic Risk Taking, *Academy of Management Review*, Vol. 10, No. 2, pp. 230–243.

Barratt, M. (2004) Understanding the meaning of collaboration in the supply chain, *Supply Chain Management: An International Journal*, Vol. 9, No.1, pp. 30–42.

Bensabat, I., Goldstein, D.K., and Mead, M. (1987) The case research strategy in studies of information systems, *MIS Quarterly*, Vol. 11, No. 3, pp. 367–386.

Beaver, W. (1966) Financial Ratios as Predictors Failure, *Journal of Accounting Research*, Vol. 4, No. 3, pp. 71–111.

Beresford, A., Pettit, S. and Liu, Y. (2011) Multimodal supply chains: iron ore from Australia to China, *Supply Chain Management: An International Journal*, Vol. 16, No. 1, pp. 32–42.

Berle, Ø., Asbjørnslett, B.E. and Rice, J.B. (2011) Formal Vulnerability Assessment of a maritime transportation system, *Reliability Engineering and System Safety*, Vol. 96, No. 6, pp. 696–705.

Bettis, R. (1981) Performance Differences in Related and Unrelated Diversified Firms, *Strategic Management Journal*, Vol. 2, No. 4, pp. 379–393.



Bettis R. and Majahan, V. (1985) Risk/Return Performance of Diversified Firms, *Management Science*, Vol. 31, No.7, pp. 785–799.

Blackhurst, J., Craighead, C.W., Elkins, D. and Handfield, R.B. (2005) An empirically derived agenda of critical research issues for managing supply–chain disruptions, *International Journal of Production Research*, Vol. 43, No. 19, pp. 4067–4081.

Blackhurst, V.J., Scheibe, P.K. and Johnson, J.D. (2008) Supplier risk Assessment and monitoring for the automotive industry, *International Journal of Physical Distribution and Logistics Management*, Vol. 38 No. 2, pp. 143–165.

Blome, C. and Schoenherr, T. (2011) Supply chain risk management in financial crises – A multiple case–study approach, *International Journal of Production Economics*, Vol. 134, No. 1, pp. 43–57.

Blomqvist, K., Kyläheiko, K. and Virolainen, V.-M. (2002) Filling a gap in traditional transaction cost economics Towards transaction benefits–based analysis, *International Journal of Production Economics*, Vol. 79, No. 1, pp. 1–14.

Blos, M.F., Quaddus, M., Wee, H.M. and Watanabe, K. (2009) Supply chain risk management (SCRM): a case study on the automotive and electronic industries in Brazil, *Supply Chain Management: An International Journal*, Vol. 14, No. 4, pp. 247–52.

Bluvband, Z. and Grabov, P. (2009) Failure Analysis of FMEA, *Advanced Logistics Development*.

Bogataj, D. and Bogataj, M. (2007) Measuring the supply chain risk and vulnerability in frequency space, *International Journal of Production Economics*, Vol. 108, No. 1–2, pp. 291–301.

Braunscheidel, M.J. and Suresh, N.C. (2009) The organizational antecedents of a firms supply chain agility for risk mitigation and response, *Journal of Operations Management*, Vol. 27, No. 2, pp. 119–140.

Brindley, C. (2004) *Supply chain risk*, Ashgate Publishing, Aldershot, UK.

Brun, A., Caridi, M., Salama, F.K. and Ravelli, I. (2006) Value and risk assessment of supply chain management improvement projects, *International Journal of Production Economics*, Vol. 99, No. 1–2, pp.186–201.

Caridi, M., Crippa, L., Perego, A., Sianesi, A. and Tumino, A. (2010) Do virtuality and complexity affect supply chain visibility?, *International Journal of Production Economics*, Vol. 127, No. 2, pp. 372–383.

Cavinato, J.L. (2004) Supply chain logistics risks: From the back room to the board room, *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 5, pp. 383–387.

Cheng, S.K. and Kam, B.H. (2008) A conceptual framework for analyzing risk in supply networks, *Journal of Enterprise Information Management*, Vol. 22, No. 4, pp. 345–360.

Chen J.K. (2007) Utility priority number evaluation for FMEA, *Journal of Failure Analysis and Prevention*, Vol. 7, No. 5, pp. 321–328.

Chen, J.V., Yen, D.C., Rajkumar, T.M. and Tomochko, N.A. (2010) The antecedent factors on trust and commitment in supply chain relationships, *Computer Standards and Interfaces*, Vol. 33, No. 3, pp. 262–270.

Chen, I.J. and Paulraj, A. (2004) Toward a theory of supply chain management: the constructs and measurements, *Journal of Operations Management*, Vol. 22, No. 2, pp. 119–150.

Chiles, C.H. and McMackin, J.F. (1996) Integrating variable risk preferences, trust, and transaction cost economics, *Academy of Management Review*, Vol. 21, No. 1, pp. 73–99.

Choi, T.Y. and Krause, D.R. (2006) The supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation, *Journal of Operations Management*, Vol. 24, No. 5, pp. 637–652.

Chopra, S. and Sodhi, M.S. (2004) Managing risk to avoid supply–chain breakdown, *MIT Sloan Management Review*, Vol. 46, No. 1, pp. 53–62.

Chopra, S. and Meindl, P. (2003) What will drive the enterprise software shakeout?, *Supply Chain Management Review*, Vol. 7, pp. 50–57.

Christensen, H. and Montgomery, C. (1981) Corporate Economic Performance: Diversification Strategy versus Market Structure, *Strategic Management Journal*, Vol. 2, No. 4, pp. 327–343.

Christopher, M. and Lee, H. (2004) Mitigating supply chain risk through improved confidence, *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 5, pp. 388–396.

Christopher, M. and Peck, H. (2004) Building the resilient supply chain, *International Journal of Logistics Management*, Vol. 15, No. 2, pp. 1–14.

Christopher, M. (2005) *Logistics and Supply Chain Management—Creating Value—Adding Networks*, (3rd edition), Financial Times, Prentice Hall, London, UK.

Christopher, M., Mena, C, Khan, O. and Yurt, O. (2011) Approaches to managing global sourcing risk, *Supply Chain Management: An International Journal*, Vol. 16, No. 2, pp. 67–81.

