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Supply Chain Risk Management in a Finnish Manufacturing Organisation's Maritime Delivery Network

A Case Study from Finland and Sweden to the US

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Abstract

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The maritime supply chain is a crucial component of global trade, as it handles over 80% of international trade. However, its vulnerabilities have been exposed by recurrent disruptions and imbalances between demand and supply. Consequently, effective supply chain risk management (SCRM) has become more critical in recent years. Research supports this, as it has demonstrated that companies that make risk management a priority in their supply chain, can even gain a competitive edge. The purpose of this study was to identify risks within a case organisation's specific maritime delivery network, assess their probabilities and consequences, find strategies to mitigate the risks and distinguish ways in which the risks can be monitored.

To gather empirical data for the study, eight semi-structured interviews were conducted with employees from the case company, as well as a questionnaire. The participants were selected based on their experience and role in the transportation of goods to the target market and represented a diverse range of roles within the company that spanned all three levels of supply chain management decision-making: strategic, tactical and operational. This ensured a well-rounded and comprehensive understanding of the issue being studied.

In this study, a total of 68 risks were identified within the maritime delivery network of the case organisation. These risks originated from environmental, network and organisational sources. The risks with the greatest potential business impact were found to be largely related to environmental sources, particularly economic and political forces. These forces were also identified as major drivers of shipping demand and supply in the literature. Therefore, it is essential for organisations to understand and analyse the key factors that determine shipping demand and supply in order to effectively manage risk in their maritime delivery networks. In terms of risk mitigation, the study identified several key enablers and actions, including flexibility, redundancies, collaboration, agility, alignment, adaptability, integration, contingency planning and visibility. For risk monitoring, the study highlighted the importance of using both qualitative and quantitative methods, as well as the role of information systems and technology and information sharing within the supply network.

Keywords: Supply Chain Risk Management, Supply Chain Management, Risk Management, Maritime Supply Chain, Distribution

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Glossary

4Rs	Responsiveness, resilience, reliability and realignment
AG	Agility
AM	Assets
CH	Chapter
CO	Costs
CPFR	Collaborative planning, forecasting and replenishment
ETA	Event Tree Analysis
EV	Environmental
FMEA	Failure Mode Effects Analysis
FTA	Fault Tree Analysis
LoLo	Lift-on/lift-off
LSP	Logistics service provider
PR	Profit
RL	Reliability
RoRo	Roll-on/roll-of
RQ	Research question

RS	Responsiveness
S&OP	Sales and operations planning
SC	Supply chain
SCF	Supply chain flexibility
SCI	Supply chain integration
SCL	Social
SCM	Supply chain management
SCOR	Supply chain operations reference
SCRM	Supply chain risk management
SCV	Supply chain visibility
US	United States
VaR	Value at Risk
VP	Vice president

1 Introduction

Supply chains (SC) have become a source of competitive advantage and effective supply chain management (SCM) can enhance organisational performance (Bratić, 2011: 1). More and more businesses are expanding globally in order to take advantage of international markets due to competitive pressures and customer demand. However, international firms are often part of a long and complex supply chain (Manuj and Mentzer, 2008a: 192), which can be risky due to the different conditions under which organisations in the chain operate (Waters, 2011: 96). Additionally, supply chains are often described as having a domino effect, meaning that any impact on one member can have ripple effects throughout the supply chain (Chopra & Sodhi, 2012: 88-89; Ivanov, 2017; Waters, 2011: 11).

Over the last two decades, globalisation has grown at an incredible rate, which has increased uncertainty and risk exponentially (Manuj and Mentzer, 2008: 192). As a result, supply chain risk management (SCRM) has become increasingly important in recent years to maintain the continuity of the supply chain, while minimising the negative impacts of risks and maximising the efficiency and effectiveness of supply chain (Schlegel and Trent, 2014: 7-11). Neither is the level of risk expected to diminish in the future (Manners-Bell, 2020: 6-7).

SCRM has been a widely discussed topic among both practitioners and academics. Both groups agree that risk management should be a central part of a comprehensive SCM approach. However, both practitioners and researchers have noted that managing risk in modern times is challenging. This is due to increasing uncertainties in supply and demand, limited visibility, complexity, dependency on external factors and globalisation. (Rao and Goldsby: 97-98)

Maritime transportation is a vital link in the global trade since over 80% of international trade is moved by sea (UNCTAD, 2021). Frequent disruptions in the supply chain in recent years have, nonetheless, exposed the vulnerability of

the maritime sector. In addition, the discrepancy between demand and supply of maritime logistics capacity has led to surges in freight rates and congestion (UNCTAD, 2022). Despite these disruptions, some companies have been better able to handle the situation than others, indicating that companies that prioritise the resilience and risk management of their supply chain may even gain a competitive advantage (Veselovská, 2020: 490-491). As a result, resilience and risk management have emerged as key concepts within the sector (UNCTAD, 2022).

The purpose of this study was to identify and evaluate the risks present within a Finnish forest industry group's maritime delivery network from Finland and Sweden to the US ports and determine effective strategies for mitigating and monitoring these risks. The study included a literature review of maritime economics, SCRM, and relevant SCM theory, as well as an empirical analysis through semi-structured interviews and a questionnaire. The results indicated that economic and political forces pose the greatest potential business impact on risk in the maritime sector. Therefore, it is crucial for the organisation to thoroughly understand, analyse and monitor these forces in order to effectively manage risks in their maritime delivery network.

1.1 Research questions and objectives

The topic of this study was chosen based on the interests of the author and the needs of the case organisation. The main objectives of this study were developed after preliminary discussions with the case organisation’s Vice President (VP) in Logistics and Logistics Planning Manager. The primary objectives formed for this study were to identify all the risks associated with transporting goods by sea from production plants in Finland and Sweden to US ports and to find ways to mitigate these risks. Maritime transportation was selected because it is the main method of transporting goods from Finland and Sweden to the US for the case organisation. Consequently, this study supports in the case organisation’s logistics and delivery network planning and execution.

The research questions were developed after reviewing the literature on SCRM and having initial discussions with the case organisation. As a result, the research questions are based on the objectives set up by the case company and the literature review. The research questions (RQs) are the following:

RQ1. What are the risks in the case organisation's maritime delivery network from Finland and Sweden to the US ports?

RQ2. What are the likelihoods and consequences of the identified risks?

RQ3. How can the risks be mitigated?

RQ4. How can the risks be monitored?

1.2 Scope of the study

This study investigates the risks related to the maritime delivery network from a Finnish manufacturing organisation's perspective, which has outsourced most of their transportation, warehousing and some of their distribution services to logistics service providers (LSP). Consequently, the scope of this study is focused on the risks related to the ports in Finland and Sweden, the sea leg of the journey and US ports. The study acknowledges that disruptions outside the maritime supply chain causes risks within the maritime supply chain. However, these are examined from the maritime delivery network's point of view and more precisely, the case organisation's perspective from the three main decision-making levels in SCM: strategic, tactical and operational.

1.3 Structure of the study

The structure of this study is visualised in figure 1.

Figure 1. Study structure

2 Literature review

The literature review provides a summary of literature explored in relation to the research objectives and questions. First, a general overview of maritime economics theory is explained to provide context for the maritime supply chain. Then, supply chain and relevant key concepts are defined. Following this, SCM and relevant models are discussed. Next, supply chain risk management is analysed. Subsequently, supply chain risks are explored including the sources, drivers, types and categories of supply chain risks. Furthermore, different perspectives on supply chain risk management processes are introduced, followed by more detail descriptions of the four steps used in this study. Finally, a concept identified as key driver for risks is discussed: the bullwhip effect.

2.1 Maritime economics

According to UNCTAD (2021), over 80% of the international trade volume is transported by sea and the percentage is even higher for most developing countries. Consequently, maritime transportation is considered the backbone of global economy (UNCTAD, 2021). The movement of cargo by sea is the result of trade between two parties, the consignor and the consignee, which is derived from customers' demand for product. The three key components of the maritime shipping system are (Lun, Cheng and Lai, 2010: 2-3):

- Ports and terminals which work as fixed infrastructure.
- Vehicles such as ships or barges that move freight between infrastructure.
- Organisational systems that make sure that vehicles and fixed infrastructure are efficiently and effectively used.

2.1.1 Freight market

There are two main categories within the freight market: tramp shipping and liner shipping. Tramp shipping is a flexible method of transporting goods worldwide by sea, making it suitable for international trade. Tramp ships typically only transport a single type of commodity at a time and usually carry

cargo from one shipper. The freight rates and terms for tramp shipping are usually negotiated individually. (Lun, Cheng and Lai, 2010: 4-5)

On the other hand, the liner market satisfies the demand for the transportation of regular cargo. Liner market transport these cargoes along predetermined routes and within set time frames, following port schedules for loading and unloading and following established conditions of carriage and timetable. Liner ships carry cargoes made up of many different consignments from different shippers. (Lun, Cheng and Lai, 2010: 5)

Cargo ships are organised around four sectors: general cargo, dry bulk, oil and chemicals and liquid gas. The different ship types organised by the four sectors are seen in figure 2 (Stopford, 2008: 569).

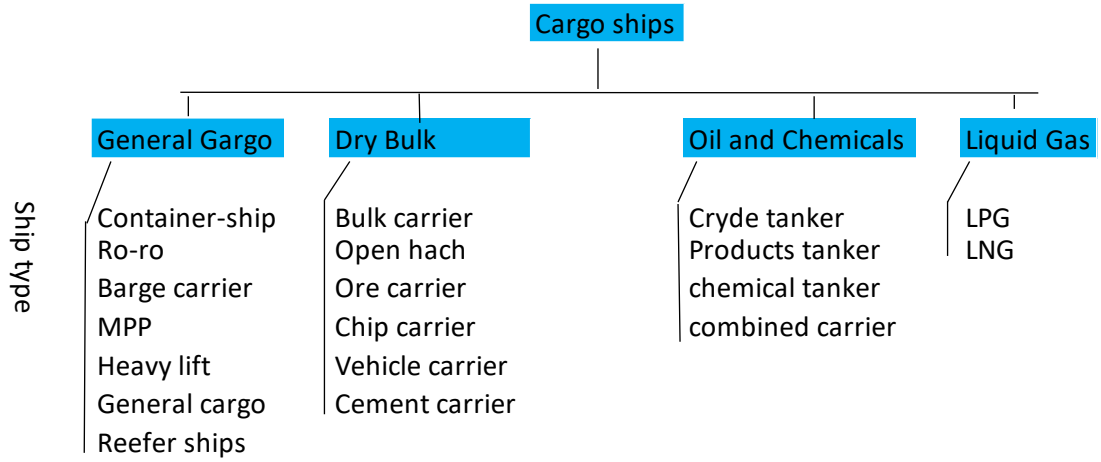

Figure 2. The cargo shipping fleet (Stopford, 2008: 569).

2.1.2 Demand for sea transport

There are five key factors that determine the demand for sea transport. These are: 1) Political factors and random shocks 2) World economy 3) Seaborne trade 4) Average haul 5) Transport costs (Lun, Cheng and Lai 2010: 18; Stopford, 2008: 136).

Political factors, or random shocks as Stopford (2008:136-149) refers to them, include government interventions in shipping and trade matters, trade policies and other factors like wars, national crises, and strikes. The world's economy

directly affects the demand of sea freight because sea transportation is the result of the importation and exportation of goods. Additionally, sea transport demand is affected by an increase or decline in commodity trade volumes, seasonality and trade patterns. Sea transport demand can also be affected by distance travelled, also known as average haul, which is measured in terms of ton-miles: tonnage of cargo multiplied by average distance over which cargo is transported. Furthermore, transportation costs affect demand as pricing decisions are greatly affected by them. (Lun, Cheng and Lai, 2010: 18-20).

2.1.3 Supply for sea transport

The capacity of sea transport for carrying cargo from one port to another is referred to as tonnage. The supply of the freight market consists of three components: active shipping supply, available shipping supply and total shipping supply. Active shipping supply refers to all ships that are currently engaged in the freight market. Available shipping supply includes ships that are not currently in use. Total shipping supply is made up of both active shipping supply and available shipping supply that are seaworthy but not in operation. (Lun, Cheng and Lai, 2010: 22-24)

There are four parties that influence on the supply of ships: shipowners, shippers or charterers, bankers and various regulatory authorities (Lun, Cheng and Lai, 2010: 22-24). Shipowners make the decision whether to purchase new ships or dispose old ones. These decisions are influenced by shippers who order shipping space to transport freight. As lenders, bankers finance ship purchases with capital investments. Regulators with safety or environmental legislation have an impact on fleet capacity (Lun, Lai and Cheng, 2010: 22-24). Factors that determine the supply of sea transport are shown in figure 3.

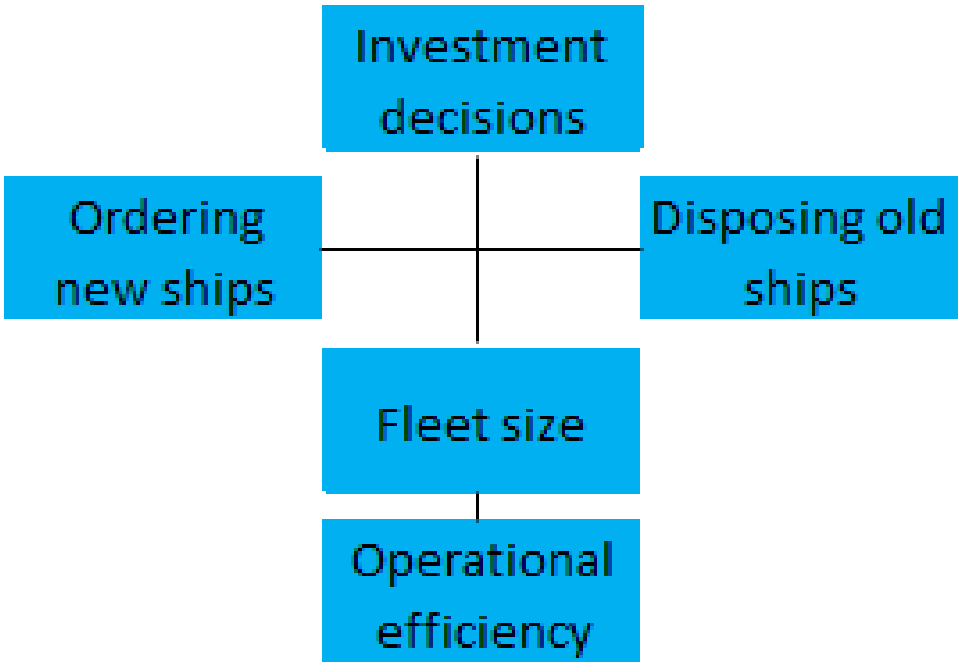

Figure 3. Key factors determining the supply of sea transport (Lun, Cheng and Lai, 2010: 23).

Technological innovation and improvements in vessel design and operation have significantly increased operational efficiency. As a result, vessels are safer, faster and more efficient and can provide shipping services at lower costs. However, this means they require deeper water and more advanced terminals. Nevertheless, due to the possibility of cost economics, shipowners favour larger vessels. (Lun, Cheng and Lai, 2010: 23)

2.1.4 Freight rates

Freight rates are the link between supply and demand. Freight rates rise when supply is tight, which causes shipowners to provide more transport. In contrast, when the opposite occurs, freight rates fall (Stopford, 2008: 160-162). Figure 4 illustrates how the freight rates mechanism works. It is composed of transactions between buyers and sellers in the market, as well as their supply and demand requirements. These are what cause the price of freight rates to move, and they form the "going price", which is the equilibrium price (Lun, Cheng and Lai, 2010: 27-28).

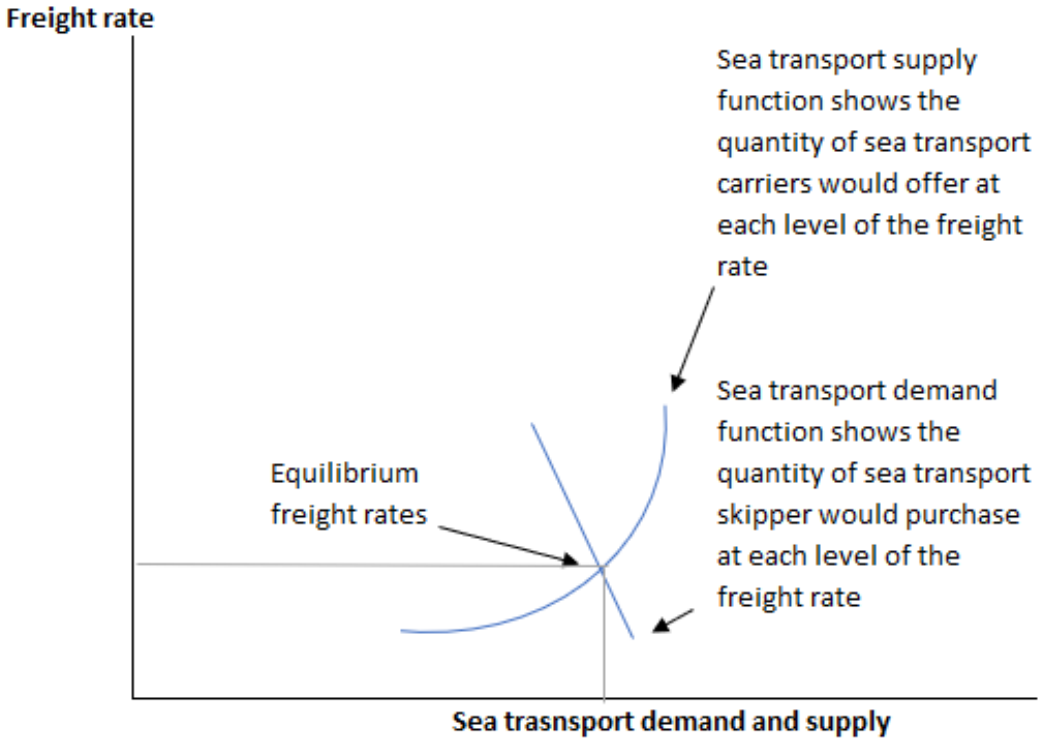

Figure 4. The freight mechanism (Lun, Cheng and Lai, 2010: 28).

2.1.5 Shipping cycle

Shipping cycles are designed to align the supply of shipping services with the demand for them in the market (Stopford 2008: CH 3). As Stopford (2008: CH 3) explains, an excess of demand leads to a shortage of ships and an increase in freight rates. Conversely, an excess of supply results in a decrease in freight rates. The length of shipping cycles may be long, short or seasonal, however, they are formed of four stages (Stopford, 2008: 98):

1. Market trough
2. Market recovery
3. Market peak
4. Market collapse

Shipping cycles are highly complex and are neither random nor regular. The economic and political forces that influence shipping can still be studied (Stopford, 2008: 133). Analysing the key factors determining the demand and

supply of shipping can help in predictions. It is also important to keep track of developments in infrastructure (Lun, Cheng and Lai, 2010: 29-31).

2.1.6 Port operations

When discussing ports, three terms need to be defined (Stopford, 2008: 81):

- Port: “a geographical area where ships are brought alongside land to load and discharge cargo – usually a sheltered deep-water area such as a bay or river mouth” (Stopford, 2008: 81).
- Port authority: “the organization responsible for providing the various maritime services required to bring ships alongside land” (Stopford, 2008: 81).
- Terminal: “a section of the port consisting of one or more berths devoted to a particular type of cargo handling” (Stopford, 2008: 81).

Ports and terminal operations are responsible for loading and discharging cargo onto or from vessels and preparing cargo for delivery to the final destination via inland transport (Song and Panayides 2022: 14-15). Ports also serve a key function by providing storage facilities for both inbound and outbound cargoes. (Verschuur, Koks and Hall, 2022: 1-3). Consequently, Notteboom, Pallis and Rodrigue (2022: CH 1) describe ports as a vital link in supply chains since they support the interaction between regional production, consumer markets and global supply chains.

Port performance is formed by two connected components: effectiveness and efficiency. Additionally, a third component that emerges is resilience to disruptions. Efficiency in ports refers to operational performance, especially to the maximisation of the produced output or the production of a given output with limited possible resources. Effectiveness in ports refers to the performance of a port in fulfilling expectations and delivering the desired services to it’s users. Resilience in ports is defined by the adaptive capacity to recover from disruptions and have ability to mitigate its impacts. (Notteboom, Pallis and Rodrigue, 2022: CH 6) Inefficient port operations reduce the profitability for the

port, increase costs for shippers and raise operating costs for transport operators (Lun, Cheng and Lai, 2010: 205).

2.1.7 Geography and transportation

Rodrigue (2020: CH 1) states that “the purpose of transportation is to overcome space, which is shaped of various human and physical constraints such as distance, time, administrative divisions and topography.” If transportation would come at no effort in terms of cost, time and capacity geography would not matter. However, since this is not the case, geography can be considered a significant constraint (Rodrigue, 2020: CH 1).

Shipping is influenced heavily by water depths and the locations of obstacles such as reefs. Furthermore, locations of port infrastructure are influenced by physical attributes such as coastlines and other natural features. Freight transportation is also impacted by hazardous weather conditions such as ice, snow, fog and heavy rainfall. Consequently, topography imposes a natural selection of routes and can assist locations on becoming a trade centre or distributor but may also work as a constraint. (Rodrigue, 2020: CH 1)

2.2 Supply chain

Supply chain is described as a network formed of different organisations with distinct roles that together lead and develop material and service flows as well as the associated money and information flows (Logistiikanmaailma, 2022). A supply chain network can include suppliers, manufacturers, logistics providers, wholesalers or distributors, retailers and end consumers. (Sodhi and Tang, 2014: 6; Logistiikanmaailma, 2022). The structure of the supply chain depends on the organisation’s customers, industry and products (Logistiikanmaailma, 2022). An example of a manufacturer’s supply chain network from the initial suppliers to the end consumer is seen in figure 5 (Lambert et al., 1998: 6-7).

