Master's degree thesis

LOG950 Logistics

A comparative case study of inbound supply chain risk management (SCRM) in Norwegian manufacturing companies before and after COVID-19

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Preface

This Master Thesis symbolises the end of my five years at Molde University College and is a part of the final assessment in the degree of Master of Science in Logistics. The research was conducted in the time period of November 2021 and May 2022.

As the COVID-19 pandemic have impacted our lives for over two years, I found it interesting to investigate further how the pandemic has influenced supply chain risk management. When the opportunity to compare results from a previous research appeared, I did not hesitate to choose this as the topic for my thesis. I would like to thank the Norwegian manufacturing companies that participated in the survey, without them the research would not have been feasible.

I would like to thank my close family and friends for inspiring words and conversations throughout this semester.

Last but not least, I would like to express my gratitude to my supervisor, Berit Irene Helgheim for good professional guidance and inspiring discussions, and for your encouragement towards the finish.

Molde, May 23rd, 2022

Ingrid Elisabeth Ynnesdal Eikemo

Abstract

Purpose: The purpose of this research is to analyze changes in inbound supply chain risk management (SCRM), before and after the COVID-19 pandemic.

Methodology: The collection of primary data was conducted through an online survey. Secondary data from a previous master thesis was accessed through Molde University Colleges database. The sample size of each dataset was 39 companies.

Findings: Results from this research indicated an increased awareness of external risks. No further measures were implemented in order to tackle the risks identified, or to increase collaboration and information sharing in the inbound logistics.

Originality/value: This research is one of the first empirical studies to compare the effects of the COVID-19 on manufacturing firms.

Keywords: Supply chain risk, supply chain risk management, sustainable supply chain management, COVID-19, collaboration, information sharing, flexibility.

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1.0 Introduction

The COVID-19 pandemic caused disruptions like never seen before, illustrating how vulnerable global supply chains (SC) are towards unpredicted disruptions, particularly when affecting supply and demand simultaneously (Fonseca and Azevedo 2020). Supply chain risk management (SCRM) has for many years been an important subject, but the outbreak has highlighted the importance of risk management. As the manufacturing sector is dependent on raw materials in many of their operations, they were heavily impacted by the governmental policies that were implemented in order to reduce the spread of the virus. Closed borders and containment policies impacted the inbound supply of goods, resulting in higher lead time and delays (Raj et al. 2022). El Baz and Ruel (2021) described how Fortune (2020) reported that the pandemic affected around 94% of top 1000 in a negative way.

There is no common definition of the supply chain risks (SCR) and SCRM, nevertheless authors all agree on the importance of the subject. Jüttner, Peck, and Christopher (2003) classified risks into enviromental-, organizational- and network-related risks, while Ho et al. (2015) developed a conceptual framework that divided risks into two groups: macro- and micro risks. The conceptual framework consists of four steps: risk identification, assesment, mitigation and monitoring. As toadys consumers and stakeholders are focusing more on aspects beyond the business side of operations, it is important that the SC partners follows this shift. Moktadir et al. (2021) presented five-dimensional sustainability approach for a more sustainable SCRM. Furthermore, the level of collaboration and information sharing are two important factors that could influence the risk management. SC partners that practice these concepts with their inbound suppliers could experience an improved flexibility in their operations.

The literature emphasizes on the importance of SCRM and how organizations may benefit from implementing a clear strategy. Varzandeh, Farahbod, and Zhu (2016) investigated how companies took advantage of risk management. The research showed that smaller firms did not have the necessary strategies to mitigate or avoid risks caused by disruptions in the SC. On the contrary, larger sized firms showed a higher level of risk management and tried to avoid the risks instead of reacting to a potential occurrence.

Based on the negative effect the pandemic has had on organizations worldwide and the global SC, this migh be an incentive towards a shift in focus towards the SCRM. Nevertheless, this has not been documented by other researchers. This paper analyzes therefore the changes in inbound SCRM in Norwegian manufacturing companies, before and after the COVID-19 pandemic.

1.1 Research problem

The focus on SCRM in the literature has exponentially grown as a response to the COVID-19 pandemic. Due to the short time period between the outbreak to when this research was conducted, there is limited research done in comparing operations before and after the pandemic. This thesis investigates how companies treat risk management, with focus on the inbound SCRM. The purpose of this study is to analyze and compare:

> "The changes in inbound SCRM in Norwegian manufacturing companies, before and after the COVID-19 pandemic."

1.2 Structure of the thesis

This thesis will follow a paper-based format, divided into two part. The thesis will start with Part I which introduces what will further be described in Part II. Part I starts in chapter 2 a by presenting a literature review over the case of the COVID-19 and SCRM challenges and processes. Chapter 3 describes the applied methodology and data collection, and chapter 4 presents a research summary and suggestions for further research. Lastly, Part II, which is the main contribution of this thesis follows.

2.0 Literature review

2.1 Covid-19

The outbreak of COVID-19 pandemic had its origin in China in later December 2019 and escalated quickly to spread throughout the world by the start of 2020. Due to uncertainties and the nature of the pandemic, governmental policies were implemented to prevent the virus from spreading any further. The COVID-19 pandemic is described by Chowdhury et al. (2021) as unique and it distinctly separates from previous outbreaks like the SARS epidemic in 2009, by having more various, serious and dynamic impacts. Furthermore, the pandemic is classified as an external risk and Ivanov (2020) describes such disruption risk as a low-frequency-high-impact event. Ivanov (2020) further describes how epidemic outbreaks has three main characteristics, such as (1): long-term disruptions and unpredictable scaling, (2): the outbreak of simultaneous disruptions in the SC and (3): simultaneously disruptions in demand, supply and logistics infrastructure.