Coase, R.H. (1937) The Nature of the Firm, *Economica*, Vol. 4, No. 16, pp. 386–405.

Conner, K.R. (1991) A Historical Comparison of Resource Based Theory and Five Schools of Thought Within Industrial Organization Economics: Do We Have a New Theory of the Firm? *Journal of Management*, Vol. 17, No. 1, pp. 121–154.

Cooper, M.C., Lambert, D.M. and Pagh, J.D. (1997). Supply chain management: more than a new name for logistics, *International Journal of Logistics Management*, Vol. 8, No. 1, pp. 1–13.

Cox, D. (1967) *Risk Taking and Information Sharing in Consumer Behaviour*, Cambridge, MA: Harvard University Press.

Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J., and Handfield, R.B. (2007) The severity of supply chain disruptions: design characteristics and mitigation capabilities, *Decision Sciences*, Vol. 38, No. 1, pp. 131–156.

Cresswell, J. and Miller, D. (2000) Determining validity in qualitative inquiry, *Theory in Practice* Vol. 39, No. 3, pp. 124–130.

Crotty, M. (2003) *The foundations of social research: Meaning and perspectives in the research process*, Sage publications, London, UK.

CSCMP (Council of Supply Chain Management Professionals) (2012) CSCMPs Definition of Logistics Management. Cited 14.1.2012, available at: <http://cscmp.org/aboutcscmp/definitions.asp>.

Cucchiella, F. and Gastaldi, M. (2006) Risk management in supply chain: a real option approach, *Journal of Manufacturing Technology Management* Vol. 17, No. 6, pp. 700–720.

Denzin, N.K. (1978) *The research act: A theoretical orientation to sociological methods* (2nd ed.), New York: McGraw Hill.

Diekmann, J.E., Sewester, E.E., and Taher, K. (1988) *Risk Management in Capital Projects*, Construction Industry Institute, Austin, US.

Dubois, A. and Gadde, L.E. (2002) Systematic combining: An abductive approach to case research, *Journal of Business Research*, Vol. 55, No. 7, pp. 553–560.

Edwards, P., Peters, M. and Sharman, G. (2001) The effectiveness of information systems in supporting the extended supply chain, *Journal of Business Logistics*, Vol. 22, No. 1, pp. 1–28.

Eisenhardt, K.M. (1989) Building Theories from Case Study Research, *Academy of Management Review*, Vol. 14, No. 4, pp. 532–550.

Eisenhardt, K.M. and Graebner, M.E. (2007) Theory building from cases: Opportunities and challenges, *Academy of Management Journal*, Vol. 50, No. 1, pp. 25–32.

Ellis, S.C., Henry, R.M. and Shockley, J. (2010) Buyer perceptions of supply disruption risk: A behavioral view and empirical assessment, *Journal of Operations Management*, Vol. 28, No. 1, pp. 34–46.

Ellram, L.M. (1996) The use of case study method in logistics research, *Journal of Business Logistics*, Vol. 17, No. 2, pp. 93–138.

Enslow, B. (2006) Global supply chain benchmark report: industry priorities for visibility, B2B collaboration, trade compliance, and risk management. Aberdeen Group.

Evers, P.T and Johnson, C.J. (2000) Performance perceptions, satisfaction, and intention: the intermodal shipper's perspective, *Transportation Journal*, Vol. 40, No. 2, pp. 27–39.

Fiala, P. (2005) Information sharing in supply chains, *The International Journal of Management Science*, Vol. 33, No. 3, pp. 419–423.

Finnish Maritime Administration (2011) Ulkomaan meriliikennetilasto 2010 (Foreign shipping statistics 2010), Publications of Finnish Maritime Administration, cited 14/01/2012]. Available at: [http://www2.liikennevirasto.fi/julkaisut/pdf3/lti\\_2011-02\\_ulkomaan\\_meriliikennetilasto\\_web.pdf](http://www2.liikennevirasto.fi/julkaisut/pdf3/lti_2011-02_ulkomaan_meriliikennetilasto_web.pdf).

Flyvbjerg, B. (2011) Case Study. In *Handbook of qualitative research*, editors: N. K: Denzin and Y. S. Lincoln, pp. 301-316.

Franceschini, F. and Galetto, M. (2001) A new approach for evaluation of risk priorities of failure modes in FMEA, *International Journal of Production Research*, Vol. 39 No. 13, pp. 2991-3002.

Frankel, R., Yemisi A.B., Reham A.E., Paulraj, A. and Gundlach, G.T. (2008) The Domain and Scope of SCM's Foundational Disciplines – Insights and Issues to Advance Research, *Journal of Business Logistics*, Vol. 29, No. 1, pp. 1–30.

Fu, Q. and Zhu, K. (2009) Endogenous information acquisition in supply chain management, *European Journal of Operational Research*, Vol. 20, No. 1, pp. 454–462.

Gattorna, J. (1998) *Strategic Supply Chain Alignment: Best Practice in Supply Chain Management*, Hampshire, GB, Gower Publishing Limited.

Gaudenzi, B. and Borghesi, A. (2006) Managing risks in the supply chain using the AHP method, *International Journal of Logistics Management*, Vol. 17, No. 1, pp.114–136.

Gerber, M. and von Solms, R. (2005) Management of risk in the information age, *Computer and security*, Vol. 24, No. 1. pp. 16–30.

Ghauri, P. (2004) Designing and conducting case studies in international business research, In R. Marschan–Piekkari and C. Welch (Eds.), *Handbook of qualitative research methods for international business* (pp. 109–124), Cheltenham, UK: Edward Elgar.

Giannakis, M. and Louis, M. (2010) A multi–agent based framework for supply chain risk management, *Journal of Purchasing and Supply Management*, Vol. 17, No. 1, pp. 23–31.

Gilmore, A. and Carson, D. (1996) Integrative qualitative methods in a services context, *Marketing Intelligence and Planning*; Vol. 14, No. 6, pp. 21–26.

Giunipero, C.L. and Eltantawy, R.A. (2004) Securing the upstream supply chain: A risk management approach, *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 9, pp. 698–713.