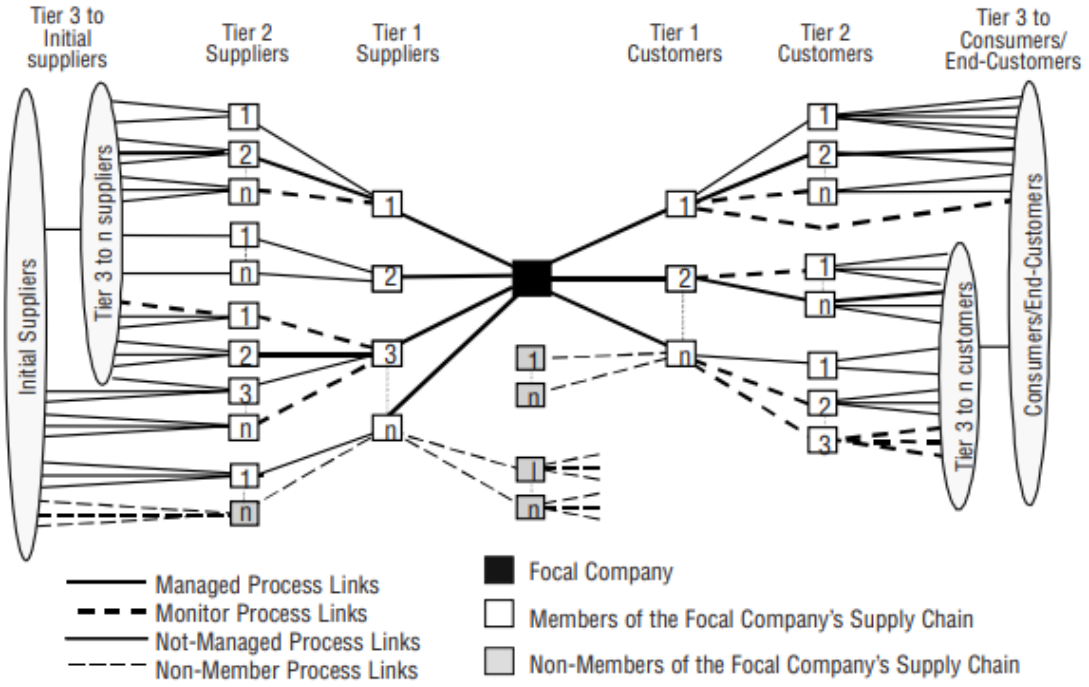

Figure 5. Supply chain network (Lambert et al, 1998: 7)

2.2.1 Collaboration

Supply chain collaboration refers to the sharing of common planning, execution, management and performance measurement information among two or more companies to execute supply chain operations. Collaboration is driven by the potential value structure benefits that organisations receive and the belief that a company cannot compete effectively on its own. As a result, companies look to collaborate across firms, with the objective to secure better performance while sharing risks and rewards. Successful collaboration requires realistic, informed and accurate information sharing with exchange of operating plans, data and financial information for improved decision-making and supply chain efficiency. (Min et al., 2014: 237-240) Achieving successful supply chain collaboration is, however, a challenging task due to the numerous supply chain parties involved, especially when there are many companies with diverse cultural backgrounds and social trust factors (Moradeyo, 2018: 42-44).

2.2.2 Integration

Supply chain integration (SCI) refers to “all processes within an organisation that involve all suppliers and customers, integrating them to come up with a product or service” (Alzoubi et al., 2022: 2). As a result, integration can be considered an alignment and coordination of supply chains (Alzoubi et al., 2022: 2; Carvalho et al., 2012). Furthermore, SCI can be divided into two levels: internal and external (Alzoubi et al., 2022: 2).

Internal supply chain integration refers “to the active and on-time communication, coordination, cooperation, and collaboration of inter-and cross-functional activities through systematic interaction within the supply chain” (Alzoubi et al., 2022: 2). External supply chain integration, on the other hand, “is related to the interaction with suppliers, customers and other partners by ensuring continuous and fruitful communication, coordination and collaboration, creating a long-term partnership and strategic alliances” (Alzoubi et al., 2022: 2). Consequently, Vilko and Hallikas (2012: 586) conclude that integration plays an important role in facilitating global supply chain processes. However, they also state that “greater integration increases dependency between companies and exposes them to more risks” (Vilko and Hallikas, 2012: 586).

2.2.3 Visibility

Supply chain visibility (SCV) refers to “the degree which supply chain partners have access to information related to supply chain operations and management to benefit each other” (Wei and Wang, 2014: 239). Therefore, SCV can be understood as the result of both information sharing and external integration (Vilko et al., 2019: 471). Visibility in supply chain operations can improve a company's performance by aiding decision-making at the strategic, tactical, and operational levels. Additionally, visibility also enables better supply chain reconfiguration. Consequently, visibility can positively affect manufacturing, planning, transaction activities, evaluation, supplying (Wei and Wang, 2014: 238-242). However, supply chains today have less visibility due to their complexity and length, which results in slow decision-making, as well as slower

responses to disruptions (Sodhi and Tang, 2014: 7). Additionally, it has become harder to spot the risks that are threatening companies and supply chains (Vilko and Hallikas, 2012: 586) which stems from the lack of visibility upstream and downstream. As a result, due to a lack of information sharing, many companies are forecast-driven rather than demand-driven and have difficulties reacting to changing market conditions (Manner-Bell, 2020: 5).

2.2.4 Flexibility

The literature in supply chain management has several different definitions for supply chain flexibility (SCF). Lee (2004) describes flexibility in terms of three distinctive components: adaptable, agile and alignment. According to Lummus et al (2003: 5), SCF can be represented by a simplified model which suggests that it is the result of five supply chain components and their characteristics. These components and characteristics are depicted in figure 6.

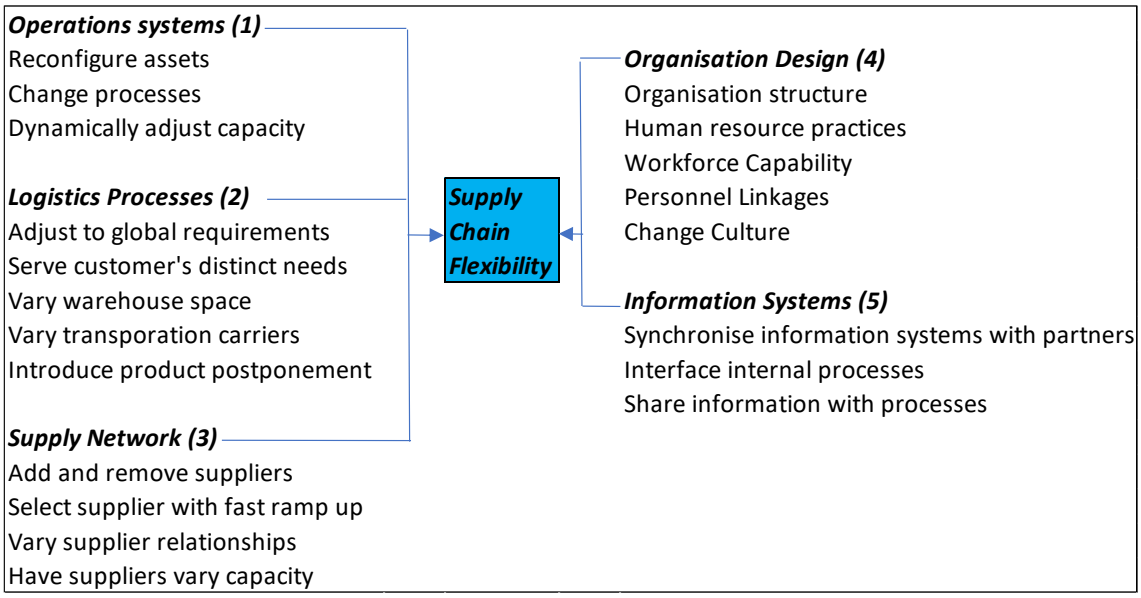

Figure 6. Supply chain flexibility components and key characteristics (Lummus et al., 2003: 5).

This study will view supply chain flexibility in terms of the five components and their characteristics described by Lummus et al. (2003: 5), as seen in figure 6. Supply chain flexibility, therefore, requires both internal and external company flexibility. Consequently, supply chain flexibility can be “defined as the supply chain’s promptness and the degree to which it can adjust its supply chain

speed, destinations and volumes in response to changes in customer demand" (Lummus et al., 2003: 4).

2.3 Supply chain management

The term supply chain management, despites its popularity, there is still confusion surrounding the precise meaning of the term in both academia and practice (Mentzer et al., 2001: 3). Tang (2006a: 453) proposes the following definition for SCM, which will be used as the definition for SCM in this study:

"*The management of material, information, and financial flows through a network of organisations (i.e., suppliers, manufacturers, logistics providers, wholesalers/distributors, retailers) that aims to produce and deliver products or services for the consumers. It includes the coordination and collaboration of processes and activities across different functions such as marketing, sales, production, product design, procurement, logistics, finance and information technology within the network of organisations."*

2.3.1 Decision-making levels

In SCM, there are three main levels of decision-making: strategic, tactical, and operational. Strategic decisions are made for the medium to long term, often one to five or more years, and involve the highest level of management decisions. These decisions often relate to broad, investigation-based policies, corporate financial plans, competitiveness and alignment with organisational goals. Tactical level decisions are made within a six-month to one-year time frame and involve resource allocation and measuring performance against targets and results established at the strategic level. Operational decisions are made on a daily or weekly basis and rely on precise measurements and data to achieve the objectives set at the tactical level. (Gunasekaran, Patel and McGaughey, 2004: 335)

2.3.2 SCOR model

The SCOR (Supply Chain Operations Reference) model is a strategic planning tool designed by the Supply Chain Council to help senior managers streamline the process of managing supply chain operations (Huan, Sheoran and Wang, 2004). The SCOR version 12.0 framework is organised into six primary

management processes, as seen in table 1. This study will focus on the 'enable' process with SCRM.

Table 1. SCOR Processes (APICS, 2017; McCormack, 2008).

SCOR Processes	Definition
Plan	"Processes that balance the aggregate demand and supply to develop a course of action which best meets sourcing, production and delivery requirements" (McCormack et al., 2008: 10).
Source	"Processes that procure goods and services to meet planned or actual demand." (McCormack et al., 2008: 10).
Make	"Processes that transform product to a finished state to meet planned or actual demand." (McCormack et al., 2008: 10).
Deliver	"Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management." (McCormack et al., 2008: 10)
Return	"Processes associated with returning or receiving returned products for any reason. These processes extend into post-delivery customer support." (McCormack et al., 2008: 10)
Enable	"Processes that prepare, maintain and manage information or relationships upon which planning and execution processes rely." (McCormack et al., 2008: 11).

The SCOR model does not try to cover every aspect of a business, however, it covers all customer interactions, all physical material transactions and market interactions. The model is divided into four main sections: performance, processes, practices and people (APICS, 2017). The performance section is focused on measuring and evaluating supply chain execution and includes three elements: performance attributes, metrics and process or practice maturity (APICS, 2017).

Performance attributes are strategic characteristics of supply chain performance which align and prioritise the business strategy with the supply chain's performance (APICS, 2017). Examples of performance attributes, their definitions and focus are seen in table 2, which this study will later refer to in terms of supply chain performance.

Table 2. SCOR performance attributes (APICS, 2022c).

	Performance attribute	Definition	Focus
Resilience	Reliability (RL)	*"The ability to perform tasks as expected. Reliability focuses on the predictability of the outcome of a process. Typical metrics for the Reliability attribute include delivering a product on time, in the right quantity, and at the right quality level." (ASCM, 2022c)*	Customer
	Responsiveness (RS)	*"The speed at which tasks are performed and the speed at which a supply chain provides products to the customer. Examples include cycle-time metrics."* (ASCM, 2022c)	Customer
	Agility (AG)	*"The ability to respond to external influences and marketplace changes to gain or maintain a competitive advantage."* (ASCM, 2022c)	Customer
Economic	Costs (CO)	*"The cost of operating the supply chain processes. This includes labor costs, material costs, and management and transportation costs." (ASCM, 2022c)*	Internal
	Profit (PR)	*"The Profit attribute describes the financial benefit realized when the revenue generated from a business activity exceeds the expenses, costs, and taxes involved in sustaining the activity."* (ASCM, 2022c)	Internal
	Assets (AM)	*"The ability to efficiently utilize assets. Assets' strategies in a supply chain include inventory reduction and insourcing rather than outsourcing."* (ASCM, 2022c)	Internal
Sustainability	Environmental (EV)	*"The Environmental attribute describes the ability to operate the supply chain with minimal environmental impact, including materials, water, and energy." (ASCM, 2022c)*	Sustainability
	Social (SCL)	*"The Social attribute describes the ability to operate the supply chain aligned with the organization's social values, including diversity and inclusion, wage, and training metrics."* (ASCM, 2022c)	Sustainability

The metrics in the SCOR model are described in a hierarchical manner in three levels and the relationships between these levels are diagnostic. This means that if you look at the performance level-2 metrics, it's possible to see the performance gaps or improvements made for level-1 metrics. Examples of Level-1 metrics for the performance attributes are seen in table 3 (APICS, 2017).

Table 3. SCOR level-1 metrics (ASCM, 2022c)

	Performance attribute	Level-1 metric
Resilience	Reliability (RL)	Perfect Order Fulfilment (RL.1.1) Perfect Supplier Order (RL.1.2) Perfect Return Order Fulfilment (RL.1.3)
	Responsiveness (RS)	Order Fulfilment Cycle Time (RS.1.1)
	Agility (AG)	Upside Supply Chain Flexibility (AG.1.1) Upside Supply Chain Adaptability (AG.1.2) Downside Supply Chain Adaptability (AG.1.3) Overall Value at Risk (AG.1.4)
Economic	Costs (CO)	Total Supply Chain Management Costs (CO.1.1) Cost of Goods Sold (COGS) (CO.1.2)
	Profit (PR)	Earnings Before Interest and Taxes (EBIT) as a Percent of Revenue (PR.1.1) Effective Tax Rate (PR.1.2)
	Assets (AM)	Cash-to-Cash Cycle Time (AM.1.1) Return on Fixed Assts (AM.1.2) Return on Working Capital (AM.1.3)
Sustainability	Environmental (EV)	Materials Used (EV.1.1) Energy Consumed (EV.1.2) Water Consumed (EV.1.3) GHG Emissions (EV1.4) Waste Generation (EV.1.5)
	Social (SCL)	Diversity and Inclusion (SCL.1.1) Wage Level (SCL.1.2) Training (SCL.1.3)

Maturity in processes and practices allows for a qualitative assessment of supply chain processes and practices compared to standardised descriptions of various levels of adoption and implementation (APICS, 2017). Lockamy and McCormack's (2004: 272-276) SCM maturity model includes five stages that represent the evolution of SCM processes towards effectiveness and maturity. The five stages of process maturity and their descriptions of them are seen in table 4.

Process Maturity	
Extended	"Competition is based on multifirm supply chains. Collaboration between legal entities is routine to the point where advanced SCM practices that allow transfer of responsibility without legal ownership are in place. Multi-firm SCM teams with common processes, goals and broad authority take shape. Trust, mutual dependency and esprit de corps are the glue holding the extended supply chain together. A horizontal, customerfocused, collaborative culture is firmly in place. Process performance and reliability of the extended system are measured and joint investments in improving the system are shared, as are the returns." (Lockamy III and McCormack, 2004)
Integrated	"The company, its vendors and suppliers, take cooperation to the process level. Organizational structures and jobs are based on SCM procedures, and traditional functions, as they relate to the supply chain, begin to disappear altogether. SCM measures and management systems are deeply imbedded in the organization. Advanced SCM practices, such as collaborative forecasting and planning with customers and suppliers, take shape. Process performance becomes very predictable and targets are reliably achieved. Process improvement goals are set by the teams and achieved with confidence. SCM costs are dramatically reduced and customer satisfaction and esprit de corps become a competitive advantage." (Lockamy III and McCormack, 2004)
Linked	"This represents the breakthrough level. Managers employ SCM with strategic intent and results. Broad SCM jobs and structures are put in place outside and on top of traditional functions. Cooperation between intra-company functions, vendors and customers takes the form of teams that share common SCM measures and goals that reach horizontally across the supply chain. Process performance becomes more predictable and targets are often achieved. Continuous improvement efforts take shape focused on root cause elimination and performance improvements. SCM costs begin decreasing and feelings of esprit de corps take the place of frustration. Customers are included in process improvement efforts and customer satisfaction begins to show marked improvement. " (Lockamy III and McCormack, 2004)
Defined	"Basic SCM processes are defined and documented. Jobs and organization basically remain traditional. Process performance is more predictable. Targets are defined but still missed more often than not. Overcoming the functional silos takes considerable effort owing to boundary concerns and competing goals. SCM costs remain high. Customer satisfaction has improved, but is still low." (Lockamy III and McCormack, 2004)
Ad Hoc	"The supply chain and its practices are unstructured and ill-defined. Process measures are not in place. Jobs and organizational structures are not based on horizontal supply chain processes. Process performance is unpredictable. Targets, if defined, are often missed. SCM costs are high. Customer satisfaction is low. Functional cooperation is also low." (Lockamy III and McCormack, 2004)

Table 4. The five stages of process maturity (Lockamy and McCormack, 2004: 272-276).

The SCOR model allows for analysis of the supply chain at multiple levels, as shown in figure 7. The six major processes that make up the Level-1 process are plan, source, make, deliver, return and enable. The capabilities within the level-1 process categories are determined by level-2 processes. Level-3 processes refer to the specific steps taken to plan supply chain activities, source materials, produce products, deliver goods and services, and handle product returns. Level-4 processes include descriptions of activities in the level-3 processes that are specific to an industry, technology, product and location. (APICS, 2017).

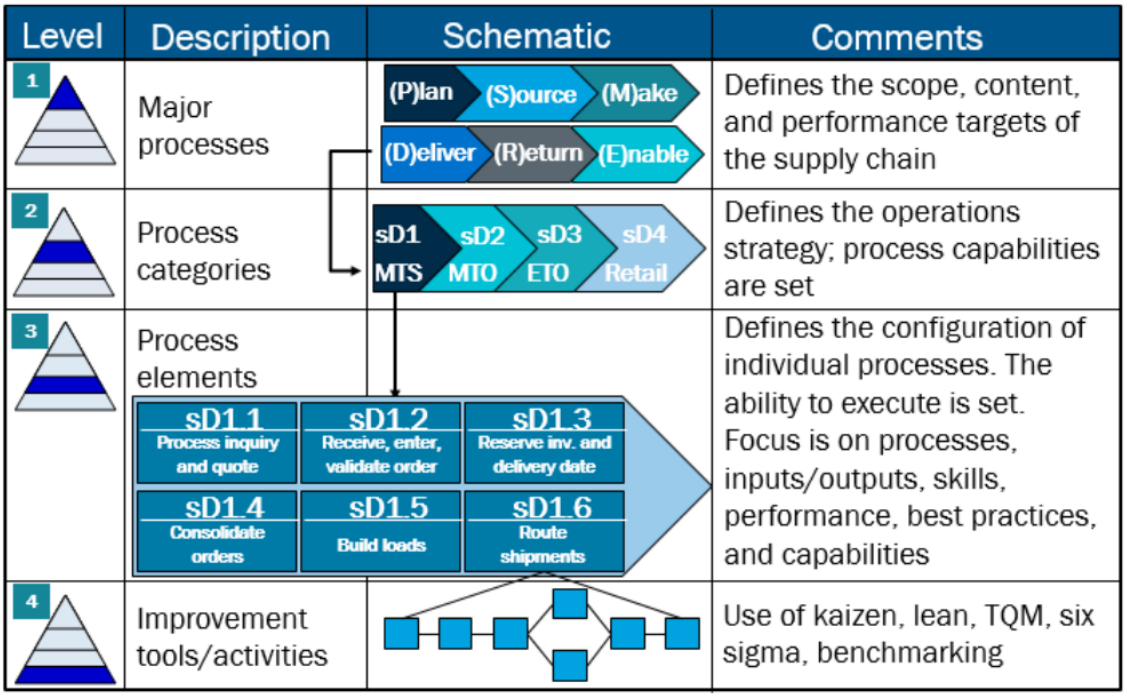

Figure 7. SCOR hierarchical process model (APICS, 2017).

The practices section contains a list of industry-neutral practices that have been recognised as being valuable by companies across all industries. These practices can be used to create a process or set of processes. SCOR recognises that there are many different qualifications for practices within any organisation and that the qualification may differ by industry or geography (APICS, 2017). The classification categories for SCOR practices are presented in table 5. An important note is that one practice may be linked to multiple categories.

Table 5. Classification of SCOR practices (ASCM, 2022b).

