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The Role of Visibility in Managing Supply Chain Risk

Master's Thesis

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AALTO UNIVERSITY ABSTRACT OF THE MASTER'S THESIS
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This master's thesis aims at enhancing the understanding of the role of visibility in managing supply chain risk. Global supply chains are increasingly important for modern societies. However, globalization and changing business trends have increased the vulnerability of these supply chains. At the same time, the increasing complexity has decreased the level of visibility in supply networks. The importance of visibility for supply chain management is widely acknowledged on a general level, but the link to risk management is a rather unexplored territory.

The thesis takes a design science approach, using the CIMO logic to structure the problem. Visibility as an intervention (I) has been studied in the context (C) of supply chain risk, concentrating especially on late deliveries. For this setting, mechanisms (M) leading to specific outcomes (O) have been identified. A literature review has been conducted on supply chain risk management and supply chain visibility, highlighting the inter-linkage of these two concepts. Further, data has been collected in seven companies from the buying end of the supply chain using a questionnaire and in five companies using interviews.

The main finding of the study is that the key role of visibility in managing supply chain risk lies in the identification phase of risk management. However, together with decision making, visibility also helps in mitigating and responding to risks. Further, visibility has an important role in improving customer relationships. The study also identifies that visibility and information sharing in the management of late deliveries are important especially between the buyer and the seller, while being less important between the buyer and logistics parties.

The study meets the requirements of rigor for case research, but the findings should however be generalized with care outside the context of this study. The role of visibility in managing supply chain risk is an unexplored field and further research is needed to verify as well as to broaden and deepen the findings of this study.

Keywords: supply chain risk; supply chain risk management; supply chain visibility; CIMO logic	Publishing language: English

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<tr><td colspan="3">Syftet med detta diplomarbete är diskutera betydelsen av informationstransparens i hanteringen av risker i leveranskedjan. Samhället idag är allt mer beroende av globala leveranskedjor. Samtidigt har globaliseringen och förändrade verksamhetsprinciper gjort dessa leveranskedjor mer utsatta för störningar, och dessa trender har även minskat informationstransparensen mellan företag. Det är allmänt accepterat att informationstransparens är av betydelse i styrningen av leveranskedjor, men kopplingen till riskhantering är ett tämligen outforskat område.

I detta arbete har den så kallade CIMO-logiken använts för att strukturera forskningsfrågan. Genom att granska informationstransparens som åtgärd (intervention, I) i hanteringen av risker i leveranskedjan (context, C) har mekanismer (mechanisms, M) som leder till specifika resultat (outcomes, O) identifierats. Inledningsvis har hanteringen av risker i leveranskedjan, informationstransparens och begreppens sammanlänkning granskats utgående från litteratur. Vidare har material samlats in i sju företag genom ett frågeformulär och i fem företag genom intervjuer. Studien koncentrerar sig speciellt på hanteringen av försenade försändelser ur köpande företags synvinkel.

Arbetets huvudsakliga slutsats är att informationstransparens kan kopplas till riskhantering i identifieringen av risk. Därtill gör informationstransparens det möjligt att tillsammans med beslutsfattande bättre reducera och bemöta risker. Informationstransparens har också en viktig roll i upprätthållandet av kundrelationer. Då det gäller försenade försändelser är informationstransparens viktigt speciellt mellan den köpande och säljande parten, men av mindre vikt mellan den köpande parten och logistiska aktörer.

Betydelsen av informationstransparens i hanteringen av risker är ett område som fått lite uppmärksamhet speciellt i akademiska sammanhang, och fortsatt forskning behövs för att såväl bekräfta som bredda och fördjupa resultaten från denna studie. Resultaten bör således tillämpas i andra sammanhang med aktsamhet.</td></tr>
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Mia Eriksson

Espoo, January 2013

Glossary

7R = the Seven R's of Logistics

APS = Advanced Planning System

ATA = Actual Time of Arrival

CASSANDRA = Common Assessment and Analysis of Risk in Global Supply Chains

CPFR = Collaborative Planning, Forecasting and Replenishment

EDI = Electronic Data Interchange

ERP = Enterprise Resource Planning

ETA = Estimated Time of Arrival

ETD = Estimated Time of Departure

FCA = Free Carrier

FP7 = European Commission's Seventh Framework Programme

GPS = Global Positioning System

IOS = Inter-Organizational System

ISO = International Organization for Standardization

IT = Information Technology

LSP = Logistics Service Provider

MRP = Material Requirements Planning

OTD = On-Time Delivery

POS = Point of Sales

RFID = Radio Frequency Identification

SCOR = Supply Chain Operations Reference

SCEM = Supply Chain Event Management

VMI = Vendor Managed Inventory

XML = Extensible Markup Language

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1 Introduction

1.1 Background and objectives

Global supply chains are increasingly important for modern societies. Extending operations to other continents allow companies for example to enter new markets, to increase the speed to customers and to lower costs (McKinsey, 2008). However, the recent large number of catastrophic events, such as terrorist attacks, natural disasters and pandemics, has drawn attention to the vulnerability of these supply chains (Jüttner, 2005). In an increasingly global world an incident in one country can affect businesses worldwide. As an example, when an earthquake hit Taiwan in 1999 (McGillivray, 2000) the personal computer industry was affected on a global level. With some 10% of the world's computer chips and 80% of the world's motherboards being produced in Taiwan, the shut-down in production following from the incident led to lost revenues of over 200 million dollars.

Also changing business trends are making supply chains more vulnerable. A report by the World Economic Forum (2012a) has identified recent supply chain trends to include globalization, specialization, complexity, and lean processes. Pfohl et al. (2010), in turn, have identified these factors to be drivers of risk. Globalization and outsourcing indeed make supply chains more complex (Jüttner et al., 2003), which Harland et al. (2003) have identified to increase risk. As an example, practitioners confirm in an article in the business magazine Fortune (Powell, 2011) that the floods in Thailand in 2011 showed on the vulnerability of using low-cost suppliers in the context of "just-in-time" manufacturing.

Consequently, interest in supply chain risk management has increased rapidly since the beginning of the 21st century (Peck, 2006). The growing importance of supply chain risk management is also visible in corporations. In a global survey to supply chain executives (World Economic Forum, 2012a) over 90% of the respondents reported that supply chain and transportation risk management have received greater priority during the last five years. Further, the concern for supply chain and transportation disruptions is shifting from considering only operational managers to include c-suite level leadership and corporate boards as external disruptions to supply

chains and transportation networks often result in falling stock prices and in having reputational implications (World Economic Forum, 2012a).

Complexity, the trends towards specialization and low levels of integration between companies do not only increase vulnerability and risk, but have likewise decreased the degree of visibility in supply chains (van Stijn et al., 2011; Vilko and Hallikas, 2012). At the same time supply chain professionals have identified the lack of shared data and information and the lack of supplier visibility to be among the top five vulnerabilities of their supply chains (World Economic Forum, 2012a). In a survey to supply chain executives 78% of the respondents stated that improved supply chain visibility is a top priority in their company, and 88% planned to invest in supply chain visibility enabling or enhancing technology within the next 12 months (Aberdeen Group, 2011).

The lack of visibility in supply chains causes problems both for businesses and for governmental agencies. For businesses, shortcomings in data and information exchange cause inefficiencies and might as well result in missed business opportunities (Almotairi et al., 2011). Further, the lack of visibility has also been identified to have a negative effect on margins and overhead (van Stijn et al., 2011). For customs, low visibility makes the assessment of risks at the border difficult (van Stijn et al., 2011). Hesketh (2010) explains that in a multilayered supply chain only the one who originally "packed the box" knows what exactly is being sent into the chain, while customs commonly has to rely on second-hand information provided by transportation parties to assess risk.

In practice, visibility can mean knowing an items instantaneous location and status and its history of processing, movements and transactions. This has been identified to reduce operational costs, improve productivity and increase customer satisfaction (Zhou, 2008; Pilli-Sihvola et al., 2012). Considering for example a shipment of fruit arriving at the port, knowing which type of fruit is packed into which container would allow to better target different hinterland transportation modes for specific containers (van Stijn et al., 2011). Most fruit is perishable and needs to be transported as quickly as possible, using road transportation, but for example bananas are picked unripe and ripen during transportation and could therefore be shipped using a slower but at the same time cheaper and more ecological barge transport.

Road transport could then be chosen for bananas only when the shipment arrives late for example because of bad weather conditions on-route.

As explained, the increasing vulnerability of supply chains and the enhanced need for visibility are widely acknowledged by both academics and practitioners. However, visibility and information sharing are often seen as generic cures to a number of different supply chain problems (Barratt and Oke 2007), while the link between visibility and supply chain risk management has received less attention. Especially when it comes to logistics risks, few seem to have a more precise understanding of the role of visibility in managing supply chain risks (Rodrigues et al. 2008).

Thus, **the objective of this study is to enhance the understanding of the role of visibility in managing supply chain risk.** Even though the need for enhanced visibility in the supply chain is highly acknowledged on a general level, less attention has been paid to the link between visibility and risk management. However, visibility and information sharing are seen as key enablers for a more efficient supply chain, and it could therefore be expected that visibility has an important role in managing supply chain risk as well.

1.2 Link to research project FP7-CASSANDRA

This thesis is written as a part of the research project CASSANDRA, financed by the European Commission's Seventh Framework Programme (FP7) for Security. The acronym CASSANDRA stands for "Common assessment and analysis of risk in global supply chains." The three-year project, started in June 2011, aims at improving business operations, extending risk assessment, and enhancing efficiency and effectiveness of government supervision of the flow of goods through enhanced supply chain visibility. CASSANDRA approaches supply chain visibility through data sharing, by introducing the idea of an "information pipeline" in which existing information sources in supply chains could be combined and made available for all parties involved. (CASSANDRA, 2012a)

The idea of the data pipeline is to re-use and share available business data from as far upstream as possible amongst agreed supply chain actors and governmental parties. This is based on two underlying principles: piggybacking, which means re-using original trade data from the transaction in down-stream processes, and the use of

synchronization points, which refer to the sales agreement and the completion of the consignment. Feeding in data in the pipeline from the synchronization points would therefore ensure that high quality data is available instantly from the moment when everything about the consignment is known. (van Stijn et al., 2011)

The role of this thesis, as part of the research project CASSANDRA, is to enhance the understanding of the role of visibility in managing supply chain risk for commercial parties. To successfully introduce the pipeline concept, it needs to make sense for businesses involved. An increased understanding of the role of visibility in managing supply chain risk helps in designing the pipeline in a way that not only benefits customs, but at the same time allows the commercial parties to improve their business operations.

2 Methodology

The objective of this study is to enhance the understanding of the role of visibility in managing supply chain risk. This section starts out by presenting the CIMO logic, which has been used to structure the problem. Further, research questions based on the CIMO logic are presented. Finally the research design, including a literature review, a field study and case studies, are reviewed.

2.1 CIMO logic

The CIMO logic, developed by Denyer et al. (2008) in their paper on design propositions, takes a design science approach to management and organization problems. The basic "do A to get B" logic works in many contexts; for example in the field of engineering a specific formula is used to calculate the maximum load of a bridge (Pawson, 2002; 2006, cited in Denyer et al., 2008). However, in management and organization problems, also the context in which an intervention is implemented and the mechanism that generates the outcome need to be taken into account (Denyer et al., 2008).

The CIMO logic is based on previous work by Bunge (1967) and Pawson and Tilley (1997) (both cited in Denyer et al., 2008). In his paper, Bunge presents a technological rule, according to which an outcome O in a context C can be obtained using a certain intervention I. Pawson and Tilley, addressing the issue of causality, further add the mechanism M to the process. Denyer et al., combining these, form the CIMO logic in which a certain problematic context C is approached using an intervention I that through a mechanism M generates an outcome O (Figure 2-1).

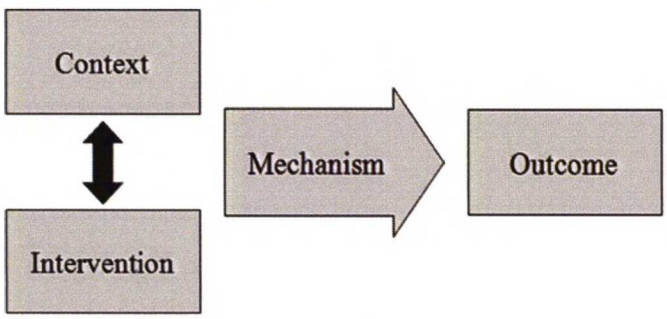

Figure 2-1 The CIMO logic, in which an intervention in a certain context through a mechanism generates an outcome (based on Eriksson, 2011)

The authors point out that using a design science approach is useful especially when solving management construction problems. In this study the question on the role of visibility in managing supply chain risk is addressed; the use of the CIMO logic offers a useful structure in organizing the problem, letting visibility represent the intervention and supply chain risk the context.

2.2 Research questions

This study aims at increasing the understanding of the role of visibility in managing supply chain risk. Taking into account the pipeline envisioned in the CASSANDRA project, the subject is approached especially from a logistics point of view. Thus, based on the CIMO logic, the study is organized into the following research questions:

1) What is the most important logistics risk in global supply chains? How does this risk relate to supply chain risk?
2) What data/information on this most important risk do companies have?
3) How does this data/information help companies manage this risk?
4) What is the outcome when making use of this data/information?

With these questions, the study aims at addressing the research problem at a concrete level. The study focuses on information sharing between supply chain partners, and does not include governmental parties such as customs in the scope. Further, the study is limited to the view of companies in the buying end of the supply chain.

2.3 Research design

As the subject chosen for this study has received less attention in literature, the study takes an exploratory approach. To begin with, a literature review was conducted to assess the existing body of knowledge on visibility in supply chain risk management. Further, a field study in form of a standardized questionnaire was conducted to enhance the understanding of the problem and support the selection of focus. Finally, managers from selected case companies were interviewed to get a deeper understanding of how visibility is used in managing supply chain risk. The research process for this study is summarized in Figure 2-2.

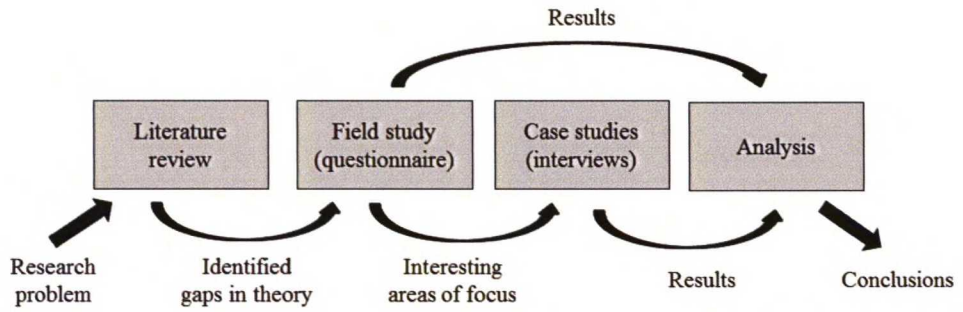

Figure 2-2 Research process for the study

2.3.1 Literature

Tranfield et al. (2003) enhance the importance of conducting a literature review in management research. The aim of the literature review is to extend the existing body of knowledge; with the literature review the researcher can map and assess the intellectual field in order to identify gaps in theory. A more reliable basis for making decisions and taking actions is obtained by enhancing the legitimacy and authority of the literature used.

In this study, a literature review was used to develop the understanding of how supply chain visibility links to supply chain risk management. Based on the review, gaps in theory were identified. The review was conducted using searches in data bases, concentrating on both different combinations of key words and established authors from the field. Literature was mainly selected from recognized academic journals, but also some selected conference papers and practitioners' reports were included to add a practical dimension to the subject.

2.3.2 Field study

Meredith (1998) points out the usefulness of field research in understanding a phenomenon; as the aim of this study is to enhance the understanding of the role of visibility in managing supply chain risk, it is justified to use field research in approaching the problem.

The field research was conducted using a standardized questionnaire (Appendix 1), which was distributed to targeted companies with global supply chains by e-mail via supply chain risk management conference participation lists, trade associations, research group contacts and other suitable forums. The contacted companies were

from the buying end of the supply chain, and managers were selected from the supply chain management, logistics and procurement departments.

The questionnaire was developed based on identified gaps in theory from the literature review, and aimed at identifying what risks the companies faced related to inbound logistics and what information they used for monitoring and managing these risks. The questionnaire as a whole is presented in Appendix 1. Before launching the study, the questionnaire was reviewed and commented by several supply chain experts and tested with two companies. Further, follow-up questions were sent to some of the respondents to further develop the answers during the analysis phase.

As it is challenging to make an exhaustive list of risk sources, inbound logistics risks were in the questionnaire defined with the help of the SCOR model and the 7R's of logistics. The SCOR model defines effective supply chain management to be *all about delivering the right product in the right quantity and in the right condition with the right documentation to the right place at the right time at the right price* (Supply Chain Council, 2010), whereas the 7R's of logistics states that the aim of logistics is to *ensure the availability of the right product, in the right quantity, in the right condition, at the right place, at the right time, at the right cost, for the right customer* (Viswanadham and Gaonkar, 2008). Based on these two definitions, possible inbound logistics risks were defined as exceptions to these ideal states, including:

- Late deliveries
- Early deliveries
- Under quantity deliveries
- Over quantity deliveries
- Wrong product deliveries
- Sub-quality deliveries
- Deliveries with damaged goods
- Deliveries to wrong place
- Actual delivery cost exceeds planned cost
- Deliveries with wrong documentation or data
- Deliveries with missing documentation or data

In the questionnaire, the companies were asked assess the frequency and the impact of these logistics problems on a qualitative five-step scale. Further, to understand what information was used to monitor and manage these risks, the companies were asked to state what risk rules they use in monitoring their operations. Risk rules, in other word standard operation procedures, are used to notify the company of an emerging problem, to define when to react on a problem, and to define actions to take when a problem occurs. Supply chain visibility is a difficult and often ill-defined term; asking for risk rules and related information takes visibility to a more concrete level in showing what information the companies currently use for managing risks. To get a picture of the current state of information sharing in the supply chains, the companies were also asked directly about data elements that they receive from or share with other actors in the supply chain. Finally, the companies were asked to rank the importance of supply risks, demand risks, operational risks and environmental risks to understand how logistics risks relate to other supply chain risks.