Emphasizing on the fragile position of global SC, Fonseca and Azevedo (2020) describes how the contaminants policies affected the demand as the governments implemented restrictions influencing all aspects of the society whilst the demand for health care supplies and workers increased. As for firms operating is this sector, the sudden spike in demand has made it particularly difficult to meet the demand (Sharma, Adhikary, and Borah 2020). Another challenge that arises is the supplier selection, whereas finding new suppliers in an unstable environment is particularly difficult and even more so when the SC are global and thus requires more attention. Moreover, the probability of disruption in a global SC is said to be higher as the number of parties involved and the supplier distance increases (Fonseca and Azevedo 2020).

The disruption in supply and demand have been challenging for manufacturing companies as it has created suboptimal production conditions (Raj et al. 2022). Sharma, Adhikary, and Borah (2020) examined the trend of 100 companies twitter messages sent out on Twitter to examine what type of problems they are facing. The results show that many experienced challenges with supply and demand, even to the point where companies were forced to make demand and supply equations daily. Challenges regarding manufacturing operations are

especially important and difficult to deal with due to the complexity of operations, lack of equipment and raw material (Raj et al. 2022)

2.2 Supply chain risk

A quickly changing environment and a complex network of SC partners are few of the main characteristics for today's market. The increased level of complexity in the SC leads to a higher level of vulnerability and risks (Munir et al. 2020) and the likelihood and impact of disruptions is more difficult to predict (Ferreira et al. 2018). The dynamic and uncertain business environment and world economy have led to the trend of globalization and outsourcing (Giannakis and Papadopoulos 2016). Moreover, technical advancements in information sharing technologies and the increasing trend of globalization have transformed domestic SC into global SC (Chu, Park, and Kremer 2020), and thus increases organizations competitive advantage (Munir et al. 2020). Also, shorter product lifecycle (Tang and Nurmaya Musa 2011), increased demand for on-time deliveries and the fact that many companies takes advantage reducing the supplier base and buffers, lean manufacturing as well as lean SC (Fan et al. 2017). Truong and Hara (2018) describe how disruptions in the inbound supply results in supply risks.

Based on their literature review overlooking the entire SC, Ho et al. (2015, 5035) defines supply chain risk (SCR) as "the likelihood of unexpected macro and/or micro level events or conditions that adversely influence any part of a supply chain leading to operational, tactical, or strategic level failures or irregularities."

While focusing on the flow of materials, products and information, Jüttner, Peck, and Christopher (2003, 200) defined SCR as "any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user."

The definition of SCR that will be used throughout this thesis will be the one described by Heckmann, Comes, and Nickel (2015, 130) who reviewed existing definitions of the SCR covering the whole SC:

> The potential loss for a supply chain in terms of its target values of efficiency and effectiveness evoked by uncertain developments of the supply chain characteristics whose changes were caused by the occurrence of triggering-events.

2.2.1 Classification of supply chain risk

In order to determine and classify the type of SCR, researchers have provided multiple frameworks. Ho et al. (2015) conducted a literature review that categorized SCR into two categories; macro and micro risks. Micro-risks refer to the internal activities of companies and can be divided into sub-categories such as demand risk, manufacturing risk, supply risk and infrastructural risk. Contrary to the micro-risk is the macro-risk that refers to rare external event or situations that may have a negative impact on the company, such as man-made or natural risk (Ho et al. 2015).

Several researchers also divide the SC risks into two domains, operational and disruption risks, where the latter relates to occurrence with low frequency and high impacts. Operational risks concern the typical disruptions such as variations in demand and lead-time (El Baz and Ruel 2021; Torabi, Giahi, and Sahebjamnia 2016).

Jüttner, Peck, and Christopher (2003) approached the risk classification by categorizing the supply risk into external, internal and network related risk. Furthermore, each risk factor was then further divided into three main categories: environmental risk sources, organizational risk sources and network-related risk sources. To distinguish the difference between these types of risks, Manuj and Mentzer (2008b) split the risks factors into different groups. Sørland and Wembstad (2016) adopted the categorization by Jüttner, Peck, and Christopher (2003) and Manuj and Mentzer (2008b) and developed a risk category model, see figure below.

Figure 1: Categorization of Supply Chain Risks (Sørland and Wembstad 2016)

As Figure 1 illustrates, the environmental risks also referred to as the external risks, occurs between the parties in the SC network. Jüttner, Peck, and Christopher (2003) describe these risks as socio-political actions, accidents, earthquakes or extreme weather. The figure has adapted the categories that Manuj and Mentzer (2008a) divided the environmental risks into, such as the policy-, macroeconomic-, resource-, and competitive risks. Policy risks refers to actions of new governmental policies, like seen in the case of COVID-19 with closed borders and travel restrictions. Next, macroeconomic risks refer to changes in the economic situation such as increased rate for wages, interest and increased prices. Resource risk relates to unforeseen changes in the resource requirements, while the competitive risks relates to the lack of knowledge to what their competitors do and how they conduct their business (Manuj and Mentzer 2008a).

Next, the model describes the network related risks, which is risks that occur between the different organizations within the SC. Manuj and Mentzer (2008a) divided the risk in demand-, supply-, security- and operational risks. First, the inbound supply which constitute the supply risk regards disruptions in the supply. These disruptions could affect the SC all the way down to the demand risks, i.e., the downstream supply towards the end customer. Operational risks occur relates to the production of goods, such as breakdown of machines, ultimately affecting the firm's ability to produce their goods. Lastly, the security factor relates to factors that may impact their information systems (Manuj and Mentzer 2008a).

The organizational risk source refers to the internal risks that related to the parties involved in the SC and the risks sources that may occur. This include risks such as production, labour or IT uncertainties (Jüttner, Peck, and Christopher 2003). Manuj and Mentzer (2008a) divided the organizational risks into process, decision, communication and knowledge risk.