Categories	
Business Process Analysis and Improvement	Planning and Forecasting
People Management (Including Training)	Order Engineering
Information and Data Management	Order Management
Product Life Cycle Management	Manufacturing and Production
Purchasing and Procurement	New Product Introduction
Sustainable Supply Chain Management	Risk and Security Management
Transportation Management	Customer Support
Distribution Management	Reverse Logistics
Warehousing	Inventory Management
Material Handling	

SCOR's people section provides guidelines for managing talent in supply chains and complements the other reference elements. Skills, training and experience are the key components of the people section (ASCM, 2022a). SCOR recognises five commonly accepted competency levels:

- A novice: “an untrained beginner with no experience who requires and follows detailed documentation.” (ASCM, 2022a)
- A beginner: “performs the work with limited situational perception.” (ASCM, 2022a)
- A competent employee: “understands the work and can determine priorities to reach goals.” (ASCM, 2022a)
- A proficient individual: “oversees all aspects of the work and can prioritize based on situational aspects.” (ASCM, 2022a)
- An expert: “has an intuitive understanding and can apply experience patterns to new situations.” (ASCM, 2022a)

2.3.3 4R model

The 4R model is based on the idea that competitive advantage can be gained through the ability of supply chain partners to meet the needs of the supply chain's customers. A customer-focused supply chain strategy aims to improve customer satisfaction by matching supply and demand, ultimately reducing costs and improving the customer experience (Mandhani, 2020: 1-3). According to Mandhani (2020: 3) the 4Rs are four components that provide a dynamic capability to enhance customer satisfaction. The 4Rs stand for responsiveness, resilience, reliability and realignment.

Responsiveness refers to “the ability to react quickly to sudden changes in demand or supply” (Mandhani, 2020: 9). It allows companies to respond quickly to any short-term fluctuations in supply or demand and enables firms to deal with external disruptions. Responsiveness is dependent on the quality of the integration and coordination within the supply chain. Consequently, to be more responsive, companies must become more customer-centric, information-intensive and flexible. Responsiveness is, therefore, closely related to agility,

which enables better synchronisation of supply and demand. (Mandhani, 2020: 9-10)

According to Mandhani (2020: 11) resilience “describes the ability to adapt overtime as market structures and strategies evolve”. Additionally, Mandhani (2020: 11-12) states that it enables “firms to adjust the supply chain’s design to meet structural shifts in markets and modify supply network according to strategies, products and technologies.” Subsequently, Christopher and Peck (2004: 2) define resilience as “the ability of a system to return to its original state or move to a new, more desirable state after being disturbed.” According to Yossi and James (2005: 41) flexibility and redundancy are two ways to create resilience. While redundancy may be expensive, investing in flexibility can provide additional benefits for your day-to-day operations. Hence, flexibility can be justified even without considering the benefits for risk mitigation (Yossi and James, 2005: 41).

A summary of Christopher and Peck’s (2004: 7) view on creating a resilient supply chain is visualised in figure 8. Therefore, it can be concluded that resilience requires flexibility, agility, adaptability, collaboration, and a risk management culture. Additionally, the design and structure of the supply chain can affect its resilience.

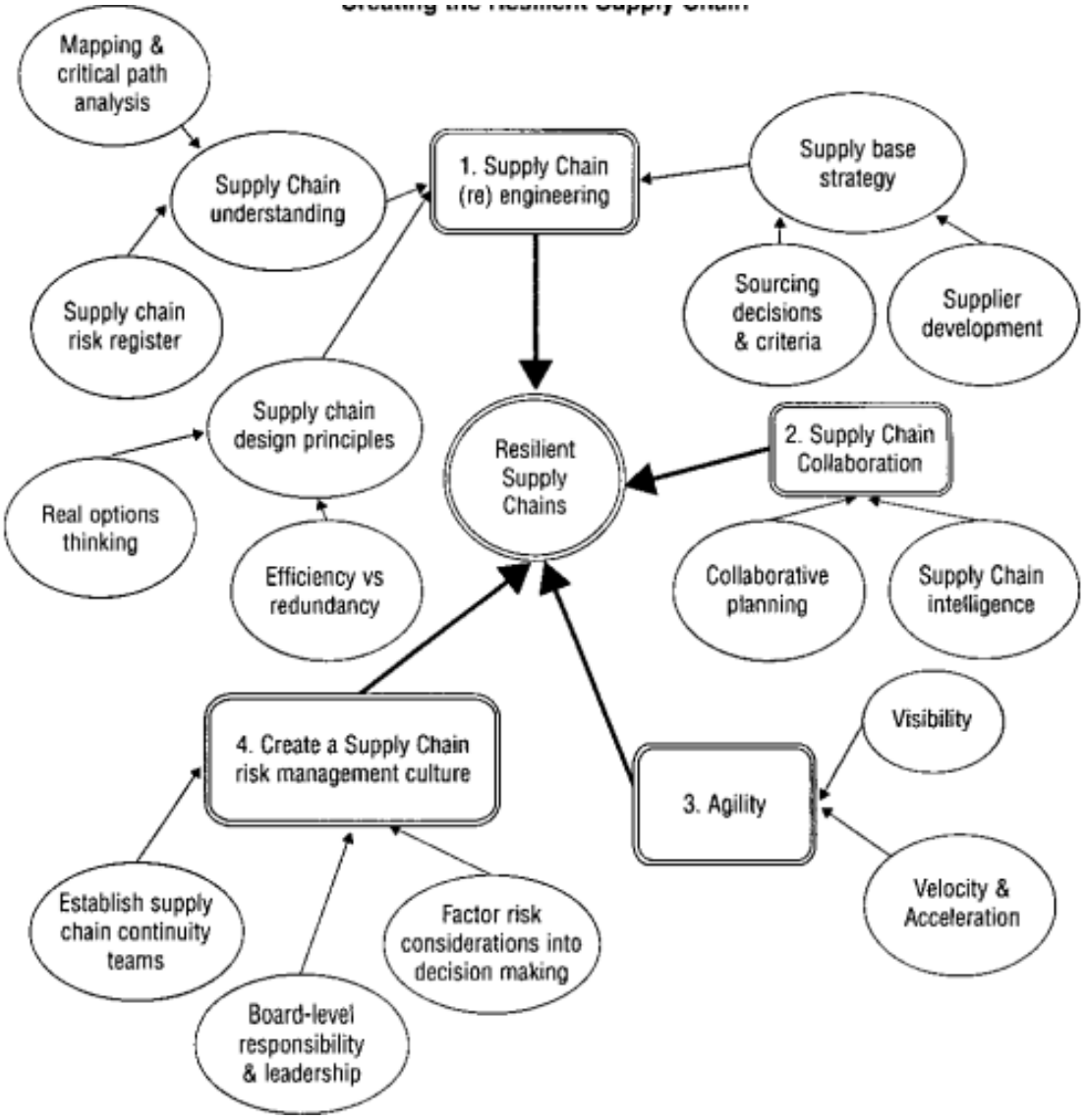

Figure 8. Creating a resilient supply chain (Christopher and Peck, 2004: 7)

Reliability refers to “the performance of the supply chain in delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.” (Mandhani, 2020: 13). According to Mandhani (2020: 13) organisations can enable better supply chain reliability with the following ways:

- Creating analytical models that consider the random relationship between disruptions in supply chain risk analysis in order to make informed decisions about supplier selection at a strategic level and improve inventory management at the operational level. Supply chain

reliability has typically been addressed at the tactical planning level by considering factors such as uncertainty in demand or lead times and maintaining sufficient safety stock.

- Improving process consistency by employing techniques like 'Six Sigma'.
- Effective transportation management through good carrier connectivity and collaboration leading to improved transportation performance and increased reliability.
- Integrating forecasting, inventory management, and transportation into a dependable supply chain.

Realignment involves aligning the goals of all partners in the supply network to optimise the overall performance of the supply chain (Mandhani, 2020: 14). This requires that organisations are synchronised both internally and with external supply chain partners. The idea is that success depends on all supply chain partners being able to prioritise customers and adapt to changing demands. As a result, Powers and Reagan (2007: 1234-1235) argue that supply chain partners gain a competitive edge from strong and long-term relationships. Additionally, Ramdas and Spekman (2000: 21) suggest that an organisation's competitive advantage is more dependent on its connections with other organisations rather than its internal capabilities.

2.4 Supply chain risk management

The competitive pressure and growing complexity of supply chains along with increasing globalisation has increased risks within supply chains. Supply chain risk management involves combining supply chain management and risk management in order to protect against and minimise the impact of negative events that could harm the supply chain and businesses (Colicchia and Strozzi, 2012: 403-418). SCRM can also be considered a strategic management activity within firms, as it can have an impact on the financial, market, and operational performance of firms (Narasimhan and Talluri, 2009: 114). There are various definitions of SCRM, despite, or may be due to the fact that it has been extensively researched. Table 6 presents a summary of several definitions of SCRM.

Table 6. Definitions of SCRM

Authors	Definitions
Manuj and Mentzer (2008a: 205)	"*The identification and evaluation of risks and consequent losses in the global supply chain, and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing one or more of the following – losses, probability, speed of event, speed of losses, the time for detection of the events, frequency, or exposure – for supply chain outcomes that in turn lead to close matching of actual cost savings and profitability with those desired.*"
Lavastre, Gunasekaran and Spalanzani (2011: 830)	*"The management of risk that implies both strategic and operational horizons for long-term and short-term assessment. It refers to risks that can modify or prevent part of the movement and efficient flow of information, materials and products between the actors of a supply chain within an organization, or among actors in a global supply chain (from the supplier's supplier to the customer's customer)."*
Norrman and Jansson (2004: 436)	*"To [collaborate] with partners in a supply chain apply risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources."*
Schlegel and Trent (2014: CH 2)	*"The implementation of strategies to manage every day and exceptional risks along the supply chain through continuous risk assessment with the objective of reducing vulnerability and ensuring continuity."*
Waters (2011: 76)	*"Supply chain risk management is the process of systematically identifying, analysing and dealing with risks to supply chains and is responsible for all aspects of risk to the supply chain."*
Jüttner, Peck and Christopher (2003: 198)	*"The identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole."*
McCormack et al. (2008: 9)	*"Supply chain risk management is the systematic identification, assessment, and quantification of potential supply chain disruptions with the objective to control exposure to risk or reduce its negative impact on supply chain performance. Potential disruptions can either occur within the supply chain (e.g., insufficient quality, unreliable suppliers, machine break-down, uncertain demand, etc.) or outside the supply chain (e.g. flooding, terrorism, labor strikes, natural disasters, large variability in demand, etc.). Management of risk includes the development of continuous strategies designed to control, mitigate, reduce, or eliminate risk."*

SCRM, therefore, involves identifying and evaluating potential risks to the supply chain and taking actions to mitigate or eliminate them, with the goal of improving supply chain performance and maximising cost savings and profitability. It also involves collaboration with other stakeholders in the supply chain. However, in order to reduce confusion, this study will later refer to McCormack et al. (2008: 9) definition of SCRM.

2.4.1 Supply chain risks

In today's business environment, there is a high likelihood of sudden and unpredictable events that can lead to uncertainty and increase risks for supply chains. This increased volatility and turbulence makes supply chains more susceptible to disruptions and business risks (Mandhani, 2020: 1-19).

In SCRM literature, there is a lack of agreement on a definition for risk, however, they tend to be similar in nature. Neither is there a clear distinction between risk and uncertainty in supply chain operations (Tang and Musa, 2010: 26). Nevertheless, according to Waters (2011: 17), “uncertainty means that we can list the event that might happen in the future but have no idea about which will actually happen or their relative likelihoods” and “risk means that we can list the events that might happen in the future and can give each a probability”. Thus, the difference between risk and uncertainty is that risk can be measured in terms of likelihood and consequence, while uncertainty cannot (Waters, 2011: 17). Additionally, Waters (2011: 14) states that uncertainty is the key driver for risk.

According to Schlegel and Trent (2014: CH 2), “risk is the probability or threat of damage, injury, liability, loss, or other negative occurrences that are caused by external or internal vulnerabilities and that may be avoided through pre-emptive action.” McCormack et al. (2008: 6) say that “supply chain risk is the negative deviation from the expected value of a certain performance measure, resulting in negative consequences for the focal firm. Hence, risk is equated with the detriment of a supply chain disruption.” Subsequently, McCormack et al. (2008:6) define supply chain disruption as “an unintended, untoward situation, which leads to supply chain risk. For the affected firms, it is an exceptional and anomalous situation in comparison to everyday business. Supply chain disruptions can materialize from various areas internal and external to a supply chain. Consequently, their nature can be highly divergent.” This study will later refer to McCormack et al. (2008:6) definitions when discussing supply chain risk and supply chain disruption.

McCormack et al. (2008: 7) state that to fully comprehend risk, it is necessary to consider multiple perspectives on risk. Figure 9 lists some risks and relates them to the three different perspectives in the supply chain: supplier-facing, internal-facing and customer-facing (McCormack et al., 2008: 7):

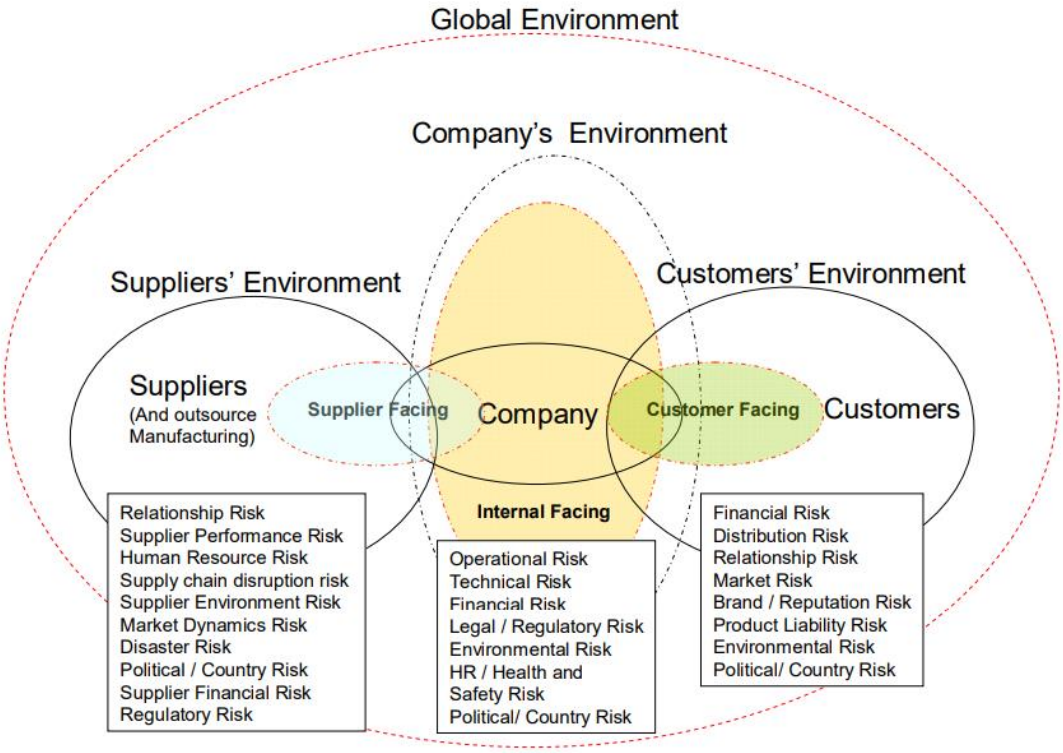

Figure 9. Supply chain risk perspectives (McCormack et al., 2008: 7)

Svensson (2002) suggests that supply chain risk is a multifaceted issue that can be broken down into sources and types of risk. According to Manuj and Mentzer (2008b: 137-138) risks can be classified as qualitative or quantitative. Qualitative risks involve the reliability, accuracy, and precision of components and materials in the supply chain. Quantitative risks include shortages, excess inventory and insufficient availability of components and materials in the supply chain.

There are many ways to classify types of risk (Manners-Bell, 2020: 4-5), but one useful approach for supply chain risk is shown in figure 10. Risks that are "Internal to the firm" and "External to the firm but Internal to the supply chain network" largely within the control of the company. Risks that are "External to the network" are largely outside the company's control (Manners-Bell, 2020: 5-6), however, the company can try to design operations as efficiently as possible

in risky environments (Waters, 2011: 99). These types of risk collectively define the vulnerability of a supply chain. Supply chain vulnerability is, consequently, defined by Waters (2011: 99) “as the exposure of a supply chain to disruption arising from the risks to operations within each organization, to interactions within the supply chain, and from the external environment." Therefore, supply chain vulnerability can be considered the risk of serious disruption (McCormack et al., 2008: 7).

Internal Risk	**Process**	Management and value-adding activities
	Control	Rules and systems which govern how a firm controls the processes
Supply Chain Risk	**External** to the firm but **Internal** to the supply chain network	Demand (downstream) Supply (upstream)
	External to the network	"Environment" (e.g., natural disasters, weather or socio-political)

Figure 10. Internal and external corporate risks (Manner-Bell, 2020: 5).

Manuj and Mentzer (2008b: 138) categorise supply chain risks as supply risks, operational risks, demand risks, security risks, macro risks, policy risks, competitive risks and resource risks. They acknowledge that there is overlapping between supply chain risks and that they do not exist in isolation. The sources of these risks are visible in table 7.

Table 7. Summary of types and sources of risks (Manuj and Mentzer, 2008b: 138)

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

Several author's categorise supply chain risks as: process risks, control risks, demand risks, supply risks and environmental risks (Bogataj and Bogataj, 2007: 292; Christopher and Peck, 2004: 4-6). Chopra and Sodhi's (2004: 54-55) categories of supply chain risks and the drivers of the risks are seen in table 8.

Table 8. Categories of supply chain risks and their drivers (Chopra and Sodhi, 2004: 54-55).

Category of Risk	Drivers of Risk
Disruptions	- Natural disaster - Labor dispute - Supplier bankruptcy - War and terrorism - Dependency on a single source of supplu as the capacity and responsiveness of alternative suppliers
Delays	- High capacity utilisation at supply source - Inflexibility of supply source - Poor quality or yield at supply source - Excessive handling due to border crossing or to change in transportation modes
Systems	- Information infrastructure breakdown - System integration or extensive systems networking - E-commerce
Forecast	- Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycles, small customer base - "Bullwhip effect" or information distortion due to sales promotions, incentives, lack of supply chain visibility and exaggeration of demand in times of product shortage
Intellectual Property	- Vertical integration of supply chain - Global outsourcing and markets
Procurement	- Exchange rate risk - Percentage of a key component or raw material procured from a single source - Industrywide capacity utilisation - Long-term versus short-term contracts
Receivables	- Number of customers - Financial strength of customers
Inventory	- Rate of product obsolescene - Inventory holding cost - Product value - Demand and supply uncertainty
Capacity	- Cost of capacity - Capacity flexibility

Schlegel and Trent (2014: CH 2) suggest that a useful way to approach risk is by considering the four categories of enterprise risk management, which are strategic, hazard, financial, and operational risks, in conjunction with the four pillars of SCRM, which are supply, process, demand, and environmental risk. Jüttner et al. (2003) suggest that supply chain risk sources fall into three broad categories: environmental risk sources, network-related risk sources and organisational risk sources. Their categorising is, therefore, similar to Manner-Bell (2020:5). Jüttner et al. (2003) view on the sources of supply chain risks is visualised in figure 11, which this study will later refer to in terms of risk sources.

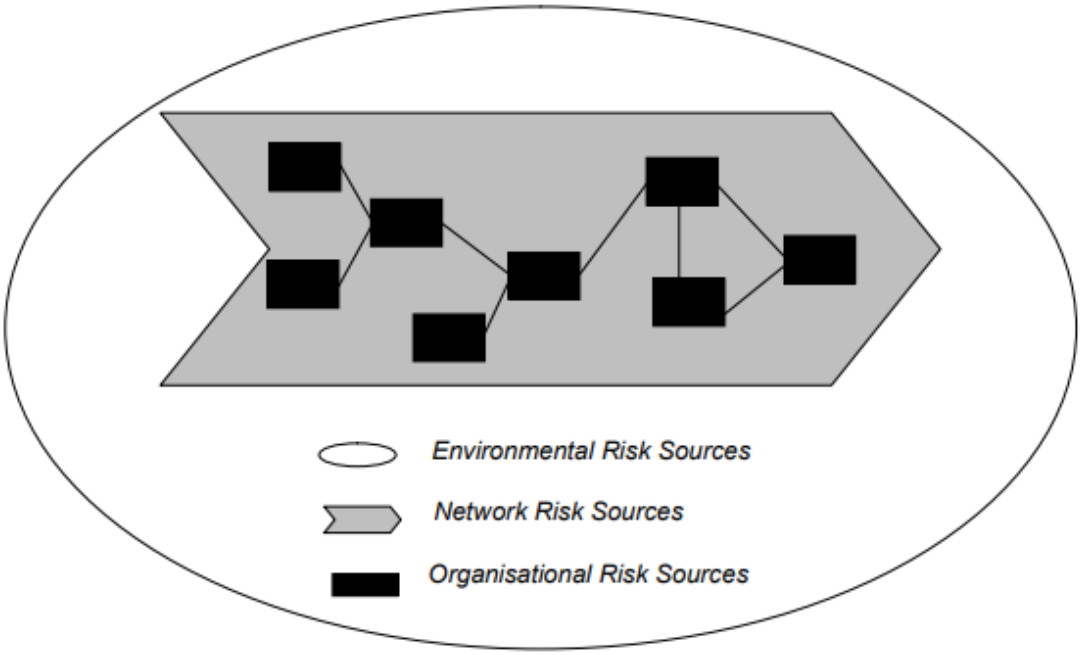

Figure 11. Risk sources in supply chain (Jüttner et al., 2003)

Based on the literature, in can be stated that there is lack of agreement on the sources of risk (Rao and Goldsby, 2009: 101). A common theme in risk management is that it involves quantifiable analysis, typically involving events with known probabilities (Waters, 2011: 31). Additionally, in most of the literature supply chain risk is associated with negative consequences of impact (Tang and Musa, 2010: 26). Christopher and Peck (2004: 3) provide a simple measure for risk by viewing it as the product of the probability of any given event multiplied by its severity: Risk = Probability (of a given event) x Severity (negative business impact).