2.3.3 Case studies

Yin (1989, cited in McCutcheon and Meredith, 1993) notes that *"the case study's purpose may be strictly to describe a situation but, more often, it is to understand how or why events occur"*. Having examined what risks companies face and what information they share related to these risks in the field study, interviews were then conducted in five selected case companies to deepen the understanding on how this information is used, what outcomes it generates, and why.

Interview questions were developed according to the objectives of the study and based on interesting findings in the field study. The questions were reviewed and commented by experienced researchers before conducting the interviews, and slightly adjusted after the first interview. The interview format was semi-structured in order to allow for the interviewees to further develop interesting points emerging during the interview. The interview structure is presented in Appendix 2.

In the field study, the most important risk identified was late deliveries, which is the reason for concentrating the interviews on this specific risk. To begin with, the companies were asked to define a late delivery, in other words to explain the context. Having defined the problem, using information sharing as a solution was addressed

in order to understand the intervention, and especially the mechanisms behind and possible outcomes from it. To attain a concrete level in the answers, the respondents were also asked to describe a recent, important late delivery they have dealt with. Finally, the role of visibility was addressed on a more general level.

Table 2-1 Attributes of the selected case companies

	Activity		Size		Goods procured[1]		Transportation mode	
Company	**Prod.**	**Distr.**	**Big**	**Small**	**Regular**	**Sensitive**	**Ship**	**Air**
Confectioner	x		x		x		x	
Consumer electronics	x		x			x		x
Engineering workshop	x		x		x		x	
Food distributor		x		x		x	x	
Office supplies distr.		x		x	x		x	
Total	**3**	**2**	**3**	**2**	**3**	**2**	**4**	**1**
Group total	**5**		**5**		**5**		**5**	

For an exploratory approach with case studies, it is suggested to choose *"multiple cases that may be maximally different"* as this highlights similarities and differences in the studied phenomenon (McCutcheon and Meredith, 1993). The interviewed companies were chosen accordingly, with companies representing different sizes, different types of products, different transportation modes, and different activities in the supply chain (Table 2-1). The interviews were conducted face-to-face when possible, but because of restrictions in physical distance and timetables some of the interviews were conducted over the phone or Skype. The face-to-face interviews were recorded and transcribed, and for phone interviews rigorous notes were taken.

[1] Division is based on how the companies express the nature of their goods procured; both companies with "sensitive goods" were especially concerned about quality of their goods during transportation.

3 Literature review

Supply chain risk management and supply chain visibility have been covered widely in literature. The literature review presented in this chapter starts out by reviewing these two concepts separately in order to create a thorough understanding of the concepts before taking on a review of how supply chain risk management and visibility link together. In the end the role of visibility in managing supply chain risk is summarized using the CIMO logic, and to conclude identified gaps in theory are presented.

3.1 Supply chain risk management

3.1.1 Defining supply chain risk

When discussing supply chain risk management it is first important to understand what is meant with supply chain risk. In general, risk is defined as an unfavorable event with a certain probability and impact, but this classical view of risk is seen as limited by several authors.

Firstly, it is pointed out that risk taking is not automatically negative and does not always relate to losses (Pfohl et al. 2010). The opposite side of risk can be seen as opportunities or chances from which the company can take advantage. Peck (2006), on the other hand, claims that there seldom is an upside for risk in the supply chain context.

Secondly, when discussing the probability and impact of risk, there is a difference between risk that occurs as a distribution and risk that occurs as a discrete event (Viswanadham and Gaonkar, 2008). One parameter within the supply chain, such as cost, demand or lead-time, can vary around an average value, whereas events such as natural disasters and accidents either occur or don't occur in a binary way. The classic definition of risk does neither takes into account uncertainty. Probability and impact define risk as something quantifiable, something that is known and can be modeled. Uncertainty, on the other hand, occurs when neither the outcome nor the probability of an event can be estimated on beforehand (Rodrigues et al., 2008). Also a report by the World Economic Forum (2012b) points out that even though possible

to identify likely types of disruption, the precise nature of disruptions and their impact on global supply chain and transport networks are hard to predict.

Thirdly, increased lead times and physical distances have led to lesser control of the supply chain, making the speed and frequency of risk important factors to consider as well. Speed of risk is associated with how fast a threat or a loss escalates, and how rapidly it can be detected, whereas frequency deals with how often similar events happen. Practitioners also identify the interrelationship and linkage between separate risks as an important aspect of supply chain risk, especially in global supply chains and networks. (Manuj and Mentzer, 2008)

Fourthly, when discussing supply chain risk – and risk in general – it is also important to understand the difference between risk as source and risk as a consequence (Pfohl et al., 2010; Jüttner et al., 2003). Risk as a source is associated with the event or hazard that impacts the performance of the supply chain (for example variables in the environment, the supply chain or the organization), whereas risk as a consequence focuses on the actual outcomes from these events.

Finally, supply chain risk can also be defined in a totally different manner. Viswanadham and Gaonkar (2008) discuss supply chain risk in terms of supply chain exceptions. They define an exception using the "Seven R's" definition for the purpose of logistics, which is *"to ensure the availability of the right product, in the right quantity, in the right condition, at the right place, at the right time, at the right cost, for the right customer"*. An exception occurs whenever the supply chain fails to meet one of these requirements. This approach to risk also agrees with how many practitioners choose to define supply chain risk (Manuj and Mentzer, 2008). Defining risk through exceptions also highlights an important observation pointed out by Peck (2006), which is that transportation and infrastructure risks often are left out when considering supply chain risk.

When it comes to categorizing supply chain risk, a multitude of different manners exist. Some authors categorize supply chain risk according to the proximity of the risk source to the focal company, in other words distinguish between internal risk, network risk and external risk (e.g. Viswanadham and Gaonkar, 2008; Pfohl et al., 2010; Peck, 2006; Lockamy and McCormack, 2010). Others categorize supply chain

risk in relation to the flows in the supply chain. Pfohl et al. (2010) address the traditional flows of goods, information and money, whereas demand and supply risks are identified by a large group of authors (e.g. Johnson, 2001; Hallikas et al., 2004; Jüttner, 2005; Wagner and Bode, 2006; Manuj and Mentzer, 2008). A third group of authors approach supply chain risk from a business management perspective, identifying operational disturbances, tactical disruptions and strategic uncertainties (Paulsson, in Lockamy III and McCormack, 2012; Norrman and Lindroth, in Jüttner et al., 2003). A fourth group of authors discuss risk based on the severity of its impact and identify three groups of risk: deviations, where one parameter such as cost or demand change; disruptions, where the structures of the supply chain is radically transformed; and disasters, where the whole supply network is temporarily shut down (Viswanadham and Gaonkar, 2008; Kneymeyr et al., 2009).

As can be seen from the discussion, supply chain risk is a very multifaceted concept with a multiple of approaches. Indeed, Sodhi et al. (2012), in an extensive study on perspective on supply chain risk management, have identified the lack of shared understanding of supply chain risk both in the academic society and among practitioners.

3.1.2 Defining supply chain risk management

Moving on from supply chain risk to supply chain risk management makes the discussion no easier as several different definitions on supply chain risk management coexist. Jüttner et al. (2003) define supply chain risk management as *"the identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability"*. This definition coincides quite well with the aspects of supply chain risk management that most authors identify. Most definitions of supply chain risk management include the following aspects:

1. **understanding the risk**, through identification (Manuj and Mentzer, 2008; Jüttner, 2005; Supply Chain Council, 2010), evaluation (Manuj and Mentzer, 2008) or assessment (Supply Chain Council, 2010; International Organization of Standardization, 2009a) of risks
2. **acting upon the risk**, through management (Jüttner, 2005), handling (Kajüter, 2003, in Pfohl et al., 2010), treatment (International Organization of

Standardization, 2009a) or mitigation (Supply Chain Council, 2010) of risks, or through implementation of strategies (Manuj and Mentzer, 2008)

3. a **structured** (Kajüter, 2003, in Pfohl et al., 2010), **systematic** (Supply Chain Council, 2010), or **disciplined** (Diessner and Rosemann, 2008) **approach**
4. a **coordinated** (Manuj and Mentzer, 2008; Jüttner, 2005) and **collaborative** (Kajüter, 2003, in Pfol et al., 2010; Jüttner, 2005) **approach** amongst supply chain partners

When discussing supply chain risk management, Harland et al. (2003) point out that focus has long been only on supply and demand risk management and little on networks. Current business trends such as globalization, outsourcing and product complexity have made supply chains evolve to complex and dynamic networks (Harland et al., 2003) with an increasing degree of interconnectedness both between supply chain parties (Pfohl et al., 2010) and supply chain risks (Chopra and Sodhi, 2004), which should be taken into account in supply chain risk management. Also Pfohl et al. (2010) recognize that the potential "domino effect" of risks need to be analyzed with regard to all partners in the supply chain.

A particular feature of supply chain risk management highlighted by several authors is the collaborative aspect. Jüttner (2005) point out that in order to reduce supply chain vulnerability as a whole vulnerability needs to be approached in a coordinated manner between supply chain members. Also a report by the World Economic Forum (2012a) highlights that a single actor in the supply chain seldom is able to take the strategic and operational decisions required to reduce the vulnerability of the supply chain. Indeed, mutual goal setting and planning is necessary across the entire supply chain as mutual identification and communication of problems is needed to reduce information asymmetries (Pfohl et al., 2010).

3.1.3 The supply chain risk management process

Blome and Schoenherr (2011) recognize that effective supply chain risk management requires a systematic approach, and suggest a four step approach with risk identification, risk analysis, risk mitigation/acceptance and risk monitoring. Harland et al. (2003) have used iterative case studies to develop a supply network risk tool, which includes the steps of mapping the supply network; identifying, assessing and managing risk; and forming and evaluating collaborative supply network strategies.

Several other authors suggest to a large extent similar processes for supply chain risk management. In a literature review based on a large number of papers from the field Sodhi et al. (2012) synthesize the supply chain risk management process elements to be identification of risk, assessment of risk, mitigation of risk, and responsiveness to risk (Figure 3-1). These coincide with the process elements suggested by the International Organization for Standardization (2009b) and the Supply Chain Council (2010), although with some differences in naming.

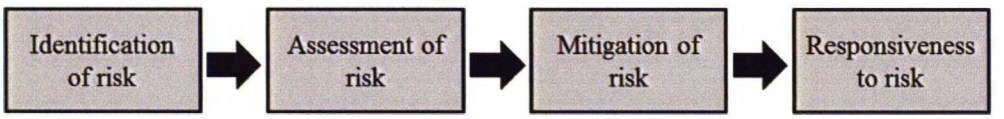

Figure 3-1 The steps in the risk management process (Sodhi et al., 2012)

The first step in the risk management process, identification of risk, includes collecting and documenting all potential risks that can affect the organization. Some authors (e.g. International Organization of Standardization, 2009b; Supply Chain Council, 2010) suggest that this step should be preceded by establishment of the context, in other words identifying relevant stakeholders and processes in the supply chain. Assessment of risk, the second step, covers the evaluation of the likelihood and the impact of the identified risks. Mitigation of risk, the third step, includes preventive risk strategies, in other words actions taken in order to reduce the likelihood and/or impact of the risks. As all risks cannot be eliminated, the final step, responsiveness to risk, proposes how to respond when a risk event realizes. The Supply Chain Council (2010) discusses this in the light of monitoring and identifying emerging risks and the effectiveness of mitigation plans. The two final steps are also named as risk treatment by the International Organization for Standardization.

According to Blome and Schoenherr (2011) the different steps in the risk management processes are interlinked, which means that a successful risk management requires that all steps in the supply chain risk management process are carried out. The International Organization for Standardization points out that the process for managing risk should be preceded by principles for managing risk and a framework for managing risk. Jüttner (2005) also talks about "philosophy" (in addition to principles) as the highest conceptual level of supply chain risk management.

3.1.4 Supply chain risk mitigation strategies

Supply chain risk mitigation strategies usually tackle three main problems: the elimination of the hazard, reduction of the likelihood of the hazard, and reduction of the impact of the hazard. In addition business continuity planning is suggested (e.g. Wagner and Bode, 2006; Zsidisin et al., 2005).

Stecke and Kumar (2009) divide risk management strategies into three groups: proactive strategies, advanced warning strategies, and coping strategies. Proactive strategies help the company avoid or reduce the likelihood of a risk, whereas advanced warning strategies warn the company of threatening events. Finally, coping strategies help the company reduce the impact of occurring disruptions and continue business operations. Most strategies presented by other authors can be classified with this division as a base.

The International Organization for Standardization (International Organization of Standardization, 2009a) proposes four general risk treatment strategies, which are risk avoidance, risk optimization, risk transfer, and risk retention. Risk avoidance is a proactive strategy, which deals with eliminating the hazard, for example by avoiding operating a certain geographic area. Risk optimization deals with reducing the likelihood and the impact of an event, i.e. minimizing the loss (or maximizing the gain). This is a broad approach that can include both proactive and coping strategies. Risk transfer, on the other hand, is a coping strategy, which through contracts or insurances shares the loss (or gain) of a risk with another party. Peck (2006) still points out that risks only should be forwarded to parties that have better conditions to handle them. Finally, risk retention simply means accepting the possible loss (or gain) of a risk, for example in situations where the risk simply cannot be avoided.

Several authors identify different supply chain risk management strategies that partly overlap with the strategies proposed by International Organization of Standardization (2009a). Jüttner et al. (2003) identify the strategies of risk avoidance, risk control, cooperation, and flexibility, whereas Manuj and Mentzer (2008) propose postponement, speculation, hedging, risk control/share/transfer, security, and avoidance as an alternative. Chopra and Sodhi (2004) on their side suggest adding capacity, adding inventory, having redundant suppliers, increasing the responsiveness, increasing the flexibility, aggregating or pooling demand, increasing

capability, and having more customer accounts. Finally, Diessner and Rosemann (2008) point out that different supply chain strategies exist on a strategic, a tactical and an execution level.

The selection of supply chain risk management strategies depends on several internal and external factors as well as the overall strategy of the supply chain. Blome and Schoenherr (2011) suggest that companies apply different types of supply chain risk management strategies depending on whether they are manufacturing or service companies, whereas Jüttner et al. (2003) identify the impact of the product type on the strategy selection. Manuj and Mentzer (2008) propose that the temporal focus (short term versus long term perspective) of performance and reward systems and the flexibility of the supply chain have an impact. It is further highlighted that adapting to the supply chain environment should be done in the same way as seeking fit for a corporate strategy (Manuj and Metzer 2008; Blome and Schoenherr 2011). The choice of supply chain risk mitigating strategies is also affected by risk/reward relationships; the benefit of the strategy must be greater than its cost (World Economic Forum, 2012a; Chopra and Sodhi, 2004).

In addition to risk management strategies, also the choice of specific supply chain strategies can affect a company's relationship to risk. Jüttner et al. (2003) identify several tradeoff situations, for example in choosing between the lowest bidder and a known supplier; between multiple and single sourcing; or between supply chain collaboration and secrecy, which expose the company to different types of risks. These decisions relate especially to demand and supply management.

The effectiveness of the chosen risk management strategies can be seen when disruptions occur. A robust supply chain can profitably continue operations in cases of a minor disruption (Peck, 2006). It is still impossible to build a supply chain that can handle catastrophic events such as a terrorist attack or an earthquake without a temporary shut-down (Viswanadham and Gaonkar, 2008). As all hazards cannot be eliminated or precisely forecasted, several authors suggest the design of a resilient supply chain (e.g. World Economic Forum, 2012b; Sheffi and Rice, 2005). A resilient supply chain is able to maintain, resume and restore its operations quickly in case of a disruption, and either returns to its original state or even moves on to a more desirable state in the restoration process (Peck, 2006; Viswanadham and

Gaonkar, 2008). The importance of resiliency is also noted by practitioners, who highlight that it important to be resilient, flexible and adaptable in order to be able to respond to a number of unexpected events, rather than to just prepare for some specific situations (World Economic Forum, 2012b). Two main strategies identified for the development of resiliency are redundancy and flexibility (Sheffi and Rice, 2005; Viswanadham and Gaonkar, 2008). Redundancy refers to having spare resources available along the chain to use in case of a disruption, for example in the form of inventory or capacity, or through multiple sourcing. Flexibility, on the other hand, refers to the company's ability to react quickly to changes in the environment (including disruptions).

3.1.5 Risk management and risk rules

Risk rules, also known as safety rules or rule-compliance, are used to monitor and mitigate operational risks. Hale and Swuste (1998) define safety rules as *"a defined state of a system or way of behaving in response to a predicted situation, established before the event and imposed upon those operating in the system, by themselves or others, as a way of improving safety or achieving a required level of safety."* Hopkins (2011) explains that risk rules are needed as the level of risk occurs on a continuum. Because of this, it is hard to assess the actual risk level in a decision making situation. In addition, inappropriate reward systems can cause a bias towards risk taking. As an example, a risk rule could be requiring a truck driver to take a break each four hours; with this rule in place the driver would not have to assess himself whether he is too tired to continue driving safely or not.

Hale and Swuste (1998) identify three types of risk rules: rules that define certain goals to achieve; rules that define when to take action, and rules that define actions to take. An example of a rule from the first group would be to keep the temperature within a specific range during the transportation of a certain type of goods. Correspondingly, as an example of a rule from the second group, it would be for the employee to take action if the temperature falls outside this specified range, and finally, as an example from the third group, to make an additional quality check if it is detected that the temperature has fallen outside this range. Likewise, in a report by the European Commission (2012b) risk rules are categorized as normative rules, deductive rules and imperative rules, where normative rules state the ideal state of a

process, deductive rules identify the risky situations, and imperative rules describe desired action or behavior. This categorization links especially to the use of rule compliance in IT systems, for example in the use of business intelligence.

Risk rules at a regulatory and at a company level are developed to guide employees and parties involved in how to operate and act to ensure secure, smooth and efficient operations. Further, Hayes (in Hopkins, 2011) identifies that on-site operating managers tend to develop their own, self-imposed rules to deal with uncertain situations.

Risk management and rule-compliance have previously been seen as opposite approaches to the same problems, with rule-compliance seen as the traditional approach and risk management as the modern approach to assuring safety in hazardous industries (Hopkins, 2011). Risk rules differ from what here is called risk management in that they set standard operation procedures for how to respond to certain incidents (Kotsiopoulos 1999), whereas risk management requires assessing the risk separately for each individual situation. Hopkins (2011) still claims that these two approaches should not be seen as mutually exclusive, but as complimentary to each other. He suggests that risk management practices should always be translated into risk rules when possible. The need for further use of risk rules is also identified by Bishra (2006).