2.2.2 Inbound supply chain risk

Disruptions in the inbound SC might cause huge managerial problems further down the SC, thus need to be managed in a way that facilitates for a quickly recovery after the occurrence of disruptions (Dabhilkar, Birkie, and Kaulio 2016). The implications a disturbance causes may be referred to as the *ripple effect*. Consequently, inbound supply risks should be accounted for in the managerial aspect of operations. Manuj and Mentzer (2008b) describes that supply risks have its origin from the supplier's supplier, and continue all the way down to the focal firm. Zsidisin et al. (2004, 397) define inbound supply risk as:

> The potential occurrence of an incident associated with inbound supply from individual supplier failures or the supply market, resulting in the inability of the purchasing firm to meet customer demand.

As it has become more obvious to many organizations that the risks connected to inbound supply need to be properly managed, the importance of the purchasing function certainly gained much attention. The strategic planning will have an impact on how the focal firm chooses to organize their supply base, and therefore conduct the supplier selection process in order to meet the company's strategic goals (Saputro, Figueira, and Almada-Lobo 2022). Moreover, Olhager and Prajogo (2012) emphasizes on the impact supplier selection may have on the relationship between the partners in a network and could result in dependency, but also high-quality products. Meanwhile, increased partnership may lead to increased risks.

Another possibility to reduce risk in the inbound SC is to have a clear sourcing strategy, e.g. single or dual sourcing. The latter requires considerably more resources than single sourcing due to a higher number of suppliers, thus increasing the need of managing several suppliers. On the other hand, single sourcing is more resilient towards opportunism at the supplier side and may reduce the quality, price and quantity risks Manuj and Mentzer (2008a).

Furthermore, Manuj and Mentzer (2008a) describe how different strategic choices may influence the supply risks. The organization must evaluate the strengths and weaknesses of the different strategies in relation to what is most suitable for their operations. In the years before the pandemic, decisions such as offshoring and outsourcing have become increasingly more popular, especially for non-critical components. Supplier reliability, centralized or decentralized sourcing strategies, and security issues are also important factors that may affect the supply risks Manuj and Mentzer (2008a). In order to illustrate the scope of research, Figure 2 shows the inbound supply risks and outbound demand risks.

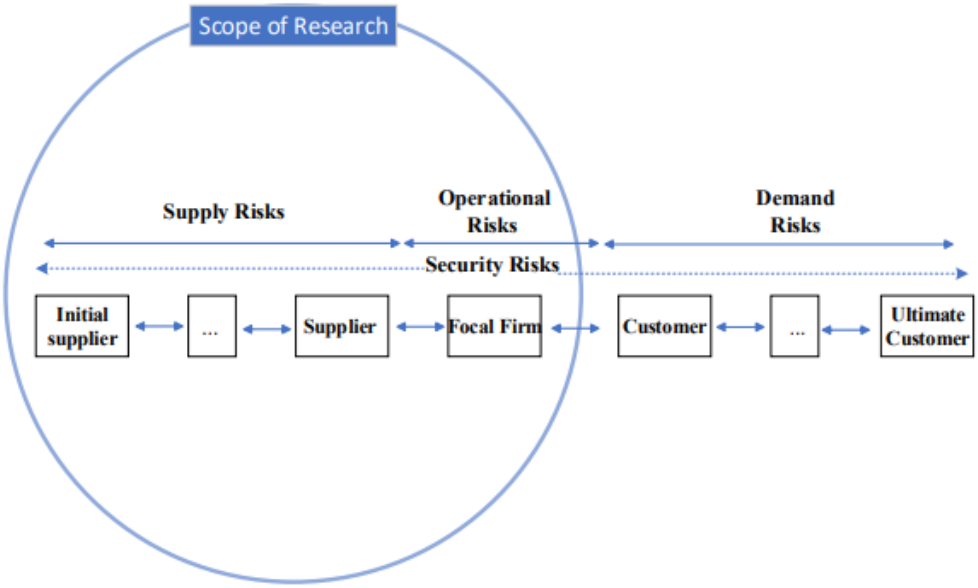

Figure 2: Risks in the extended SC, adapted from Manuj and Mentzer (2008a)

2.3 Supply Chain Risk Management

The increased use of global SC has led the SC to become longer and thus more vulnerable to risk and disruptions. Supply chain risk management (SCRM) is by Munir et al. (2020, 1) referred to as the "identification and management of supply chain risk trough coordinated approaches among supply chain partners."

Researchers are yet to agree on a common definition of SCRM. As Fan et al. (2017) states, the absence of holistic approaches to SRCM and the sub-processes that follows might give an unclear picture of the SCRM-process. Moreover, it can provide an opportunity to research more on the topic to give a common and clear understanding of the process. However, many definitions consider the integration of risks along the SC, including partners both downstream and upstream (Wieland and Wallenburg 2012).

The findings from the literature review conducted by Ho et al. (2015) shows that all of the definitions reviewed focuses on the collaboration with SC partners, but some limitations are met. Moreover, certain definitions only focus on specific elements of the SCRM, types of events, methods and their lack of spanning the SCRM process in their organization. A more recent literature review of the SCRM conducted by Fan and Stevenson (2018, 210) provided the following definition of SCRM:

> The identification, assessment, treatment, and monitoring of supply chain risks, with the aid of the internal implementation of tools, techniques and strategies and of external coordination and collaboration with supply chain members so as to reduce vulnerability and ensure continuity coupled with profitability, leading to competitive advantages.