Grant, R.M. (2005) *Contemporary Strategy Analysis*, 5th ed., UK: Blackwell Publishing.

Grover, V. and Malhotra, M. (1997) Business process re–engineering: a tutorial on the concept, evolution, method, technology and application. *Journal of Operations Management*, Vol. 15, No. 3, pp. 192–213.

Gummesson, E. (2005) Qualitative research in marketing: Road-map for a wilderness of complexity and unpredictability, *European Journal of Marketing*, Vol. 39, No. 3/4, pp. 309–327.

Gunasekaran, A., Lai, K.H. and Cheng, T.C.E. (2008) Responsive supply chain: a competitive strategy in a networked economy, *International Journal of Management Science*, Vol. 36, No. 4, pp. 549–64.

Halinen, A. and Törnroos, J.-Å. (2005) Using case methods in the study of contemporary business networks, *Journal of Business Research*, Vol. 58, No. 9, pp. 1279–1285.

Hallikas, J. (2003) Managing risk in supplier networks: Case studies in inter-firm collaboration. PhD thesis, Lappeenranta University of Technology, Lappeenranta, Finland

Hallikas, J., Karvonen, I., Pulkkinen, U., Virolainen, V.-M., Tuominen, M. (2004) Risk management processes in supplier networks, *International Journal of Production Economics*, Vol. 90, No. 1, pp. 47–58.

Handfield, R.B. and McCormack, K. (2008) *Supply chain risk management: Minimizing Disruptions in Global Sourcing*, Auerbach Publications, Taylor and Francis group, New York, US.

Harland, C. (1996). Supply chain management: relationship, chains and networks, *British Journal of Management*, Vol. 7, No. 1, pp. 63–80.

Harland, C., Brenchley, R. and Walker, H. (2003) Risk in Supply Networks. *Journal in Purchasing and Supply Management*, Vol. 9, No. 2, pp. 51–62.



Harland, C., Zheng, J., Johnsen, T. and Lamming, R. (2004) A conceptual model for researching the creation and operation of supply networks, *British Journal of Management*, Vol. 15, No. 1, pp. 1–21.

Harrison, S. J., Hitt, M. A., Hoskisson, R. E. and Ireland, R.D. (2001) Resource Complementarity in Business Combinations: Extending the Logic to Organisational Alliances, *Journal of Management*, Vol. 27, No. 6, pp. 679–690.

Heiner, R. (1983) The origin of predictable behavior, *American Economic Review*, Vol. 73, No. 4, pp. 560–595.

Hendricks, K.B. and Singhal, V.R. (2003) The effect of supply chain glitches on shareholder value, *Journal of Operations Management*, Vol. 21, No. 5, pp. 501–522.

Hendricks, K.B. and Singhal V.R. (2005a) An empirical analysis of the effect of supply chain disruptions on long-run stock price performance and equity risk of the firm, *Production and Operations Management*, Vol. 14, No. 1, pp. 35–52.

Hendricks, K.B. and Singhal, V.R. (2005b) Association between supply chain glitches and operating performance, *Management Science*, Vol. 51, No. 5, pp. 695–711.

Hendricks, K., Singhal, V. and Zhang, R. (2009) The effect of operational slack diversification, and vertical relatedness on the stock market reaction to supply chain disruptions, *Journal of Operations Management*, Vol. 27 No. 3, pp. 233–246.

Hetland, P. (2003) Unceirtainty management, in *Appraisal, Risk and Uncertainty*, NJ Smith, Thomas Telford, London.

Hobbs, J.E. (1996) A transaction cost approach to supply chain management, *Supply Chain Management*, Vol. 1, No. 2, pp. 15–27.

Holcomb, T.R., and Hitt, M.A. (2007) Toward a Model of Strategic Outsourcing, *Journal of Operations Management*, Vol. 25, No. 2, pp. 464–481.

Holton, G. (2004) Defining risk, *Financial Analysts Journal*, Vol. 60, No. 6, pp. 19–25.

Hong, P., Youn, S. and Nahm, A. (2008) Supply chain partnerships and supply chain integration: the mediating role of information quality and sharing, *International Journal of Logistics Systems and Management*, Vol. 4, No. 4, pp.437–456.

Hsu, C.C., Tan, K.C., and Cross, J. (2011) Influence of resource-based capability and inter-organizational coordination on supply chain management focus, The 11th International DSI and the 16th APDSI Joint Meeting, July 12 – 16, Taipei, Taiwan.

Hu, Z.-H. (2011) A container multimodal transportation scheduling approach based on immune affinity model for emergency relief, *Expert Systems with Applications*, Vol. 38, No. 3, pp. 2339–2632.

Hu, A.H., Hsu, C-W., Kuo, T-C. and Wu, W-C. (2009) Risk evaluation of green components to hazardous substance using FMEA and FAHP, *Expert Systems with Applications*, Vol. 36, No. 3, pp. 7142–7147.

Hult, G.T.M. (2004) Global supply chain management: An integration of scholarly thoughts, *Industrial Marketing Management*, Vol. 33, No. 1, pp. 3–5,

Hurmerinta-Peltomäki, L. and Nummela, N. (2006) Mixed methods in international business research: A value-added perspective, *Management International Review*, Vol. 46, No. 4, pp. 439–459.

Jensen, J.L. and Rodgers, R. (2001) Cumulating the intellectual gold of case study research, *Public Administration Review*, Vol. 61, No. 2, pp. 235–246.

Jiang, B., Baker, R.C. and Frazier, G.V. (2009) An analysis of job dissatisfaction and turnover to reduce global supply chain risk: Evidence from China, *Journal of Operations Management*, Vol. 27, No. 2, pp. 169–184.

Johnson, M.E. (2001) Learning from toys: Lessons in managing supply chain risk from the toy industry, *California Management Review*, Vol. 43, No. 3, pp. 106–124.

Johnston, W.J., Leach, M.P. and Liu, A.H. (1999) Theory testing using case studies in business-to-business research, *Industrial Marketing Management*, Vol. 28, No. 3, pp. 201–213.

Jüttner, U. (2005) Supply chain risk management: Understanding the business requirements from the practitioner's perspective, *International Journal of Logistics Management*, Vol. 16, No. 1, pp. 120–141.