3.2 Supply chain visibility

3.2.1 Defining supply chain visibility

Supply chain visibility is a highly discussed subject among academics (Francis 2008), but several authors acknowledge that no common and generally accepted definition of supply chain visibility exist (e.g. Caridi et al., 2010; Francis, 2008; Zangh et al., 2011). Caridi et al. (2010) still identify three trends in the different definitions of supply chain visibility. To begin with, some authors see visibility as simply having access to and/or sharing information within the supply chain. Further, another group of authors extend this definition by also focusing on the properties of the information; they define visibility to be the exchange of accurate, trusted, timely and useful information. A final group of authors highlight that visibility means sharing useful information with partners.

An example of the first approach to visibility is found in the definition of visibility presented by Francis (2008). Francis takes a quite practical approach and defines visibility to be *"the identity, location and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times for these events"*, highlighting the information that is exchanged. Barratt and Oke (2007), on the other hand, choose to define visibility as *"the extent to which actors within a supply chain have access to or share information which they consider as key or useful to their operations and which they consider will be of mutual benefit''*, hence putting more emphasis on the partnership and the usefulness of the information. Tse and Tan (2011), in turn, define supply chain visibility as *"traceability and transparency of supply chain processes"*, emphasizing the process perspective.

Different ways of categorizing visibility are also addressed. Barratt and Oke (2007) and Goh et al. (in Zhang et al., 2011) divide visibility into demand visibility, inventory visibility, and process/logistics visibility. Diessner and Rosemann (2008) for their part identify process visibility, product and asset visibility, and performance visibility.

As described, the definition of visibility is somewhat unclear. It is therefore useful to examine the relationship between visibility and the closely related concepts of supply chain integration and information sharing. The following sections try to clarify how visibility relates to these two concepts.

3.2.1.1 Supply chain integration

A variety of perspectives on supply chain integration exist. Many authors examine relationships and collaboration with either customers or suppliers, while others focus on managing the supply chain as a single system (e.g. Flynn et al., 2010; Vickery et al., 2003). Flynn et al. (2010) take a broad approach to integration and define it to be *"the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organization processes".* Kocoglu et al. (2011) adds the aspect of information sharing to their definition, as they see that supply chain integration *"converges the interests, objectives and opportunistic behavior of supply chain partners and allows effective information*

sharing". Nurmilaakso (2008), on his part, simply sees that integration equals information sharing.

The idea for supply chain integration stems from Porter's value chain model with value creating linkages between the supply chain members, even though also other authors long have articulated a need for close, integrated relationships between manufacturers and supply chain partners (e.g. Kocuglu et al., 2011; Vickery et al., 2003). Barratt and Barratt (2008) have studied the internal and external linkages in the supply chain, and conclude that one purpose of linkages is information sharing. Vickery et al. (2003) identify integrative practices in the supply chain to be for example supplier partnering, close customer relationships, and cross-functional teams, which all include information sharing among the parties. Holweg at al. (2005) suggest collaboration on for example inventory replenishment and forecasting, new product introductions, and promotions. Information sharing can thus be seen as an important activity within supply chain integration.

The view of the supply chain is in many cases narrow when discussing supply chain integration. Several authors point out integration/inter-linkages with the traditional supply chain partners, in other word with customers, with suppliers and intra-organizationally (e.g. Kocoglu et al., 2011; Flynn et al., 2010). Integration with other supply chain actors, such as transportation and logistics partners, has still received less attention both from academics and practitioners. Mortensen and Lemoine (2008) also identify that integration is less common between manufacturers third party logistics providers than between other parties in the supply chain. The importance of third party logistics companies in the extended supply chain has still increased in recent years, and according to Jayaram and Tan (2010) they have a crucial role in facilitating supply chain integration.

As explained, integration is a widely discussed concept in supply chain management literature. However, the relationship between supply chain visibility and integration is not directly addressed. On the other hand, literature closely links integration to information sharing.

3.2.1.2 Information sharing

As for supply chain integration, several authors identify the need for information sharing in the supply chain (Du et al., 2012), not least because it is seen as a route to more effective supply chain management (Peck, 2006). Indeed, information sharing has long been considered a generic cure for a variety of supply chain problems, starting from Forrester's discovery of the Bullwhip effect in late 1950s (Barratt and Oke, 2007). More recent applications of information sharing are found among others in point-of-sales data sharing (POS), vendor managed inventory (VMI) and collaborative planning, forecasting and replenishment (CPFR). Most applications of information sharing still consider only supplier and customer collaboration, whereas for example a report by the World Economic Forum (2012a) identifies the need for data and information sharing also between businesses and governments.

The relationship between information sharing and visibility is identified by Christopher and Lee (2004) and Barratt and Barratt (2008), who explain that information sharing is the antecedent to supply chain visibility. Or, as Barrat and Oke (2007) put it: *"information sharing is an activity and visibility is a potential outcome"*.

Reaching visibility hence requires information sharing, but also information sharing has its requirements. Key enablers for information sharing are seen to be knowledge and skills for collaboration (Crook et al., 2008), trust and confidence (Christopher and Lee, 2004; Jüttner, 2005; Crook et al., 2008; Du et al., 2012), and integrative technology (Vickery et al., 2003; Crook et al., 2008; Jayaram and Tan, 2010). Supply chain actors thus firstly need to have useful information to share, such as inventory levels or sales data, and the skills required to work together in the supply chain. Secondly, trust and confidence is needed between the actors in order to enable data sharing, risk sharing, and possible joint investments (Crook et al., 2008). Finally, companies need to develop interoperable technologies to be able to share data in practice. Interoperable technologies mean having integrated IT systems that can exchange information at high speed within and across organizations (Rai et al., 2006). This requires data consistency, which includes both common definitions (Rai et al., 2006) and common data formats (Klein et al., 2007).

Du et al. (2012) also highlight the importance of willingness to share information. Information sharing can be divided into predetermined, which is template based and agreed upon on beforehand for example in contracts, and spontaneous, which is non-predetermined and proactive. The quality of the information is reflected by the willingness of the parties to share information, and higher degrees of contract based information sharing seems to correlate with a higher degree of spontaneous information sharing.

New technologies, especially the Internet, have made it easier to share information (Swaminathan and Tayur, 2003), but in a report by the World Economic Forum (2012a) it is still claimed that even though new software products are under development, the tools and software currently available do not support data and information sharing at the needed level. Vickery et al. (2003) discuss the costs associated with integrative technology and conclude that in addition to the direct cost of the investment, there is a cost associated with the possibility that the partner exploits the shared information. This is why trust between supply chain partners is important.

The relationship between IT integration and process integration is also brought forward. Marquez et al. (2004) identify the full integration of the supply chain, which in addition to information sharing enables the adjustment of processes to conform along the chain. Rai et al. (2006) find that it is IT integration that helps supply chains overcome a fragmented, functional and silo-oriented approach and instead develop integrated, cross-functional and inter-firm operations.

3.2.2 Supply chain visibility technologies

Information technology allows supply chain partners to exchange different type of data, which is seen to improve the agility (Sambamurthy et al. 2003) as well as the flexibility and responsiveness of the supply chain (Du et al. 2012). Nurmilaakso (2008) identifies three types of integration, or information sharing, between the actors in the supply chain: manual, semi-automated, and fully automated. Manual information sharing refers to human-to-human contact, for example by phone, e-mail or fax. Semi-automated information sharing refers to human-to-system processes, whereas in fully automated processes information is shared system-to-system.

Inter-organizational systems (IOSs) are IT-systems that connect companies over organizational borders. IOSs facilitate cooperation and coordination among parties by creating visibility, i.e. by making consistent, timely information available for all parties involved (Du et al., 2012) using for example electronic data interchange (EDI) (Lim and Palvia, 2001). Examples of IOSs include advanced planning system (APS), material requirement planning systems (MRP), enterprise resource planning system (ERP), and e-business systems (Du et al., 2012).

As mentioned earlier, interoperability is an important enabler for information sharing, and Nurmilaakso (2008) concludes that supply chain integration would be easier if companies would not use different information systems, terms and modes of operations. The complexity and uncertainty of information sharing can be reduced by using standards, for example the Electronic Data Interchange (EDI) or the Extensible Markup Language (XML) formats (Nurmilaakso and Kotinurmi, 2004). It has been identified that EDI can speed up and reduce errors in information sharing (Riggins and Mukhopadhyay, 1994) and thus reduce operating costs (Mukhopadhyay et al., 1995) and improve customer satisfaction (Lim and Palvia, 2001).

Also identification and monitoring technologies have an important role in providing visibility. Zhou (2008) points out the importance of being able to track and trace items on their journey through the supply chain. Indeed, the use of monitoring technologies is seen to improve the responsiveness and thus improve the performance of the supply chain (Pilli-Sihvola et al., 2012). Examples of monitoring technologies are automated identification technologies such as barcodes and RFID, positioning technologies such as GPS, and monitoring technologies such as electronic seals (Pilli-Sihvola et al. 2012). Zhou (2008) identifies that the main benefit with RFID is the reduced uncertainty which is achieved through visibility. Important areas of application for RFID are found in acquisition of raw materials, manufacturing, transportation, and retailing (Zhou, 2008) and product safety (Marucheck et al., 2011).

3.2.3 Decision making and supply chain performance

As follows from the reported need for increased supply chain integration and information sharing, several authors report a positive relationship between these concepts and performance. Supply chain integration (e.g. Kocoglu et al., 2011; Kim,

2009; Flynn et al., 2008; Vickary et al., 2003; Frochlich and Westbrook, 2001), as well as information sharing (e.g. Kocuglu et al., 2011; Jayaram and Tan, 2010) has indeed been found to improve supply chain performance. What should be particularly noted is the findings of Kocuglu el al. (2011), which present that supply chain integration has both a direct positive impact on supply chain performance, and a direct positive impact on information sharing, which in turn has a positive impact on supply chain performance, explaining the dynamics between supply chain integration, information sharing and performance (Figure 3-2).

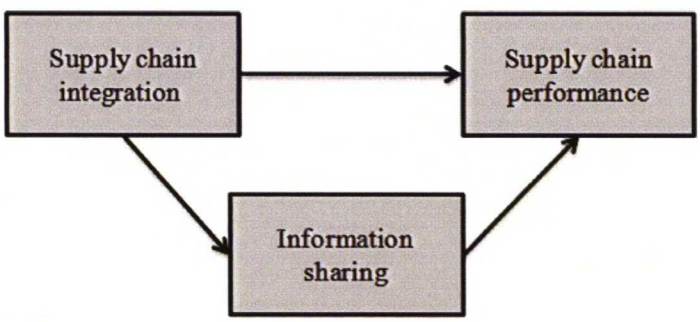

Figure 3-2 Relationship between supply chain integration, information sharing and supply chain performance (adapted from Kocuglu et al., 2011)

Suggested benefits of information sharing in the supply chain include reduced supply chain cost, improved partner relationships, increased material flow, faster deliveries, improved decision making, and achievement of competitive advantage (Barratt and Barratt, 2008; Kocuglu et al., 2011). It is on the other hand suggested that increased visibility leads to benefits such as improved responsiveness, improved planning and replenishment capabilities, and improved decision making (Barratt and Barrat, 2008). Visibility is also important in meeting arising demands on supply chains in areas such as environmental and social accountability (van Stijn et al., 2011).

But how are supply chain integration and information sharing actually linked to improved performance? Agndal and Nilsson (2008) have found that sharing cost data between suppliers and the focal company supported cost management decision making as well as improved the collaboration and relationship between the companies. It is suggested that system-wide information improves operational performance, but it is also noted that performance might decrease if a person is exposed to too much information, as cognitive limitations make it hard to process all

information and make informed decisions (Cantor and Mcdonald, 2009). But, as these authors explain, visibility seems to be linked to performance through decision making.

Christopher and Lee (2004) explain the dynamics behind supply chain visibility and operational performance with what they call "the risk spiral" (Figure 3-3). They claim that long pipelines reduce supply chain visibility, which in turn leads to a lack of confidence between supply chain partners. This leads to the build-up of inventory buffers, over-production, non-reliable quotes on delivery times, etc., as a way to hedge against the uncertainty, which in turn further lengthens the pipeline, which further reduces the visibility. Lack of visibility therefore leads to a less efficient supply chain. The authors suggest that only improved confidence can break the spiral and improve operational performance. Improved confidence allows information sharing among supply chain partners, which is seen as the key to improved visibility, which in turn leads to better decision making. They point out that visibility alone is not enough, but that the ability to take control of supply chain operations (in other words ability to make decisions) is also required.

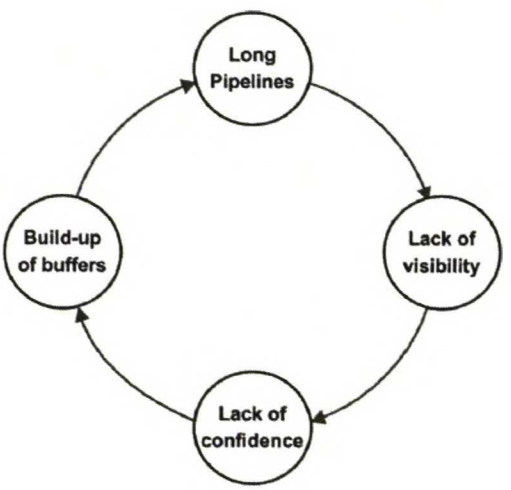

Figure 3-3 The risk spiral, explaining how lack of visibility increases risk in the supply chain (Christopher and Lee, 2004)

Other authors still find a less positive relationship between supply chain integration and information sharing, and performance. Sezen (2008) concludes in his study that supply chain design has a higher influence on supply chain performance than supply

chain integration or information sharing. Also Kim (2009) identifies supply chain management practices to have an important impact on supply chain performance, in addition to supply chain integration. Jayaram and Tan (2010) have studied the relationship between supply chain integration with third party logistics providers and supply chain performance, and conclude that the supply chain integration strategy does not in itself show as a variance in performance. Instead, they suggest that the right level and form of integration might be more important than integration itself.

To conclude, supply chain visibility is, as identified by for example Barratt and Barratt (2008), the outcome of information sharing. It is a state at which companies have more information available about what is going on in other parts of the supply chain, based on which they can make better decisions. Information sharing, visibility and improved decision making, together with an number of other collaborative activities between supply chain actors, are part of what is called supply chain integration. Supply chain integration, more specifically information sharing, requires certain enablers, such as availability of data, trust and confidence between parties, and integrative technology. Supply chain integration, on the other hand, leads to enhanced performance through improved decision making. These relationships between supply chain visibility and closely linked concepts are presented in Figure 3-4.

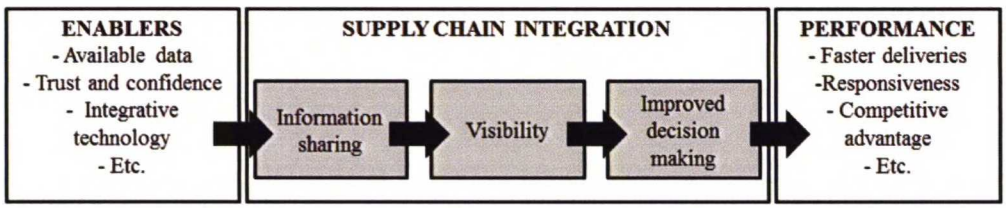

Figure 3-4 Relationship between visibility and closely linked concepts

3.3 Visibility in risk management

Supply chain visibility is identified to have a crucial role in managing risk (Diessner and Rosemann 2008). However, Tse and Tan (in press) point out that most supply risk frameworks overlook the importance and impact of visibility for supply chain risk. Having examined supply chain risk management and supply chain visibility separately it is now time to examine how these concepts link together.

To begin with, an important link between visibility and risk management is in the identification and assessment of risks. Vilko and Hallikas (2012) identify that specialization and low levels of integration have decreased the visibility of operations outside the company. This in turn has made it harder for companies to identify risks threatening both their own operations as well as the whole supply chain. It is indeed claimed that enhanced supply chain visibility improves the managing of risks in supply chains, as it through visibility is possible to immediately identify critical situations, and thus respond to them in a more optimal way (Diessner and Rosemann, 2008; Kleindorfer and Saad, 2005).

The importance of visibility in identifying risk can also be seen in what is called "weak signals". Sudden changes in the environment can often be identified at an early stage through "weak signals", which over time grow stronger and more specific (Ansoff, 1975). Thus, early warnings can give indications about possible coming problems (Nikander and Eloranta, 2001). Ansoff suggests that companies can use these weak signals for risk (and opportunity) management, and points out that by identifying these weak signals companies can, through awareness and flexibility, be better prepared for the possible event if it realizes.

Further, several authors address the improved decision making enabled by visibility as an important link between visibility and risk management (e.g. Zhang et al., 2011). Simchi-Levi and Simchi-Levi (in Almotairi et al., 2011) identify that the goal of information technology in supply chain management is to create visibility in order to enable informed and thus more effective decision-making. Piramuthu (in Zhou, 2008) further explains that using a tracking and tracing system allows the company to take action in targeted situations in order to reduce operational cost and increase productivity. The value of available information can be seen for example in how a German manufacturer was able to react to the upcoming disruptions in the supply chain during the hurricanes Katrina and Rita in 2005 (Diessner and Rosemann 2008). The visibility on the supply chain created through a SAP-system provided the company with up-to-date information on all their goods and made it possible to track and reroute the shipments to harbors in areas not affected by the storms. This helped the company to maintain a high level of service despite of the difficult external situation and to keep its customers fully informed about the situation.

Hence, it can be concluded that enhanced supply chain visibility allows improved risk identification and risk assessment, whereas the improved decision making capability that stems from enhanced visibility improves the mitigation of and responsiveness to risk (Figure 3-5).