Authors	Definition of SCRM	Scope of research
(Ho et al. 2015, 5036)	An inter-organizational collaborative endeavour utilizing quantitative and qualitative risk management methodologies to identify, evaluate, mitigate and monitor unexpected macro and micro level events or conditions, which merge adversely impact any part of a supply chain.	Extent literature review over the whole SC. Holistic approach.
Kilubi and Haasis (2015, 46)	SCRM implies the identification, assessment, monitoring and evaluation of risks and potential threats within and outside supply chain network with all members and entities involved. It supports cooperative and collaborative management of supply chain risks with the aid of adequate tools, techniques, and strategies as to mitigate or eliminate risk exposure. SCRM, therefore, aims at ensuring flexibility and agility to deliver operational excellence and to achieve superior performance and customer value.	Systematic literature review of papers published between 2000 and 2015.
(Fan and Stevenson 2018, 210)	The identification, assessment, treatment, and monitoring of supply chain risks, with the aid of the internal implementation of tools, techniques and strategies and of external coordination and collaboration with supply chain members so as to reduce vulnerability and ensure continuity coupled with profitability, leading to competitive advantages.	Extent literature review covering existing SCRM definitions. Provides future research suggestions.
Jüttner, Peck, and Christopher (2003, 201)	The identification and management of risks for the supply chain, through co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole.	Conducted in the early years of SCRM, providing a agenda for future research within SCRM.

Table 1: Definitions of SCRM

2.3.1 Conceptual framework of the SCRM process

The most used and referred to framework for the SCRM process is developed by Ho et al. (2015). The SCRM-process is divided into four steps based on the conducted literature review: (1) risk identification, (2) risk assessment, (3) risk mitigation and (4) risk monitoring. The model below is adapted from Sørland and Wembstad (2016) with a few alterations. As questions regarding sustainability is becoming increasingly more important and relevant, it will not be long before several companies must take sustainable questions into consideration. Based on this, the sustainable supply chain risk management (SSCRM) will also be included in this literature review.

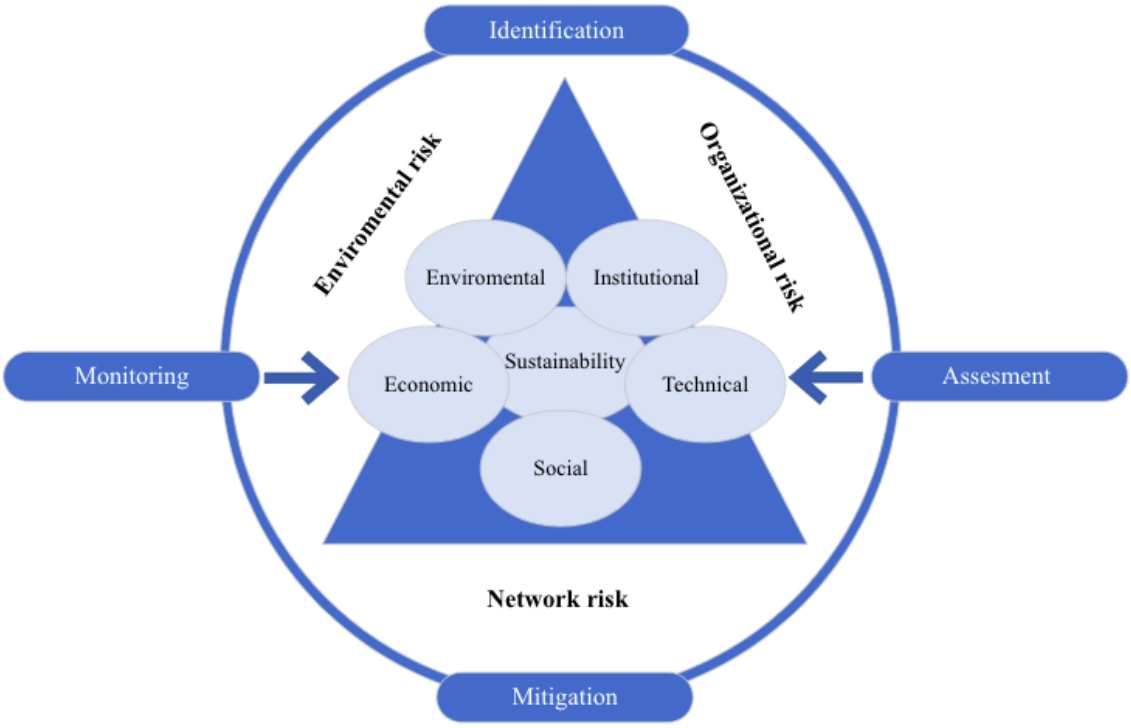

Figure 3: SCRM and SSCRM, adapted from (Sørland and Wembstad 2016 and Moktadir et al. 2021).

2.3.1.1 Risk identification

As being the first step in a risk management process, risk identification is of high importance in order to discover all relevant risk types and factors (Kern et al. 2012). This step lays the premises for further investigation of the risks identified. Accordingly, both present and potential risk sources are discovered to alert decision makers of potential events that may cause disruptions in the SC (Norrman and Jansson 2004), and it is crucial to detect possible risks to further consider if the risk identified poses a potential threat or not in order to determine whether or not they should proceed with the risk assessment (Kern et al. 2012).

2.3.1.2 Risk assessment

The next step in the SCRM-process will be to assess the risks identified in the first step. The assessment is determined by two important factors, the likelihood of occurrence and the potential severity level for the risk identified (Ferreira et al. 2018). Moreover, the process aims to provide a profound understanding of the potential risks threatening the SC, in addition to the risks strengths and weaknesses (El Baz and Ruel 2021). Fan and Stevenson (2018) reviewed 354 papers, whereas 76 referred to different risk assessment methods, where the probability-impact risk matrix was the preferred method. Furthermore, the importance of looking at risk factors beyond the focal firm's boundaries in the SC is crucial. An important objective with the risk assessment step is to prepare for the risk mitigation step that follows next (El Baz and Ruel 2021).

2.3.1.3 Risk mitigation

Risk mitigation seeks to apply the correct and suitable measures towards the supply risks, either before a disturbance occur or after (El Baz and Ruel 2021). The most applicable risk mitigation strategy may vary from different organizations and the possible risks and threats it faces (Fan and Stevenson 2018). Raj et al. (2022) reviewed different risk mitigation strategies post COVID-19 and suggested the focal firm to divide their main challenges in respectively the supply, demand and logistical side of their operations. By mapping their potential treats, firms are more resilient towards risk.