Jüttner, U., Peck, H. and Christopher, M. (2003) Supply chain risk management: Outlining an agenda for future research, *International Journal of Logistics: Research and Applications*, Vol. 6, No.4, pp. 197–210.

Järvensivu, T. and Törnroos, J.Å. (2010) Case study research with moderate constructionism: Conceptualization and practical illustration. *Industrial Marketing Management*, Vol. 39, No. 1, pp. 100–108.

Keith, O.R. and Webber, M.D. (1982) *Supply-Chain Management: Logistics Catches Up with Strategy*, Outlook. Booz, Allen and Hamilton Inc.

Ketchen, D.J. Jr., and Hult, G.T.M. (2007) Bridging Organization Theory and Supply Chain Management: The Case of Best Value Supply Chains, *Journal of Operations Management*, Vol. 25, No. 2, pp. 573–580.

Kleindorfer, P.R. and Saad, G.H. (2005) Managing disruption risks in supply chains, *Production and Operations Management*, Vol. 14, No.1, pp. 53–68.

Knemeyer, A.M., Zinn, W. and Eroglu, C. (2009) Proactive planning for catastrophic events in supply chains, *Journal of Operations Management*, Vol. 27, No. 2, pp. 141–153.

Knight, F.H. (1921) *Risk, uncertainty and profit*, Boston and New York: Houghton Mifflin company.

Kogut, B. and Zander, U. (1996) What firms do? Coordination, identity and learning, *Organization Science*, Vol. 7, No. 5, pp.502–518.

Kovács, G. and Spens, K. (2005) Abductive reasoning in logistics research, *International Journal of Physical Distribution and Logistics Management*, Vol. 35, No. 2, pp. 132–144.

Kovács, G. and Tatham, P. (2009) Responding to disruptions in the supply network – from dormant to action, *Journal of Business Logistics*, Vol. 30, No. 2, pp. 215–228.

Kujala, P., Hänninen, T. and Ylitalo, J. (2009) Analysis of the marine traffic safety in the Gulf of Finland, *Reliability Engineering and System Safety*, Vol. 94, No. 8, pp. 1349–1357.

Kvale, S. (1995) The social construction of validity, *Qualitative Inquiry*, Vol. 1, No.1, pp. 19–40.

Kähkönen, A.-K. (2010) The role of power relations in strategic supply management – a value net approach. PhD thesis, Lappeenranta University of Technology, Lappeenranta, Finland.

Laequddin, M., Sardana, G.D., Sahay, B.S., Waheed, K.A. and Sahay, V. (2009) Supply chain partners trust building process through risk evaluation: the perspectives of UAE packaged food industry, *Supply Chain Management: An International Journal*, Vol. 14 No. 4, pp. 280–290.

Lambert, D., García–Dastugue, S. and Croxton, K. (2008) The role of logistics managers in the cross–functional implementation of supply chain management, *Journal of Business Logistics*, Vol. 29, No. 1, pp. 113–132.

Lambert, D.M., Cooper, M.C. and Pagh, J.D. (1998) Supply chain management: implementation issues and research opportunities, *The International Journal of Logistics Management*, Vol. 9, No. 2, pp. 1–19.

Lather, P. (1993) Fertile obsession: Validity after poststructuralism, *Sociological Quarterly*, Vol. 35, pp. 623–694.

Larson, P., Poist, F. and Halldórsson, Á. (2007) Perspectives on logistics vs. SCM: A survey of SCM professionals, *Journal of Business Logistics*. Vol. 28, No. 1, pp. 1–24.

Lassar, W., Haar, J., Montalvo, R. and Hulser, L. (2010) Determinants of strategic risk management in emerging markets supply chains: the Case of Mexico, *Journal of Economics, Finance and Administrative Science*. Vol. 15, No. 28, pp.125–140.

Lavastre, O., Gunasekaran, A. and Spalanzani, A. (2011) Supply chain risk management in French companies, *Decision Support Systems*, In press, corrected proof. Available online 22 November 2011, DOI:10.1016/j.dss.2011.11.017.

Leonard–Barton, D. (1990) A dual methodology for case studies: Synergistic use of a longitudinal single site with replicated multiple sites, *Organization Science*, Vol. 1, No. 3, pp. 248–266.

Lincoln, Y.S. and Guba, E.G. (1985) *Naturalistic inquiry*, Thousand Oaks, CA :Sage.

Lindroth, B. and Norrman, A. (2004) *Categorization of Supply Chain Risk and Risk Management*, in: Brindley, C. (ed.), *Supply Chain Risk*, Wiltshire, UK: Ashgate Publishing Limited.

Lysons, K. and Farrington, B. (2006) *Purchasing and Supply Chain Management*. Ashford Colour Press, Hants, UK.

Manuj, I. and Mentzer, J.T. (2008a) Global supply chain risk management strategies, *International Journal of Physical Distribution and Logistics Management*, Vol. 38, No. 3, pp.192–223.

Manuj, I. and Mentzer, J.T (2008b) Global supply chain risk management, *Journal of Business Logistics*, Vol. 29, No. 1, pp. 133–155.

Manthou, V., Vlachopoulou, M. and Folinias, D. (2004) Virtual e-Chain (VeC) model for supply chain collaboration, *International Journal of Production Economics*, Vol. 87, No. 3, pp. 241–250.

Martha, J. and Subbakrishna, S. (2002) Targeting a just-in-case supply chain for the inevitable next disaster, *Supply Chain Management Review* Vol. 6, No 5, pp. 18–23.

Mason, R., Lalwani, C. and Boughton, R. (2007) Combining vertical and horizontal collaboration for transport optimisation, *Supply Chain Management: An International Journal*, Vol. 12 No. 3, pp. 187–199.

Mason-Jones, R. and Towill, D.R. (1998) Shrinking the supply chain uncertainty cycle, *Control*, The Institute of Operations Management, Vol. 24, No. 7, pp. 17–22.

Mason–Jones, R., Naylor, B. and Towill, D.R. (2000) Lean, agile or leagile? Matching your supply chain to the marketplace, *International Journal of Production Research*, Vol. 38, No. 17, pp. 4061–4070.