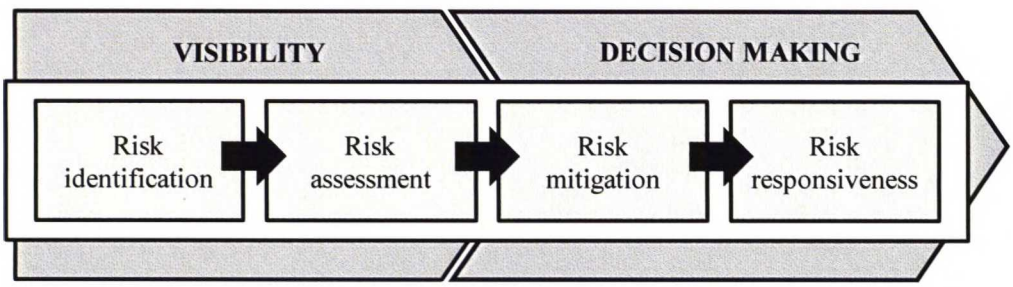

Figure 3-5 Linking supply chain visibility to supply chain risk management

A practical example of how supply chain visibility is used for risk managing purposes is supply chain event management (SCEM). The goal of SCEM is to recognize disruptive events as early as possible, and to minimize their impact (Otto, 2003). This includes the monitoring, assessment and evaluation of disruptive events as well as suggesting possible responses to the identified risks (Masing, 2003, and Zimmermann, 2006, in Bearzotti et al., 2006). Further, SCEM can be seen both as a management perspective, a software solution and as a software component; these still link to each other in that SCEM as a component is part of a SCEM software, which is used when applying SCEM as a managerial perspective (Otto 2003).

Another example of how visibility is used for risk managing purposes is the use of monitoring technologies. With monitoring technologies the location, status and history of the goods can be followed as they moves along the supply chain (Zhou et al., 2008). Mele et al. (2005) identify that these technologies should aid managers in making decisions as they warn of disruptions. Further, they suggest that the technologies also could suggest possible solutions to the situations. The use of risk rules is in an important position when setting alert limits for monitoring technologies.

At the same time as enhanced visibility and information sharing is highlighted, also a broader need for collaboration and cooperation in supply chain risk management is identified. Jüttner (2005) sees that it would be important to openly share risk-related information to improve supply chain risk management. He further suggests that

supply chain risks need to be accepted as joint risks in the supply chain and not as separate risks of individual actors. Recent major disruptions such as the 9/11 terrorist attacks and the outbreak of the foot and mouth disease might indeed have increased the willingness to share information as companies in these situations have seemed to understand the importance of a common perspective on supply chain risk management.

3.4 CIMO logic summary on literature

Literature on the role of visibility in managing supply chain risk is situated in the intersection between literature concentrating on supply chain risk and risk management, and literature concentrating on supply chain visibility. Because of this, the role of visibility in managing supply chain risk is often approached from two different angles in literature: the first approach takes its starting point in supply chain risk (i.e. the context); the second approach takes its starting point in visibility (i.e. the intervention). Both approaches are discussed below.

Literature on supply chain risk and risk management identifies and discusses a broad range of different supply chain risk contexts. Still, when discussing supply chain risk management, risks are often treated on a general level and papers on risk management strategies (i.e. interventions) do seldom address specific risks. This means risk in itself is often seen as the context for which visibility, information sharing, or supply chain integration, are suggested as interventions (e.g. Jüttner et al., 2003; Diessner and Rosemann, 2008). This literature does though usually not highlight visibility as an intervention, and visibility is only presented as one solution alongside a number of other strategies. Further, strategies are seldom presented in more detail, and the mechanisms and outcomes of applying visibility are not covered in these papers. Hence, literature addressing contexts (C) of supply chain risk tends to link together only with interventions (I), leaving out mechanisms (M) and outcomes (O).

Literature on supply chain visibility, on the other hand, emphasizes visibility, together with information sharing, supply chain integration, and collaboration, as interventions that can improve the performance of the supply chain in several different ways. This approach highlights the link between the intervention and the

outcome, but hardly any papers discuss in more detail in which contexts visibility should be used to achieve these outcomes. Diessner and Rosemann (2008) and Kleindorfer and Saad (2005) are amongst the few who specifically discuss the use of visibility in context of supply chain risk. Thus, literature on visibility tends to link together interventions (I) and outcomes (O), with a lesser emphasis on the contexts (C). The mechanisms (M) behind visibility are more or less completely left out from the discussion.

Literature on the role of visibility in managing supply chain risk is as presented divided into two main camps, both representing incomplete CIMO cycles. On one hand, contexts and interventions are linked together, on the other hand interventions and outcomes. In both approaches the mechanism behind visibility is left out. One of the only papers on the role of visibility in managing supply chain risk covering all steps in the CIMO logic is by Christopher and Lee (2004). In this paper the authors present the "risk spiral" in which supply chain problems (C), when approached with information sharing and improved visibility (I), improve their performance (O) because of improved decision making (M).

3.5 Identified gaps in theory

Supply chain risk management and visibility have been studied from a number of different viewpoints, and an extensive amount on literature on the subjects exists. However, some gaps in theory can be identified.

Firstly, the current definition of supply chain risk is somewhat ambiguous, and as also noted by Rodrigues et al. (2008), many supply chain frameworks build upon the uncertainty of supply, production, and demand (e.g. Davis, 1993; Supply Chain Council, 2010). Strategies addressing these problems often focus on different sourcing alternatives, inventory levels, and forecasting models in order to cope with the uncertainty. At the same time the role of logistics in form of transportation and infrastructure is often neglected (Peck, 2006; Rodrigues et al., 2008), even though disruptions in transportation can cause significant problems.

Secondly, data sharing technologies such as RFID, EDI and XML figure in many studies (e.g. Nurmilaakso, 2008; Du et al., 2012), pointing out the role of these technologies in enhancing information sharing and supply chain visibility. This

technology based approach does though not necessary address the real problems managers face, for example in forms of late or sub-quality deliveries, but takes its starting point in what the existing technology can offer and not in the actual need for data itself.

Thirdly, visibility and information sharing are in many studies discussed on a very general level, often claiming visibility or information sharing itself to be a solution (e.g. Christopher and Lee, 2004). Almotairi et al. (2011) have studied the specific information flows in hinterland transportation by rail in Sweden, but few other studies on this level of specificity exist on information sharing in logistics. There is a clear need to enhance the understanding of visibility and information sharing on a more concrete, operational level.

Finally, as highlighted in the CIMO logic analysis on the literature, the link between visibility and the outcome, i.e. the mechanism, seems to be poorly understood. Visibility is claimed to improve performance in several different ways, but few studies explain how it works and why it is useful.

4 Information sharing for logistics risk

To address the role of logistics risks in supply chain risk management and to identify information sharing related to these risks a field study was conducted. A questionnaire based on identified gaps in theory from the literature review was distributed to targeted companies from the buying end of global supply chains. In this section the results from this study are presented.

4.1 Sample

The questionnaire was distributed to targeted companies with global supply chains via supply chain risk management conference participation lists, trade associations, research group contacts and other suitable forums. The contacted companies were from the buying end of the supply chain, and managers were selected from the supply chain management, logistics and procurement departments. The questionnaire was answered by seven companies, including:

- a plastic materials manufacturer,
- an aircraft manufacturer,
- an engineering workshop,
- a food distributor,
- an electrical components manufacturer,
- a paints manufacturer, and
- a consumer electronics manufacturer.

As suggested by McCutcheon and Meredith (1993) for an exploratory approach, the participating companies represent differing characteristics, for example concerning industry, product type, size and geographical coverage. Details on the companies are presented in Appendix 3.

4.2 Results

4.2.1 Inbound logistics risks

For this study, inbound logistics risks were defined to be late deliveries, early deliveries, under quantity deliveries, over quantity deliveries, wrong product deliveries, sub-quality deliveries, deliveries with damaged goods, deliveries to wrong

place, actual delivery cost exceeds planned cost, deliveries with wrong documentation or data, and deliveries with missing documentation or data (based on Supply Chain Council, 2010; Viswanadham and Gaonkar, 2008). The average impact and frequency of these risks in the studied companies are presented in Figure 4-1.

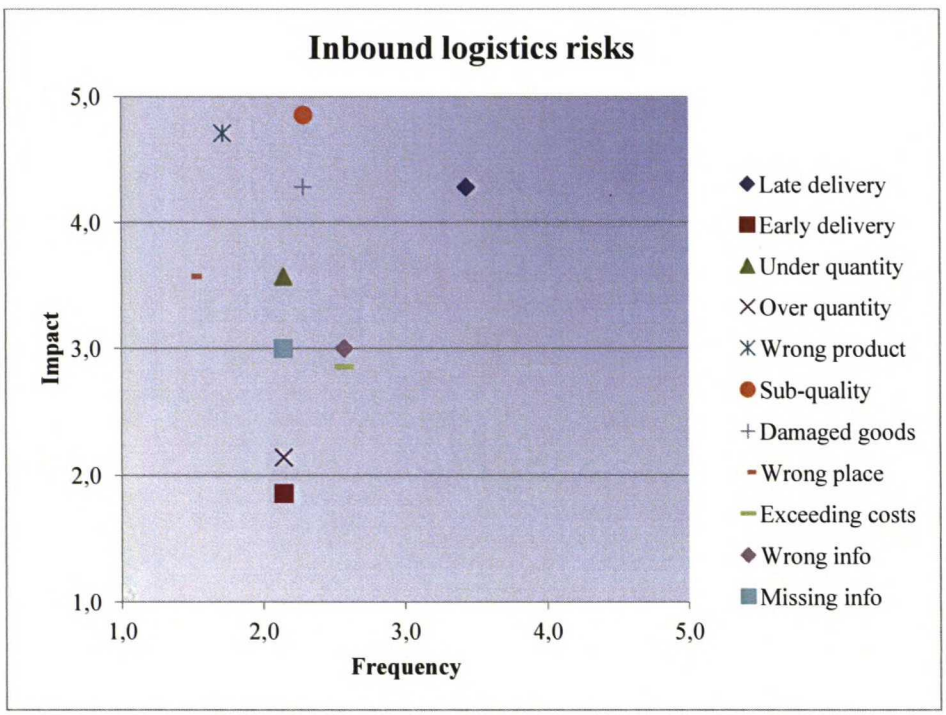

Figure 4-1 Risk matrix for inbound logistics risks (1 referring to low and 5 to high impact/frequency)

As shown in the figure, late deliveries, wrong information and exceeding costs are identified by the companies to be the most frequent problems they face in their inbound logistics, whereas sub-quality deliveries, wrong product deliveries, late deliveries and deliveries with damaged goods are identified as the problems with the highest impact.

Based on this, the most important problem, when defining overall risk as frequency times impact, is late deliveries, and late deliveries is likewise the only risk that ranks high on these both criteria. Accordingly, all companies except for the food company ranked late deliveries as their most important problem. The food company ranked late deliveries as their second most important problem, clarifying that *"the greatest risks we face has to do with food safety issues rather than the more common issues*

arising from logistics snags. This isn't to suggest that late shipments or shipments to wrong ports with wrong products aren't important". Other inbound logistics problems that ranked high were sub-quality deliveries, deliveries with damaged goods and wrong product deliveries. According to the companies these risks have a high impact but are not very frequent. Early deliveries and over quantity deliveries did neither rank as very frequent, nor with a high impact.

When asked about which parties cause possible problems, the seller was the most often mentioned party. All companies agreed on the seller being the party causing under/over quantity deliveries, wrong product deliveries and sub-quality deliveries. For deliveries with missing or wrong information all companies mentioned the seller, but the electrical components manufacturer also brought up the freight forwarder. The freight forwarder, sea terminal operator and other transportation parties were, in addition to the seller, also mentioned for late/early deliveries (aircraft manufacturer, electrical components manufacturer, paints manufacturer, plastic materials manufacturer) and deliveries with damaged goods (engineering workshop, aircraft manufacturer, paints manufacturer).

To understand the role of logistics risks in overall supply chain risk management, the companies were also asked to rank the importance of supply, demand, operational and environmental risks (Table 4-1). For all companies except for the materials manufacturer, supply risk ranked as their most or second most important risk, whereas the demand and operational risks ranked quite equally in the middle on average. There was still a wide spread in the answers for demand risk between the companies; two of the companies (plastic materials manufacturer, paints manufacturer) ranked it as their most important risk whereas two of the companies (aircraft manufacturer, electrical components manufacturer) ranked it as their least important risk. For the rest of the companies demand risk ranked in the middle. Operational risks, on the other hand, ranked second or third for all companies, whereas environmental risks ranked low for all companies.

Table 4-1 Ranking of different types of supply chain risk (1 being the most important, 4 the least important) in the studied companies

Company	Demand risk	Supply risk	Operational risk	Environ-mental risk
Plastic materials manufacturer	1	3	2	4
Aircraft manufacturer	4	1	2	3
Engineering workshop	2	1	3	4
Electric components manufacturer	4	1	2	3
Food distributor	N/A	N/A	N/A	N/A
Paints manufacturer	1	2	3	4
Consumer electronics manufacturer	2	1	3	4
Average	**2,3**	**1,5**	**2,5**	**3,7**

4.2.2 Information sharing

Data about the current state of visibility was collected both through an analysis on the most important risk rules the companies use for monitoring their deliveries, and by asking directly about what data the companies receive or share related to their deliveries. As the companies were asked to answers these parts of the questionnaire based on their three most important problems, this part does not cover all problems equally but concentrates especially on late deliveries, which all companies ranked among their most important problems. A summary of all data elements used for monitoring logistics risks is presented in Appendix 4, and a more detailed, company-wise summary of data elements used for managing late deliveries is presented in Appendix 5.

In general, the current state of visibility in the supply chain of the companies in this study is quite limited to the traditional view of the supply chain, which means information sharing mainly takes place between the buyer and the seller. As presented in Appendix 4, much of the information currently used for monitoring deliveries comes from the supplier. Exceptions to this still occur, especially regarding the monitoring of late deliveries.

Information about incoming deliveries received from the supplier includes order confirmation data, order follow-up data, and supplier quality control data, which are used to monitor that the deliveries are on time, in the right quantity and in the right quality. In addition, the respondents reported that they receive time stamps and other location data related to the flow of goods from logistics parties to monitor late (or early) deliveries. It is also worth noting that the respondents use an important part of in-house information, such as data on outstanding orders and quality control data from testing of arriving goods, to monitor their inbound logistics. The importance of following inventory levels was also pointed out by a couple of the respondents.

Regarding future possibilities, the companies desired improved information sharing with suppliers especially when it comes to inventory statuses and quality information. The companies would also like to have better and more up-to-date information on location and status of deliveries from transportation and logistics parties. Some respondents also wished for improved information sharing with governmental actors, especially regarding accreditation of suppliers and submission of transportation documents. All this speaks for a need for improved information sharing and visibility in the supply chain, both regarding inbound logistics and supply chain management in general. In addition several respondents mentioned that they would like to have automatically updated data and automated alerts for deviations or problems, indicating that there is a need for more interlinked technology solutions, either through EDI/XML or over the Internet. For the moment much of the data is shared via phone or e-mail, or collected manually from a website.

When it comes to late deliveries, all companies reported that they track or monitor their deliveries on the route from the seller to the buyer at least at some points in the supply chain, which means all companies have some sort of visibility on their deliveries. Six companies reported that they receive order statuses or shipping information via e-mail or phone, or check for order statuses manually on a website, whereas only the consumer electronics manufacturer gets automatic updates on this into their management system. In most of the companies information sharing is thus currently not automated and the information available necessary not up-to-date. This indicates that there could be room for improved real time information sharing in the supply chain.

As for information sharing in general, the supplier has an important role and most companies report using information received from the supplier in monitoring late deliveries. Information currently received from the supplier concerns order confirmations and order status follow-ups. In addition, the companies would like to have information on production and inventory levels at the supplier.

All companies except for the materials manufacturer reported that they currently follow their deliveries on the way from the supplier to their site via different types of location data. Data elements mentioned by several companies are for example Estimated Time of Departure (ETD), Estimated Time of Arrival (ETA), Actual Time of Arrival (ATA), and arrival notices. Also delay information was mentioned by several companies. This data is provided by transportation and logistics companies such as freight forwarders, ocean carriers and brokers. For the future the companies wished for more up-to-date time data, which would mean receiving real time information through automated updates. Time stamps seem to the most important information the companies use for monitoring late deliveries; for example one of the manufacturing companies sees ETA, ATA and delay information as the most important information they would like to receive also in the future.

Besides information received from other actors in the supply chain, several companies also report that they follow up on late deliveries in-house by checking on outstanding deliveries or with on-time-delivery (OTD) measurement. One of the companies explained they use OTD data for statistics and feedback on the operations.

For the future, a couple of the companies did not express any opinions, and one of the companies stated they are satisfied with how they currently monitor their deliveries. At the same time other companies envisioned sophisticated systems with automated updates, real time information and automated alarms and rescheduling. As one of the respondents put it: "*I would like to see in real time and with good visualization where our goods are and in which amount. A one interface for all information would be a best solution.*"

Despite seeing benefits with improved information sharing and wishing for more developed information sharing, another respondent still highlighted possible problems that can arise from it: *"I would love to see a cheap system whereby our IT*

system could be automatically updated with ocean carrier ETS, ETA and container status updates, but there'd need to be some assurance that the information is correct under some penalty to the ocean carrier as a service provider supplying the information if the information is grossly incorrect."

4.3 Discussion

Late deliveries ranked high on both frequency and impact, and were identified by all companies to be among their most important problems. Still, it is important to bear in mind that risks can seldom be separated from each other, but are on the contrary often interlinked. As Pfohl et al. (2010) and Jüttner et al. (2003) have pointed out, risks can be seen both as sources and as consequences. Taking into account how risk is defined in this study (as a deviation to an ideal state), one consequence, for example a delivery to the wrong place, could at the same time be the source for another deviation, for example a late delivery. A delivery to the wrong place could in turn be due to the delivery having wrong or missing information. Late deliveries might on the other hand cause exceeding costs if the goods then have to be transported using air and not ocean freight. Wrong or missing information could also cause delays at the border, leading to late deliveries. These inter-linkages are though not possible to identify directly based on the answers in this study; for example one company which ranks late deliveries as frequent still rank exceeding costs only as rare, whereas another company states deliveries to the wrong place are very rare, but late deliveries still frequent. The impact of wrong or missing information ranks as medium, even though one could assume it could cause a lot of other problems.