2.3.1.4 Risk monitoring

Risk monitoring is a continuously process where actors in a SC must monitor and evaluate the risks previously identified in the SCRM process (Fan and Stevenson 2018). Another vital factor that must be taken into consideration, is the possibility of new risks occurring. Hallikas et al. (2004) suggests monitoring a wide range of their operations in the SC, as well as external factors, for instance their competitors, new technology, the network and their partners' strategies. As time goes by and the possible risks may change, the risk assessment step must be updated to the new risks identified (Hallikas et al. 2004). A reoccurring subject is that researchers point out the lack of attention this process has attracted throughout the years, in comparison to the three previous steps in the process (Blackhurst, Scheibe, and Johnson 2008; Fan and Stevenson 2018).

2.4 Sustainable supply chain risk management

As a result of global SC, organizations are facing stricter audits, regulations and certifications of sustainability (Song, Ming, and Liu 2017). The term *sustainability* is described as "the degree to which firms take social and ecological criteria into account beyond minimum legal requirements" (Hofmann et al. 2014, 162). A trend in the market is that stakeholders have shifted focus from purely being business oriented towards the more social and environmental aspect of the SC operations. The objective of SSCRM is to meet the environmental, economic, and social dimensions, also referred to as the triple bottom line (Xu et al. 2019). The sustainability approach has traditionally been focused towards the mentioned dimensions, but the model was further developed by Iddrisu and Bhattacharyya (2015) to also include the entire system of an organization. The new five dimensional sustainability approach incorporated the technical, institutional, social, environmental and economic dimensions (Moktadir et al. 2021).

The focus in the literature is moving more towards a sustainability approach, yet there is no common definition of SSCRM. Köksal et al. (2017, 3) defines the SSCRM as:

> The management of material, information and capital flows as well as cooperation among companies along the supply chain while integrating goals from all three dimensions of sustainable development, i.e., economic, environmental and social, which are derived from customer and stakeholder requirements.

Carter and Rogers (2008, 366) on the other hand defines SSCRM as "the ability of a firm to understand and manage its economic, environmental, and social risks in the supply chain."

2.4.1 Social dimension risk factors

The impact of dangerous industrial events culminates in the social risk factors. Depending on the industry, the social risk factors may be such as dangerous working conditions, unfriendly relationship between top management and workers, lack of work culture and a unhealthy relationship between the SC actors (Moktadir et al. 2021). As for the manufacturing industry, Oduoza (2020) refers to the social dimensions as the human risk factors, and highlights the social risk factors in correspondence to manufacturing environment. Furthermore, risk factors such as inexperienced workers pose a much higher risk for both injuries and accidents in their first months of working in a demanding working environment, like we often find in the manufacturing sector. Moreover, due to the nature of the operations and the high demand for their products, the sectors which often have operations running 24/7, thus often make use of overtime. Tired workers have increasingly higher risks of being prone to accidents or injuries on both human personnel and facilities (Oduoza 2020).

2.4.2 Environmental dimension

The production of materials and finished goods often consist of complex operations that generates different types of waste, and in many situations the waste may be hazardous to the environment (Oduoza 2020). Moktadir et al. (2021) describe natural disasters, hazardous air emission, poor ventilation, fire, chemical accidents as possible environmental risks. By not properly dispose of hazardous material and waste the organizations image and reputation may be damaged, and consequently have a negative impact on the organizations sale and profit (Song, Ming, and Liu 2017). Moreover, Song, Ming, and Liu (2017) describe this as a “hidden influence”, meaning that the risk can be interconnected with other risk types in the SC (Chopra and Sodhi 2004).

2.4.3 Economic dimension

The economic dimension refers to the current investments made by the firms in the SC, how stable their financial situation are and the likelihood of any significant changes in their economic situation (Moktadir et al. 2021). The economic conditions the organizations must follow are regulated by policies, and Oduoza (2020) focuses on the connection between economic, political and financial factors such as inflation, cash flow, interest rate and political instability, and the impact this will have on the organizations situation.

Furthermore, the findings in the literature review conducted by Moktadir et al. (2021) show that factors such as absence of strategic planning, high maintenance cost, volatility of cost and price, lack of laws and legislation and high cost for disposing hazardous waste are all contributing to the economic dimension. Manufacturing companies often depend on raw material from other part of the world and changes in policies and import or export rate could potentially affect the economic dimension.

2.4.4 Technical dimension

Furthermore, the technical risks are related to the technical systems within an organization and the possible errors that may occur in the interaction between humans and technical systems (Moktadir et al. 2021). The literature review conducted by Moktadir et al. (2021) present different types of technical risk factors, such as lack of technical expertise, frequent machine breakdown, change in consumer preference, supplier failure, raw materials scarcity and wrong supplier selection. The intention of the technical risk factors is to work as a preventative tool when important systems break down or stop working (Moktadir et al. 2021).

As for the manufacturing sector, it has been said that the prospects are to achieve a high level of atomization in the manufacturing processes. Industry 4.0, also called the fourth industrial revolution, has enabled computers and intelligent machines to communicate with each other, without human involvement, e.g. reduces the risk of human errors (Ghobakhloo 2020). By implementing new technology the organizations are prone to new risk factors, creating the need for a up to date cyber security strategy (Oduoza 2020).

2.4.5 Institutional dimension

The last of the five dimensions are the institutional risk factors that have overall focus on how the management responds and treats risks facing the firm. Moktadir et al. (2021) found that factors such as lack of laws and legislation, internal auditing programs and the absence of strategic planning are important factors that may influence the top management positions towards risks factors.

2.5 Collaboration and information sharing

The SCRM-process is described by Munir et al. (2020) as an information sensitive process that relies on collaboration and information sharing amongst SC partners. Despite the fact that external and internal integration have been stated to improve flexibility, not all manufacturers manage to implement, thus misses out of the advantages such implementation brings (Chaudhuri, Boer, and Taran 2018). Frohlich and Westbrook (2001) sited in Chaudhuri, Boer, and Taran (2018) state that manufacturing firms who have their focus solely on the internal integration tend to miss out of the benefits from also viewing and implementing external integration.