2.5 Supply chain risk management process

Olson (2014: CH 2) says that the typical process applied to the SCRM process includes 1) risk identification, 2) risk assessment, 3) risk avoidance and risk mitigation. Waters (2011: 75) framework for managing risks in supply chain includes: 1) risk identification 2) risk analysis 3) risk control. Manuj and Mentzer (2008b: 137) propose a five-step process for global supply chain risk management and mitigation: 1) risk identification 2) risk assessment and evaluation 3) selection of appropriate risk management 4) implementation of supply chain risk management strategy(s) 5) mitigation of supply chain risks. McCormack et al. (2008: 21-22) advise a three-phase approach for SCRM: 1) risk identification 2) risk assessment 3) risk mitigation. However, they acknowledge the importance of risk monitoring as part of SCRM. Hallikas et al. (2004: 52) state that a typical risk management process of an enterprise consists of: 1) risk identification 2) risk assessment 3) decision and implementation of risk management actions 4) risk monitoring.

The four-phase approach according to Hallikas et al. (2004: 52) for SCRM will be considered in this study since the objective is to identify risks, assess the likelihood and business impact of the risks, identify different risk management actions to either reduce the probability of potential consequences occurring or their impact and find ways of monitoring the risks.

1) Risk identification
2) Risk assessment
3) Risk mitigation
4) Risk monitoring

2.5.1 Risk identification

Risk identification is considered to be the initial phase in the process of supply chain risk management (Manuj and Mentzer, 2008b: 137; Olson, 2014: CH 2; Waters, 2011: 97). Identifying risks is a fundamental activity that forms the basis for all other aspects of the process. Risk identification involves examining the uncertainties in the supply chain and identifying the resulting risks (Waters,

2011: 105). However, Waters (2011: 105) also notes that many risks are unknowable in advance. A summary of Waters (2011: 106) risk identification framework is seen in figure 12.

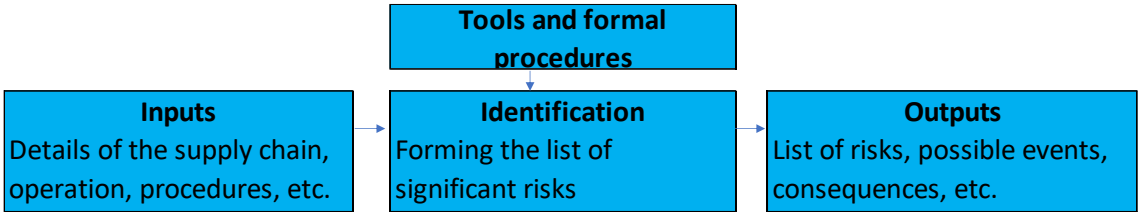

Figure 12. A summary of risk identification (Waters, 2011: 106).

McCormack et al. (2008: 21) say that in risk identification step two things should be noted:

- What can go wrong?
- What is uncertain?

The result should be a list of all relevant supply chain risks, which allows an organisation to proactively develop plans to manage risks before they occur. The reason for this is that reacting to adverse events before they occur is generally more cost effective (McCormack et al., 2008: 21).

Vilko and Hallikas (2012: 576) say that when assessing supply chain vulnerabilities, companies should consider risks not only within their own operations, but also those affecting other entities in the supply chain and those resulting from the interconnections between organisations. This is because disruptions at any point in the supply chain can impact a company's ability to produce and deliver goods or services to customers. While it may not be possible to identify every potential risk, risk identification should focus on the most significant ones in the supply chain (Vilko and Hallikas, 2012: 587). Tools and procedures for risk identification identified in the literature are seen in table 9.

Table 9. Tools and procedures for risk identification

Technique	Definition
Geomapping/Supply chain mapping	"Visual maps of supply chains reveal supply chain structures, dependencies, and handoffs that may contain risk. SCOR mapping and Value Stream Mapping are two types of supply chain mapping that can be used." (McCormack et al., 2008: 22)
Looking at historical problems	"Historical problems may have a high chance of recurring. Those problems may have happened to the organization itself or to others." (McCormack et al., 2008: 22)
Researching industry trends	"Other organizations and industry groups may have already researched risks that are applicable." (McCormack et al., 2008: 22)
Group of experts brainstorming	"People with experience in different areas of your organization and supply chain have lots of knowledge of risks. Getting them together increases the knowledge sharing. (The Delphi method is one technique to conduct expert interviews.)" (McCormack et al., 2008: 22)
Assessment surveys	"Well designed surveys can be an effective way to quickly gather information on risks in your supply chain." (McCormack et al., 2008: 22)
Site visits	"Site visits to supply chain partners allow you to collect detailed and less "filtered" information on risks." (McCormack et al., 2008: 22)
Information audits	"Data system audits can reveal issues and trends from the past. It can show areas of the supply chain that have had poor performance in the past and are thus more likely to perform poorly in the future. Some tools used in risk" (McCormack et al., 2008: 22).
Interviews	Interviews with knowledgeable individuals. The advantage is that these are easy and fast to organise as a way of mean to collect "detailed information about specific risks from the people who are most familiar with conditions" (Waters, 2011).
Risk checklists	"A list of risks that are common for your environment. It may come from past experience or industry research." (McCormack et al., 2008: 22)
Cause-and-effect diagrams (i.e., fishbone, Ishikawa)	"A diagram that traces back the causes for events." (McCormack et al., 2008: 22)
Process charts	"Collecting information systematically studies the operations and identifies the risks at each stage." (Waters, 2011: 114)
Group meetings	"A group of around 10 knowledgeable people are collected to discuss risks in the supply chain." (Waters, 2011: 113)

This study uses interviews with knowledgeable individuals who are most familiar with conditions as a tool to collect detailed information about specific risks related to the study's scope.

2.5.2 Risk assessment

Risk assessment and evaluation can be identified as the second step of the SCRM process (Manuj and Mentzer, 2008b: 137; Olson, 2014: CH 2). Waters (2011: 127) names the second step "risk analysis", however, the characteristics are mainly the same. In this step, the risks are analysed, assessed and evaluated with qualitative and quantitative measures (McCormack et al., 2008:

23-24; Waters 2011: 127-128) such as decision analyses, case study(s), perception-based approaches (Manuj and Mentzer, 2008b: 139-141) and other methods such as Failure Mode Effects Analysis (FMEA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA) (McCormack et al., 2008: 24) and ABC analysis (Waters, 2011: 136).

Several authors have divided risk into two parts which are illustrated in figure 13 (Manuj and Mentzer, 2008b: 135; Norrman and Jansson, 2004: 437). The horizontal axis describes the impact of the potential risk and how large consequences it could have for the firm. The vertical axis describes the likelihood of the risk occurring.

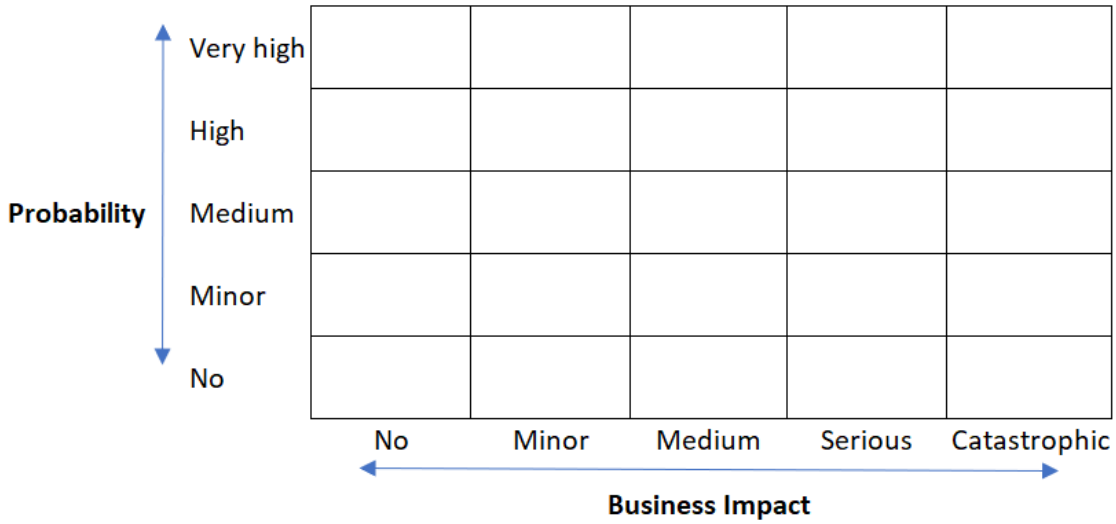

Figure 13. Example risk matrix (Norrman and Jansson, 2004: 437)

The exact probability of a particular event can be challenging to accurately determine unless there is historical data available that can be used to work out how often the event occurs. However, an alternative that organisations can use is a subjective probability or level of belief based on expert opinion. To be more accurate, a time horizon is necessary to be defined (McCormack et al., 2008: 23-24). Example of probability assessment scale is seen in table 10.

Table 10. Probability assessment scale (Hallikas et al., 2004: 53)

Rank	Subjective estimate	Description
1	Very unlikely Improbable	Very rare event
2	Improbable	There is indirect evidence of event
3	Moderate	There is direct evidence of event
4	Probable	There is strong direct evidence of event
5	Very probable	Event recurs frequently

Business impact may be measured in various ways, including in monetary terms or on a scale ranging from 'none' to 'catastrophic', or numerically from zero to five, for example. Methods for measuring business impact include 'what-if' simulations, financial models and expert opinions. Other SCOR metrics may also be used to assess business impact (McCormack et al., 2008: 23-24). An example of a business assessment scale is seen in table 11.

Table 11. Impact assessment scale (Hallikas et al., 2004: 53)

Rank	Subjective estimate	Description
1	No impact	Insignificant in terms of the whole company
2	Minor impact	Single small losses
3	Medium impact	Causes short-term difficulties
4	Serious impact	Causes long-term difficulties
5	Catastrophic impact	Discontinue business

Risk score for each risk can be calculated by multiplying the business impact by the probability, resulting in an expected value for the risk (Christopher and

Peck, 2004; McCormack, 2008: 24). Risks can then be ranked by risk score and visualised on a map or graph. Risk assessment tools, such as spreadsheets or specialised software, can also provide information on the causes of risks, methods for mitigating them, and the impact of different mitigation plans. (McCormack, 2008: 23-24).

There are numerous ways of categorising supply chain risks in the literature. Nevertheless, according to Rao and Goldsby (2009: 98) supply chain risks are usually evaluated based on risk sources. However, Vilko et al (2019: 478) note that it may be more useful to categorise risks based on their impact, as this would provide a better understanding of a management team's ability to control them. In consequence, this study will categorise risks based on their business impact. Additionally, subjective probability and business impact, based on the opinions of experts, is used to assess the risks due to lack of historical data, as McCormack et al. (2008: 23-24) suggest.

2.5.3 Risk mitigation

The goal of this phase is to identify actions that will either reduce the negative effects of risks or decrease the probability of negative outcomes (McCormack et al, 2008: 25). Consequently, in this step risk mitigation actions, enablers and strategies to address risks or to overcome potential disruptions are discussed.

According to Olson (2014: CH 2) risk mitigation focuses on the management of uncertainty with respect to supply, demand, product management and information management. Well acknowledged risk mitigation strategies by many authors are postponement, avoidance, speculation, control, sharing, transferring, hedging, security (Jüttner, Peck and Christopher, 2003; Manuj and Mentzer, 2008b: 142) and acceptance (Fan & Stevenson, 2018: 216).

The postponement strategy involves delaying the allocation of resources and the incurrence of costs in order to maintain flexibility (Manuj & Mentzer 2008b: 142). Packaging, labelling and assembly are all examples of form postponement. Time postponement is the delay in moving goods from

manufacturing facilities after receiving customer orders. (Manuj and Mentzer 2008b: 142).

The aim of avoidance is avoiding situations that can lead to the occurrence of risk (Ritchie and Brindley, 2007: 1405). If there are unacceptable risks involved in operating with a product, geographic market, suppliers or customers, then an avoidance strategy can be used. This means that managers recognise the potential risks associated with the option and the balance between supply, demand and operational costs and choose to avoid these risks (Manuj and Mentzer 2008b: 142).

Speculation anticipates customer demand; hence it is a demand-side risk management strategy (Manuj and Mentzer 2008b: 142). It includes forward placement of inventory, early commitment to the product form and other actions in anticipation of future demand (Manuj and Mentzer 2008a: 207).

Control is used to manage the risks that may lead to vertical integration, such as opportunism, asset specificity, capacity constraints, and imbalances in supplier-buyer power. Vertical integration can increase control by mitigating demand or supply issues in the supply chain, but it also has the potential to convert variable costs into fixed costs and reduce the flexibility of supply chains to adapt to changing circumstances (Manuj, Mentzer 2008b: 142-143). As a result, organisations are increasingly focusing on their core competencies and outsourcing non-critical functions. To address potential changes and associated risks in the environment, organisations may also use contracts with clauses addressing these issues as a control mechanism. (Manuj and Mentzer 2008b: 142-143)

In a supply chain, outsourcing, offshoring, and contracting can all be used to share and transfer risk (Manuj and Mentzer 2008b: 143). Risk sharing involves a company sharing some or all of its risk with another organisation, while in risk transferring the risks are passed on to another company. If the company that takes on the risk is able to manage the risks better, it may lower the total risk (Hallikas et al., 2004: 54).

Hedging in a supply chain involves having a diverse range of suppliers, customers and facilities around the world so that a single event does not impact all entities simultaneously or with the same level of severity. This approach can be particularly effective in situations where there are high supply risks in the supply chain. However, because it requires considering multiple variables, it can be costly to implement. (Manuj und Mentzer 2008a: 208)

Security strategy aims to improve the ability of a supply chain to spot suspicious or unusual elements and distinguish them from moving items. To implement this strategy, it may be necessary to work closely with government and port officials to ensure compliance and prevent delays at border crossings (Manuj and Mentzer 2008a: 210).

Acceptance is the acknowledgement of a certain risk occurring but not taking any action to reduce the risk. However, to ensure that the accepted consequences do not escalate, they should be recorded. Acceptance, therefore, is not the same as ignoring the risk (Fan & Stevenson, 2018: 216).

Sodhi and Tang (2012: 53) state that risk mitigation strategies could be classified into the following broad categories: alignment, flexibility and redundancies. Alignment among supply chain partners to reduce behavioural risks within the supply chains. Flexibility to reduce demand, supply and process risks. Redundancies or “buffers” are used to mitigate the financial impact of certain unfavourable events that can occur due to supply, demand and process risks. This includes extra inventory, backup production, or extra suppliers to absorb disruptions and delays in the supply chain. Additionally, they state that top companies minimise risk by building "reserves", which include redundant suppliers, inventory capacity, responsiveness, and other forms of resilience.

According to McCormack et al. (2008: 25) risk mitigation strategies can include the following:

- Multiple sources of supply
- Strategic agreements or partnerships with suppliers
- Collaborative planning, forecasting and replenishment (CPFR)
- Joint product design and delivery

Additionally, McCormack et al. (2008: 26) state that risk management business rules, such as sharing orders among multiple suppliers to maintain a strong supplier base, predefined procedures for re-routing orders in the event of a node failure and prioritising customer allocation of resources in an emergency, are important. They also highlight the importance of information sharing within the supply chain network for risk mitigation, which requires establishing agreements on information sharing and clearly identifying supply chain partners to reduce overall risk.

Tang (2006b: 39) and Sodhi and Tang (2012: 98) suggest using diverse supply chain strategies to improve a company's ability to manage supply or demand in normal circumstances and enhance the company's resilience in the face of major disruptions. A summary of their robust strategies and key features is seen in table 12.

Table 12. Robust SC strategies (Tang, 2006b: 39; Sodhi and Tang, 2012: 98).

Robust supply chain strategy	Main objective	Benefit(s) under normal circumstances	Benefit(s) after a major disruption
Postponement	Increase product flexibility	Improves capability to manage supply	Enables a firm to change the configuration of different products quickly
Strategic stock	Increase product availability	Improves capability to manage supply	Enables a firm to respond to market demand quickly during a major disruption
Flexible supply base	Increase supply flexibility	Improves capability to manage supply	Enables a firm to shift production among suppliers promptly
Make-and-buy	Increase supply flexibility	Improves capability to manage supply	Enables a firm to shift production between in-house production facility and suppliers rapidly
Economic supply incentives	Increase product availability	Improves capability to manage supply	Enables a firm to adjust order quantities quickly
Flexible transportation	Increase flexibility in transportation	Improves capability to manage supply	Enables a firm to change the mode of transportation rapidly
Revenue management	Increase control of product demand	Improves capability to manage demand	Enables a firm to influence the customer product selection dynamically
Dynamic assortment planning	Increase control of product demand	Improves capability to manage demand	Enables a firm to influence the demands of different products quickly
Silent product rollover	Increase control of product exposure to customers	Improves capability to manage demand	Enables a firm to manage the demands of different products swiftly
Flexible supply contracts	Increase replenishment flexibility	Improves capability to manage Supply	Shift order quantities across time
Flexible manufacturing process	Increase flexibility in producing different products	Improves capability to manage demand	Shift production quantities across internal resources (plants or machines)

Chopra and Sodhi (2004: 60) state that after companies have a clear understanding of their supply chain risks, they can choose appropriate general

mitigation approaches and specific tailored strategies. These approaches and strategies are outlined in table 13.

Table 13. General mitigation approaches and tailored strategies (Chopra and Sodhi, 2004: 60).

Mitigation Approach	Tailored Strategies
Increase Capacity	Focus on low-cost, decentralised capacity for predictable demand. Build centralised capacity for unpredictable demand. Increase decentralisation as cost of capacity drops.
Acquire Redundant Suppliers	Favour more redundant supply for high-volume products, less redundancy for low-volume products. Centralise redundancy for low-volume products in a few flexible suppliers.
Increase Responsiveness	Favour cost over responsiveness for commodity products. Favour responsiveness over cost for short life-cycle products.
Increase Inventory	Decentralise inventory of predictable, lower-value products. Centralise inventory of less predictable, higher-value products.
Increase Flexibility	Favour cost over flexibility for predictable, high-volume products. Favour flexibility for low-volume unpredictable products. Centralise flexibility in a few locations if it is expensive.
Pool or Aggregate Demand	Increase aggregation as unpredictability grows.
Increase Capability	Prefer capability over cost for high-value, high-risk products. Favour cost over capability for low-value commodity products. Centralise high capability in flexible source if possible.

Tang and Tomlin (2008: 12) say that negative effects of risks such as process, supply and demand risks can be mitigated by using the three traits of Triple-A developed in year 2004 by Lee. Lee (2004) asserts that supply chains will fail if

they lack any of the three traits. These traits are agility, adaptability and alignment.

Agility can be described as flexible and responsive to changes in a market. It also means having the ability to quickly respond through information sharing within the supply chain (Alzoubi et al., 2022: 2-3). Nowadays, supply and demand fluctuate rapidly and more widely in almost all industries. Firms can use agility to minimise the impacts of short-term changes in demand or supply and gain an advantage over their rivals (Sodhi, Tang, 2012: 9 and Lee, 2004). Lee (2004) states that if companies adhere to the following six rules, they can improve their supply chain agility and respond quickly and economically:

- Continuously share data on changes in supply and demand with partners so they can quickly respond.
- Establish collaborative relationships with suppliers and customers to work together on designing or redesigning processes, components, and products, as well as preparing backup plans.
- Design products that share common parts and processes initially, with differences occurring only towards the end of the production process.
- Keep a small inventory of inexpensive, non-bulky components that are often the cause of bottlenecks.
- Create a reliable logistics system that allows your company to quickly regroup in response to unexpected needs.
- Assemble a team that is skilled in implementing backup plans.

Sodhi and Tang (2012: 9) define adaptiveness as the ability to respond quickly and effectively to the changes in the environment and demand. Lee (2004) states that supply networks need to change when markets or strategies changes and that adapting to changes when markets or strategies changes is key for sustainable advantage. Building adaptable supply chains requires two key components (Lee, 2004):

- Ability to spot trends.
- The capability to change supply networks.

To predict future trends, it is important to monitor economic shifts and be aware of the needs of end consumers – not just the immediate customers. Capability to change supply networks requires that companies retain suppliers that complement existing ones. It is also important for product designers to consider the effects their designs may have on the supply chain. (Lee, 2004)

Aligning the interests of partners in the supply chain can minimise supply chain risks and reduce the risk of supply cost issues (Sodhi and Tang, 2012: 8-9). If an organisation's interests diverge from those of other firms in the supply chain, it can hinder the overall performance of the chain. Misaligned interests can also cause disruptions within the supply chain. Companies can align the interests within their supply chain by following the guidelines outlined by Lee (Lee, 2004):

- Aligning information: Provide equal access to information such as forecasts, sales data, and plans for all companies in the supply chain.
- Aligning identities: Define the roles and responsibilities of each partner, so that everyone has a clear understanding of their role in the process.
- Aligning incentives: Ensure that when companies seek to maximise their own incentives, they are also contributing to the overall success of the supply chain.