It is worth noting that the most important risks – late deliveries, sub-quality deliveries, deliveries with damaged goods, and wrong product deliveries – all are risks which, if realized, directly lead to delay in production and/or require the company to keep safety stock. Correspondingly, early deliveries and over quantity deliveries, which do not directly delay production, ranked the lowest. Related to this, some respondents pointed out that they monitor stock levels in order to manage their inbound logistics risks. This interestingly links to the fact that most of the companies ranked supply risk as their most important risk. If inbound logistics risks, as defined in this study, lead to the goods not being at the right place, at the right time, in the right condition and in the right amount, one could actually say the company faces a

supply problem, and not an operational problem – even though the supply problem originates in an operational problem.

In this study, much of the current information sharing was reported to take place between the buyer and the seller. Information sharing between these parties has been widely studied for example related to point-of-sales data sharing (POS), vendor managed inventory (VMI) and collaborative planning, forecasting and replenishment (CPFR), which all address problems related to demand and supply. However, the importance of information sharing also with logistics parties has been pointed out in some studies related to the Bullwhip effect. In addition to addressing the amplification of demand as a forecasting problem due to poor communication on demand between buyers and seller, it has been claimed that transportation delays or poor communication between supply chain actors – including transportation parties – could trigger the Bullwhip effect because of variability in lead times and batch sizes (Chatfield et al., 2004; Chen et al., 1999).

In this study, information sharing with logistics parties was reported by the companies only for late deliveries and to some extent sub-quality deliveries. Regarding late deliveries it is apparent that tracking of deliveries using for example time stamps and delay information is important, and it was also within this field that the companies wished to develop information sharing. This could thus be a fruitful area to continue the development of information sharing in the logistics chain.

When it comes to sub-quality deliveries and deliveries with damaged goods, only two of the companies mentioned the role of transportation and logistics. In most of the companies quality was thus apparently mostly seen as a problem that originates at the seller, and not as much because of wrong handling or wrong transportation conditions. The two companies which mentioned the role of transportation in managing sub-quality and damaged goods were the food distributor and the consumer electronics manufacturer. As the other companies in the study procure more bulk type of goods the nature of the goods procured could be a factor that explains this difference.

In the food industry quality is an issue that cannot be overlooked; history shows that quality problems in food supply chains have led even to bankruptcies. As a supply

chain manager in a report on risks in the food supply chain by Peck (2006) states: *quality must always override cost at each time.* Still, the food distributor in this study sees some serious barriers in improving information sharing especially with ocean carriers. Even though technology exists for having data on location, cargo temperature, tilt, vibration, intrusion detection, etc., of the goods while in transit, and the ocean carrier in fact collects all this information, they are unwilling to share this information with the buyer. *I've even offered to pay a nominal fee for the container temperature data they are already recording, but not a single carrier was interested; carriers simply aren't interested in letting shippers know too much about their cargo.* The company also sees a serious problem in the current liabilities which allow the carriers to take no responsibility for any problems: S*orry, our fault, but per the back of the OBL we can't be held responsible for anything.....not even our own human errors... thank you for shipping with us.*

The high tech industry is characterized by high-value consumer goods. In addition to causing a direct financial loss, damaged goods that reach the end consumers could have an important reputational impact on the company. In this study, the consumer electronics manufacturer reported that they map the flow of their goods in cooperation with the logistics service provider in order to minimize the number of touch points and through that the risk of damage on the goods.

An interesting point emerging in the answers was the role and importance of in-house information in monitoring inbound logistics risks. The companies reported that they follow outstanding orders, check for the right products being delivered, test quality, check documents, etc., of incoming goods. With these procedures in place, problems are noticed only when risks are already realized. Even though improved visibility would not eliminate all problems, improved information sharing and the possibility to check much of this information earlier on in the supply chain would give the companies more time to react, cope with and prevent risks from realizing.

The only company which reported a high degree of sophistication in monitoring deliveries was the consumer electronics manufacturer. It should still be noted here that this company uses air freight and not ocean freight for their deliveries; the difference could have its origin in the transportation mode as different modes have different requirements and practices. The choice of transportation mode is of course

also linked to the type of product, and the difference could also have its origin in this, as high tech products with high value could require more close monitoring also during transportation.

The companies in this study showed great differences in their wishes for how to develop information sharing in the supply chain. Some respondents had clear visions for sophisticated, automated systems, whereas others expressed no wishes at all. The reasons for this could be several, but it could simply be that only those who had given the question of improved visibility a thought earlier had concrete ideas of what it could mean. It is easy to talk about improved visibility in general, but giving concrete ideas on data and technologies is another question. The industry could of course always have its role in this, but both a company procuring mainly bulk as well as companies procuring more valuable products envisioned sophisticated IT systems for information sharing. Understanding the reasons for why certain companies or industries look for or invest in improved information sharing would be of greatest interest, but is a question out of the scope of this study.

4.4 Summary and input for interviews

In the field study, companies faced several different problems related to their inbound logistics, of which late deliveries was the most important one. All companies except for the food distributor ranked late deliveries as their most important problem; for the food company quality was a risk that could not be overlooked. Also sub-quality deliveries, wrong product deliveries and under-quantity deliveries ranked high for all companies, but were not as frequent as late deliveries. However, operational risk was still seen as noticeably less important risk than supply risk.

Information sharing related to inbound logistics risk was reported to take place mainly between the buyer and the seller, and regarding late deliveries and sub-quality deliveries also between the buyer and logistics parties. Important data shared included order confirmations, order follow-ups and time stamps. Also data collected in-house, such as outstanding orders and quality testing, had an important role in managing inbound logistics risk.

The role of technology in providing visibility varied between the companies, but for the moment much of the reported information exchange was manual. For the future some of the companies envisioned sophisticated information systems with automated information exchange and alerts, but other companies had no comments at all.

Based on this study, late deliveries seem to be an important risk for companies regardless of industry and size. In addition, late deliveries were a risk for which all companies reported at least some degree of visibility, and was one of the few risks for which information sharing also took place with logistics parties. Therefore, the role of visibility in managing late deliveries showed to be an interesting field for further research, and was chosen as the focus in the interview part of this study.

5 The visibility process for late deliveries

Based on the results from the field study, interviews were conducted with five companies from the buying end of global supply chains. In this chapter, the results from the interviews are presented and discussed. The interviews concentrated on understanding how information sharing and visibility is used to manage risks related to late deliveries. Still, to understand why and how a solution works, one must first understand the problem. Because of this, late deliveries and the current state of visibility in the companies are also discussed.

5.1 Sample

Interviews were conducted with experts from logistics and procurement departments in five companies from the buying end of the supply chains. As suggested by McCutcheon and Meredith (1993) for an exploratory approach, the selected case companies are maximally different from each other, being represented by:

- a confectioner,
- a consumer electronics manufacturer,
- an engineering works company,
- a food distributor, and
- an office supplies distributor.

The companies represent different sizes, different industries, use different transportation modes and represent different activities in the supply chain (manufacturing vs. distribution). Details on the companies are presented in Appendix 6.

5.2 Results

5.2.1 Late deliveries

To understand the role of the context for visibility, the companies were first asked to define a late delivery. All companies more or less agreed that the definition in its simplest form is that *"a delivery is late if it doesn't arrive when it should*". Some differing and more precise views on late deliveries were still distinguishable in the answers.

The most common understanding of a late delivery in the companies was from an operational point of view, as all companies agreed that a delivery is late if it does not arrive at the buyer's site to be forwarded to production (producers) or the customer (distributors) as planned. This type of lateness can be due to the shipment not leaving the supplier's site on time or because of delays during transportation. However, all companies emphasized that most problems with late deliveries usually have to do with the supplier being unable to send out the shipment from their own site on time, therefore making the delivery arrive after the originally specified delivery date. Reasons for this type of lateness were identified to raw material shortage at the supplier (food distributor, confectioner), quality problems with the raw material at the supplier (food distributor), problems in the production schedule at the supplier (food importer, engineering works), or problems with quality in the production process at the supplier (food distributor, engineering works).

The views on the role of the logistics phase in making the deliveries arrive late differed among the companies. To begin with, it should be noted that the different terms of delivery divide the responsibility for the transportation differently between the actors in the supply chain; when using for example the incoterm Free Carrier (FCA)[2] the buyer is responsible for the transportation of the goods from the port of origin, compared to using a VMI-type of setup where the supplier is responsible for keeping the inventory levels on the buyer's site. However, this did not seem to have a big impact on the view of late deliveries, and the responsibility for transportation was however in many cases outsourced to a logistics service provider (engineering works company, confectioner, consumer electronics company).

When considering the concrete impact of the transportation phase, the engineering workshop, using FCA, explained that "*a problem with Asian suppliers has been that it takes time for them to get the goods from their site to the port*". The company had still not experienced problems with delays during the transportation overseas: *"when we have the goods on board and the vessel is moving the schedule usually holds"*. The consumer electronics company, using air freight, also claimed lateness because of the carrier to be unusual. *Our carriers are very reliable, the accuracy might be +-*

[2] "Free Carrier (FCA) means that the seller fulfils his obligation to deliver when he has handed over the goods, cleared for export, into the charge of the carrier named by the buyer at the named place or point." (http://www.worldclassshipping.com/incoterm_fca.html)

1 day, but that's all. The food distributor and the confectioner, on the other hand, recognized the role of for example weather conditions in causing delays during the transportation phase. However, they did not seem to find this to be a big problem. All companies also emphasized the role of the logistics service provider in managing the transportation.

In addition to an operational approach to late deliveries, some of the companies (confectioner, engineering works company, consumer electronics company) also brought forward the problem of mismatch in demand and supply as a type of lateness. *The supplier plans according to our forecast, but then it might be that we make some changes in our schedule that they cannot react to anymore,* explains the confectioner. This definition of late deliveries emphasizes the inability of the whole supply chain to react on changing demand, making deliveries late not to an agreed delivery date but to customer demand. The companies highlight here that in this case the supplier alone should not be blamed for the late deliveries.

5.2.2 Visibility and information sharing

When explaining the role of supply chain visibility the companies used words like *extremely important*, *fantastic* and *indispensable*. Nonetheless, some of the respondents addressed difficulties such as the quality of information (consumer electronics) and the agent-principal dilemma (food distributor) already in the same sentences. In describing what visibility is, all except for the food distributor adhered to the traditional view of sharing information up-streams and down-streams in the supply chain, mentioning customers and suppliers, and preferably also customers' customers and suppliers' suppliers. Some of the companies (confectioner, consumer electronics company, engineering works company) also highlighted the role of visibility inside the company, sharing information between departments. Logistics parties were mentioned only by the food distributor.

Also when describing the information the companies receive about late deliveries, the companies mainly mentioned information coming from the supplier, such as changes in delivery dates and other notices about delays. As the engineering works company put it: *"changes in the delivery dates is the most important information we receive that helps us manage late deliveries"*. Consequently, the engineering works company, the confectioner and the consumer electronics company have web-based

systems through which they receive automatic updates and alerts if for example the delivery dates are changing. The importance of keeping a constant dialogue with the supplier to hear about possible delays as early as possible was also brought forward by some of the companies (food distributor, confectioner).

When specifically asked to address the role of information sharing with logistics parties, all companies also describe at least some visibility into the logistics chain. Even though being able to track their shipments through the logistics service provider (LSP), the engineering works company and the confectioner still leave it to the LSP to take care of the shipment. *"We have found that the LSPs perform well and that our shipments arrive on time"*, explains the engineering works company. The confectioner agrees with this and continues by explaining that they usually keep in close contact with the LSP only if the delivery is critical. The engineering works company still expresses that they do not think having more accurate tracking information would help them very much in managing late deliveries.

However, the other companies do follow their deliveries more closely on their journey from the supplier to their own site, finding this information useful. The information they receive about their shipments is the arrival of the goods to certain check-points on the way (in other words arrival notices, ETA, ATA, etc). The office supplies company receives this information by fax, e-mail and phone, whereas the food distributor tracks their goods through the ocean carriers' websites. The consumer electronics company, on the other hand, has an EDI/XML-based system that is interlinked with the logistics service providers' systems, giving them up-to-date information on where their goods are moving, automatically checking for example ETD and ETA.

All companies except for the consumer electronics company also emphasize the importance of the activity of the buyer in receiving information. As the engineering works company explains: *"if the buyer is active in checking on the delivery dates with the supplier we usually receive information about late deliveries early on, but then there might be deliveries for which we start asking only when they do not show up the day they are supposed to arrive"*. This is closely linked to the overall more proactive approach in increasing visibility and information sharing suggested by several of the companies. For example, both the food distributor and the consumer

electronics company highlight the role of relationship building in increasing visibility and managing late deliveries.

5.2.3 Making use of visibility

All companies agreed that the most important thing with visibility into late deliveries is that it helps the company to better prepare for and react on coming problems. As the food importer states: *"it [i.e. visibility] helps us make better decisions"*. Moreover, the companies also identify three concrete ways for using visibility in managing late deliveries.

Firstly, knowing about late deliveries makes it possible to rearrange transportation and change to faster modes of transportation for critical deliveries. "*There is quite a lot of this that we have ordered by ship, but then the supplier informs about delays, and as we know these components are critical we change for air freight*", explains the engineering works company. The consumer electronics company, using air freight, also explains they have the opportunity to change to better flights to receive their goods faster if they know they are late.

Secondly, all producing companies (engineering works company, confectioner, consumer electronics company) emphasize the usefulness of receiving information about late deliveries as it allows to rearrange production. The consumer electronics company explains: *"If a delivery doesn't arrive on a certain date it is late, and production is planned for next day. If we know a delivery will be late we always try to fix the problem so that the customer won't notice, we can for example schedule for extra capacity in order to catch up in the production"*. For the engineering workshop, knowing about late deliveries allows to freeze the production plan and prepare for production. *"If we don't know a delivery will be late we might have picked all the other parts for assembly, which means we might have to start over with another product. This causes extra work and is a waste of time."*

Finally, all companies highlight that knowing about late deliveries, if nothing else, at least allows them to inform their customers about the coming delay. The companies still emphasize that they always first try to work out the problem internally before letting it affect their customers.

Besides these concrete actions following from visibility, some of the companies (consumer electronics, office supplies importer, food importer) also discuss the role of visibility as an alternative or a complement to buffers when managing late deliveries. *"This problem [with late deliveries] could be solved with buffers, but we try to keep them down"* explains the consumer electronics company, which has a sophisticated tracking system of all their deliveries. As a manufacturer, the company can use the visibility to rearrange transportation and production, making it possible to deal with late deliveries without buffers. The office supplies company, on the other hand, explains that they do keep some inventory and admits that late deliveries still cause problems in being able to deliver to customers on time. They also report that visibility only help them in the way that they can inform their customers of coming delays.

5.2.4 Outcomes

The companies identify a number of different problems arising from late deliveries. To begin with, if not known in advance, late deliveries can cause the production lines to stand (confectioner) or to wrong products being picked (engineering works company) in producing companies. Further, when know in advance, late deliveries lead to adjustments in transportation and production schedules, causing extra work and costs (consumer electronics company, engineering works company, confectioner, food distributor). Finally, as identified by all companies, if the company cannot absorb the delay through internal adjustments, late incoming deliveries make the companies unable to deliver on time to their own customers.

It is the last one, decreased delivery accuracy to own customers, that all companies are most concerned about. As the food distributor explains: *"Customers buy to have the product; if it is late, we cannot deliver"*. In the discussions the companies repeatedly return to the customer and delivery accuracy, emphasizing that internal adjustments are always done to avoid letting late deliveries affect the company's own customers. *"We have worked hard so that our own customers won't be affected if our incoming deliveries are late"* says the engineering works company. The consumer electronics company agrees with this, stating *"we always first try to fix the problem [with late deliveries] internally"*. The role of visibility in this is thus that it helps the

companies to make rearrangements in transportation and production in order to absorb the delay in order to not let late incoming deliveries affect the customer.

The second role of visibility is that it allows the companies to inform their customers about late deliveries (if not possible to avoid). *"We do what we can to avoid letting late deliveries affect the customer, but if a delivery will be late we can then at least inform our customer as early as possible when we know it is late"* (consumer electronics company). This role of visibility is also something all companies agreed on and emphasized, and the reasons go back to the beginning where the companies identified problems arising from late deliveries and the benefits of having visibility into late deliveries. Knowing about late deliveries on beforehand gives the customers the possibility to react on coming problems in the same way as the companies here have identified. Further, it was highlighted that informing the customer has an important role in customer relationship building.

5.3 Discussion

The interviewed companies saw late deliveries mainly from an operational point of view, defining late deliveries as shipments which do not arrive at the buyer's site as planned. Still, a couple of the companies also brought forward a more strategic view on late deliveries, where late deliveries were seen as deliveries that did not arrive on time to meet customer demand. These differing views once again highlight the difficulty in defining risk in an unambiguous way, as also highlighted by for example Sodhi et al. (2012). Late deliveries aimed in this study at addressing logistics and operational risks, but ended up considering also strategic aspects of risk in form of demand and supply. Further, late deliveries were assumed to describe risk as a consequence of various logistics problems, but showed in the discussions to simultaneously represent a source of risk for delivery accuracy. This highlights the difficulty of dividing risks into sources and consequences (Jüttner et al. 2003).

An interesting point emerging in the study was the companies' quite low interest in visibility into the logistics phase, and for example the engineering workshop did not think more accurate tracking information would be very useful in managing late deliveries. One simple explanation for this could be that the interviewed persons in this study mainly were from the procurement departments; if a delivery is late it is

production and sales that are directly affected and have to deal with the consequences. Another reason could be that if a company has outsourced the transportation to a logistics service provider they do not see transportation as a core competence and are therefore happy to let their partner take care of the transportation without having to bother about it themselves. At least the engineering works company and the confectioner simply stated that they are happy with the performance of their LSPs, indicating they are not interested in where their goods are as long as they arrive as they should. The consumer electronics company has nonetheless a totally different approach, collaborating closely with their logistics service providers and receiving up-to-date tracking information about their shipments. These differences in the interest in visibility into the transportation phase could though also be explained by several other aspects not considered in this study, including the role of buffer stock, terms of delivery, and the nature of demand.