Maxwell, J.A. (1992) Understanding and validity in qualitative research, *Harvard Educational Review*, Vol. 62, No. 3, pp. 279-300.

Maxwell, J.A. (1996) *Qualitative research design: An interactive approach*, Thousand Oaks, CA: Sage.

Mentzer, J., DeWitt, W., Keebler, J., Min, S., Nix, N., Smith, C. and Zacharia, Z. (2001) Defining supply chain management, *Journal of Business Logistics*, Vol. 22, No.2, pp.1–24.

Merriam, S.B. (1998) *Qualitative research and case study applications in education*, San Francisco: Jossey–Bass.

Miles, R.E., and Snow, C.C. (1978) *Organizational Strategy, Structure, and Process*. New York: McGraw-Hill.

Minahan, T. (2005) *The Supply Risk Benchmark Report*, Aberdeen Group, Boston, MA.

Min, S., Roath, A.S., Daugherty, P.J., Genchev, S.E., Chen, H., Arndt, A.D. and Richey, R.G. (2005) Supply Chain Collaboration: What’s Happening?, *The International Journal of Logistics Management*, Vol. 16, No. 2, pp. 237–256.

Minh, H. (1991) International intermodal choices via chance–constrained goal programming, *Transportation Research A*, Vol. 25, No. 6, pp. 351–362.

Modell, S. (2010) Bridging the paradigm divide in management accounting research: The role of mixed methods approaches, *Management Accounting Research*, Vol. 21, No. 2, pp. 124–129.

Moran, D. (2000) *Introduction to Phenomenology*, London, Routledge.

Müller, M. (2002) *Die Koordination von Supply Chains – Eine transaktionskosten-theoretische Untersuchung (The coordination of Supply Chains – A transaction Cost Analysis)*, Discussionpapier des Lehrstuhls für Production und Umwelt, der Carl von Ossietzky Universität Oldenburg, Oldenburg.

Möller, K. and Rajala, A. (2007), Rise of strategic nets – New modes of value creation, *Industrial Marketing Management*, Vol. 36 No. 7, pp. 895–908.

Narasimhan, R. and Talluri, S. (2009) Perspectives on risk management in supply chains. *Journal of Operations Management*, Vol. 27, No. 2, pp. 114–118.

Neiger, D., Rotaru, K. and Churilov, L. (2009) Supply chain risk identification with value-focused process engineering, *Journal of Operations Management*, Vol. 27, No. 2, pp. 154–168.

Norrman, A. and Jansson, U. (2004) Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident, *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 5, pp. 434–456.

Norrman, A. and Lindroth, B. (2002) *Supply Chain Risk Management: Purchasers' vs. Planners' Views on Sharing Capacity Investment Risks in the Telecom Industry*. Paper presented at the 11th International IPSERA conference, Enschede, The Netherlands.



Oke, A. and Gopalakrishnan, M. (2009) Managing disruptions in supply chains: A case study of a retail supply chain, *International Journal of Production Economics*, Vol. 118, No. 1, pp.168–174.

Olavarrieta, S. and Ellinger, A.E. (1997) Resource-based Theory and Strategic Logistics Research, *International Journal of Physical Distribution and Logistics Management*, Vol. 27, No. 9/10, pp. 559–587.

Park, J., Gordon, P., Moore, Ii, J.E., Richardson, H.W. (2008) The State-by-State Economic Impacts of the 2002 Shutdown of the Los Angeles–Long Beach Ports, *Growth and Change*, Gatton College of Business and Economics, University of Kentucky, Vol. 39, No. 4, pp. 548–572.

Parnell, J. A. and L. Hershey (2005) The Strategy-performance Relationship Revisited: The Blessing and the Curse of the Combination Strategy, *International Journal of Commerce and Management*, Vol. 15, No. 1, pp. 17–33.

Patton, E. and Applebaum, S.H. (2003) The case for case studies in management research. *Management Research News*, Vol. 26, No. 5, pp. 60–71.

Paulsson, U. (2004) Supply chain risk management, in: Brindley, C. (ed.), *Supply Chain Risk*, pp.79–96, Wiltshire, UK: Ashgate Publishing Limited.

Peck, H. (2005) Drivers of supply chain vulnerability: an integrated framework, *International Journal of Physical Distribution and Logistics Management*, Vol. 35, No. 4, pp. 210–232.

Peck, H., Abley, J., Christopher, M., Haywood, M., Saw, R., Rutherford, C., Strathern, M. (2003) *Creating Resilient Supply Chains*. Cranfield University, Cranfield School of Management, UK.

Pelto E. (2003) Environmental risk of the increasing oil transportation in the Gulf of Finland, Electronic publications of the Pan-European Institute 1/2003. Turku School of Economics and Business Administration.

Penrose, E.T. (1959) *The Theory of the Growth of the Firm*. Oxford University Press: New York.

Pereira, J.V. (2009) The new supply chain's frontier Information management, *International Journal of Information Management*, Vol. 29, No. 5, pp. 372–379.

Peteraf, M.A. (1993) The Cornerstones of Competitive Advantage: A Resource-Based View. *Strategic Management Journal*, Vol. 14, No. 3, pp. 179-191.

Petersen, K.J, Ragatz, G.L. and Monczka, R.M. (2005) An examination of collaborative planning effectiveness and supply chain performance, *The Journal of Supply Chain Management*, Vol. 41, No. 2, pp. 14–25.

Pillay, A. and Wang J. (2003) *Technology and Safety of Marine Systems*, Ed. Bhattacharyya R. and McCormick, M.E., Elsevier Ocean Engineering Book Series, Vol. 7, Elsevier Science Ltd, Oxford, UK,.

Rao, S. and Goldsby, T.J. (2009) Supply chain risks: a review and typology, *The International Journal of Logistics Management*, Vol. 20, No. 1, pp. 97–123.

Rao, S., Goldsby, T.J. and Iyengar, D. (2009) The marketing and logistics efficacy of online sales channels, *International Journal of Physical Distribution Logistics Management*, Vol. 39, No. 2, pp. 106–130.

Rhee, S.J. and Ishii, K. (2003) Using cost based FMEA to enhance reliability and serviceability, *Advanced Engineering Informatics*, Vol. 17, No. 3–4, pp. 179-188.