SC integration covers three important objectives; the customer, supplier and internal integration. (Munir et al. 2020). Furthermore, this can be categorized into vertical and horizontal integrating, whereas horizontal integration covers the focal firm's competitors and other organization and vertical refers to upstream and downstream supply (Raweewan and Ferrell Jr 2018). The latter will be the subject in focus in this thesis.

When partners in a SC determines to vertically integrate, its implied that they consent to share information with their partners in order to optimize the coordination throughout the SC. Accordingly, there must be a level of trust between the partners as they disclose sensitive information about their processes, capabilities and production constraints. This will accommodate for better forecasting regarding inbound supply, as well as production planning. For the downstream side of operations, the same level of trust and information sharing applies in order to meet the customers demand (Munir et al. 2020). As Raj et al. (2022) describe, increased partnership linking the upstream and downstream firms can result in increased coordination of the entire SC network, thus improving the ability to meet the customers demand.

Furthermore, Sharma, Adhikary, and Borah (2020) discussed the need for increased implementation of collaboration in SC post COVID-19, and characterizes many of today's SC as transactional, meaning that the parties involved treats their relationship purely as a business transaction. Increased level of collaboration may facilitate for better information sharing, thus making the SC more resilient towards risks. Collaboration facilitates for shared risks between the SC partners (Sharma, Adhikary, and Borah 2020). Zsidisin *, Melnyk, and Ragatz (2005) state that integration in the SC may contribute to achieve and maintain a competitive position in the market. Moreover, the benefits from collaboration and information sharing may result in products of better quality, lower costs and reduced lead time.

2.5.1 Visibility

Ivanov and Dolgui (2020, 2905) define visibility as "the system ability to meet the demands of surviving in a changing environment." Increased coordination amongst SC partners facilitate for better visibility, thus reducing the risks and threats that may occur when not collaborating (Tang 2006). As the complexity of global SC are quite high, the need for visibility is indeed present. According to Sharma, Adhikary, and Borah (2020) visibility beyond the focal firm's direct or tier 1 supplier is not common in global SC, thus making it even more difficult to detect risks in the inbound supply. Furthermore, Spieske and Birkel (2021) address how visibility increases the probability of generating the appropriate countermeasures to an disruption in the SC.

2.5.2 Flexibility

Flexibility is defined by Erol, Sauser, and Mansouri (2010, 166) as "the ability of a system to adapt to the changing requirements of its environment and its stakeholders with minimum time and effort." Systems that incorporate flexibility practices such as postponement and flexible supply base-, transportation-, and order- fulfilment are more likely to tackle disruptions in the SC, thus being more resilient (Erol, Sauser, and Mansouri 2010; Tukamuhabwa et al. 2015). Furthermore, Chaudhuri, Boer, and Taran (2018) address the possibilities internal integration of functions such as manufacturing and purchasing may have on the flexibility of a manufacturing firm. For instance, the purchasing function may

revise their sourcing strategy to improve flexibility and consequently gain competitive advantage.

2.6 Lean and agile supply chains

Lean is characterized by minimizing waste, e.g., costs throughout their operations. When implementing this principle in the SC, the objective expands to optimize costs and operations throughout the value chain, resulting in the best possible product to the end customer (Srinivasan, Srivastava, and Iyer 2020). Similar to lean, but again different, there is the concept of agility. Tarigan, Siagian, and Jie (2021, 2) defines agile SC as "a company's ability to meet and immediate customer demand challenges by involving all internal functions of the company", and are characterized by the capability of adjusting to the changes in lead times, delivery time, surge in demand to meet the end customer's demand, e.g., the SC ability to be flexible (Christopher 2000). Accordingly, agility is most suitable in high variety environments where the demand is volatile. Contrary, predictable environments with low variety is best suitable for lean SC (Christopher 2000).

The goal of optimizing activities throughout the SC has led to an increased application of the lean principle in many SC. However, Fonseca and Azevedo (2020) argue that the extended use of this principle may cause operational conflicts due to external disruptions as the principle is intended for stable operations. Lean operations combined with global SC increase the vulnerability to epidemic outbreaks (Ivanov 2020), and the nature of the simultaneously outbreaks causes disruptions in both supply and demand, making it even more difficult to respond to the rapid changes (Fonseca and Azevedo 2020).

3.0 Research methodology

This chapter will give a review of the applied methodology. First, the research design is described in section 3.1, followed by the survey design in section 3.2. Next, the results from the data collection are described in section 3.3. The three statical methods applied are described in the last sections.

3.1 Research design

The technique of collecting data is referred to as the research method and is conducted in different forms such as by using a questionnaire, observations or interviews (Bryman 2015). It is important to differentiate the research method from research methodology, where the latter is the philosophy behind all research (Adams, Khan, and Raeside 2007). Research design is to give an overall understanding of what is to be done during the collection and analysis of data, where Schwartz-Shea and Yanow (2012, 16) refer to this as "the basic structure of a research project, the plan for carrying out an investigation focused on a research question that is central to the concerns of a particular epistemic community."

Because the previous study was conducted in a qualitative manner, this thesis will follow the same methodology in order to meet the requirement for comparison. The quantitative research strategy "emphasizes on quantification in the collection and analysis of data" (Bryman 2015, 37) contrary to the qualitative strategy which focuses "more on words rather than quantification" (Bryman 2015, 38).

Case studies are a common method to implement when researches want to investigate a specific phenomenon. Yin (2014, 16-17) states that the background for implementing such a model is the desire to understand a real-world case and provides a twofold definition of case studies as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context" that "relies on multiple sources of evidence". Furthermore, a case study can consist of both single- and multiple case designs, in which for the single case study design the research focuses on a single organization, location or event (Bryman 2015).