Perhaps the most likely explanation for the quite low interest in the visibility of the logistics chain is still that logistics risk, when compared to other risks, simply isn't a big problem for the companies when it comes to late deliveries. Several of the companies explained that even though logistics problems do affect them, a far greater problem is still that the supplier is unable the send out the shipment on time. The two companies that showed some more interest in the logistics phase were the consumer electronics company and the food distributor. However, the consumer electronics company emphasized that problems with the supplier nonetheless are far greater than with logistics, whereas the food importer also was more concerned about the quality of the goods than of late deliveries and other logistics problems. This comes back to the discussion on defining risk. As identified by for example Rodrigues et al. (2008) and Peck (2006), the role of transportation has receive less attention when discussing supply chain visibility and risk. However, if – as perceived by the companies in this study – the supply risk is far greater than the logistics risk at least when it comes to late deliveries, it seems natural that transportation and logistics have been less discussed. Why fine tune on logistics if the goods are not even sent out on time?

Another interesting point emerging in the interviews was that the benefit of visibility seemed to be more important for producing companies than for distributors, as the producers can try to absorb the delay using internal adjustments in production. This

gets back to the risk spiral presented by Christopher and Lee (2004). They claim that the usefulness with visibility is that it allows improved decision making, which in turn leads to better performance. However, Christopher and Lee especially highlight that visibility alone is not enough to improve performance (as claimed for example by Kocuglu et al., 2011), but to make use of visibility also control – in other words the ability to make decisions – is required. This gets highlighted when considering the situation of the distributors in this study; *if it [i.e. the delivery] is late [...] we are very frustrated, but have no control and need to have flexibility,* explains the food importer.

Regarding the outcomes of visibility when used as a means to manage late deliveries, this study suggest that the main outcome is improved delivery accuracy. Several other studies have identified a number of possible outcomes of information sharing and visibility, including improved performance (e.g. Barratt and Barratt, 2008; Kocuglu et al., 2011). However, none of these studies have concentrated on the role of visibility especially in the context of managing risk or especially for late deliveries. Another outcome of visibility identified in this study was improved customer relationships, as visibility into coming late deliveries makes it possible to inform customers about coming delays. This type of outcome is usually not discussed in literature on visibility, but is instead captured in literature on supply chain collaboration and integration.

When discussing supply chain visibility, it is important to understand that it can be examined at different levels. Thus, when for example discussing outcomes, improved delivery accuracy can be seen both as a subclass to the in literature identified improved performance, and as a predecessor to it. Seen in one way, visibility through rearrangements of production lead to improved delivery accuracy, which in turn leads to improved performance. On the other hand, visibility through rearrangements in production can also be seen to lead to improved performance in the form of improved delivery accuracy. Many of the outcomes identified in literature are on a general level, and thus go together with delivery accuracy either as predecessors, successors or general level outcomes.

Finally, an interesting point on supply chain visibility highlighted by a couple of the companies was the reactive nature of visibility as a means to manage late deliveries.

Even though identifying benefits from having visibility on incoming late deliveries, it was pointed out that it is important to proactively collaborate with supply chain partners, especially suppliers, to address the actual, underlying problems with late deliveries. Visibility can be useful in dealing with occasional lateness, but is not a way to manage repeated problems. This relates to using proactive strategies versus coping strategies for managing supply chain risk (Stecke and Kumar, 2009). Collaboration with supply chain partners was also brought forward when it comes to trust and quality of information, which also are identified to be important enabler for supply chain visibility (e.g. Du et al., 2012; Crook et al., 2008).

5.4 Summary

In interviews on the role of visibility in managing late deliveries, the companies identified two main types of late deliveries: firstly, late deliveries which arrive late to the buyer's site, and secondly, deliveries that are late to meet customer demand. The greatest problem for late deliveries was seen to be that the suppliers are unable to send out the shipments on time.

The companies reported having varying degrees of visibility into their incoming supply chains. All companies emphasized the role of visibility in knowing about late deliveries from the supplier, but only some of the companies also showed interest in visibility into the logistics phase. This links to the view that the greatest problems with late deliveries originate at the supplier and not in transportation.

The main use of visibility in managing late deliveries was seen to be in rearranging transportation and production in order to absorb the delay internally, thus achieving improved delivery accuracy. If not possible to avoid the delay, visibility was used to inform customers about coming late deliveries, thus taking care of the customer relationship. The role of visibility in managing late deliveries was though pointed out to be a reactive way of managing late deliveries, and collaboration and relationships building with the supplier was brought forward as important ways of managing late deliveries.

The use of visibility in managing late deliveries is summarized in Figure 5-1.

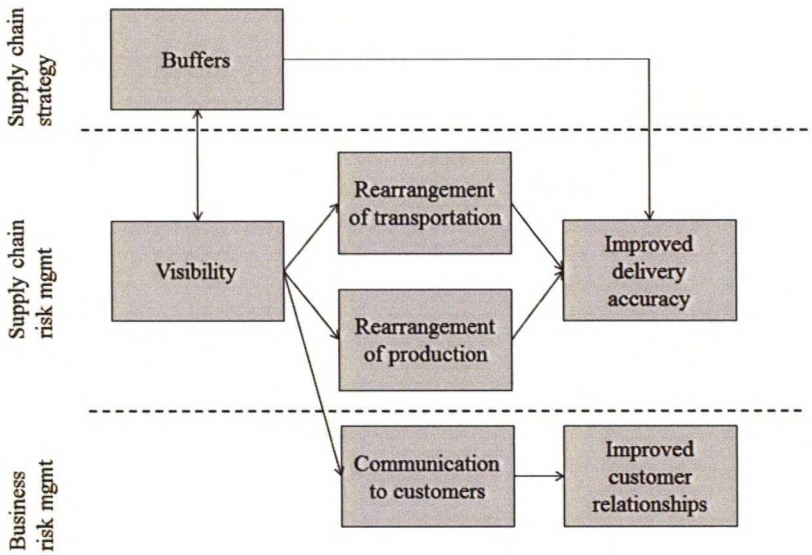

Figure 5-1 The use of visibility in managing late deliveries

6 CIMO logic summary on results

In this section, the outcomes of the study are summarized and compared to literature using the CIMO logic framework, whilst also addressing the four research questions presented in the beginning of this report. The review starts out by discussing risk as a context (C), continues with a review on visibility as an intervention (I), and finally discusses mechanism (M) and outcomes (O) of these. In general, the outcomes of this study correspond fairly well with how the role of visibility in managing supply chain risk is discussed in literature. At the same time, this study takes a far more concrete approach to the issue than what can be found in literature, according to the best understanding of the author.

To begin with, the study identifies late deliveries as the most important logistics risk for companies in the buying end of global supply chains. Logistics risks have received less attention in the supply chain risk literature, and when considered, have only been discussed on a general level. When considering supply chain risk as a context for visibility, the CIMO logic –based analysis on literature showed that the context of risk is often discussed on a general level when considering interventions for managing supply chain risk, and not at all when discussing supply chain visibility. By defining the most important logistics risk, the study succeeded in addressing visibility as an intervention to manage risk in a more concrete context than found in literature. However, the study does not still consider whether late deliveries form the most useful context for using visibility as an intervention to manage risk.

Further, the study offers a new approach to logistics risks. However, the definition of risk used in this study, defining risk as exceptions to an ideal state, showed some deficiencies. Firstly, as emerging in the field study, this definition does not capture risk in an exhaustive way as one risk can at the same time be seen both as a source and as a consequence. Secondly, as emerging in the interviews, the concept of late deliveries does not only capture the dimension of a logistics risk, but is also seen as a supply risk by several of the companies in the study. At the same time, Sodhi et al. (2012), in an extensive literature study, have identified the difficulty in defining risk in an unambiguous way. Literature on risk perception also underlines that risk can be

understood differently between different actors in a shared context (e.g. Rundmo, 1992).

Regarding visibility on late deliveries, the companies in this study report information sharing mainly with the supplier, and in some cases also with logistics parties. Data elements mentioned include order confirmations, delivery dates, and delay information from the supplier; and tracking information such as time stamps and arrival notices from the freight forwarder, logistics service provider and/or carrier. The companies still emphasize that information sharing as an intervention to manage late deliveries is needed especially with the supplier, giving the logistics phase less importance. In literature, few studies specifically address the role of visibility as an intervention to manage risk, and the approaches on visibility often concentrate either on visibility in general or on specific technologies. As identified in the CIMO logic analysis on literature, visibility is often linked only to outcomes, whereas contexts and mechanisms are left out. In this study, visibility is taken to a concrete level, linking visibility as specific information to a specific risk, in other words tying together the intervention and the context. When considering visibility as a means to manage risk, the reactive nature of visibility as an intervention in the context of late deliveries also emerged.

When it comes to making use of visibility in managing late deliveries, two main actions were identified: rearrangement of transportation and rearrangement of production. These are both forms of internal adjustments used to absorb the delay. The main outcome identified from using visibility as an intervention to manage late deliveries was consequently improved delivery accuracy. This similar sequence is captured in the risk spiral presented by Christopher and Lee (2004); when using visibility in the context of supply chain risk, it leads to improved performance (improved delivery accuracy) because of improved decision making (rearrangement of transportation and production). Barratt and Barratt (2008) also see that improved decision making and improved responsiveness relates to visibility, but according to them these are outcomes rather than mechanisms of visibility. This highlights the difficulty in separating mechanisms from outcomes, and also points out that these can be considered at different levels of detail. If considering responsiveness as the outcome, the mechanism could be increased knowledge or understanding of the

situation, but if considering improved decision making as the mechanism, the outcome is improved performance.

In addition to using visibility to make rearrangements, the companies highlight that if not possible to absorb the delay with internal adjustments, having visibility on late deliveries at least allows to inform the customer about coming delays. In this case the mechanism seems to be communication, and the outcome improved customer relationship. This view links closely to literature on supply chain collaboration and integration, but usually falls outside the context of supply chain risk. However, improving customer relationships does still link to managing business risk.

When considering the mechanisms and outcomes identified in this study it should be noted that they are far from comprehensive. As the discussion highlights, identifying mechanisms and outcomes is partly a choice of level of detail, while tying together with the desired outcome. In this study, outcomes were tied to the used definitions of risk, seeing in particular that the delivery should be at the right place at the right time.

Further, in this study, outcomes were not quantified and financial outcomes not considered, meaning the mechanisms and outcomes are captured on a more general, qualitative level. In addition, the mechanisms and outcomes of visibility are here studied only for one specific context (late deliveries), which means further studies are needed on other specific risks in order to broaden the understanding on mechanisms and outcomes of visibility in the context of supply chain risk. Still, this study succeeds in defining the process in such a limited context, taking the discussion on the role of visibility in managing supply chain risk to a more concrete level than before

To summarize, in this study the following complete CIMO cycle for the role of visibility in managing supply chain risk has been identified: in the context of late deliveries, visibility as an intervention provides the outcome of improved delivery accuracy through rearrangements in transportation and production. If explaining this process on a more general level together with input from literature, one could state that in the context of supply chain risk, visibility, through improved decision making, provides improved performance. This process is visualized in (Figure 6-1) below.

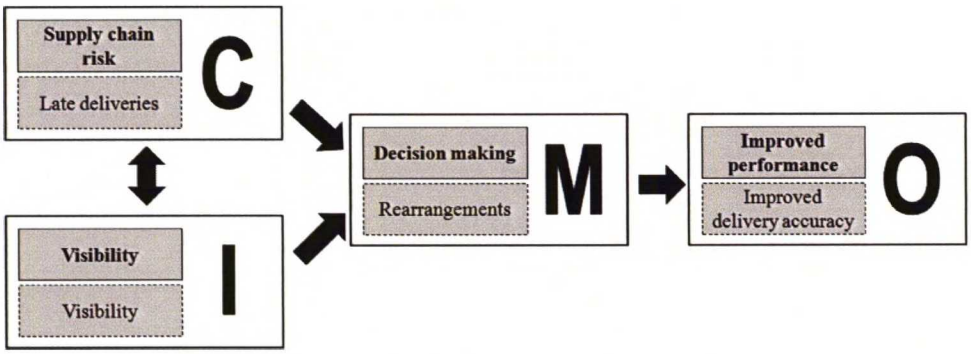

Figure 6-1 A CIMO analysis for the role of visibility in managing supply chain risk (late deliveries)

7 Evaluation of methods and results

The significance of a case study in creating new knowledge is essentially impacted by the study's design quality and the researcher's analysis (McCutcheon and Meredith, 1993). It is thus important to critically review the methods used and the results obtained in this study. Lee (1989) describes four "requisites of rigor" for case studies, namely controlled observations, controlled deduction, replicability, and generalizability. This chapter discusses how this study meets these requirements.

To begin with, controlled observations refers to how certain variables are held constant whereas others are left free to vary when studying a phenomenon. In case research the empirical part is neither performed in a laboratory environment, nor as a statistical observation; however, with natural controls controlled observations can be obtained also in case studies. In this study, when examining the use of visibility in managing late deliveries, the context and intervention were given to the interviewees as constants, allowing them to explain different mechanisms and outcomes related to this setting. For the field study, the context of risk was given as a constant, allowing the interventions (i.e. information) to vary.

Further, controlled deduction refers to applying formal logic when drawing conclusions. In applying controlled deduction in case research, Lee highlights that *"mathematics is a subset of logic, not vice versa"*. In this study, the CIMO logic has been used to review the results and to establish casual relationships in the answers.

Replicability usually refers to obtaining the same results if duplicating a study. For a case study, however, the exactly same conditions can never be fully obtained if duplicating a study, meaning that the exactly same results will hence not emerge. For case studies, replicability therefore refers to obtaining the same theory from the prediction. In this study, a standardized questionnaire was used for the field study, and an interview protocol for the interviews. Further, the selection of cases was done as suggested by McCutcheon and Meredith (1993) for a study of an exploratory nature. Thus, the basic settings of the study can be replicated, even though not within the exactly same conditions. However, with this, the same theory can still be tested in a duplicated study.

Finally, generalizability (or external validity) refers to how the results of the study can be applied in a broader context. This is generally the most difficult part in justifying the contribution of a study. In this study, a sample with maximally different companies has been used, which according to Lee is a good way to increase the generalizability for a multiple case study. However, to further increase the generalizability, the phenomenon should be studied both including more variables and more populations. This study has been conducted only for companies at the "end of the supply chain" from the view of procurement, and the theory on the visibility process has been developed based on one specific risk (late deliveries). The role of the companies' supply chain strategy, information sharing inside the company and the role of border processes have not been considered. Thus, the results should be generalized with care outside the original population and context.

All in all, the design quality of the study still shows to be rigorous and the study can be seen to contribute to research in the field within the limits of its generalizability.

8 Conclusions

In this final chapter, the main findings of the study are summarized. To begin with, the conclusions on role of visibility in managing supply chain risk are presented. Further, the implications of these conclusions for the research project CASSANDRA are discussed. Finally, suggestions for further research are made.

8.1 The role of visibility in managing supply chain risk

This study approaches a broad theme, trying to enhance the understanding of the little studied area of visibility in managing supply chain risk. The study is only a scratch on the surface, and does by no means cover the topic exhaustively. Further, the conclusions are drawn based on a rather small sample and in the context of one specific risk, meaning these conclusions should be generalized with care. However, the following insights on the role of visibility in managing supply chain risk could still be identified in this study.

To begin with, when considering supply chain risk, supply risk arises as the most important risk, ranking above logistics and operational risks both in literature and among practitioners. When considering the implication of this for using visibility as a means to manage risk, it seems improved information sharing is needed especially between the buyer and the seller and less between the buyer and logistics parties. Why fine tune on logistics if the real problem is that the goods do not even leave on time or in the right quality from the supplier?

Further, despite of being held as the future of supply chain management, practitioners point out that visibility as a means to manage risk – at least when considering late deliveries – is a reactive way to respond to risk and does not address the actual underlying problem. Indeed, for late deliveries visibility helps in identifying and assessing upcoming risks, but when a risk is seen further upstream it is already about to realize. However, even though visibility alone cannot mitigate risk, it still allows acting upon risk when accompanied by control (i.e. through decision making). Visibility thus also helps in responding to risk and in mitigating the outcomes of these risks.

Despite of its shortcomings, visibility has its role in the management of supply chain risk, and perhaps especially when it comes to logistics risk. If supply risks could be dealt with and goods would leave the supplier on time, visibility would offer a good way to respond to occasional incidents in the logistics phase.

To conclude, the role of visibility in managing risk is in the identification and assessment of risk, whereas it through decision making also can help to mitigate and respond to risk, in order to reduce the outcome of risk (Figure 8-1). However, also closer collaboration and improved relationships with supply chain partners are needed to proactively act upon supply chain risks.

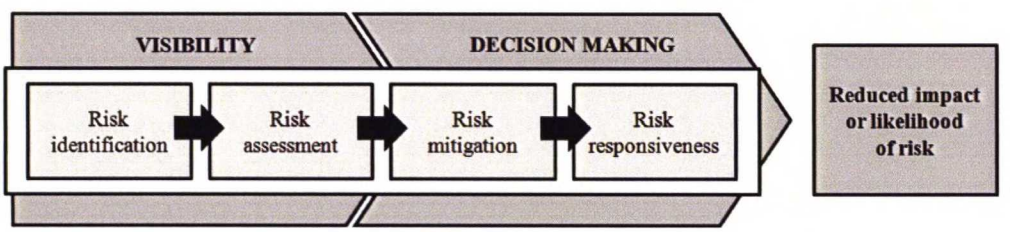

Figure 8-1 The role of visibility in managing supply chain risk

8.2 Implications for CASSANDRA

Based on the conclusions from this study, the pipeline concept proposed in CASSANDRA most likely offers some benefits for the commercial parties in the supply chain. As identified, visibility offers a way to identify and assess risk, and together with the ability to make decisions it can help in mitigating and responding to risk, in other words improve performance of the supply chain. Further, visibility was also identified to have its part in maintaining customer relationships. However, it is important to understand that the biggest problems in companies' inbound logistics seem to have their origins at the supplier and not in the logistics phase. Consequently, the biggest opportunities for information sharing seem to be between the buying and selling parties and not between the buyer and logistics parties. This is something that is important to understand especially when considering the commercialization potential of the pipeline.

In considering the business case for CASSANDRA, there is a vast amount of factors not considered in this study, including for example the cost versus benefit of improving visibility, the role of visibility in managing other risks than late deliveries,

and the impact of industry differences on the need for and benefits of visibility. Further, this study considers the role of visibility only from the buyer's perspective, and can therefore not assess the usefulness of the pipeline for example for sellers or logistics parties. It should also be noted that information exchange with governmental parties was not ultimately considered in this study. If the pipeline remarkably improves the overall customs declaration process and risk management processes, the business case for CASSANDRA might as well lie in improved border procedures.