Rindfleisch, A. and Heide, J.B (1997) Transaction cost analysis: Past, present, and future applications, *Journal of Marketing*, Vol. 61, No. 4, p. 30–54.

Rumpunen, H. (2010) Metsäteollisuuden huoltovarmuus (Free translation in English: Security of supply in forest industries), Study of cargo flows in the Gulf of Finland in emergency situations –seminar, October 25th, 2010, Helsinki, Finland.

Samuel, K.E., Goury, M.–L., Gunasekaran, A. and Spalanzani, A. (2011) Knowledge management in supply chain: An empirical study from France, *The Journal of Strategic Information Systems*, Vol. 20, No. 3, pp. 283–306.

Sankar, N.R. and Prabhu, B.S. (2001) Modified approach for prioritization of failures in a system failure mode and effects analysis, *International Journal of Quality & Reliability Management*, Vol. 18 No. 3, pp. 324-335.

Sawhney R., Subburaman, K., Sonntag, C., Rao, P.R.V. and Capizzi, C. (2010) A modified FMEA approach to enhance reliability of lean systems, *International Journal of Quality and Reliability Management*, Vol. 27 No. 7, pp. 832-855

Scarff, F., Carty, A. and Charette, R. (1993) Introduction to the management of risk, Norwich: HMSO.

Seal, W., Cullen, J., Dunlop, A., Berry, T. and Ahmed, M. (1999) Enacting a European supply chain: a case study on the role of management accounting, *Management Accounting Research*, Vol. 10 No. 3, pp. 303–322.

Seuring, S and Müller, M (2003) Strategy and Organization in Supply Chains –. New Frontiers for Research, p. 1–14. In *Strategy and Organization in Supply Chains*, Seuring, S.; Müller, M.; Goldbach, M.; Schneidewind, U. (Eds.), Physica–Verlag, Heidelberg.

Schwandt, T. A. (1997) *Qualitative inquiry: A dictionary of terms*. Thousand Oaks, Sage, CA.

Senge, P.M. (1990) *The Fifth Discipline: The Art and Practice of the Learning Organization*, New York: Doubleday Currency.

Shaer, S. and Goedhart, J. (2009) Risk and the consolidated supply chain: rethinking established best practices, *APICS Magazine*, July/August, pp. 41–3.

Sheu, C., Lee, L., and Niehoff, B. (2006) A voluntary logistics security program and international supply chain partnership, *Supply Chain Management: An International Journal*, Vol. 11, No. 4, pp. 363–374.

Singhal, V., Hendricks, K. and Zhang, R. (2009) The effect of operational slack diversification, and vertical relatedness on the stock market reaction to supply chain disruptions, *Journal of Operations Management*, Vol. 27, No. 3, pp. 233–246.

Smaros, J., Lehtonen, J.M., Appelqvist, P. and Holmstrom, J. (2003) The impact of increasing demand visibility on production and inventory control efficiency, *International Journal of Physical Distribution and Logistics Management*, Vol. 33, No. 4, pp. 336–354.

Smith, M. and Buddress, L. (2005) Supply chain management: borrowing our way to a discipline, *International Journal of Services and Operations Management*, Vol. 1, No. 4, pp. 305–319.

Snell, P. (2010) Beware of the risks, and snap up the opportunities in 2010. *IFPSM ezine Highlights*, January 11, 2010, cited 20.1.2012, available at: <http://www.ifpsm-ezine.org/S>.

Sodhi, M.S., Son, B.G. and Tang, C.S. (2012) Perspectives on Supply Chain Risk Management, *International Journal of Production and Operations Management*, Vol. 21, No. 1, pp. 1–13.

Sodhi, M.S. and Lee, S. (2007) An analysis of sources of risk in the consumer electronics industry. *Journal of Operation Research Society* Vol. 58, No. 11, pp. 1430–1439.

Soosay, C., Hyland, P. and Ferrer, M. (2008) Supply chain collaboration: capabilities for continuous learning, *Supply Chain Management: An International Journal*, Vol. 13, No. 2, pp. 160–169.

Spekman, R.E. and Davis, D.E. (2004) Risky business: Expanding the discussion on risk and the extended enterprise, *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 5, pp. 414–433.

Spekman, R.E., Kamauff, J.W. Jr and Myhr, N. (1998) An empirical investigation into supply chain management: a perspective on partnerships, *International Journal of Physical Distribution and Logistics Management*, Vol. 3 No. 2, pp. 53–67.

Stake, R.E. (1995) *The art of case study research*. Sage Publications, Thousand Oaks, California.

Stake, R.E. (2000) Case studies. In *Handbook of qualitative research*, editors: N. K: Denzin and Y. S. Lincoln, pp. 435–454.

Stank, T.P., Keller, S.B. and Daugherty, P.J. (2001) Supply Chain Collaboration and Logistical Service Performance, *Journal of Business Logistics*, Vol. 22, No. 1, pp. 29–48.

Svensson, G. (2001) A conceptual framework for the analysis of vulnerability in supply chains, *International Journal of Physical Distribution and Logistics Management*, Vol. 30, No. 9, pp. 731–50.

Swink, M., and Zsidisin, G. (2006) On the benefits and risks of focused commitment to suppliers, *International Journal of Production Research*, Vol. 44, No. 20, pp. 4223–4240.

SÖKÖ II (2011) Alusöljyvahingon riski Suomenlahden pelastustoimialueella (Free english translation: risk of oil spill in shipping in the Gulf of Finland rescue region), SÖKÖ II-manuaali, ohjeistusta alusöljyvahingon rantatorjuntaan. Publications of the Kymenlaakso University of Applied Sciences, Series A, Learning Material No. 31, Tammerprint.

Tan, K.C. (2001) A framework of supply chain management literature, *European Journal of Purchasing and Supply Management*. Vol. 7, No. 1, pp. 39 – 48.

Tang, C. (2006) Perspectives in supply chain risk management, *International Journal of Production Economics*, Vol. 103, No.2, pp. 451–488.