Managers often avoid addressing supply chain risks because they believe that risk reduction will negatively impact cost efficiency (Chopra and Sodhi, 2014: 9). However, Chopra and Sodhi (2014: 9) suggest that it is possible to both maintain cost efficiency and reduce risk by avoiding excessive concentrations of resources such as suppliers and capacity. Managers can achieve this by overestimating the probability of disruptions, as this can be more beneficial in the long term than underestimating or ignoring the likelihood of disruptions. They also point out that the pursuit of making supply chains more efficient and leaner has led to an increase in fragility. As a result, Chopra and Sodhi (2014: 5) propose two strategies for reducing supply chain fragility while simultaneously improving financial performance:

- Segmenting the supply chain
- Regionalising the supply chain

Segmenting large organisations' supply chains can be done using volume, product variety, and uncertainty. Decentralisation with more segments is often more feasible for higher volumes, while decentralisation with fewer segments may be necessary for high product diversity, which is often accompanied by low volumes of individual products. In cases of high demand uncertainty, centralisation may be necessary to ensure satisfactory performance. However, even if production is centralised, the supply chain should still be flexible to avoid concentrating risk in a single location. (Chopra & Sodhi 2014: 5-6)

According to Chopra and Sodhi (2014:7-8), the rise in fuel prices offers incentives for regionalising supply chains to lower distribution costs while also reducing risks in global supply chains. Consequently, they state that the most cost-effective network has more branches and multiple plants, even within one country. Regionalisation is also helpful in mitigating the impact of disruptive factors such as natural disasters, geopolitical flare-ups, and other events that may affect a specific area.

Chopra and Sodhi (2014: 8-9) also argue that it is important for managers to react to disruptions in the supply chain when they occur, but the way they respond will depend on the configuration of the supply chain. Segmenting or regionalising the supply chain can make it easier and faster to detect, design, and deploy responses to disruptions. If a company and its associates can develop contingency plans for various types of disruptions in advance, it can significantly reduce the time needed to design supply chain responses. These containment strategies can also increase the resilience of the supply chain. (Chopra and Sodhi, 2014: 8-9)

2.5.4 Risk monitoring

The monitoring of the external and internal environments within an organisation is crucial for predicting new events and predicting them. Real-time metrics and periodic reports can provide decision-makers with information about potential risk events in the future, while statistical analysis of key metrics may reveal trends that could be useful for risk management. Monitoring capabilities can be enhanced by having visibility of supplier and customer metrics. Indicators that

are visible early in a potential risk event, or better yet, before it happens, are important since they can indicate an increasing likelihood. Monitoring can also include qualitative data sources. (McCormack et al., 2008: 23)

According to Hallikas et al. (2004: 54) the environment in which a company operates is constantly changing and can cause risk statuses to change. Therefore, it is imperative to monitor the risk factors that are known for increasing likelihood and consequences.

2.6 Bullwhip effect

The bullwhip effect refers to the demand distortion that travels upstream in the supply chain from the retailer to the manufacturer due to the variability in orders in the supply chain infrastructure (Lee, Padmanabhan and Whang, 1997: 95). The distortion reduces the smoothness of supply chain processes because each link in a supply chain will either underestimate or overestimate product demand (Ivanov, 2017). The four major causes of the bullwhip effect are demand forecast updating, rationing and shortage gaming, order batching and price fluctuations. The bullwhip effect is created by each of the four causes combined with the supply chain's infrastructure (Lee, Padmanabhan and Whang, 1997: 95).

The detriments of the bullwhip effect can be reduced through information sharing, avoiding multiple demand forecast updates, breaking order batches, stabilising prices and eliminating "gaming" in shortage situations. Additionally, managers can find strategies to mitigate the bullwhip effect by understanding the bullwhip effect along with channel alignment and operational efficiency. (Lee, Padmanabhan and Whang, 1997: 97-101)

The bullwhip effect is introduced in this study, even though it is not assessed or measured in this study because it was identified in the empirical part of the study as a key driver for demand risks affecting lead time, inventory parameters and capacity availability at ports.

3 Research methodology

The purpose of this chapter is to describe the methods that were used to carry out this study. To succeed in this, first, the research approach and process will be discussed. Following this, the data collection method for the study will be presented. Then, the data analysis method used in this study will be introduced. Finally, the research gap identified in the literature, which this study fills, is given.

3.1 Research approach and process

The first methodological choice in the research design is deciding whether you follow a qualitative, quantitative or mixed method (Saunders et al., 2019: 174). However, before discussing the three research methods, the meanings for the three main approaches for theory development will be provided and the research philosophies related to them. Deduction, induction and abduction are the main three approaches to theory development (Saunders et al., 2019: 152).

Deduction involves forming a hypothesis or theory and then testing it through a series of logical steps in order to determine whether the theory is supported by the evidence (Saunders et al., 2019: 153). Deduction is used to identify cause and effect relationships between concepts and variables, operationalise concepts in a way that allows them to be quantitatively measured and generalise matters. Therefore, deduction emphasises structure, quantification, generalisability and testable hypotheses which are most likely to pinned with positivist research philosophy (Saunders et al., 2019: 154). In positivism, the natural scientist utilises observable social reality to generate generalizations like laws (Saunders et al., 2019: 144).

Induction, on the other hand, tries to understand the nature of the problem and make sense on the of the data collected through analysis. Research using the inductive approach tends to focus on the context in which events occur and may involve studying a smaller number of subjects in depth rather than a large

sample size. Due to the emphasis on subjective interpretations and its connection to humanities, the inductive approach is often connected to interpretivism philosophy. (Saunders et al., 2019: 154-155) Interpretivism seeks to gain deeper insights into organisational realities through subjective interpretation (Saunders et al., 2019: 160).

Abduction involves a combination of deduction and induction, moving back and forth between theory and data or data and theory. This matches with what many business and management researchers do because pure induction or pure deduction can be difficult to achieve. Applying an abductive approach to research allows to explore the phenomenon, identify and explain themes and patterns. The flexibility of abduction allows it to be used with several research philosophies, including pragmatism, postmodernism and critical realism. (Saunders et al., 2019: 155-156) Pragmatism involves using a wide range of research strategies that are tailored to the specific research question. Postmodernism challenges traditional ways of thinking and gives voice to alternative perspectives that may have been marginalised. Critical realism focuses on understanding the underlying structures of reality that shape observable events through the lens of human experience. (Saunders et al., 2019: 160)

Qualitative research is often associated with interpretative philosophy because it involves understanding subjective and socially constructed meanings related to the phenomenon being studied. In general, qualitative research commences with an inductive approach to theory. However, some qualitative strategies may use a deductive approach. Additionally, qualitative research may also incorporate an abductive approach to theory development. (Saunders et al., 2019: 179) It is associated with a variety of strategies such as case study research (Saunders et al., 2019: 179), which involves in-depth examination of a topic or phenomenon within its real-life context (Saunders et al., 2019: 196). An example of a technique used to collect qualitative data are interviews (Saunders et al., 2019: 180).

The empirical part of this case study was conducted as qualitative research using an abductive approach to theory development. Figure 14 summarises the research process for this study.

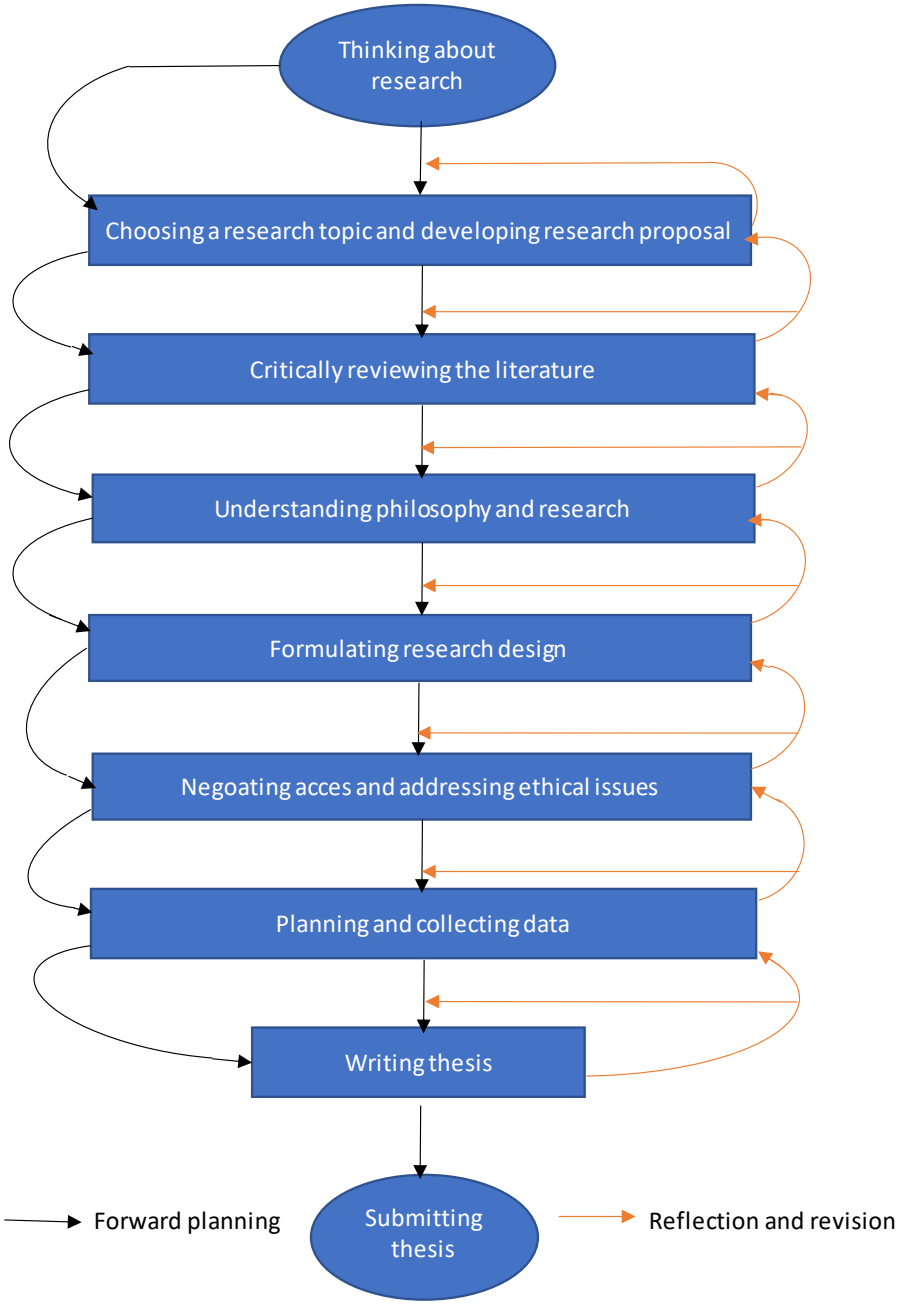

Figure 14. Research process (Saunders et al., 2019: 12).

3.2 Data collection

According to Saunders et al. (2019: 436-437) research interviews can be classified into three categories: structured, semi-structured and unstructured research, based on the level of structure present in the interview. This study utilised semi-structured interviews as the primary method for collecting data in order to answer the research questions. More precisely, semi-structured interviews were used to identify the risks, risk mitigation actions and ways how risks can be monitored.

Semi-structured interviews are a type of qualitative data collection method that involves predetermined themes and possibly some related key questions. The way these predetermined lists of themes or questions are used will depend on the researcher's philosophical assumptions (Saunders et al., 2019: 437). There are various situations in which collecting data using semi-structured research interviews may be beneficial. These advantages can be grouped into four categories (Saunders et al., 2019: 437-438). Table 14 provides a description of the advantages of using semi-structured research interviews.

Table 14. Semi-structured interview advantages (Saunders et al., 2019: 437-438).

Category	Reason
The purpose of the research	Undertaking exploratory study Able to infer causal relationships between variables Necessary to understand the reasons for decision that participans have taken, or to understand the reasons for their attitudes and opinions Opportunity to 'probe' Lead discussion into areas that had not been previously considered Rich and detailed set of data Offers interviewees an opportunity to hear themselves thinking aloud of things they might had not previously thought of
The importance of establishing personal contact	Managers and employees more likely to agree to be interviewed than complete questionnaire, which results in higher response rate Provides interviewees with an opportunity to reflect on events without needing to write down Control over those whom you wish to respond and also possibly the reliability of data you receive
The nature of the data collection questions	Large number of questions to be answered Questions are either complex or open ended Order and logic of questioning may need to be varied
The length of time required and completeness of the process	Complexity of issues to be covered or their number and variety

Consequently, semi-structured interviews were seen the most suitable primary data collection method for this study, since the interviewees' positions varied and, in consequence, the interview questions varied. Additionally, all advantages mentioned in table 14 were ticked. Furthermore, there were predetermined themes that needed to be discussed to find answers to the research questions.

The interviewees were selected based on their experience and knowledge in SCM, current job position in the organisation and role in the transportation of goods by sea from Finland and Sweden to US. In total eight interviews were conducted with eight people with six different job titles who work in the three different decision-making levels of supply chain management: strategic, tactical and operational. The goal behind this was to identify as many risks as possible related to the scope and to gain different perspectives on risks, risk management actions and risk monitoring. One of the respondents was located in the US, which provided a better view of the risks from the receiving end of the goods. Table 15 provides the interviewees' job position and letter, by which the interviewee will later be referred to in the study. The alphabetical order is the same order as which the interviews were held.

Table 15. The job titles of the interviewees.

Interviewee	Job position
A	Logistics Coordinator
B	Logistics Coordinator
C	VP, Ports & Terminals
D	Regional Logistics Manager, Americas
E	Maritime Service Logistics Manager, Liner & Dedicated Traffic
F	VP, Maritime Logistics
G	Logistics Coordinator
H	VP, Logistics

The interviews were held between weeks 44 and 45 in year 2022 either face to face or in teams based on convenience. All interviews were held either in Finnish or English based on the interviewee's preference. The duration of the

interviews varied between 35 to 75 minutes. The interview questions were based on the key themes of SCRM identified in the literature: risk identification, risk mitigation and risk monitoring.

All interviewees were asked beforehand by email their willingness to be part of the study, to which all the interviewees gave a green light. In the same email all interviewees were informed of the topic and themes to be discussed. This gave the possibility for the respondents to think beforehand on the themes and possible questions. Example questions were provided as well, however, all planned questions were not provided beforehand.

All interviews were recorded and transcribed afterwards for better analysis. Only interviewee D's and G's interviews were held in English, which means that six out of the eight interviews were translated by the author from Finnish to English as accurately as possibly. This should be kept in mind when reading the quotations of interviewee A, B, C, E, F and H.

According to Saunders et al. (2009: 394), questionnaires are an appropriate method of collecting data when participants are requested to respond to a set of standardised questions, with the aim of gathering descriptive and explanatory information about opinions, behaviours and attributes. Consequently, to assess the risks, a questionnaire was seen as a suitable way to collect data, since the aim was to only assess the probability and the business impact of the risks on a level of one between five. The questionnaire was built after all interviews had been carefully analysed so that all risks mentioned during the interviews were identified.

For the risk assessment, five of the eight participants, who were considered expert level in terms of competency, based on the SCOR model, were chosen to assess all the risks identified during all the interviews subjectively. These were interviewees C, D, E, F and H. All five participants responded to the questionnaire. However, only three out of the five respondents evaluated all the risks. This can be interpreted in many ways, such as that they did not feel comfortable giving their subjective opinions on all the risks outside their

expertise, the questionnaire was not built enough well for them, or that they did not simply have time to respond to all.

One major defect identified in the questionnaire afterwards, was the fact that descriptions of the risks were not provided in the questionnaire. This left much interpretation for the risks, especially since some risks were rather unorthodoxy and qualitative. Therefore, the meanings behind the risks may have been unclear to the respondents. Additionally, some risks mentioned were recognised to have more positive effects rather than negative effects. As a result, a stochastic approach, instead of the deterministic approach used in the study, may have also been better for assessing risks, since the probabilities and impacts are hard to assess and may vary. This is due to the reason that direct impacts may be small for the case company, but the indirect impacts may be large, as one of the respondents commented.

Throughout the study, all material and information provided, gained and accessed by the researcher was handled carefully according to Metropolia University of Applied Sciences and the case organisation's rules and ethics. For privacy reasons, none of the participants' names has been published. Additionally, exact names for places, volumes and values that are, or could be sensitive for the case organisation, have been changed.

3.3 Data analysis

This study utilises thematic analysis method to analyse the data. Thematic analysis allows for a thorough and flexible approach to analysing qualitative data, leading to rich descriptions, explanations and theorising by helping the researcher to (Saunders et al., 2019: 651):

- Understand large amounts of qualitative data
- Combine data from different sources
- Identify important themes or patterns in the data
- Create a summary of the data based on these themes
- Develop and test theories based on the identified themes or patterns

- Draw conclusions based on the data analysis

Thematic analysis can be used with any research philosophy and is not limited to a specific approach (Saunders et al., 2019: 651-652). The process involves four elements in a concurrent and recursive fashion (Saunders et al., 2019: 652):

- Familiarising with the data
- Coding the data
- Identifying themes and relationships in the data
- Refining and testing the identified themes.

3.4 Research gap

From the literature review, it can be concluded that supply chain risk management has been researched extensively. However, there are not many studies that have focused on the transportation of goods from North Europe to the US. Consequently, this study fills the gap by studying supply risk management in this specific trade route, which has been identified as a bottleneck within the case company.

4 Case company overview

This chapter is the first part of the empirical research concerning the background of the case company. At first, a short description of the case organisation's industry will be presented and relevant information regarding their transportation needs will be discussed. Following this, pertinent supply chain processes to the study will be illustrated.

4.1 Background

The case organisation is a large Finnish forest industry group. It is formed of several different business areas that have centralised certain parts of their operations together, such as sourcing and logistics, due to economies of scale. The volumes transported are high and ocean freight is the preferred mode of

transportation to transport the goods from Finland and Sweden to the US, due to economic and environmental reasons. More precisely, liner and dedicated traffic are mainly used with RoRo (roll-on/roll-off) and LoLo (lift-on/lift-off) ships due to cost efficiency, since the prices for container shipping have been more expensive for the trade route examined.

Figure 15 shows the case company's supply chain process areas relevant to the case. The process map follows a hierarchical structure, similar to the SCOR process model. Level-1 defines the two major processes: planning and fulfilment. Planning refers to the actions taken to create plans for supply chain operations and fulfilment refers to the actions taken to complete customer orders or services. Level-2 process categories identify the abilities within the level-1 processes. Level-3 processes are the specific steps taken within level-2 processes to plan or carry out supply chain activities. (APICS, 2017).

L0	Supply Chain							
L1	Planning				Fullfilment			
L2	Demand forecasting and planning	Supply and capacity planning	Demand and supply balancing	Logistics and delivery planning	Sales order management	Production scheduling	Logistics and delivery execution	Customer invoicing
L3	Manage demand master data	Manage supply master data	Maintain S&OP processes and data	Manage logistics master data	Manage reservations	Manage production planning master data	Process transport requests and capacity	Create customer invoice
	Plan product mix and changes	Determine production capacity (constraints)	Maintain supply chain models	Determine delivery network set-up	Create and confirm sales order	Create short-term productions plan	Book transportation	Manage special payment methods
	Generate statistical forecast	Determine sub-contractor capacity	Analyse S&OP performance	Determine transportation needs	Manage sales order	Generate detailed line level plan, trim plan	Manage internal warehouse operations	Manage invoice Corrections
	Incorporate sales forecast	Review stock levels and rotation	Agree scenarios for S&OP	Establish and commicate logistics plan	Manage call-offs and releases	Manage production planning exceptions	Manage external warehouse operations	Manage debit/credit invoices
	Generate and review demand forecast	Review materials constraints	Create optimal S&OP plan				Follow-Up transportation	
		Review logistics and warehouse capacity constraints	Validate and communicate optimal S&OP				Manage logistics invoices	
		Generate and review supply capability	Monitor performance and manage deviation				Manage logistics quality deviations	

Figure 15. Case company supply chain processes.

5 Findings and results

In this chapter the findings and results of the study will be discussed with the focus on answering the research questions. At first, all the risks identified during the interviews will be introduced, followed by further description of them. Then, the probabilities and consequences of the risks will be visualised and analysed. Next, the acknowledged risk management actions and enablers will be summarised and discussed. Finally, methods and tools for monitoring risks be presented.

5.1 Risks identified

In this sub-section, the first research question will be answered:
RQ1. What are the risks in the case organisation's maritime delivery network from Finland and Sweden to the US ports?

In total 68 risks were identified during the interviews within the case organisation's maritime delivery network. Table 16 summarises all the risks identified during the interviews and provides all the risks an ID number, by which they will be later referred to in the study.

Table 16. Summary of all the risks.