8.3 Suggestions for further research

The literature review showed several existing gaps in theory regarding the role of visibility in managing supply chain risk. Consequently, this study tried to address firstly information sharing related to logistics risk on a concrete level, and secondly the process of using visibility in managing a specific risk. Despite adding new insights to the field within these contexts, this study is only a scratch on the surface. The role of visibility in managing supply chain risk is a rather unexplored territory, and further research is needed to both deepen and broaden the understanding of the phenomenon.

To begin with, this study addressed the role of visibility especially in managing late deliveries, concentrating on the buyer's perspective on the question. To verify and enhance the generalizability of the findings from this study, the theory needs to be tested on alternate populations (Meredith, 1998). Further research is thus needed on the role of visibility in managing other specific risks, and from the perspective of other supply chain actors.

Further, this study concentrated on understanding the process of the use of visibility, and did not address outcomes of visibility other than on a subjective level of the respondents. A more rigorous and quantitative approach on the outcomes of the use of visibility would add important insight on the actual benefits of visibility in managing risk.

Finally, most importantly, in this study the existing definitions on both supply chain risks and supply chain visibility showed a lack of unambiguous and shared understanding both in literature and among practitioners. In order to be able to carry

on further research on the subject and enhance the understanding of these phenomena, a common language needs to be created in the first place.

9 References

Aberdeen Group, 2011. *Globalization and global trade drive renewed focus on supply chain visibility.* [online] Available at: http://www.worldtradewt100.com/ext/resources/archives/a/Aberdeen-Lenovo-SCV-GTNexus.pdf [Accessed 18.1.2013]

Agndal, H. & Nilsson U., 2008. Supply chain decision-making supported by an open books policy. *International Journal of Production Economics,* 116(1), pp. 154-167.

Almotairi B., Flodén, J., Stefansson, G & Woxenius, J., 2011. Information flows supporting hinterland transportation by rail: applications in Sweden. *Research in Transportation Economics,* 33(1), pp. 15-24.

Ansoff, H.I., 1975. Managing strategic surprises by response to weak signals. *California Management Review*, 18(2), pp. 21-33.

Barrat, M. & Barrat, R., 2008. Exploring internal and external supply chain linkages: evidence from the field. *Journal of Operations Management,* 29(5), pp. 514-528.

Barratt, M. & Oke, A., 2007. Antecedents of supply chain visibility in retail supply chains: A resource-based theory perspective. *Journal of Operations Management,* 25(6), pp. 1217-1233.

Bishara, R.H., 2006. Cold chain management – an essential component of the global pharmaceutical supply chain. *American Pharmaceutical Review.* [online] Available at: <http://www.sensitech.eu/assets/articles/lsbisharaapr.pdf> [Accessed: 25.8.2012]

Blome, C. & Schoenherr, T., 2011. Supply chain risk management in financial crises—A multiple case-study approach. *International Journal of Production Economics,* 134(1), pp. 43-57.

Cantor, D.E. & Mcdonald J.R., 2009. Decision-making in the supply chain: examining problem solving approaches and information availability. *Journal of Operations Management,* 27(3), pp.220-232.

Caridi, M., Crippa, L., Perego, A., Sianesi, A. & Tumino, A., 2010. Do virtuality and complexity affect supply chain visibility? *International Journal of Production Economics,* 127(2), pp. 372-383.

European Commission, 2012a. *Common assessment and analysis of risk in global supply chains D1.1 Compendium.*

European Commission, 2012b. *Common assessment and analysis of risk in global supply chains D2.2 Compendium – Risk based approach.*

Chatfield D.C., Kim, J.G., Harrison, T.P. & Hayya J.C., 2004. The Bullwhip effect – impact on stochastic lead time, information quality and information sharing: a simulation study. *Production and Operations Management,* 13(4), pp. 340-353.

Chopra, S. & Sodhi, M.S., 2004. Managing Risks to Avoid Supply Chain Breakdown. *MIT Sloan Management Review,* 46(1), pp. 53-61.

Christopher, M. & Lee, H., 2004. Mitigating supply chain risk through improved confidence. *International Journal of Physical Distribution & Logistics Management,* 34(5), pp. 388-396.

Crook, T. R., Giunipero, L., Reus, T. H., Handfield, R. & Williams, S. K., 2008. Antecedents and outcomes of supply chain effectiveness: An exploratory investigation. *Journal of Managerial Issues*, 20(2), pp. 161–177.

Davis, T., 1993. Effective supply chain management. *Sloan Management Review,* 34(4), pp. 35-46.

Denyer, D., Tranfield, D. & van Aken, J.E., 2008. Developing design propositions through research synthesis. *Organization Studies,* 29(3), pp. 393-413.

Diessner, P. & Rosemann M., 2008. Supply chain event management: managing risk by creating visibility. *Strategies and Tactics in Supply Chain Management,* pp. 83-98.

Du, T.C., Vincent, S.L., Cheung, W. & Cui, X., 2012. Willingness to share information in a supply chain: a partnership-data-process perspective. *Information & Management,* 49(2), pp. 89-98.

Eriksson, M., 2011. *Implementing demand side energy efficiency – supplier, customer and third party perspectives.* B.Sc. Aalto University School of Science and Technology.

Flynn, B.B., Huo, B. & Zhao, X., 2010. The impact of supply chain integration on performance: a contingency and configuration approach, *Journal of Operations Management,* 28(1), pp. 58-71.

Francis, V., 2008. Supply chain visibility: lost in translation? *Supply chain management: An international journal,* 13(3), pp. 180-184.

Frolich, M.T. & Westbrook, R., 2001. Arcs of integration: an international study of supply chain strategies. *Journal of Operations Management,* 19(2), pp. 185-200.

Hale, A. & Swuste, P., 1998. Safety rules: procedural freedom or action constraint? *Safety Science,* 29 (3), pp. 163-177.

Hallikas, J., Karvonen, I., Pulkkinen, U., Virolainen, V-M. & Tuominen, M., 2004. Risk management processes in supplier networks. *International Journal of Production Economics,* 90(1), pp. 47-58.

Harland, C., Branchley, R. & Walker, H., 2003. Risk in supply networks. *Journal of Purchasing and Supply Management,* 9(2), pp. 51-62.

Hesketh, D., 2010. Weaknesses in the supply chain: who packed the box? *World Customs Journal*, 4(2), pp. 3-20.

Holweg, M., Disney, S, Holmström, J. & Småros, J., 2005. Supply chain collaboration: making sense of the strategy continuum. *European Management Journal,* 23(2), pp. 170-181.

Hopkins, A., 2011. Risk-management and rule-compliance: decision-making in hazardous industries. *Safety Science,* 49(2), pp. 110-120.

International Organization for Standardization, 2009a. *Risk management – Vocabulary (ISO 73).*

International Organization for Standardization, 2009b. *Risk management – Principles and guidelines on implementation (ISO 31000).*

Jayaram, J. & Tan, K-C., 2010. Supply chain integration with third-party logistics providers. *International Journal of Production Economics,* 125(2), pp. 262-271.

Johnson, M.E., 2001. Lessons in managing supply chain risk from the toy industry. *California management review,* 43(3), pp. 106-124.

Jüttner, U., 2005. Supply chain risk management – Understanding the business requirements from a practitioner perspective. *International Journal of Logistics Management,* 16(1), pp. 120-141.

Jüttner, U., Peck, H. & Christopher, M., 2003. Supply Chain Risk Management: Outlining an Agenda for Future Research. *International Journal of Logistics: Research and Applications,* 6(4), pp. 197-210.

Kim, S.W., 2009. An investigation on the direct and indirect effect of supply chain integration on firm performance. *International Journal of Production Economics,* 119(2), pp. 328-346.

Klein, R., Rai, A. & Straub, D.W., 2007. Competitive and Cooperative Positioning in Supply Chain Logistics Relationships. *Decision Sciences*, 38(4), pp.611–646.

Kleindorfer, P.R. & Saad, G.H., 2005. Managing disruptions risks in supply chains. *Production and Operations management,* 14(1), pp. 53-68.

Knemeyer, A.M., Zinn, W. & Eroglu, C., 2009. Proactive planning for catastrophic events in supply chains. *Journal of Operations Management,* 27(2), pp. 141-153.

Kocoglu, I., Imamoglu, S.Z., Ince, H. & Keskin, H., 2011. The effect of supply chain integration on information sharing: Enhancing the supply chain performance, *Procedia- Social and behavioral sciences,* 24, pp.1630-1649.

Kotsiopoulos, I.L., 1999. Railway operating procedures: regulating a safety-critical enterprise. *Computers in Industry,* 40(2-3), pp. 221-230.

Lee, A.S., 1989. A scientific methodology for MIS case studies. *MIS Quarterly,* 13(1), pp. 33-50.

Lim, D. & Palvia D.C., 2001. EDI in strategic supply chain: impact on customer service. *International Journal of Information Management,* 21(3), pp. 193-211.

Lockamy III, A. & McCormack, K., 2010. Analysing risks in supply networks to facilitate outsourcing decisions. *International Journal of Production Research,* 48(2), pp. 593-611.

Lockamy III, A. & McCormack, K., 2012. Modeling supplier risks using Bayesian networks. *Industrial Management and Data Systems,* 112(2), pp. 313-333.

Manuj, I. & Mentzer J.T., 2008. Global supply chain risk management strategies. *International Journal of Physical Distribution & Logistics Management,* 38(3), pp. 192-223.

Marquez, A.C., Bianchi, C. & Gupta, J.N.D., 2004. Operational and financial effectiveness of e-collaboration tools in supply chain integration. *European Journal of Operational Research,* 159(2), pp. 348-363.

Marucheck, A., Greis, N., Mena, C. & Cai, L., 2011. Product safety and security in the global supply chain: issues, challenges and research opportunities. *Journal of Operations Management,* 29(7), pp. 707-720.

McCutcheon, D.M. & Meredith, J.r., 1993. Conducting case study research in operations management. *Journal of Operations Management,* 11(3), pp. 239-256.

McGillivray, G., 2000, Commercial risk under JIT, *Canadian Underwriter*, 67(1), pp. 26-30.

McKinsey, 2008. *McKinsey global survey results – managing global supply chains.* [online] Available at: <http://businessassurance.com/downloads/2008/08/managing-global-supply-chains.pdf> [Accessed: 18.1.2013]

Mele, F.D., Musulin, E. & Puigjaner, L., 2005. Supply chain monitoring: a statistical approach. *Computer Aided Chemical Engineering,* 20, pp. 1375-1380.

Meredith, J., 1998. Building operations management theory through case and field research. *Journal of Operations Management,* 16(4), pp. 441-454.

Mortensen, O. & Lemoine, O.W., 2008. Integration between manufacturers and third party logistics providers? *International Journal of Operations & Production Management,* 28(4), pp. 331-359.

Mukhopadhyay, T., Kekre, S., & Kalathur, S., 1995. Business value of information technology: a study of electronic data interchange. *MIS Quarterly*, 19(2), pp. 137–156.

Nikander, I.O. & Eloranta, E., 2011.Project management by early warnings. *International Journal of Project Management,* 19(7), pp. 385-399.

Nurmilaakso, J-M., 2008. Adoption of e-business functions and migration from EDI-based to XML-based e-business frameworks in supply chain integration. *International Journal of Production Economics,* 113(2), pp. 721-733.

Nurmilaakso, J-M. & Kotinurmi, P., 2004. A review of XML-based supply-chain integration. *Production Planning and Control,* 15(6), pp. 608-621.

Otto, A., 2003. Supply chain event management: three perspective. *International Journal of Logistics Management,* 14(2), pp. 1-13.

Overbeek, S., Klievink, B., Hesketh, D., Heijmann, F. & Tan, Y. H., 2011. A Web-Based Data Pipeline for Compliance in International Trade. *Proceedings of the 1st Workshop on IT Innovations Enabling Seamless and Secure Supply Chains (WITNESS 2011). CEUR Workshop Proceedings*. 769, pp. 32-48.

Peck, H., 2006. Reconciling supply chain vulnerability, risk and supply chain management. *International Journal of Logistics: Research and Applications,* 9(2), pp. 127-142.

Pfohl, H-C., Köhler, H. & Thomas, D., 2010. State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice. *Logistics Research,* 2(1), pp. 33-44.

Pilli-Sihvola, E., Rantasila, K., Permala, A & Huhtaniemi, J., 2012. *Solutions for monitoring multimodal supply chain.* [online] Available at: <http://www.efreightconference.com/uploadfiles/papers/efreight2012_submission_4.pdf> [Accessed: 18.1.2013]

Powell, B., 2011. *The global supply chain: so very fragile.* [online] Available at: < http://tech.fortune.cnn.com/2011/12/12/supply-chain-distasters-disruptions/> [Accessed 18.1.203]

Rai, A., Patnayakuni, R. & Seth, N., 2006. Firm performance impacts of digitally enabled supply chain integration capabilities. *MIS Quarterly*, 30(2), pp.225–246.

Riggins, F.J. & Mukhopadhyay, T., 1994. Interdependent benefits from interorganizational systems: opportunities for business partner reengineering. *Journal of Management Information Systems*, 11 (2), pp. 37–57.z§z

Rodrigues, V.S., Stantchev, D., Potter, A., Naim, M. & Whiteing, A., 2008. Establishing a transport operation focused uncertainty model for the supply chain. *International Journal of Physical Distribution and Logistics Management,* 38(5), pp. 388-411.

Rundmo, T., 1992. Risk perception and safety on offshore petroleum platforms. *Safety Science,* 15(1), pp. 39-52.

Sambamurthy, V., Bharadwaj, A. & Grover, V., 2003. Shaping agility through digital options: reconceptualizing the role of information technology in contemporary firms. *MIS Quarterly,* 27(2), pp. 237-263.

Sezen, B., 2008. Relative effects of design, integration and information sharing on supply chain performance. *Supply chain management: an international journal,* 13(3), pp. 233-240.

Sheffi, Y. & Rice Jr., J.B., 2005. A supply chain view of the resilient enterprise. *MIT Sloan Management Review,* 47(1), pp.40-48.

Sodhi, M.S., Son, B-G. & Tang, C.S., 2012. Researchers' perspectives on supply chain risk management. *Production and Operations Management,* 21(1), pp. 1-13.

Stecke, K.E. & Kumar, S., 2009. Sources of supply chain disruptions, factors that breed vulnerability, and mitigating strategies. *Journal of Marketing Channels,* 16(), pp. 193-226.

van Stijn, E., Hesketh, D., Tan, Y-H., Klievink, B., Overbeek, S., Heijmann, F., Pikat, M. & Butterly, T., 2011. The data pipeline. In: Global Trade Facilitation Conference 2011, *Connecting International Trade: Single Windows and Supply Chains in the Next Decade.*

Supply Chain Council, Inc., 2010. *Supply Chain Operations Reference (SCOR) model, Overview - Version 10.0.* [online] Available at: <http://supply-chain.org/f/SCOR-Overview-Web.pdf> [Accessed 18.1.2013]

Swaminathan, J.M. & Tayur, S.R., 2003. Models for supply chains in e-business. *Management Science,* 49(10), pp.1387-1406.

Chen, F., Drezner, Z., Ryan, J. K., & Simchi-Levi, D., 1999. The Bullwhip effect: managerial insights on the impact of forecasting and information on variability in a supply chain. In: Tayur, S., Ganeshan, R. and Magazine, M., ed. 1998. *Quantitative models for supply chain management*, Springer. Ch.14.

Tranfield, D., Denyer, D. & Smart, P., 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management,* 14(3), pp. 207-222.

Tse, Y.K. & Tan, K.H., 2011. Managing product quality in a multi-tier global supply chain. *International Journal of Production Economics,* 49(1), pp. 139-158.

Vickery, S.K., Jayaram, J., Droge, C. & Calantone, R., 2003. The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships. *Journal of Operations Management,* 21(5), pp. 523-539.

Vilko, J.P.P. & Hallikas, J.M., 2012. Risk asssessment in multimodal supply chains. *International Journal of Production Economics,* 140(2), pp. 586-595.

Viswanadham, N. & Gaonkar, R.S., 2008. Risk Management in Global Supply Chain Networks. *International Series in Operations Research & Management Science,* 119, pp. 201-222.

Wagner, S.M. & Bode, C., 2006. An empirical investigation into supply chain vulnerability. *Journal of Purchasing and Supply Managemen,* 12(6), pp. 301-312.

World Economic Forum, 2012a. New models for addressing supply chain and transport risks. [online] Available at: http://www.weforum.org/reports/new-models-addressing-supply-chain-and-transport-risk [Accessed: 18.1.2013]

World Economic Forum, 2012b. Global risks 2012: Seventh edition. [online] Available at: http://www.weforum.org/reports/global-risks-2012-seventh-edition [Accessed: 18.1.2013]

Zangh, A.N., Goh, M. & Meng, F., 2011. Conceptual modeling for supply chain inventory visibility. *International Journal of Production Economics,* 133(2), pp. 578-585.

Zhang, K., Chai, Y., Yang, S.X. & Weng, D., 2011. Pre-warning analysis and application in traceability systems for production supply chains. *Expert systems with applications,* 38(3), pp. 2500-2507.

Zhou, W., 2008. RFID and item-level information visibility. *European Journal of Operational Research,* 198(1), pp. 252-258.

Zsidisin, G.A., Melnyk, S.A. & Ragatz, G.L., 2005. An institutional theory perspective of business continuity planning for purchasing and supply management. *International Journal of Production Research,* 43(16), pp. 3401-3420.

Appendix 1: Questionnaire used in field study

CASSANDRA

Dear Sir/Madame,

We would like to kindly ask you to fill in this survey about **inbound logistics risks** in your supply chain. This survey has been developed by the Cross-border Research Association (CBRA) within a research project financed by the Seventh Framework Programme (FP7), CASSANDRA. The purpose of this survey is to understand how companies are monitoring risks related to their inbound logistics, and how companies are exchanging information for risk managing purposes.

Please answer all questions from your inbound logistics perspective, concentrating on multi-modal and intercontinental shipments that have a maritime leg. If you don't use maritime mode for your shipments, please contact CBRA to agree on another logistics approach. We ask you to consider an average trade lane from 2011 in all questions.