Tang, O. and Nurmaya Musa, S.N. (2010) Identifying risk issues and research advancements in supply chain risk management, *International Journal of Production Economics*, Vol, 133, No.1, pp. 25–34.

Tang, C.S. and Tomlin, B. (2008) The power of flexibility for mitigating supply chain risks, *International Journal of Production Economics*, Vol. 116, No. 1, pp. 12–27.

Teece, D.J. (1986) Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy, *Research Policy*, Vol. 15, No. 6, pp. 285–305.

The Royal Society (1992) *Risk: Analysis, Perception and Management*, The Royal Society, London, UK.

Thun, J-H. and Hoenig, D. (2011) An empirical analysis of supply chain risk management in the German automotive industry, *International Journal Production Economics*, Vol. 131, pp. 242–249.

Treleven, M. and Schweikhart, S.B. (1988) A risk/benefit analysis of sourcing strategies: Single vs. multiple sourcing, *Journal of Operations Management*, Vol. 7, No. 3–4, pp. 93–114.

Trkman, P. and McCormack, K. (2009) Supply chain risk in turbulent environments – A Conceptual model for managing supply chain network risk, *International Journal of Production Economics*, Vol. 119, No. 2, pp. 247–258.

Tummala, R and Schoenherr, T. (2011) Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP), *Supply Chain Management: An International Journal*, Vol. 16, No. 6, pp. 474–483.

Van Leeuwen, J.F., Nauta, M.J., de Kaste, D., Odekerken–Rombouts, Y.M.C.F., Oldenhof, M.T., Vredenburg, M.J. and Barends, D.M. (2009) Risk analysis by FMEA as an element of analytical validation, *Journal of Pharmaceutical and Biomedical Analysis*, Vol. 50, No. 5, pp. 1085–1087.

Van Veen–Dirks, P.M.G. and Verdaasdonk, P.J.A. (2009) The dynamic relation between management control and governance structure in a supply chain context, *Supply Chain Management: An International Journal*, Vol. 16, No. 6, pp. 466–478.

Vanany I, Zailani S. and Pujawan N. (2009) Supply chain risk management: literature review and future research, *International Journal of Information Systems and Supply Chain Management*; Vol. 2, No.1, pp.16–33.

Vissak, T. (2010) Recommendations for using case study method in international Business Research, *The Qualitative Report*, Vol. 15, No. 2, pp. 370–380.

Voss, C., Tsikriktsis, N. and Frohlich, M. (2002) Case research in operations management, *International Journal of Operations and Production Management*, Vol. 22, No. 2, pp. 195–219.

Wagner, S. and Bode, C. (2006) An empirical investigation into supply chain vulnerability, *Journal of Purchasing and Supply Management*, Vol. 12, No. 6, pp., 301–312.

Wagner, S. and Bode, C. (2008) An empirical examination of supply chain performance along several dimensions of risk, *Journal of Business Logistics*, Vol. 29, No. 1, pp. 307–325.

Wagner, S.M. and Neshat, N. (2010) Assessing the vulnerability of supply chains using graph theory, *International Journal of Production Economics*, Vol. 126, No. 1, pp. 121–129.

Wang, Y.M., Chin, K.S., Poon, G.K. and Yang, J.B. (2009) Risk evaluation in failure mode and effects analysis using fuzzy weighted geometric mean, *Journal of Expert Systems with Applications*, Vol. 36 No. 2, pp. 1195-1207.

Waters, D. (2007) *Supply chain risk management: Vulnerability and resilience in logistics*, Kogan Page Limited: London. UK.

Watjatrakul, B. (2005) Determinants of IS sourcing decisions: a comparative study of transaction cost theory versus the resource-based view, *Journal of Strategic Information Systems*, Vol. 14 No. 4, pp. 289–415.



Weick, K. E. (1969) *The social psychology of organizing*, 1st ed. Reading: Addison–Wesley, MA.

Williamson, O.E. (1975) *Markets and hierarchies: Analysis and antitrust implications: a study in the economics of internal organization*, The Free Press: New York.

Williamson, O.E. (1981) *The economics of organization: The transaction cost approach*, *American Journal of Sociology*, Vol. 87, No. 3, pp. 548–577.

Williamson, O.E. (1985) *The Economic Institutions of Capitalism*, The Free Press, New York.

Williamson, O.E. (1994) *Transaction cost economics and organizational theory*, pp. 77–107, In: Smelser, N.J., Swedberg, R. (Eds.), *The Handbook of Economic Sociology*, Princeton University Press, Princeton.

Winter, S.G. (2000) *The satisficing principle in capability learning*, *Strategic Management Journal*, Special Issue, Vol. 21, No. 10–11, pp. 981–996.

Xia, D. and Chen, B. (2011) *A comprehensive decision–making model for risk management of supply chain*, *Expert Systems with Applications*, Vol. 38, No. 5, pp. 4957–4966.

Xiao, N., Huang, H.-Z., Li, Y., He, L., Jin, T. (2011) *Multiple failure modes analysis and weighted risk priority number evaluation in FMEA*. *Engineering Failure Analysis*, Vol. 18, pp. 1162–1170.

Xu, K., Dong, Y. and Evers, P. T. (2001) *Towards better coordination of the supply chain*, *Transportation Research Part E: Logistics and Transportation Review*, Vol. 37, No. 1, pp. 35–54.

Yan, S., Bernstein, D. and Sheffi, Y. (1995) International pricing using network flow techniques, *Transportation Research B*, Vol. 29, No. 3, pp. 171–180.

Yang, Y.-C. (2011) Risk management of Taiwan's maritime supply chain security, *Safety Science*, Vol. 49, No. 3, pp. 382–393.

Yin, R.K. (1994) *Case Study Research – Design and Methods*, Applied Social Research Methods Series, Vol. 5, Sage Publications, Thousand Oaks, CA.

Yin, R.K. (2003) *Case study research, design and methods*, 3rd ed., Sage Publications, Thousand Oaks, CA.

Yu, H., Zeng, A. Z., Zhao, L. (2009) Single or dual sourcing: decision-making in the presence of supply chain disruption risks, *International Journal of Management Science*, Vol. 37, No. 4, pp. 788–800.