ID	Risk
1	Availability of the ice- strengthened dedicated capacity
2	Under investment in the maritime sector
3	Geopolitical issues (e.g., wars)
4	Pandemic
5	Environmental regulation and legislation (e.g., emission trade)
6	Increase in shipping costs
7	Better market opportunities for shipping companies elsewhere
8	Global dispersion / disagreements in environmental regulations and legislations
9	Increase in energy prices (Fuel, electricity)
10	International trade sanctions
11	Limited number of carriers
12	Inflation
13	Logistics price escalation
14	Availability of warehouse capacity in ports
15	Disruptions in production
16	Extra costs due to transhipment
17	Uneven traffic balance between trading areas
18	Limited amount of warehouse capacity
19	Demand for products drops
20	Inventory turnover decreases
21	Limited amount of port operators
22	More capital tied into inventory
23	Politics and trade policy (e.g., tariffs and taxes)
24	Carriers' poor financial results
25	Oil spill/leak
26	Congestions at ports
27	Labour disputes (e.g., FI AKT Strike)
28	Customer service level reduction
29	Insufficient number of trucks to transport goods out of the ports
30	Disruptions in land logistics (e.g., railway closed)
31	Product damages during maritime transportation
32	Demurrage costs
33	Dead freight
34	Demand exceeds transportation capacity
35	Forecasting inaccuracy
36	Inefficiency and ineffectiveness at ports
37	Resource adequacy (workforce and machinery)
38	Scheduling / coordination risk
39	Availability of trained workers
40	Competition risks
41	Demand fluctuation / volatility
42	Inflexibility in supply network
43	Invisibility within the network
44	System inadequacy
45	Carrier bankruptcy
46	Insufficient infrastructure at ports (water depth and ship width)
47	Vessel quarantine
48	Product damages at ports (human errors or equipment malfunctioning)
49	Insufficient processes at ports
50	Claims from customers
51	Missing closing times
52	Production delays
53	Vessel delays
54	Additional short-term resources required (workforce or capacity)
55	Hazardous weather conditions (e.g., flood, ice, snow)
56	Increase in vessel sizes
57	Insufficient communication / Information concentration / Misaligned communication
58	Over production
59	Over stocking
60	Carrier declines booking
61	Blank sailing (Cut and run)
62	Demand distortion
63	Employee / occupational safety
64	Operator failure (ports)
65	Process failure
66	System breakdown
67	Unalignment (e.g., information and incentives)
68	Vessel breakdown (declared as a joint liability)

5.1.1 Description of the risks

During the interviews, it became apparent that the biggest issue for the case organisation, in terms of maritime traffic, is the availability of capacity. The main causes behind this are the environmental regulations and legislations, the uneven traffic balance between trading areas and underinvestment in the maritime sector. Consequently, the case organisation is having issues transporting the goods from Finland and Sweden to the US.

> *The main problem on the surface is the availability of capacity and also the availability of capacity for ice-strengthened ships – this will probably continue until the end of this decade. This is largely due to environmental regulations and the fact that shipping companies have made bad results in recent years... As a result, their investment ability is restricted at the moment… Traditionally, a lot of forest industry products have gone from Scandinavia as Breakbulk in that direction… Kaolin, grain and North American forest industry products have then come back to European countries from there. Of these, kaolin and the forest industry products are gone. As a result, we are in a situation where some of the ships come back empty. Is this profitable for shipping companies in a hot market situation? Is this a smart situation or even a possible situation according to environmental regulations? … A risk related to the environmental regulation side, are the new fuels, which will probably come at some time. With regards to this, we will see that the world is not balanced in relation to these environmental issues and how these are carried out. For example, Europe is ahead in this, and you can possibly find new fuels in Europe and get their distribution networks in order, but will you find these same fuels in the USA? So how do you get back from there? Additionally, decarbonisation regulations are going to have a direct impact on cost levels. (Interviewee F)*

Since there is not a lot of Finnish carrier capacity to transport the products across the Atlantic Ocean from Finland or Sweden, the case organisation would require international shipping companies' transport capacity. However, due to the uneven maritime traffic balance between the trading points, the trading route is not enough attractive for them - especially in a hot market where there are better opportunities elsewhere for carriers.

> *A big challenge comes from our Mills' locations in Finland and Sweden and how many different export industries there are and how attractive export market Finland is for international shipping companies because there is not a lot of Finnish carrier capacity in Finland to take products across the Atlantic Ocean. Consequently, receiving good connections from Finland and our Mill in Sweden to our target countries, so that there*

would also be competition is difficult… If it happened that even one shipping company dropped out, we would need a new ship from somewhere else. However, you can't get them quickly, and how attractive is this market for shipping companies to invest, in a situation where this global trade balance is out of balance… (Interviewee H)

The case organisation is currently mainly dependable on two shipping companies for their transportation, and if anything were to go wrong with them, the business impacts would be large. Consequently, a major challenge and risk that the case organisation faces, is that its options are limited.

At the moment, we are dependent on two shipping companies, and if something happens there, for example, there is a problem with a single ship, it is immediately visible at our end because our transport capacity is reduced. The same applies to other operational challenges - there are no easy backup plans… For example, if a carrier would go bankrupt, well then, we would be quite shocked concerning how this problem is solved… So, such things as how few alternative suppliers, and what kind of risks are related to them and their delivery reliability, are of course a risk to us. These are such that they won't appear overnight, however, they can materialise during the short or medium term. A big challenge and risk for us is that our options are limited… (Interviewee H)

The uneven trade balance is not only associated with North Europe; it is also visible in Central Europe, not as drastically though. The growing trend there, nevertheless, is also a concern. Additionally, finding the required storage space in Central Europe is difficult. The transhipment from Central Europe is, nonetheless, an acknowledged risk mitigation strategy within the case organisation. The major issue related to the transhipment, are all the extra costs due to, for example, extra handling and storage spaces, which may eat the profitability from sales. Consequently, risk management actions may also contain their own risks or even increase risks in certain levels.

Then if we go to Central Europe and the main ports there, there is more traffic between Europe and the USA. However, if we look at it in terms of this year, last year or future years, there is still that trade imbalance and limited capacity. Additionally, we also need more storage capacity and other things, which means that we cannot suddenly transfer this traffic there into containers. So, finding capacity from Europe is difficult and then of course this causes extra costs due to extra handling. But this is possible and is part of risk mitigation. However, there is the possibility that the extra costs can be so much that it takes away the profitability from the business. So, the profitability may drop down so much that it eats away from sales. If logistics costs increase too much, the product price

may increase so much that it drops the demand. This is one risk related to this. Additionally, when this chain slows down, then the entire chain's inventory turnover decreases and more capital is tied up into inventory, which means that capital utilisation and efficiency drops. (*Interviewee H)*

Since the maritime sector is underinvested, enhanced maintenance has been used to extend the life cycle of the vessels. This, however, means that the ships have operational breakdowns more often at the sea. Additionally, which oceans a vessel travels and weather conditions have an effect on the ship in the long term. Technical issues in the vessels may then cause product damages or delays.

When the maritime sector is underinvested, it means that enhanced maintenance has been used to extend the life of the ships, which can be approached in two ways: Technical life and commercial life. The commercial lifetime is around 20-25 years, and the technical lifetime is around 30-40 years. This means that technically the ships are available longer than is considered commercially viable, for example in terms of cargo conditions… However, when the life cycles of the vessels are extended with enhanced maintenance, this causes, for example, violation of machinery risks which causes all kinds of water damage risks. In addition, deck hatches leak more easily, which are then attempted to be repaired… Deck leaks are largely caused by two things: the seals and the type of use the ship has been in. For example, if it sails a lot in the Atlantic Ocean, where there are higher winds, the vessel hull is strained and bent more, which impacts the way decks fit in the long term… but water damages, machine damages and leaks of all kinds have been seen earlier. For example, the ship may leak some hydraulic oil… If there is a mechanical breakdown, then the damage may easily already be so big that it is easily declared as a joint liability. This means that we are liable to participate in the repair of the vessel with the value of our cargo. (Interviewee F)

The growing trend of larger ship sizes may also test the case organisation's infrastructure at ports. Additionally, this will mean that inventory will need to be increased which means that more capital will be tied up and inventory turnover may decrease. Furthermore, customer service levels may decrease due to infrequent deliveries and longer lead times. However, this trend increases the operational efficiency of vessels and should bring some savings. Consequently, the benefits may outweigh the negatives.

The sizes of the ships are increasing, which means that we must increase the ship lot sizes. What does this mean for the port network and the ports and generally for the

delivery frequency and customer service level when the ships arrive with a slower frequency and thus, we have to load them with a slower frequency as well? And if or when the sizes of the ships will grow, what will this mean for our ports? Are the ports able to handle larger ships in terms of water depths and ship widths? This also means that we need to also have larger warehouses since we need to have considerably more goods stored in warehouses, so that we are able to ship. And as a general rule, our customer service preference is frequent shipments- small shipping lots. That goes in the opposite direction compared to the shipping market, which is fewer shipments - larger shipping lots. Coordinating these two will mean that we will have to do what we have always wanted to avoid, which is storing products somewhere. Unfortunately, this will only increase over time and that is a fact we can't do anything about. For example, if you only look at European traffic, the ice-strengthened ships in the Bay of Bothnia are twice as big as before. We will have challenges and risks with infrastructure. (Interviewee F)

The increase in ship sizes will test our infrastructure. Considering that our Mills will push the products at the same pace, we will need to gather larger batches, which means that we will need to grow our inventory. Consequently, we will need to increase our facilities at both departing and receiving ends. This may also lower our customer service level since the order-delivery time (lead time) will increase if orders are done based on customer orders. Additionally, responsiveness to customer order changes will be slower. So, even though this increases economic and logistical efficiency, it indirectly causes the throughput slow down, more capital is tied up and may potentially impair customer service levels. (Interviewee H)

Inflexibility in the contracts, in terms of capacity, was also recognised as a reason for capacity problems. This is due to the fact that this requires accurate forecasts many years forwards, which is something that the company has not been successful at. Additionally, seasonal fluctuations in volumes during a calendar year were acknowledged to cause challenges due to the inflexibility of the logistic processes and the supply network.

When we have long contracts (with regards to dedicated traffic), this means that we have requested our forecasts from the business areas years before. Then when we go to next year, we will find that these are not true at all and need to conclude that there is not enough capacity for all of our business areas. For example, let's say that we have 5-year contracts, this requires that our business areas forecast our demand for the next 5 years. Who is able to forecast this accurately, when we are not even certain about our next year demand? … Carriers only provide the capacity which are in the contracts… I know that there have been cases where carriers have cut off ties with customers that do not have

contracts, so that they are able to handle their contractual obligations. In consequence, they are unable to offer flexibility in our direction. (Interviewee E)

One thing that also causes issues are these business cycles where all kinds of things can occur during the year and volumes can go up or down. On top of these, these systems are rather inflexible. For example, if we do not need a vessel anymore, it is hard to stop using the ship without extra costs. On the other hand, if we need more capacity, this is also challenging. We are talking about a rather inflexible set-up. Consequently, adapting to this in our logistics set-up is challenging. (Interviewee H)

During the interviews, it became apparent that the capacity challenges are not only related to maritime transportation; there are also warehouse capacity challenges. Due to the limited warehouse capacity, there is not much space for errors in the coordination and planning of production cycles and vessel schedules. When there are deviations or even disruptions that cause vessel or production schedule changes, the impacts are felt immediately in terms of extra costs such as demurrage, dead freight and labour costs.

If we begin with the Mill in Sweden, we all know that there is very limited warehouse capacity… How does the production and available warehouse capacity interact with the vessel capacity and its scheduling? Do all these production cycles, warehouse capacity and inbound vessel schedules go to together? Because it would not be the first time that we would need to push goods to USA, but our warehouses are full and there is a vessel arriving in a week. Then we need to think of alternative solutions to where we push the goods… This can go the opposite way also. What if the products do not come out of the Mills for one reason or another? The vessel arrives but needs to wait for the goods… These kinds of coordination aspects have caused issues as long as shipping has been practiced. So scheduling is a very important aspect to ensure everything happens on time. If they do not take place in a timely fashion, it can cause issues such as that the vessel needs to wait. Sometimes the vessel cannot wait and leaves partially empty which causes dead freight and has some effects on the limitation of customer deliveries… Capacity issues are especially related to the Mill in Sweden; however, this is also relevant to Mills in Finland, which also have very limited warehouse capacity. Of course, we always believe that there is space in the ports, but what if this is not the case? Consequently, other places may also face similar issues, where the vessel needs to wait, and this may cause us extra costs. Additionally, these kinds of situations may require people to work overtime, which causes extra costs for us if these need to be done outside normal working hours… (Interviewee C)

Consequently, it was acknowledged during the interviews that the warehouse capacities have been taken to too tight levels and cannot cope with sudden changes in the supply chain. Therefore, it can be noted that a certain level of redundancy is missing in terms of buffers.

> *The capacities at the warehouses have been taken to too tight levels which means that we are not able to manage situations when something changes in the supply chain… (Interviewee A)*

The limited warehouse capacities also apply to the US, which has caused problems also at the discharging end and has resulted in extra costs and delays.

> *In America, we also have extremely limited warehouse capacity in all our port terminals, which has caused situations where we have needed to re-route the vessel to another port. For example, Port A warehouse capacity has been so full that the vessel has not been able to unload the cargo there which has caused us to send the vessel to Port B. Or then, there have been times when we have not had space in the warehouse, which has caused situations where the unloading of the ship has slowed down, similar to the situation at the loading end but in reverse. And again, we are talking about vessel delay costs and that we or someone else must source additional resources, workforce or capacity which most times incur extra costs. (Interviewee C)*

The problems are not, however, limited to only capacity challenges. There have been cases when there has been resource adequacy at the ports which has led to situations were goods have not been transported out on time.

> *Then, we have had situations where we have not been able to deliver goods out of the warehouse on time which of course affects the vessel unloading or does not at least help the matter. Why are we not then able to move goods out of the port on time? Well, there can be many different reasons but a few that come to my mind are that the quantity to be unloaded and the workforce resource adequacy. Is it sufficient? For example, you should load 75 trucks, but you have capacity for only 50. So, it's clear that this cannot work… (Interviewee C)*

It was also pointed out that there is the risk that demands drops suddenly causing over production situations, which leads to over stocking. Late changes in customer orders were also acknowledged to cause problems in Europe.

> *… And then, do we have customer orders? If we do not have customer orders it means that our warehouse levels grow and when it is too full it cannot operate well, meaning that*

it becomes more inefficient and ineffective, which again means that we cannot transport goods out at sufficient speed... (Interviewee C)

There is the risk that we produce goods that do not move in the receiving end, i.e., too much stock is made. With this, an overbooking situation is created in the receiving end… The throughput at the discharging end should also be improved. (Interviewee A)

… Something that also creates delays and problems in Europe is when we try to change our orders due to customer requests and priority… For example, the customer has first requested an order for January, but then they ask it already for December… then we need to change the order to go on an earlier vessel. (Interviewee D)

Additionally, one of the reasons identified as a driver for port inefficiencies and congestions, at times, was the fact that most of the trucks and ships arrive within the same timeframe.

For example, when you are at port x, it is common to have most of the trucks arrive there between 8 and 10 am… This means that someone must always wait there… The same thing at the discharging end… whenever you are there, you never see a vessel or a person at work… then you are informed that there are no vessels arriving today but tomorrow there will be 5 vessels arriving… (Interviewee C)

Furthermore, the way products are loaded in the vessel at Europe was acknowledged as a reason for inefficiencies and ineffectiveness at US ports.

How the product is loaded in the vessel can create problems. So, if the stowage plan is not done correctly, it can create delays and inefficiencies at the discharging end…. that can be a big issue. The ports in the USA would like to have the goods stowed in a certain way, but that of course is not always possible because the vessels have to be stowed in Europe based on different reasons… That creates discharging problems here in the US. (Interviewee D)

When discussing the reasons for unavailability of port warehouse capacity, two major reasons were identified; the bullwhip effect and the fact that there is limited amount of port operators that can handle the case organisation's goods. The result has been the same as with the maritime transportation; a sellers' market.

I do not believe that there have been many times in our history a situation where everywhere in the world port warehouses are full. It is not only us or our competitors that move in the same market, but it applies to all moving goods… I just talked with one port

operator in The Netherlands, and they said that they have over 1500 40ft containers staying put in their port, from one company only, which are not expected to move before next spring. Consequently, there is everything from… which has led to the fact that the availability of capacity, one could say almost globally, is no longer self-evident compared to what it used to be. This of course can be a risk by itself, since people have assumed that you can just put your goods to stand at the port if the goods are not moving. This, however, is not anymore always the case… I would like to know if this is the new normal or if this is an exceptional situation that will last a little longer. There are of course many influencing factors such as the Ukraine war, but this not the only reason. Demand should be high, but why are the goods not moving to the customers? I would not say that something is wrong with the demand, but I would like to ask why the goods are being pushed into those ports when they do not move at the same pace to the customers? What else could explain the fact that the stock level has grown so drastically? This is one view regarding this… Traditionally, we have been almost used to the fact that in the market we have buyers' market position at the ports and when we go somewhere everyone likes us and wants to do business with us. However, for example the USA, which is the focus here, it's as much of a sellers' market as you can get. Consequently, we must be selling ourselves there. For example, on the east coast of the United States, there are dozens of ports, and you could imagine that you would find all kinds of things there as well. The unfortunate fact is that there are ports and then ports. By this I mean that one specialises in container traffic, one in RoRo traffic, another in dry cargo… So those where we can find facilities and infrastructure are only a few (5 fingers shown). And these are also full. In other words, the worst possible situation from the point of view of procuring services. (Interviewee C)

During many of the interviews, the effects of macro risks such as geopolitical clashes, pandemics, energy price increases, international trade sanctions, tariffs, taxes, labour disputes and inflation, in general, were highlighted. This was due to the significant business impacts that they may have.

When you think about the current global political problems, geopolitical issues cannot be underestimated. For example, what if there is a clash in Taiwan between China and the US… What does this mean for our business in the USA? Consequently, geopolitical issues are on our risk maps. Additionally, pandemics, energy prices and sanctions are on them. (Interviewee F)

Inflation is seen everywhere. Port operations are a very labour-intensive sector and labour costs are a big part of expenses, being around 50% of their costs. In ports, the machinery used runs on diesel, although electrically powered machinery is increasing. These make up around 10-20% of their running costs… So, the expenses are growing

tremendously higher due to inflation… One question is whether our sales prices will rise in the same proportion as our costs. The port operators and terminal operators then come to us with these… asking for money and understanding… And since we do not want to suffocate them, we are better to accept them. (Interviewee C)

… Then there is the US political environment… and the effects of these on the role of exports and imports. Anything can happen in the world of politics and trade policy. For example, in the USA, protectionism grew in the past during Trump's presidency which made customs clearance more difficult, and North American products were preferred… In general, the competition is growing in the USA but can such things as the political environment speed the process? And can the competitive position change there? Of course, we have been following this and we believe that we will be competitive there in the future as well. However, whether this can change due to tariffs, or other such mechanisms is uncertain. (Interviewee H)

Disruptions in land logistics and production were also recognised to cause disruption propagation in the supply chain and potentially even causing larger consequences downstream or upstream the supply chain.

Road logistics is not so strongly associated with the capacity problem here in Finland. Especially if you are close to the port of departure, there are not such big red risks. However, when the mill is further away from the port, there are large volumes on the railways, so the risks increase… If there are disruptions in the railway traffic, then the games are stopped very quickly since you can't get goods to the port. Additionally, you must shut down the factory pretty quickly if there isn't enough storage capacity. (Interviewee H)

Port disturbances such as labour disputes that cause strike sensitivity and result in continuity risks were identified as risks. Additionally, weather conditions were recognised to cause issues at ports.

Then there are these port disturbances and the problems that follow from them. For example, at the beginning of the year, the AKT contract will be renewed, or the current collective agreement will expire. So, there is this kind of strike sensitivity in relation to collective agreements or collective bargaining, which results in a continuity risk. Then there are these issues related to winter shipping such as how to keep the ports open, especially when you go up north and it's a hard winter and there are challenges in terms of icebreaking capacity. (Interviewee H)

Competition risks in the long term and the uncertainty related to market positions were also acknowledged. Additionally, the competitive nature of supply chains was brought up.

> *The market is growing in the USA and also South America which means that our competitors are also aiming for these markets now. For now, the market demand is growing more than supply. However, at some point the ceiling for this might also be reached if everyone is pursuing the same market. This is of course one question mark when looking many years forwards, since we need to make long terms contracts; for example, 10-year contracts, in order to achieve the capacity required. However, in 10 years' time competition positions might change tremendously… What is the risk related to this since there will be winners and losers? What is the risk that we make contracts of the right value and duration with our operators in our supply chain when competition positions change? (Interviewee H)*

A rather interesting topic that came up during the interviews was a certain type of unalignment within the case organisation. More precisely, the company is well aligned one way, but not both. This is visible in the organisation's sales in the US, which does not seem to acknowledge the big capacity issues faced by the logistics department. Transportation is of course possible, but the costs can be so large that it eats profitability away from the business, or drives demand down due to price increases, as it was stated during the interviews.

> *…This organisational design structure of ours is designed really well in one direction. But does alignment mean that it should be both ways? Because I would say that we are not enough aligned both ways. For example, when we (sourcing & logistics) have identified a clear problem, and especially when it is a very big and difficult problem, how is it seen in our sales?... For example, if there is not transport capacity to a market, why are we planning additional sales there? This is a bit of exaggeration, but my point is that when we have acknowledged years ago that capacity is shrinking compared to demand, why is this not reflected backwards by any means? (Interviewee F)*

Another internal risk identified was information concentration within the organisation's information systems, especially on the operative side, which hinders agility and responsiveness. Additionally, the inadequacy of current systems was brought up. Furthermore, the lack of information sharing, misaligned communication flows and invisibility within the network were seen as drivers for risks.