The matter of multiple-case studies has progressively been taken into use by researchers and allows the researcher to compare the cases in question. The comparative design allows the researchers to use similar methods to compare two or more cases in order to see if there are any significant similarities or distinctions between the cases (Bryman 2015).
In many ways, the comparative design is much alike the cross-sectional design, which is based on data collection from more than two cases, thus preferably collected at the same point of time. The goal of the cross-sectional design is to detect any variations in the data.
However, this case study is structured in a comparative way, meaning that the study repeats the case study material two times in an explicitly comparative mode (Bryman 2015).

3.2 Survey design

Due to the nature of this thesis, a new survey was not developed. Instead, the questionnaire designed by Sørland and Wembstad (2016) was used with a few moderations. Sørland and Wembstad (2016) explored both the inbound and outbound SC. Questions regarding the outbound supply e.g., transport and customer related issues, part 3 and 4 of the questionnaire, are excluded from the new version of the questionnaire. In addition, the previous questionnaire did not include questions regarding pandemic as a risk. Therefore, it was added as a variable on the two last questions in the questionnaire, regarding external factors.

Before the process of data collection began, the project was reported to the Norwegian Centre for Research Data (NSD), to ensure the correct and legal data collection. After the project was approved, the data collection started. Both primary and secondary data were used in the data collection. Primary data were collected though an online survey platform called Nettskjema.no (2022) through the University of Oslo, meeting all requirements regarding confidentiality and secure data collection determined by NSD.

3.2.1 Primary and secondary data

To distinguish and separate data, it is common to divide them into two groups: primary and secondary data. Boslaugh (2007) describes that "if the data set in question was collected by the researcher for the specific purpose or analysis under consideration, it is *primary data*." On the other hand, "if the data was collected by someone else for the same purpose, it is *secondary data*" (Boslaugh 2007). It is important to distinguish the difference between the two groups because data can change its classification depending on the nature of the project. A data set may be a primary set in a project where the researcher collects the data. If the data are used again in a new research later, it has changed to secondary data. In this project, secondary data are obtained from the university college electronic database, while primary data are collected though a new questionnaire.

Method	Primary data	Secondary data
Quantitative	Survey from 2022	
		Survey from 2016
Qualitative data		Existing literature and previous research

Table 2: Primary and secondary data used

3.2.2 Validity and reliability

According to Bryman (2015) the quality of the research is reflected in the collected data. The researcher should strive to conduct their research in a way that ensures their results to be valid and reliable, consequently conduct their research in an ethical manner (Merriam and Tisdell 2015). Cited by Merriam and Tisdell (2015), Firestone (1987) describes the importance of validity and reliability in quantitative research:

> The quantitative study must convince the reader that procedures have been followed faithfully because very little concrete description of what anyone does is provided. The qualitative study provides the reader with a depiction in enough detail to show that the author's conclusion make sense.

Furthermore, Yin (2014) explains the criteria of reliability, construct validity, internal validity and external validity as of great importance to case studies. Reliability ensures that a researcher documents and describes the research in a way that enables future researcher to conduct the same research, and most importantly conclude to the same results. In other words, the research should be transparent and replicable (Merriam and Tisdell 2015). This thesis is conducted with information extracted from previous research reported by Sørland and Wembstad (2016), and is a real life example of the importance of reliability, especially in a quantitative research.

Construct validity refers to issues connected to identifying the accurate operational measures for the subject in question, but for this to apply the researcher must collect multiple sources of evidence, for instance observations or any available documentation (Yin 2014). The next validation criteria is the internal validity. Merriam and Tisdell (2015) refers to the internal validity as another measurement of credibility. The criteria give an understanding of to what extent the findings in the research corresponds to reality. To increase and secure the internal validity, the researcher could collect multiple sources of data. Lastly, the external validity explains to which extent the findings are applicable to other studies (Merriam and Tisdell 2015).

3.2.3 Search methods

To address important and relevant theories to this thesis, a literature review was conducted. The review was carried out through search engines such as Science Direct, ProQuest, Oria – Molde University College library search engine and lastly Google Scholar. The search terms used was “Supply chain risks”, “Supply chain risk management”, Sustainable supply chain risk management”, “inbound supply”, “Covid-19”.

3.3 Results data collection

The database respondents was predetermined by Sørland and Wembstad (2016), and consists of Norwegian manufacturing firms, respectively twelve different industries. The new data collection was conducted in the time period of 2nd of March until the 6th of April. The response rate was a total of 39 out of 92 participants.

Industry	2016	2022	Response rate
Electronics	9	4	44,44%
Fisheries	17	7	41,17%
Rubber and plastic	6	3	50%
Machines and equipment	12	10	83,33%
Food and drink	21	6	28,57%
Metal goods	5	3	60%
Furniture and textile	5	1	20%
Paper and paper products	2	1	50%
Ships and equipment	12	3	25%
Lumber and equipment	1	1	100%
Total	92	39	42,39%

Table 3: Questionnaire response rate 2022

3.4 Factor analysis

When conducting analysis based on results from a questionnaire, factor analysis is regarded as one of the preferred methods. The factor analysis is a multivariate statistical procedure, meaning that the analysis allows the researcher to reduce a large number of variables into a smaller set of factors (Williams, Onsman, and Brown 2010). Factor analysis aims to determine the "underlying dimension between measured variables and latent constructs" (Williams, Onsman, and Brown 2010, 2). This method is used by researches to examine if there is any correlation between the variables in the model, and ultimately determine if there are any latent variables affecting the factors generated (Williams, Onsman, and Brown 2010). An important dimension to this model, is whether to what degree the variables correlates to other variables within the factor they load on. A common criterion to the correlation level is with a loading value preferably ≥0.50. Values at this level are viewed as practically significant. Nevertheless, values below this level (≥0.40 or ≥0.30) may be accepted in some situations, but to ensure a high correlation researchers should strive to achieve the highest loading values (Williams, Onsman, and Brown 2010). Williams, Onsman, and Brown (2010) further describes that for a factor to be valid and significant, at least two or three variables should load at the same factor, and the eigenvalue of the factors should be >1. As the figure below illustrates, variables may load on multiple factors. The variable may also be affected by measurement errors (Columbia Public Health 2015).