Zsidisin, G.A. (2003) Managerial perceptions of supply risk, *Journal of Supply Chain Management*, Vol. 39, No 1, pp. 14–25.

Zsidisin, G.A., Ellram, L.S., Carter, J.R. and Cavinato, J.L. (2004) An analysis of supply risk assessment techniques, *International Journal of Physical Distribution and Logistics Management*, Vol. 34 No. 5, pp. 397–413.

Zsidisin, G.A. and Ritchie, B. eds. (2008) *Supply Chain Risk: A Handbook of assessment, Management, and Performance*. Springer Publishers, New York, USA.

## ACTA UNIVERSITATIS LAPPEENRANTAENSIS

428. MARKELOV, DENIS. Dynamical and structural properties of dendrimer macromolecules. 2011. Diss.
429. HÄMÄLÄINEN, SANNA. The effect of institutional settings on accounting conservatism – empirical evidence from the Nordic countries and the transitional economies of Europe. 2011. Diss.
430. ALAOUTINEN, SATU. Enabling constructive alignment in programming instruction. 2011. Diss.
431. ÅMAN, RAFAEL. Methods and models for accelerating dynamic simulation of fluid power circuits. 2011. Diss.
432. IMMONEN, MIKA. Public-private partnerships: managing organizational change for acquiring value creative capabilities. 2011. Diss.
433. EDELMANN, JAN. Experiences in using a structured method in finding and defining new innovations: the strategic options approach. 2011. Diss.
434. KAH, PAUL. Usability of laser - arc hybrid welding processes in industrial applications. 2011. Diss.
435. OLANDER, HEIDI. Formal and informal mechanisms for knowledge protection and sharing. 2011. Diss.
436. MINAV, TATIANA. Electric drive based control and electric energy regeneration in a hydraulic system. 2011. Diss.
437. REPO, EVELIINA. EDTA- and DTPA-functionalized silica gel and chitosan adsorbents for the removal of heavy metals from aqueous solutions. 2011. Diss.
438. PODMETINA, DARIA. Innovation and internationalization in Russian companies: challenges and opportunities of open innovation and cooperation. 2011. Diss.
439. SAVITSKAYA, IRINA. Environmental influences on the adoption of open innovation: analysis of structural, institutional and cultural impacts. 2011. Diss.
440. BALANDIN, SERGEY, KOUCHERYAVY, YEVGENI, JÄPPINEN, PEKKA, eds. Selected Papers from FRUCT 8 .2011.
441. LAHTI, MATTI. Atomic level phenomena on transition metal surfaces. 2011. Diss.
442. PAKARINEN, JOUNI. Recovery and refining of manganese as by-product from hydrometallurgical processes. 2011. Diss.
443. KASURINEN, JUSSI. Software test process development. 2011. Diss.
444. PEKKANEN, PETRA. Delay reduction in courts of justice – possibilities and challenges of process improvement in professional public organizations. 2011. Diss.
445. VANHALA, MIKA. Impersonal trust within the organization: what, how, and why? 2011. Diss.
446. HYNYNEN, KATJA. Broadband excitation in the system identification of active magnetic bearing rotor systems. 2011. Diss.
447. SOLONEN, ANTTI. Bayesian methods for estimation, optimization and experimental design. 2011. Diss.
448. JABLONSKA, MATYLDIA. From fluid dynamics to human psychology. What drives financial markets towards extreme events. 2011. Diss.

449. MYÖHÄNEN, KARI. Modelling of combustion and sorbent reactions in three-dimensional flow environment of a circulating fluidized bed furnace. 2011. Diss.
450. LAATIKAINEN, MARKKU. Modeling of electrolyte sorption – from phase equilibria to dynamic separation systems. 2011. Diss.
451. MIELONEN, JARI. Making Sense of Shared Leadership. A case study of leadership processes and practices without formal leadership structure in the team context. 2011. Diss.
452. PHAM, ANH TUAN. Sewage sludge electro-dewatering. 2011. Diss.
453. HENNALA, LEA. Kuulla vai kuunnella – käyttäjää osallistavan palveluinnovoinnin lähestymistavan haasteet julkisella sektorilla. 2011. Diss.
454. HEINIMÖ, JUSSI. Developing markets of energy biomass – local and global perspectives. 2011. Diss.
455. HUJALA, MAIJA. Structural dynamics in global pulp and paper industry. 2011. Diss.
456. KARVONEN, MATTI. Convergence in industry evolution. 2011. Diss.
457. KINNUNEN, TEEMU. Bag-of-features approach to unsupervised visual object categorisation. 2011. Diss.
458. RUUSKANEN, VESA. Design aspects of megawatt-range direct-driven permanent magnet wind generators. 2011. Diss.
459. WINTER, SUSANNA. Network effects: scale development and implications for new product performance. 2011. Diss.
460. JÄÄSKELÄINEN, ANSSI. Integrating user experience into early phases of software development. 2011. Diss.
461. KÄÄRIÄINEN, TOMMI. Polymer surface modification by atomic layer deposition. 2011. Diss.
462. KOCHURA, ALEKSEY. Growth, magnetic and transport properties of InSb and II-IV-As<sub>2</sub> semiconductors doped with manganese. 2011. Diss.
463. PUTKIRANTA, ANTERO. Possibilities and challenges of longitudinal studies in operations management. 2011. Diss.
464. HAPPONEN, ARI. Muuttuvaan kysyntään sopeutuva varastonohjausmalli. 2011. Diss.
465. VASAVA, PARITOSH. Application of computational fluid dynamics in modelling blood flow in human thoracic aorta. 2011. Diss.
466. PURO, LIISA. Identification of extractives and polysaccharides as foulants in membrane filtration of pulp and paper mill effluents. 2011. Diss.
467. LAPPALAINEN, PIA. Socially Competent Leadership – predictors, impacts and skilling in engineering. 2012. Diss.
468. PLAMTHOTTATHIL, ANSHY OONNITTAN. Application of electrokinetic Fenton process for the remediation of soil contaminated with HCB. 2012. Diss.
469. EBRAHIMI, FATEMEH. Synthesis of percarboxylic acids in microreactor. 2012. Diss.
470. JANTUNEN, SAMI. Making sense of software product requirements. 2012. Diss.