Tools should be available to everyone. This is already a risk in itself, which is the fact that we are centralising access to information. For example, only production sees what comes from production. Or the fact that only logistics see what vessels are arriving and when. The communication of different units and the tools obtained through it should be available to everyone. In this way, we would be able to prepare for things better and more proactively and we would not create a bottleneck through people… By this, I don't mean that people don't do their jobs, but that we don't have systems that provide transparency at a sufficient level, which means that communication relies heavily on people, which means that somewhere someone is always left without being informed on time… At the moment, in my opinion, the current systems do not optimally support the real-life situation with regards to these changes in production, demand, vessel schedules, vessel capacity and warehouse capacity, etc... When these changes occur, it is challenging to adapt to these through the system, because we do not currently have the required visibility. And this in turn creates an uncertainty factor… we need to have the people, information, processes and systems in place which enable both short and long-term planning on an accurate level. It is the accuracy level that we need to improve. (Interviewee A)

5.2 Risk assessment

In this sub-section the second research question will be answered:
RQ2. What are the likelihoods and consequences of the identified risks?

The results for the probabilities and consequences for the risks were gathered through the questionnaire based on the subjective estimation by experts within the case organisation. Based on the responses, a median score was collected for the likelihood and consequence of a risk. This study categorises the risks based on their business impacts, as Vilko et al. (2019: 478) recommend since this provides a better view of the management team's ability to control them.

In figure 16, the distribution of the risks is visualised with a risk matrix. The numbers inside the risk matrix represent the risk ID given for each risk. Descriptions for the likelihood and consequences provide more accurate information about the scale. However, something that should be noted is that the euro sums have been altered, in order to protect the case organisation

privacy. Additionally, it should be noted that all risk consequences and their likelihoods have been rounded to the closest whole number.

Likelihood						
Almost certain /annual	5	50 51 52 53 54	**31 32 49**	**26**	**5 6**	
Very likely / Once in next 3 years	4	55 56 57 58 59 60 61	33 34 35 36 37 38	**14 15 16 17 18 27 28 29**	**7 8 9 12 13**	**1 2**
Likely / Once in next 6 years	3	62 63 64 65 66 67 68	39 40 41 42 43 44 45	**19 20 21 22 23 24 30**	**10 11**	**3**
Unlikely /Once in next 10 years	2		46 47 48	25		**4**
Rare / Realisation unlikely in next 10 years	1					
		1	2	3	4	5
		Low	**Minor**	**Moderate**	**Major**	**Severe**
	EUR	Up to 20k€	20k€ - 200k€	200k€ - 1M€	1M€- 2M€	>2M€
	Reputation	Local mention only, quickly forgotten	Local reputational damage, impact on local activieties	Short-term national concern. Long term impact on image.	National long-term concern. Significant change of market share.Major operations restricted	International long-term concern. Game-changing change of market share.
	Work Safety	Minor injury	Injury requiring medical treatment	Major injury (hopitalisation)	Single death and/or multiple major injuries	Multiple deaths
	Consequence					

Figure 16. Risk matrix.

In total, four risks were identified as severe risks. All severe risks are linked to the supply and demand determinants that drive maritime transportation. This highlights the importance of monitoring and analysing economic and political factors that drive the maritime sector. Additionally, it should be noted that the largest risks that the company faces originate from the environment which are outside the management team's control. List of severe risks is seen in table 17.

Table 17. Severe business impact risks.

ID	Risk	MEDIAN LIKELIHOOD (1-5)	MEDIAN CONSEQUENCE (1-5)
1	Availability of the ice- strengthened dedicated capacity	4	5
2	Under investment in the maritime sector	4	5
3	Geopolitical issues (e.g., wars)	3	5
4	Pandemic	2	5

Nine risks in total were recognised as major risks. The major risks are seen in table 18. The characteristics of major risks are almost identical to the severe risks: environmental risk sources, outside the management team's control and they are linked to the supply and demand determinants that influence the maritime sector.

Table 18. Major business impact risks

ID	Risk	MEDIAN LIKELIHOOD (1-5)	MEDIAN CONSEQUENCE (1-5)
5	Environmental regulation and legislation (e.g., emission trade)	5	4
6	Increase in shipping costs	5	4
7	Better market opportunities for shipping companies elsewhere	4	4
8	Global dispersion / disagreements in environmental regulations and legislations	4	4
9	Increase in energy prices (Fuel, electricity)	4	4
10	International trade sanctions	3	4
11	Limited amount of carriers	3	4
12	Inflation	4	4
13	Logistics price escalation	4	4

In total, 17 risks identified during the interviews can be categorised as moderate risks. The sources of moderate risks are environmental, network related and organisational. Additionally, it can be noted that the largest organisational risk that the company faces are disruptions in production. List of the moderate risks are seen in table 19.

Table 19. Moderate business impact risks.

ID	Risk	MEDIAN LIKELIHOOD (1-5)	MEDIAN CONSEQUENCE (1-5)
14	Availability of warehouse capacity in ports	4	3
15	Disruptions in production	4	3
16	Extra costs due to transhipment	4	3
17	Uneven traffic balance between trading areas	4	3
18	Limited amount of warehouse capacity	4	3
19	Demand for products drops	3	3
20	Inventory turnover decreases	3	3
21	Limited amount of port operators	3	3
22	More capital tied into inventory	3	3
23	Politics and trade policy (e.g., tariffs and taxes)	3	3
24	Carriers' poor financial results	3	3
25	Oil spill/leak	2	3
26	Congestions at ports	5	3
27	Labour disputes (e.g., FI AKT Strike)	4	3
28	Customer service level reduction	4	3
29	Insufficient amount of trucks to transport goods out of the	4	3
30	Disruptions in land logistics (e.g., railway closed)	3	3

A total of 19 risks can be categorised as minor risks. The sources of minor risks are environmental, network related and organisational. However, most of the risks rise from the network. Table 20 summarises the minor risks.

Table 20. Minor business impact risks.

ID	Risk	MEDIAN LIKELIHOOD (1-5)	MEDIAN CONSEQUENCE (1-5)
31	Product damages during maritime transportation	5	2
32	Demurrage costs	5	2
33	Dead freight	4	2
34	Demand exceeds transportation capacity	4	2
35	Forecasting inaccuracy	4	2
36	Inefficiency and ineffectiveness at ports	4	2
37	Resource adequacy (workforce and machinery)	4	2
38	Scheduling / coordination risk	4	2
39	Availability of trained workers	3	2
40	Competition risks	3	2
41	Demand fluctuation / volatility	3	2
42	Inflexibility in supply network	3	2
43	Invisibility within the network	3	2
44	System inadequacy	3	2
45	Carrier bankruptcy	2	2
46	Insufficient infrastructure at ports (water depth and ship width)	2	2
47	Vessel quarantine	2	2
48	Product damages at ports (human errors or equipment malfunctioning)	5	2
49	Insufficient processes at ports	3	2

In total, 19 risks can be categorised as low business risks. The sources of minor risks are environmental, network related and organisational. Most of the risk sources are also from the network. Therefore, it can be noted that minor and low business risks share the same characteristics. List of all the low business impact risks is seen in table 21.

Table 21. Low business impact risks.

ID	Risk	MEDIAN LIKELIHOOD (1-5)	MEDIAN CONSEQUENCE (1-5)
50	Claims from customers	5	1
51	Missing closing times	5	1
52	Production delays	5	1
53	Vessel delays	5	1
54	Additional short term resources required (workforce or capacity)	4	1
55	Hazardous weather conditions (e.g., flood, ice, snow)	4	1
56	Increase in vessel sizes	4	1
57	Insufficient communication / Information concentration / Misaligned communication	4	1
58	Over production	4	1
59	Over stocking	4	1
60	Carrier declines booking	4	1
61	Blank sailing (Cut and run)	3	1
62	Demand distortion	3	1
63	Employee / occupational safety	3	1
64	Operator failure (ports)	3	1
65	Process failure	3	1
66	System breakdown	3	1
67	Unalignment (e.g., information and incentives)	3	1
68	Vessel breakdown (declared as a joint liability)	3	1

Six important patterns that can be recognised from the risk assessment and categorisation are the following:

- The sources of the risks extend from the environment, network and organisations operations.
- Majority of the risks extend from external sources to the case organisation, highlighting the importance external environment monitoring and supplier relationship management.
- Major vulnerability for the case organisation's maritime supply chain, more precisely their delivery network, extends from environmental sources that are outside their control.
- The number of risks reduces as business impacts get higher.
- Low business impact risks have the highest likelihood of occurring annually in terms of total count.

- Over 90% of the risks are expected to occur at least once in next 6 years and all the risks identified are expected to occur at least once in next 10 years.

5.3 Risk mitigation

In this sub-section, the third research question will be answered:
RQ3. How can the risks be mitigated?

A total of 28 risk mitigation actions or enablers were identified during the interviews. Table 22 summarises all the risk mitigation actions and enablers. Almost all of the risk mitigation actions and enablers identified in the study were also acknowledged in the literature. Many of them were also brought up during multiple interviews, such as flexibility, redundancies, collaboration, agility, alignment, adaptability, contingency planning and visibility. Hence, the results had high correlation with previous studies.

Table 22. Summary of risk mitigation actions and enablers.

Risk Mitigation
Internal risk management control/process
Risk transferring and sharing
Control
Supporting suppliers with long commitments and contracts
Joint product design and delivery
Multiple sources of supply
Strategic agreements or partnerships with suppliers
Security
Alignment (e.g., information, incentives, identities)
Flexibility (e.g., alternative routes, contracts, suppliers, mode of transport)
Adaptability (e.g., spot trends, change supply networks)
Responsiveness
Agility
Redundancies (e.g., extra inventory and warehouse capacity, back-up operators)
Collaborative planning, forecasting and replenishment
Workforce training
Sharing criteria and guidelines how products should be handled
Reliable partners
Visbility (e.g., information sharing and integration)
Supplier audits
Understanding and monitoring of the environment
Longevity / forward planning
Improving efficiency and effectiveness
Contingency plans
Postponement
Acceptance
Automatisation
Speculation

5.3.1 Description of risk mitigation actions and enablers

The first step for risk management is doing risk management. Consequently, a risk management culture and having risk management processes in place was identified as the first step for risk mitigation. This means that identifying risks and assessing the risks is already part of risk mitigation. Additionally, it was stated that identifying risks and assessing them is useless if no action is taken to mitigate them.

…Then of course we do this kind of risk management. Now is actually the time of year that we are doing our 3-year plan which is updated yearly. In this we update our operators and risks related to our categories (e.g., ports and maritime traffic). Additionally, we do quarterly risk assessment, so risks are gone through quarterly and updated as necessary and thought of ways how to mitigate them… Identifying risks is not much of use if we do not think of ways how to tackle the risk and of ways how to reduce the probability or impact. (Interviewee H)

Everything starts from risk identification and then documenting them. Additionally, we need to understand that deviations will always occur and need to be able to react to them. (Interviewee A)

Since all of the case company's traffic is contractual, it was pointed out that an important part of risk mitigation is acknowledging the risks in contracts and also clarifying responsibilities and liabilities. Consequently, risk transferring and sharing takes place through the contracts.

All of our traffic is contractual traffic, and, consequently, we try to take these risks into account in our contracts… So, we check that these are considered in our contracts, at least to some extent. (Interviewee F)

Supporting suppliers financially with long commitments and contracts was identified as a crucial risk mitigation action in the liner- and dedicated traffic since it supports suppliers' investment ability. Additionally, assisting suppliers with mutually beneficial innovative solutions was recognised as a risk management action.

Our traditional way of supporting carriers and influencing investments is by making long contracts that enable a steady flow of income, which is something that financial institutions look for. In other words, what kind of contracts carriers have, impact how financial institutions are going to finance their operations - especially reform projects. Financial institutions also view sustainable development investment more favourably than these investments based on old technologies. Can we then be helping this, for example by paying a premium for more environmentally friendly technology? But I'm thinking more about whether we can be innovating how these ships, for example, are more suitable for our products and whether, in addition to these long commitments, can we find versatile cargo flows, different products from our side, not just some single product. Additionally, can we somehow be helping shipping companies to find, for example, opportunities for return cargo to Europe. (Interviewee F)

The importance of collaboration was also highlighted in all the interviews, in one way or another. Sharing responsibility and risks, exchanging common planning execution and performance measurements enables better risk mitigation within the supply network.

> *One aspect that I want to highlight in this dedicated traffic is so called "I scratch your back; you scratch mine" mentality. Collaboration and flexibility from both sides in both directions, and in this case this palette works well… (Interviewee A)*

> *We try to help our suppliers by striving for long-lasting collaborations and deepening our relationships with them. (Interviewee H)*

When discussing maritime capacity issues, flexible transportation in terms of routes, suppliers and mode of transport were identified as risk management actions. In addition, negotiations with existing carriers and entering more strategic partnerships was recognised as risk management actions for capacity unavailability. Similar strategies, such as alternative routing and having back up operators, were also identified as ways to mitigate capacity problems or disruptions at ports.

> *In a situation where there is a lack of capacity, the way we try to mitigate the risk is by looking for those alternative routes and carriers. We currently have two shipping companies, and when we see that our volumes are increasing, we need more… One clearly recognised route is transhipment through Central Europe and this would give us two options: container traffic and ice classless vessels. This would multiply our supply, however, it would increase our intermediate storage costs and possibly handling damages. (Interviewee F)*

> *… One thing that we are also currently doing is that we are discussing with one carrier about environmentally friendly vessel and vessels, which would then come precisely for this American traffic. (Interviewee F)*

> *… We are pushing for more capacity from our existing providers and looking at outside providers to provide more capacity. (Interviewee D)*

Furthermore, to mitigate the effects of uneven trade balance between Finland and US, accessing and utilising nearby flows from South America and Russia was recognised as a risk management action. Consequently, it can be noted that even macro level risks outside the company's influence can be mitigated

with supply chain network design. Additionally, understanding and monitoring external supply network environment is also an important aspect of risk management.

> *The trade balance is such a big challenge that we cannot really do anything regarding that. However, we are currently trying to take usage of return flows from South America to Europe and the hole created by Russian exports. Consequently, we are trying to get into these rotations… and solve the problems caused by the trade balance in US and Finland, by accessing these alternatives traffics… Building alternative routes is risk mitigation. (Interviewee H)*

Flexibility in contracts and customer order delivery dates were also identified as ways actions to reduce risks.

> *… There should be a certain amount of flexibility in our contracts. We cannot be lulled into having stable volumes. We should acknowledge that our capacity needs change…Additionally, there should be better flexibility in customer order delivery dates. (Interviewee A)*

During interviewee C's interview it was pointed out that many of the risks could be mitigated with steady production, enough warehouse and transportation being always on schedule. However, it was also noted that this is not realistic since deviations always occur. Additionally, it was pointed out that there are many things out of the focal company's influence. Nevertheless, warehouse capacity is something that can be influenced and should be increased in order to build better resilience to disruptions and deviations.

> *Enough warehouse capacity and vessels on schedule… and also, steady production. I know that this not realistic, but this is how it should go… Especially in this kind traffic, where the distances are so long, there are a lot of things here that are beyond our control which we cannot influence, which then cause desynchronisation. But this is how it could be roughly said: steady production, enough storage space and vessels always on time… (Interviewee C)*

For product damages at ports, workforce training and sharing criteria and guidelines how products should be managed were acknowledged as risk mitigation actions.

> *With regards to mechanical damages, workforce training so that people know how the products need to be handled and the right kind of handling equipment. Additionally, we have placed in our port contracts standard attachments for our criteria and guidelines how the products should be handled, which the port operator should follow. (Interviewee C)*

When discussing ways of mitigating scheduling risks with interviewee C, it was said that better planning and forecasting, dependable partners, right processes in place, adequate labour always and information sharing within the entire network would be the key.

> *…Having reliable partners everywhere doing the things that they have promised. Of course, there isn't one that is perfect and always does what has been asked… But adequate monitoring and responses and then having the right processes in place to handle these deviations. Additionally, always having the correct amount of labour in place at the ports. However, neither is this realistic since there are also constraints regarding workforce and machinery. But somehow all of these need to be reconciled. Consequently, these all have one common denominator: forecasting and planning in advance. The better and more reliable we are at these… or actually, it is not enough that we are… We should be able to provide others this information also, so that they are able to organise their plans… which is hard when there are so many variable factors… But with better and more reliable planning we would be able to mitigate most of the risks… this is of course something that we strive to improve all the time. (Interviewee C)*

More accurate forecasts were also seen as a crucial factor for mitigating other risk, such as capacity related risks.

> *If we would have unbelievably good and precise plans for years ahead, we would be able to mitigate better the risks. But the problem again, is that we are not able to forecast enough accurately our volumes many years forwards… (Interviewee E)*

A concept that was brought up as a key enabler for better risk management was visibility. The thought process behind this was that more accurate information on hand would improve planning capabilities and reaction abilities. Reliable data, trained people, clear work-supporting processes, systems and information sharing were seen as important factors in reducing risks.

> *…Risk mitigation would be visibility, which would enable the clearest possible long-term and short-term planning. This would be the key to everything. This would enable us to plan several weeks in advance on an accurate level. In order to succeed in this, the tools should be in place and reliable data… so we would need to receive more accurate sales forecasts… which we should then carry out. With these, we would be able to prepare better for things… So, trained people, the tools, visibility of the entire supply chain, clear work-supporting processes and systems that support the visibility of the supply chain. With these, it would be possible to clearly reduce these risks… Information sharing should get on a better level… in every direction. (Interviewee A)*

…Correct information on hand at all times would improve tremendously our planning capabilities and mitigate a lot of our risks. Having better visibility, even 6 months forwards would allow us to react better... For example, we are currently guessing next month's volumes, which means that we are running out of time, in case we need to get more capacity… (Interviewee E)

Consequently, on many occasions, throughout the interview process, the importance of communication, both upstream and downstream, with both internal and external stakeholders was stressed. In order to improve communication, especially on the operative and tactical level, more frequent meetings with relevant stakeholders were suggested. Additionally, it was said that information clarity should be emphasised. Since information flow has been acknowledged as such an important factor for risk mitigation and the functionality of the supply chain, a great deal of emphasis has been placed on it already within the case organisation.

Communication is the main thing that needs to be improved and needs to be timelier. This would give us time to react better to sudden changes. So, timely communication is the key which would provide us better visibility. If one party forgets to inform another party, no one knows and then information is lost somewhere… Meetings with carriers about once a month, where we could discuss problems etc. could help… (Interviewee G)

Something that we could improve is more accurate communication towards our business areas, and same thing the other way around. Business areas are aware of our transport capacities, but awareness should be increased. For example, we have a specific amount of capacity for business area x from Finland to US. But this is from two different ports, and then it is not clear to our business areas that they cannot throw goods at any port, because we have contracts for different carriers in different ports… For example, let's say that we have 70 000 tons of capacity from port A and then 30 000 tons of capacity from port B, but our contracts go exactly opposite. This just does not work since our contracts do not match… I guess that we should do a better job at clarifying these kinds of things… information flow should be improved. (Interviewee E)

There needs to be good communication. Consequently, we have increased our communication… (Interviewee D)

Having a certain level of redundancy in place, in terms of buffer stocks, was also recognised as a risk mitigation strategy during the interviews, increasing

product availability. Additionally, it would enable better responsiveness to market demand in case of disruptions.

> *In the US market, you have to take into account that we are not the only shippers, which means that schedules may change for vessels. The lead time for vessels going to the USA is on average 2-3 weeks and there is an ocean in between. Consequently, there must be buffer stocks so that stocks are not emptied, AKA safety stocks, as we do currently, however, we should not let these be so tight. With this, we would allow better adaption, both in production and the entire supply chain, because we know that changes may occur. (Interviewee A)*

Another concept that was brought up as an important risk mitigation enabler was adaptability. Additionally, it could be noted that a certain level of redundancy enables better adaptability and responsiveness to deviations within the supply network.

> *Capacities cannot be pulled too tight…Unlike buses, you cannot get ships to stop for the next day. Consequently, I would like to underline adaptability from our side. (Interviewee A)*

Reviewing supplier reliability and performance in terms of financials, sustainability and operational processes with supplier audits was also identified as an important risk mitigation action.

> *Well one thing is that we know our operators and check that these are solid firms and that they have their things organised economically, sustainably and operational process wise. For this we have auditing processes in place… We monitor our suppliers so that surprises will not occur (e.g., bankruptcy). (Interviewee H)*

A major contributor to better proactive and reactive risk management was said to be understanding and monitoring of the environment from both internal and external perspective. Additionally, it was noted that these need to be monitored from both an operational and strategic viewpoint.

> *Sensors must be in the operative environment, and we need to see how that is working and the see what kind of signals come from there. Our visibility with regards to our operational reliability comes from there. Then of course there are various levels of risk. For example, things that occur in regulation and legislation; is there something occurring that we need to consider or even risks that impact our business environment, transportation and demand. (Interviewee H)*

Another important aspect brought up, with regards to SCRM and supply chain management in general, was longevity. Decision making and risk management actions should be done in terms of long term prospective. Additionally, the importance of forwards planning was highlighted.