In the first part of the questionnaire we ask you to assess different logistics problems in your supply chain. In the second part we ask you how you monitor these problems. Finally we ask for your opinion on information sharing between supply chain actors for risk managing purposes.

The survey should take around **30 minutes** to complete. All answers will be kept confidential. As a thanks for your contribution we will send an executive summary of the survey's results (please specify your email address in the questionnaire).

The survey can be handed in either by filling in the questionnaire as a Word document and sending it to mia@cross-border.org, or by printing the questionnaire and sending the completed form by fax (+41-21-6255336), or by mail (Cross-border Research Association, CBRA-BMT Ave d'Echallens 74, 1004 Lausanne, Switzerland). We kindly ask you to return the form by **September 6th.**

You are welcome to contact Mia Eriksson (mia@cross-border.org) for any further questions.

Thank you for your help!

A. BACKGROUND INFORMATION

Please fill in some background information below. The name and e-mail address will only be used for sending a copy of the executive summary, and will be separated from all analysis. For the product, components and trade lanes, please specify the ones you are considering when filling in this questionnaire.

1. Name:	
2. E-mail:	
3. Position in the company:	
4. Company annual turnover:	
5. Main product type:	
6. Main components/raw materials procured:	
7. Main geographical coverage of inbound logistics trade lanes (e.g. Asia-Europe):	

Appendix 1: Questionnaire used in field study

CASSANDRA

B. IDENTIFYING YOUR LOGISTICS PROBLEMS

In this part we ask you to assess the frequency and impact of different problems related to your inbound logistics, and to identify the three most important problems your company faces. We also ask about the parties that are related to these problems.

6. How would you rank the frequency of these logistics problems in your inbound supply chain? ***(Please use the mouse or tab to tick a box.)***

	Very rare	Rare	Occasional	Frequent	Very frequent	Cannot say
Late deliveries	☐	☐	☐	☐	☐	☐
Early deliveries	☐	☐	☐	☐	☐	☐
Under quantity deliveries	☐	☐	☐	☐	☐	☐
Over quantity deliveries	☐	☐	☐	☐	☐	☐
Wrong product deliveries	☐	☐	☐	☐	☐	☐
Sub-quality deliveries	☐	☐	☐	☐	☐	☐
Deliveries with damaged goods	☐	☐	☐	☐	☐	☐
Deliveries to wrong place	☐	☐	☐	☐	☐	☐
Actual delivery cost exceeds planned cost	☐	☐	☐	☐	☐	☐
Deliveries with wrong documentation or data	☐	☐	☐	☐	☐	☐
Deliveries with missing documentation or data	☐	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐	☐

7. How would you assess the negative impact of the following logistics problems? ***Please do not take into account the frequency of the problem when assessing the impact, but assess the impact resulting from problems with one delivery being e.g. late.***

	Insignificant impact	Low impact	Medium impact	High impact	Very high impact	Cannot say
Late deliveries	☐	☐	☐	☐	☐	☐
Early deliveries	☐	☐	☐	☐	☐	☐
Under quantity deliveries	☐	☐	☐	☐	☐	☐
Over quantity deliveries	☐	☐	☐	☐	☐	☐
Wrong product deliveries	☐	☐	☐	☐	☐	☐
Sub-quality deliveries	☐	☐	☐	☐	☐	☐
Deliveries with damaged goods	☐	☐	☐	☐	☐	☐
Deliveries to wrong place	☐	☐	☐	☐	☐	☐
Actual delivery cost exceeds planned cost	☐	☐	☐	☐	☐	☐
Deliveries with wrong documentation or data	☐	☐	☐	☐	☐	☐
Deliveries with missing documentation or data	☐	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐	☐

Appendix 1: Questionnaire used in field study

CASSANDRA

8. Please identify your three most important inbound logistics problems as frequency x impact based on your assessments in questions 6 and 7, and list them below (1 being the most important risk, 2 being the second most important risk, etc.):	
1.	
2.	
3.	

9. For each of these inbound logistics problems, which one actor in the supply chain causes most trouble? ***(COO=Country of origin, COD=Country of destination)***

	Seller	Freight forwarder	Logistics service provider (3PL)	Container depot (COO)	Inland carrier (COO)	Sea terminal operator (COO)	Shipping line/sea carrier	Sea terminal operator (COD)	Inland carrier (COD)	Inland terminal operator (COD)	Empty container depot (COD)	Other party (please specify):	Cannot say
Late deliveries	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Early deliveries	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Under quantity deliveries	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Over quantity deliveries	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wrong product deliveries	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sub-quality deliveries	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Deliveries with damaged goods	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Deliveries to wrong place	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Actual delivery cost exceeds planned cost	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Deliveries with wrong documentation or data	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Deliveries with missing documentation or data	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

C. MONITORING RISK THROUGH RISK RULES

In this section we ask about **risk rules** that you use for monitoring and mitigating the risks identified in question 8. With a risk rule we mean a rule or regulation, in other words standard operation procedures, that you follow in order to enhance secure, smooth and efficient operations of your supply chain. Risk rules are used to define **when to react to a problem** (e.g. to take action if the temperature falls below 2 °C in a storage) or to define **actions to take when a problem is detected** (e.g. to make an additional quality check if temperature has fallen below 2 °C). Risk rules are often embedded in monitoring systems, setting the limits for when to receive an alert.

Please note that **risk rules differ from general risk management practices and strategies**, i.e. having a supply chain risk management program is not a risk rules (but a supply chain risk management program may well include several risk rules).

Appendix 1: Questionnaire used in field study

CASSANDRA

Please answer the questions below about risk rules for each of the three most important inbound logistics problems you identified in question 8.

10. Most important problem:	
a) What are the three most important risk rules that you use to monitor/mitigate this problem?	
1.	
2.	
3.	
b) For these rules, from where do you get the data or information for identifying that something is going wrong or that actions are needed? ***(e.g. checking goods manually on arrival, receiving an alert from own IT-system, checking status on shipping lines webpage)***	
1.	
2.	
3.	
c) If you had better access to information in the supply chain, which three rules would you like to use to better monitor/mitigate this problem?	
1.	
2.	
3.	
d) For these rules, from where would you like to get the data or information for identifying that something is going wrong or that actions are needed? ***(e.g. checking goods manually on arrival, receiving an alert from own IT-system, checking status on shipping lines webpage)***	
1.	
2.	
3.	

11. Second most important problem:	
a) What are the three most important risk rules that you use to monitor/mitigate this problem?	
1.	
2.	
3.	
b) For these rules, from where do you get the data or information for identifying that something is going wrong or that actions are needed? ***(e.g. checking goods manually on arrival, receiving an alert from own IT-system, checking status on shipping lines webpage)***	
1.	
2.	
3.	
c) If you had better access to information in the supply chain, which three rules would you like to use to better monitor/mitigate this problem?	
1.	
2.	
3.	
d) For these rules, from where would you like to get the data or information for identifying that something is going wrong or that actions are needed? ***(e.g. checking goods manually on arrival, receiving an alert from own IT-system, checking status on shipping lines webpage)***	
1.	
2.	
3.	

Appendix 1: Questionnaire used in field study

CASSANDRA

12. Third most important problem:	
a) What are the three most important risk rules that you use to monitor/mitigate this problem?	
1.	
2.	
3.	
b) For these rules, from where do you get the data or information for identifying that something is going wrong or that actions are needed? *(e.g. checking goods manually on arrival, receiving an alert from own IT-system, checking status on shipping lines webpage)*	
1.	
2.	
3.	
c) If you had better access to information in the supply chain, which three rules would you like to use to better monitor/mitigate this problem?	
1.	
2.	
3.	
d) For these rules, from where would you like to get the data or information for identifying that something is going wrong or that actions are needed? *(e.g. checking goods manually on arrival, receiving an alert from own IT-system, checking status on shipping lines webpage)*	
1.	
2.	
3.	

D. INFORMATION SHARING WITH SUPPLY CHAIN ACTORS

In this section we ask about how enhanced information sharing with other supply chain actors could help you better monitor/mitigate the three most important inbound logistics problems identified in question 8.

For an list of examples of data elements in the supply chain, please see Appendix 1.

13. At the moment, which are the three most important data elements you receive from other supply chain actors that help you monitor/mitigate your three most important inbound logistics risks?	
1.	
2.	
3.	

14. From whom and how do you receive/get this data?		
	Supply chain actor	Means of communication *(e.g. EDI/XML, e-mail)*
1.		
2.		
3.		

15. Which would be the three most important data elements you would like to receive from other supply chain actors that would help you better monitor/mitigate your three most important inbound logistics risks?	
1.	
2.	
3.	

16. From whom and how would you like to receive/get this data?		
	Supply chain actor	Means of communication *(e.g. EDI/XML, e-mail)*
1.		
2.		
3.		

Appendix 1: Questionnaire used in field study

CASSANDRA

17. Which three data could you in turn share with other supply chain actors that could help them better monitor/mitigate your three most important inbound logistics risks?	
1.	
2.	
3.	

18. With whom and how would you like to share this data?		
	Supply chain actor	Means of communication *(e.g. EDI/XML, e-mail)*
1.		
2.		
3.		

E. OTHER

We finally ask you about how your operational problems or risks relate to supply chain risks in general. You are also welcome to elaborate any of your answers or add other comments concerning this questionnaire.

19. Please rank the importance of the following risk types in your supply chain (1 being the most important risk, 2 being the second most important risk, etc.).	
Demand risk (e.g. new product introductions, variation in demand, forecast problems (Bullwhip effect))	
Supply risk (e.g. disruption of supply, price escalation, quality issues, product complexity)	
Operational risk (e.g. logistics problems, internal production problems)	
Environmental risk (e.g. weather, natural disasters, crime, terrorism)	

20. Other comments

Thank you very much for your answers!

Appendix 1: Questionnaire used in field study

CASSANDRA

APPENDIX 1: Examples of data elements
This list shows examples of data elements in the supply chain. The list does not claim to be exhaustive and should only be seen as a guideline.

Data on organizations and people involved
- Carrier
- Consignee
- Consignor
- Notify party
- Person lodging summary declaration

Data on container (or vehicle)
- Container Nr (equipment identification number)
- Container Type
- Conveyance reference number
- Gross Weight

Data on cargo
- Cargo net/gross mass (kg) and cube (m3)
- Cargo type
- Certificate of Origin
- Commodity Code (HS Code)
- Goods Description
- Goods Item number
- Item price
- Number of packages (cartons, packages)
- Types of packages (code)
- UN Dangerous Goods Code

Data on consignment
- Calculation of taxes
- Port/place of loading
- Port/place of discharge
- Destination
- Location of goods
- Shipping Marks
- Unique consignment reference number (CRN)
- Country(ies) of transit (routing) code
- Transport document number

Data on handling of goods
- Mode of transport at the border
- Special Handling
- Safety Procedures
- Other specific circumstance indicators

Data on movements and milestones (tracking, tracing and monitoring data)
- Actual Time of Arrival (ATA)
- Expected Time of Arrival (ETA)
- Delay information

Data on container/cargo integrity
- Container integrity
- CSD number
- Seal number

Appendix 2: Interview structure

INTERVIEW WITH BUYER

Introduction:

- Please present yourself and your job/position
- Please describe the company/supply chain you work with briefly

Contexts:

- What is a late delivery (for your company)?
- Why are late deliveries a problem? How are you impacted?
- Defining risk: frequency and impact for late deliveries

Interventions:

- What is the most important information you use to manage (prevent, cope with) late deliveries?
    - From whom do you receive this information, when, how?
    - What do you do with this information?
    - Why does it help?

Case:

- Please describe the latest important late delivery you have dealt with
    - What type of goods/delivery was it?
    - Where did it come from? Where was it going?
    - Why was it late?
    - When did you know it was going to be late? Who told you? How? (What data?)
    - How did this information help you? (What did you do when you knew it was late?)
    - Why did this action help?
    - Did you get any further information about the delivery later on?
    - What was the impact on your company?
- How could you **a)** prevent **b)** better manage **c)** cope with this type of situation?
    - What data/information would help you? Which parties? etc. - Please elaborate…
- Can you think of other important late deliveries you have dealt with lately? - Please elaborate…

Appendix 2: Interview structure

Visibility:

- Supply chain visibility is a current topic in supply chain management… any thoughts on it?
    - What is visibility for you/your company? (How would you define it?)
    - How would you describe the current state of visibility in you company?
    - Do you have ongoing projects/plans/goals to improve supply chain visibility? Please elaborate…
        - …specifically in managing late deliveries?
    - What are the possibilities/need for improved visibility in your company? Please elaborate…
        - …specifically in managing late deliveries?
        - How does visibility help in this?
    - What are the possibilities/needs for improved visibility in the supply chain as a whole? Please elaborate…
        - …specifically in managing late deliveries?
        - How does visibility help in this?
    - Which parties should be involved in visibility projects?
    - Who is responsible for improving visibility?
        - Why do you think so?
        - What is your/your company's role in it?

Closing:

- Other thoughts/comments?
- Thank you very much!

Appendix 3: Details on companies and respondents in field study

Company	Industry	Products	Goods procured	Mode of transportation	Geographical coverage of supply chain	Sales (MEUR)	Position of interviewee
Plastic mterials manufacturer	Plastics	Laminates. packing materials	Paper, aluminum foils, plastics	Ocean freight	Asia – Europe	300	Group Supply Chain Manager
Aircraft manufacturer	Aviation	Aircrafts and defense systems	Aircraft parts. aluminum, composites	Ocean freight	Several global trade lanes	53,000	Senior Manager, Supply Chain Security
Engineering workshop	Industrial components	Industrial valves	Valves and components	Ocean freight	Asia – Europe	6,600	Purchasing Director
Food distributor	Food	Frozen foodstuff	Frozen foodstuff	Ocean freight	Several global trade lanes	77	Director, Trade Compliance
Electrical components manufacturer	Electrical	Electrical installation products	N/A	Ocean freight	Asia – Europe	100	Procurement accountant
Paints manufacturer	Paints and chemicals	Industrial paints and coatings	Paints and chemicals	Ocean freight	Asia – Europe, Europe – Europe	250	Purchase manager
Consumer electronics manufacturer	High tech	Smartphones	Semi-finished products	Air freight	Asia – North America	39,000	Director, Customer Logistics

Appendix 4: Summary on information used by the buyer to monitor incoming deliveries (party refers to the party from which the buyer receives the information)

Risk	**Information for monitoring incoming deliveries (current)**		**Information for monitoring incoming deliveries (future)**	
	Information	**Party**	**Information**	**Party**
Late/early deliveries	Order confirmations; Manual order status follow-ups	Supplier	Production and inventory information; Automated order status follow-ups	Supplier
	Estimated Time of Departure (ETD), Estimated Time of Arrival (ETA), etc.; Arrival notices	Freight forwarder and other logistics parties; Broker	Real time information on location and status; Automated updates on location and status	Freight forwarder and other logistics parties
	Outstanding orders	In-house	-	-
Sub-quality deliveries / Deliveries with damaged goods	Supplier certification; Quality control data	Supplier	Quality control report with photo	Supplier
	Marks on waybills	Logistics parties	-	-
	Quality checking on arrival; In-house testing	In-house	-	-

Appendix 4: Summary on information used by the buyer to monitor incoming deliveries (party refers to the party from which the buyer receives the information)

Risk	**Information for monitoring incoming deliveries (current)**		**Information for monitoring incoming deliveries (future)**	
	Information	**Party**	**Information**	**Party**
Under/over quantity deliveries	Order confirmations; Notices on upcoming problems	Supplier	Automated alerts on capacity problems	Supplier
	Outstanding orders	In-house	-	-
Wrong product deliveries	Order confirmations	Supplier	-	-
	Goods checked on arrival	In-house	-	-
Deliveries with exceeding costs	-	-	-	-
Deliveries with wrong/missing data or information	Checking of documents when received	In-house	Automated alerts if late/missing documents	In-house
Deliveries to wrong place	-	-	-	-

Appendix 5: Company-wise summary on information used by the companies to monitor late deliveries (party refers to the party from which the buyer receives the information)

Company	**Information for monitoring late deliveries (current)**		**Information for monitoring late deliveries (future)**	
	Information	**Party**	**Information**	**Party**
Plastic materials manufacturer	Order confirmation	Supplier	Real time information on location and status (one interface system, automated alarms)	Supplier; Logistics parties
	Delay information	Supplier		
Aircraft manufacturer	Estimated Time of Arrival (ETA)	Freight forwarder	-	-
	Actual Time of Arrival (ATA)	Broker		
	Delay information	Supplier		
Engineering workshop	Order status follow-up	Supplier	Order status follow-up in ERP	Supplier
	On-time-delivery measurement	In-house		
Food distributor	Pre-confirmed schedule	Supplier	Production and inventory information	Supplier
	Tracking information	Ocean carrier	Automatic updates of tracking information	Ocean carrier

Appendix 5: Company-wise summary on information used by the companies to monitor late deliveries (party refers to the party from which the buyer receives the information)

Company	**Information for monitoring late deliveries (current)**		**Information for monitoring late deliveries (future)**	
	Information	**Party**	**Information**	**Party**
Electrical components manufacturer	Outstanding orders	In-house	-	-
	Shipping information	Freight forwarder		
Paints manufacturer	Purchase order confirmations	Supplier	-	-
	Arrival notices	Freight forwarder		
Consumer electronics manufacturer	13 different data from transportation phase (e.g. ETA, ATA)	Freight forwarder	-	-

Appendix 6: Details on companies and respondents in interviews

Company	Industry	Products	Goods procured	Mode of transportation	Geographical coverage of supply chain	Sales (MEUR)	Position of interviewee
Confectioner	Food	Confectionery	Raw materials, packaging materials	Road, ocean freight	Europe – Europe, domestic	960	Purchaser
Consumer electronics manufacturer	High tech	Smartphones	Semi-finished products	Air freight	Asia – North America	39,000	Director, Customer Logistics
Engineering workshop	Industrial components	Industrial valves	Valves and components	Ocean freight	Asia – Europe	6,600	Purchasing Director
Food distributor	Food	Frozen foodstuff	Frozen foodstuff	Ocean freight	Several global trade lanes	77	Director, Trade Compliance
Office supplies distributor	Computer and office equipment	Computer and office supplier	Computer and office supplier	Road, ocean freight	Asia – Europe, Europe – Europe. and domestic	54	Merchandising Manager