> *Longevity is an important aspect when playing this game… If we, for example, think that we are doing one-year contracts, there would always be a big question mark. On the container side this is possible because the supply is so good and wide globally. However, in the dedicated traffic, where there are such large volumes and only few carriers available that can provide for our needs, this is not possible. Things need to be done thinking about the long term. (Interviewee H)*

> *We try to look forward as much as possible, more accurately, see if we have got the required capacity. (Interviewee E)*

Locking customer orders earlier was also noted as a pre-emptive risk mitigation action. The rationalisation behind this was that it would reduce loading errors. Additionally, locking customer orders earlier would improve planning accuracy and reduce dead freight.

> *The deadline that the orders cannot be changed should be increased on customer side, so that orders on vessels could be locked earlier. This would probably reduce loading errors. (Interviewee D)*

Improving discharge efficiency at ports was seen as a key driver for reducing congestions at ports. Maximising vessel tonnage and reducing vessel count was identified to improve discharge efficiency. Therefore, the trend of increasing vessel sizes should improve discharging efficiency at ports.

> *Improving discharge efficiency, so it takes less hours to discharge the same amount of tonnage. That would improve congestion. Then, limiting the number of vessels that we bring to the US. For example, if we had 100 000 tons to bring to the US and you could do it in 10 or 15 vessels. Well, if you do it in 10 vessels at 10 000 tons per vessel versus 15 vessels at around 7000 tons per vessel, you are going to get a more efficient discharge and reduce congestion because there are less vessels calling at the port. Maximising what we are putting on the vessels coming to the US would thereby reduce the number of vessels. That would reduce port congestions in the US. (Interviewee D)*

Having contingency plans in place was also identified as an important part of risk mitigation since it shortens reaction times when disruptions occur.

Additionally, it should be noted that recovery plans increase the robustness of the supply chain.

> *We pay close attention to contract negotiations in different ports and have contingency plans in place in case something was to go wrong. For example, if port A has issues… then we would divert that volume to port B and keep the products moving. I think part of mitigation is having contingency plans in place. (Interviewee D)*

Acceptance was also an acknowledged risk management action in case of operational risks. These should, however, be monitored and investigated since they may foretell larger issues. In addition, this would ensure that accepted consequences do not escalate.

> *In case the carrier informs us that the goods cannot be loaded and will be postponed to another vessel, there is not really anything else we can do than accept this. (Interviewee G)*

For operational risks, automatization was also identified as a risk management action during interviewees B's and G's interviews, since it could reduce human errors.

5.4 Risk monitoring

In this sub-section the fourth research question is answered:
RQ4. How can the risks be monitored?

Both qualitative and quantitative monitoring of the case organisation's internal and external environment were identified as methods for risk monitoring. Quantitative risk monitoring methods and tools identified were KPIs, statistical analysis of key metrics and utilisation of the large mass of data. Qualitative sources of information, such as monitoring the environmental regulations and legislation and information sharing, both internally and externally, were also recognised as important factors for risk monitoring.

The importance of ERP software, reporting tools and integration, both internally and externally, were highlighted on many occasions as key enablers for risk monitoring. Additionally, visibility to supplier metrics was recognised as a crucial factor for better risk management.

5.4.1 Description of risk monitoring methods and tools

During the interviews, it came apparent that the case organisation does not have any specific risk management KPI in terms of their supply chain, such as Value at Risk (VaR), which quantifies the extent of possible losses. However, the company does category risk mapping once a year where the likelihoods and consequences of risks are evaluated subjectively based on expert opinions. Additionally, the company has other KPIs in place such as logistics cost per ton, throughput capacity, inventory turnover, service level, supplier sustainability metrics and monitors costs in general closely. Furthermore, they do supplier audits to check their supplier's reliability and track fuel prices.

> *I don't believe we have any kind of KPI for this kind of risk monitoring at the moment. The only thing we have is that we make a category plan once a year for three years ahead, called long range planning, and there we have risk mapping, where these issues come up and we think about ways to mitigate these risks. But we do not have a direct measurement for this. Of course, we have our operational team in charge of the liner and dedicated traffic, who know what kind of a risk it is to get the goods moving. And this is a daily activity, but it is not a measured activity. (Interviewee F)*

> *…We have auditing and KPIs (e.g., logistics cost per ton, throughput capacity, inventory turnover, service level, supplier sustainability metrics) so that we know how we are performing operatively and how our suppliers are doing. If there are any red flags, then we attack them. (Interviewee H)*

> *We follow closely our nominations to see how much capacity we have used and how accurate our estimations have been and then reflect back to the available capacity. Additionally, we monitor costs closely. (Interviewee F)*

Nonetheless, it came apparent during the interviews that risk monitoring remains on a qualitative level, for the most part. A common theme that was recognisable from almost all the interviews was that risk monitoring has space for improvement. This is something that the case organisation has acknowledged themselves also previously and is currently working on its ERP software and reporting tools, which would provide them with more quantitative measures for both internal and external operations. The importance of visibility to supplier metrics was highlighted for better monitoring abilities. Additionally,

information sharing in general, such as schedules, with both internal and external parties, was identified as a key factor for risk monitoring during many of the interviews.

> *Yes, this is something that we are not so good at currently. This is something that we have recognised and are currently trying to improve… This is of course then more connected with the short-term and more operative risks. (Interviewee H)*

> *This is currently a rather timely topic, since this is an area where we have quite a lot of work to do with terminal operators... We do have KPIs at ports in place, but they still need to be improved. However, it is precisely with these kinds of metrics, how we follow relevant matters for us, such as how long it takes to load or discharge a truck and the same thing with vessels… Within our freight contracts, we have defined certain times or time windows in which a vessel, for example, needs to be loaded or unloaded. If these do not materialise, then the meter starts to tick. So, monitoring such things and then focusing on the root causes, that have led to situations where someone incurs additional costs, is important. In general, these are due to the fact that the resources have not been met in quantity or time. Consequently, the temporal and quantitative measurement of resources is important. (Interviewee C)*

> *The ports in the US track and share with us KPIs such as discharging times, damaged products, total tonnage going in and out, average inventory, rail cars loaded, truck loading times and vessel productivity. (Interviewee D)*

Better monitoring and tracking of risks were also recognised as a way to be more proactive in terms of risk management. Additionally, it was pointed out that the organisation currently works too much in different silos within different parts of the organisation. As a result, better integration both internally and externally was identified as a key for better visibility and risk monitoring. Furthermore, the importance of having data available in the systems, which reflect accurately the happenings in the real world, was highlighted.

> *There should also be better tracking because I do not think we currently do monitor risks. Of course, exceptional situations are reacted to. However, when we live in such an adaptable and changing traffic, we should strive to be more proactive. Currently we also work perhaps too much in different silos within different functions of our organisation. This should be made more fluid, because what we do is like a combination of planning, production, logistics, sales and customer service. In other words, we should have better visibility throughout our organisation. We cannot look at our operations just from one point of view, we should look at our operations from the entire supply chains point of view. In*

order to succeed in this, we need to be well integrated internally and externally… In order for us to be able to reliably monitor risks, the data must be available in the systems, so that it does not remain at the level of people's thoughts and remain dependent on tacit information, in which case the risks are not necessarily identifiable… So that risks can be identified, there should be processes and tools in place which reflect the operative world. By this I mean that the things we see in the systems and communications may differ greatly from what actually is happening in the real world. This is one of the reasons why identifying the risks and monitoring them is so difficult; they are not visible in the systems… I would like to note that we are currently working on ERP software and reporting tools which will provide us better tools. (Interviewee A)

It was also stated that finding root causes for risks may be difficult due to insufficient monitoring and the complexity of supply chains. In addition, it was noted that when upper-level figures are bad, then further investigation is always required.

… Finding the roots causes may be difficult, due to the fact that there is insufficient monitoring in place. Additionally, there might be many reasons simultaneously behind a deviation, or why a risk is realised. But of course, some may be very self-evident and easy to measure, while others more difficult… There are so many moving parts dispersed globally… so it is not about focusing on individual cases… but more about the upper-level figures… Then if the upper-level figures are awry, well then you need to go through the details to find what is wrong. (Interviewee C)

When discussing with interviewee F about ways how risk monitoring could be improved, it was said that it has something to do with the operational side and that it could be more frequent. More precisely, it was stated that the risks identified on the strategic level should be measured and monitored on the tactical and operational levels in some way because they affect operational performance.

Something that we could be doing better, with regards to risk monitoring, is presumably something related to the operational side. And probably, it should be better in terms of frequency… When we look at these once a year, we try to look at the big contractual situation and picture three years ahead… I would say when we have that three-year plan, which is based on the company's longer-term strategy, so this company has a very clear structure in these matters, and when we have this, it's like a three-year view of the category. So, the question is, how does this come down to the operational side in a so-called tactical plan that is year-long and how it is seen there… For example, if we have

noticed on the sourcing side that this is a big risk, how is it viewed in the operational side? When our organisational design is clearly structured and we see that this will be a problem in terms of sourcing, then it will be a problem on the operational side as well. So, I would say that there it should be measured in some way. Consequently, our biggest issue is that this risk monitoring remains at a too planned level. (Interviewee F)

The main challenge that became apparent during interviewee H's interview was that collecting data is currently difficult when the current systems are being renewed. Additionally, as Interviewee A pointed out on many occasions during the interview, there are not currently sufficient tools in place for risk monitoring. Consequently, the ability to collect data for KPIs from the ERP and reporting software, with better integration internally and externally, was acknowledged as a key factor for better tracking abilities.

Well one thing is data collection. For example, how are we able to collect the data for the KPIs from our ERP and reporting software in a situation where systems are renewed? In the future, we will have this kind of new LBN (Logistics Business Network) system where our operators and suppliers will be integrated. This will enable us to track better, for example, delivery accuracy and more… (Interviewee H)

Better utilisation of the large mass of data was also recognised as a way to spot trends, get a better view of the maritime market and, in general, get more of hard facts. Therefore, better data utilisation was also acknowledged to improve the case organisation's agility and adaptiveness. In addition, it was pondered whether risk management currently relies too much on "gut feeling" due to unavailable data.

How we could get better, has probably something to do with medium- and long-term factors. So how does the market develop and what are the impacts of these on balance sheets…. Would it be possible to get something out of the larger mass of data? For example, during the Corona time, challenges came when the ports started to get blocked and then all ships were late. In consequence, the circulation of the ships slowed down. Could we somehow get a better view of the maritime market? For example, how is the rotation of vessels going and are there any other market disruptions visible… Could it be, that this risk management is based on too much on "gut feeling"? Would it be possible to get more of these hard facts? (Interviewee H)

6 Conclusions

This study researched SCRM in a Finnish manufacturing organisation's maritime delivery network from Finland and Sweden to the US ports from the focal company perspective. The study was formed of two parts: a theoretical part and an empirical part. The theoretical part contained a comprehensive literature review regarding maritime economics, SCRM and relevant SCM theory. The empirical part of the study was conducted as qualitative research using semi-structured interviews and a questionnaire to collect the data. The findings provide valuable insights into the causes, potential likelihoods and consequences of risks involved in maritime delivery networks to the US from Finland and Sweden. Furthermore, the study offers ways how to mitigate risks, as well as methods and tools for monitoring them.

The study identified a total of 68 risks in the organisation's maritime delivery network. The sources of the risks extended from the environment, network and organisational operations. The largest risks in terms of their business impacts were identified to extend from environmental sources, which were also identified as the major determinants of sea transportation demand and supply in the literature. Key risk mitigation actions and enablers identified in the study were flexibility, redundancies, collaboration, agility, alignment, adaptability, contingency planning and visibility, which correlates with previous studies. For risk monitoring, the importance of both qualitative and quantitative methods and the role of information systems and technology were highlighted.

6.1 Discussion

The findings and results of this study had high correlation with the literature. The complexity, turbulence, volatility, interconnectedness of so many different things and the vulnerability to disruptions that drive risks, which have been highlighted in the literature, became apparent during this study also. Subsequently, there were many risks identified in the case organisation's specific supply chain studied, which extended from the environment, network

and organisational sources, as described by Jüttner et al. (2003). Additionally, the risks identified could be divided into sources and types of risks (Svensson, 2002). Furthermore, both qualitative and quantitative risks were recognised. During the study, it was also recognised that there is a lot of overlap between the risks, as previous literature suggests (Manuj and Mentzer, 2008b: 137-138). Many of the risk mitigation strategies and key enablers for better risk management abilities explored in the literature, were identified during the study. The benefits of both qualitative and quantitative methods for risk monitoring, were also acknowledged both in the literature and study.

During the interviews, it came apparent that risk assessment is currently rather subjective in the case organisation due to the lack of hard facts and therefore, relies heavily on the experience and knowledge of the company's management. In other words, there are not enough risk measurement methods and tools in place, which is why decision-making relies on the opinions, experience and knowledge of individual people in risk assessment. This highlights the importance and need for knowledge management.

It was also noted by many of the participants that the business impacts of risks are difficult to assess, since the risk impacts of a single risk may be in fact large or small. This is because a risk may have a small direct impact but large indirect impact (Interviewee H). Additionally, a disruption may have ripple effects into other areas of the supply chain, causing even higher consequences (Ivanov, 2017). Hence, assessing and evaluating the consequences and likelihoods of risks is difficult. As a result, a stochastic method or probabilistic thinking could be a better option than deterministic thinking for risk assessment, since it relates better to the real world.

There are many different trade-offs that need to be considered when mitigating risks, since the mitigation of one risk might cause another risk, as it was noted in the interviews and in the literature. Consequently, risk management requires a great deal of understanding and knowledge from the management team, as well as an emphasis on the big overall picture. In addition, since most of the

risks extend from external sources, most of the risks are outside the firm's control. This highlights the importance of key concepts discussed in the literature such as collaboration, integration, visibility, agility, alignment, adaptability, responsiveness, redundancies and flexibility, which enable better resilience in the entire supply chain.

Processing data into a usable form, so that it can be analysed and utilised for decision-making, is currently a challenge within the case company, but something that can be developed. By refining raw data to better information, risk identification, risk assessment, risk mitigation and risk monitoring abilities could be improved, which would potentially enable a better proactive approach to risk management. Additionally, with the monitoring of different performance metrics, it is possible to monitor the realisation of risks in real-time and react to them in a timely manner (McCormack et al., 2008: 23). Consequently, the importance of information systems and technology can be seen and should be emphasised in SCRM as well.

The case organisation has centralised maritime logistics in one place for economic reasons. In maritime transportation, as in logistics in general, it is of great importance what size and type the operator one is (Interviewee H). Unity, therefore, creates a clear advantage for the company from an economical point of view. At the same time, however, this creates a big challenge for day-to-day operations, because it is challenging to drive the interests of the different business areas within the organisation in an equal and unified manner due to their different needs and operating methods. As a result, further emphasis on integration between the Group services and the business areas should be placed.

Clear challenges for the case organisation also arise from their business environment. The difficult predictability of demand and cyclical fluctuations, combined with the inflexibility of freight contracts, is a challenging combination. Hence, flexibility in long-term freight contracts would be an important addition and would provide better control elements for the company.

Low competition and availability on behalf of both shipping companies and terminal operators is also a clear problem from a procurement perspective, in the case organisation. Because of this, the importance of collaboration and more strategic partnerships with port operators and shipping companies should be emphasised even more in the coming years.

With regard to maritime transportation, overestimating demand in freight contracts could also be a better option from a procurement perspective, in a situation where there is capacity scarcity. However, this kind of ‘game’ thinking is not fair for the shipping companies or other logistics operators and would eat away the trust in the long run if the supply remains insufficient. This would also be reflected in the contract negotiations and pricing in the long term and would bring unalignment in the supply chain. Consequently, this highlights the importance of CPFR and visibility throughout the supply chain, which would enable more precise nominations for freight contracts. This also showcases the negative effects of the bullwhip effect on a manufacturing company’s distribution network.

From a strategic point of view, understanding and monitoring the business environment and external global events was emphasised in the interviews due to their business impacts. These were also identified in the study to have the largest consequences for the case organisation. Disruptions were acknowledged to affect all levels of decision-making in supply chains, which is why comprehensive information sharing regarding risks should be emphasised. Hence, in the interviews, the importance of tactical and operative activities in risk management was also emphasised, especially in relation to follow-up and monitoring of these.

Social responsibility is something that has been of concern for supply chains in recent years and this will only become more prominent in the future. Future regulations and legislation are large factors in the maritime sector, and they will affect all parties involved in global trade. One big problem related to these is the global dispersion related to environmental matters, which will cause issues in

the maritime sector. The long-term under-investment in the maritime sector will also cause major problems in this regard because new regulations and legislations will most likely require newer and more efficient vessels. Consequently, the maritime sector currently faces great uncertainty which drives risks.

6.2 Managerial implications and suggestions

The maritime sector is largely driven by economic and political factors, which have a direct effect on cost levels. This was also visible in the risk matrix since the most severe and major risks were from environmental sources. Consequently, the important determinants of sea transport demand and supply that drive the shipping cycles should be monitored and analysed for better risk management capabilities with both quantitative and qualitative methods from a holistic point of view. The important determinants of sea transport are summarised in table 23.

Table 23. Determinants of sea transport demand and supply (Lun, Cheng and Lai 2010: 18-23; Stopford, 2008: 136)

Demand	Supply
Political factors and random shocks	Investment decisions
World economy	Ordering new ships
Seaborne trade	Ship scrapping
Average haul	Fleet size
Transport costs	Operational efficiency

In order to mitigate the effects of the uneven trading balance between the destinations, transhipment from Central Europe is suggested. This would improve transportation flexibility and transport capacity availability. Additionally, it would offer better segmentation for the increasing sales volume. This should, however, be centralised to one location in order to face little loss in economies of scale. Furthermore, speculation combined with form postponement could be

used to mitigate the effects of demand risk, since it would enable better responsiveness to sudden demand changes. More thorough research on cost and benefit analysis should, nonetheless, be conducted for optimisation.

The leanness of the case organisation's supply chain became also apparent during the interviews. The trend of increasing vessel sizes will only increase the need for investments in extra warehouse capacity. Consequently, the recommendation is that the case organisation would increase their buffer stocks and invest in extra warehouse capacity. This form of redundancy would increase the case organisation's resilience to disruptions, reliability and adaptiveness to changing demand and supply. Investing in redundancy, however, represents cost increases and, therefore, further analysis on optimal levels of inventory is required.

The need for strategic partnerships and closer collaboration with suppliers in the maritime sector was also seen as a key enabler for better risk management capabilities. This relates especially to RoRo and LoLo traffic, where there is capacity scarcity in this specific trade route. These would include mutually beneficial solutions such as joint product designs, delivery and assisting shipping companies to find return cargo to Europe. Long contracts and commitments also support carriers' investment abilities since they enable a steady flow of income, which is something that financial institutions require in order to finance operations of shipping companies. Hence, the suggestion is that further emphasis is placed on long-lasting and deeper collaborations with suppliers.

The importance of information systems and technology was highlighted on multiple occasions during many of the interviews as a key enabler for better risk management. Examples of the benefits were the following:

- Information accuracy, availability and visibility.
- Better monitoring, flexibility, agility, alignment, coordination, reporting and decision-making abilities.

A key factor for achieving optimal information system performance was integration, both internally and externally. Better process maturity can, therefore, also be recognised as an important factor for better risk management abilities. Consequently, the suggestion is to continue emphasising the improvement of information systems and technology, with further integration, both internally and externally, which offers many benefits outside risk management capabilities also. A special note regarding this, is that information concentration within the organisation's internal systems was also seen as a limitation for holistic SCM and SCRM during the interviews. Therefore, a further suggestion would be information decentralisation within the company's value chain. In addition, better utilisation of the large mass of data was also recognised as a potential enabler for proactive risk management. As a result, further emphasis should be placed on processing data into a usable form, so that it can be utilised and analysed for better decision-making abilities.

6.3 Limitations

This study has some limitations, which are discussed here. The first limitation is that this study was done based on a single company and all the participants work in the same company. This means that the results could vary significantly if the participants would have been from another company or even if interviewees had been selected from different areas of the supply chain such as production, customer service or sales and operations planning (S&OP). The case company in question was large in scale and their transportation volumes to the USA are large in nature. Consequently, smaller companies with lower transportation volumes might not face the same challenges in their maritime delivery network. Neither did this study involve port operators' or carriers' perspectives, which limits the outlook of risks. In addition, since this study was conducted as qualitative research, the research approach also contained certain limitations.

6.4 Future research

Further studies could delve into more quantitative approaches and tools for supply chain risk management, such as cost-benefit analysis or predictive simulation models in maritime delivery networks. Another area of interest could be the potential impact of future maritime regulations and legislation on the maritime industry and international trade. Additionally, research could examine the perspectives of port operators and carriers on managing supply chain risks, as well as explore ways how risk monitoring could be improved within organisations. Finally, more research could be done on the role of information systems and technologies in SCRM, more specifically in the maritime sector.

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Appendices

Interview questions

1) What are the risks in transporting goods from the Mills to USA ports? (e.g., What can go wrong? what is uncertain?)

2) What may be their causes? (i.e., why would they occur?)

3) What may be their effects? (i.e., what could be the consequences?)

4) How are the risks managed? (i.e., what risks management actions are done or used to mitigate or control the impacts or probabilities of risk occurring?

5) How should the risks be managed (i.e., what risks management actions could be done or used to mitigate or control the impacts or probabilities of risk occurring?

6) What are the main issues or difficulties in managing the risks?

7) How are the risks monitored?

8) How should the risks be monitored?

9) What are the main issues and difficulties related to the monitoring of risks?