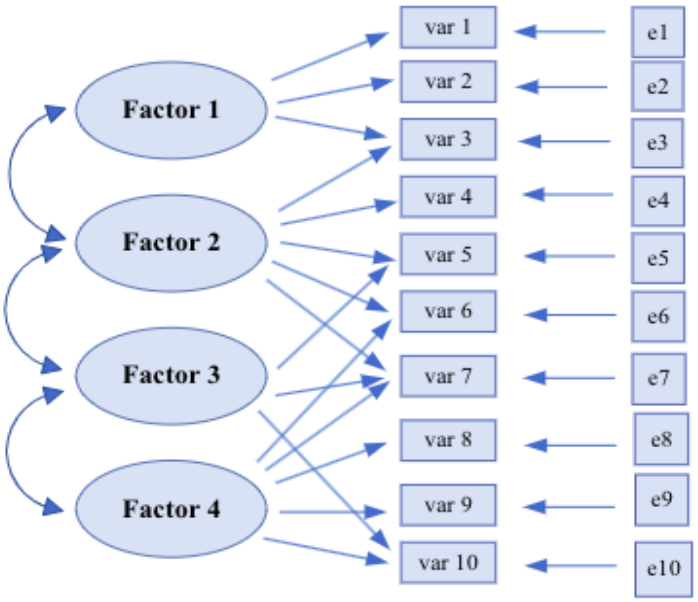

Figure 4: The Exploratory Factor Analysis structure, adapted from (Columbia Public Health 2015)

3.5 Cronbach Alpha

The Cronbach alpha measures internal consistency, meaning that it measures to what extent a group of variables are related (Bonett and Wright 2015). The objective of this model is to ensure that each variable has a high correlation with the other variables in the group. The result of the correlation, e.g., the alpha value, gives an understanding if the measurement accuracy if sufficient or not. According to Bonett and Wright (2015), the lower bound for accepting the correlation normally lies within the bound of $\alpha \geq 0.80$. Due to the small sample size of the data collected, the adjusted lower bound is sat to $\alpha \geq 0.70$. When measuring the internal consistency, e.g., the correlation between the variables loading on a factor generated from the factor analysis, the Cronbach Alpha result should show an alpha value a $\alpha \geq 0.70$, indicating a sufficient reliability (Harerimana and Mtshali 2020). The formula for calculating the Cronbach alpha value is defined in Spiliotopoulou (2009) as:

$$p = \frac{\alpha}{n - (n-1)\alpha}$$

Where p is the estimator of the reliability, α is the coefficient alpha and lastly, the number of items is denoted by n.

3.6 Wilcoxon rank sum test

The Mann-Whitney test, also referred to as the Wilcoxon rank-sum test and Mann-Whitney U-test is a non-parametric test that does not assume a normal distribution (Harpe 2015; Bergmann, Ludbrook, and Spooren 2000).

The applied method in this thesis will be the Wilcoxon rank sum test, thereby comparing the rank sum for two samples, in this case 2016 and 2022. Newbold, Carlson, and Thorne (2010) state that the current test is suitable for sample sizes containing at least 10 observations. Furthermore, each observation in the data set have been collected using the Likert scale, providing observed values on the rank from 1-5. The Wilcoxon rank sum calculates the observed ranks in the two independent samples, which generates the final P-value (Marx et al. 2016). The Wilcoxon rank sum is defined by the following formula Newbold, Carlson, and Thorne (2010, 667-668):

Mean:

$$E(T) = \mu_T = \frac{n_1(n_1 + n_2 + 1)}{2}$$

and variance:

$$Var(T) = \sigma_T^2 = \frac{n_1 n_2(n_1 + n_2 + 1)}{n_1 + n_2}$$

to find the final p-value:

$$Z = \frac{T - \mu T}{\sigma_T^2}$$

Where n_1 are the observations for the first population and n_2 represent the second population.

Moreover, when the p-value is determined, hypothesis testing is used to detect whether the findings between the two groups(years) are significant or not. The null hypothesis H_0 states that there is no statistically significant difference between the two groups, contrary the alternative hypothesis H_1 states that there is a statistical significant difference (Bergmann, Ludbrook, and Spooren 2000). The p-value is sat at p-value *≤ 0.1 or ** ≤ 0.05.

4.0 Research summary

The COVID-19 pandemic disrupted global SC with great magnitude in a way no one had foreseen. The unpredictable scaling of the virus made it particularly difficult to forecast operations, and new global containment policies were implemented, resulting in closed borders, travel restrictions and quarantines (Ivanov 2020; Fonseca and Azevedo 2020). In the years leading up to the outbreak of the pandemic, the topic of SCRM had gained much attention and the topic has never been more relevant. This study has investigated the changes in inbound SCRM. The literature shows that despite the fact that the topic is well researched, there is yet much to be done, for instance creating a common definition and understanding of the topic. This research has brought attention to the importance of inbound SCRM, and the need for Norwegian manufacturing companies to take actions towards risks. As this is a comparative study, the data collection consisted of the data collected in this research and the results from previous survey conducted by Sørland and Wembstad (2016), provided by Molde University College database. The new survey was sent out to all 92 respondents from the previous survey. The new survey had a total of 39 respondents.

The results from the analysis indicates that there is a significant difference in how Norwegian manufacturing companies rates the likelihood of an external event to occur. The new governmental policies also seem to have had an influence on transportation of raw material and goods, as there is a significant change towards how often the respondents experience inbound delays. However, there is still several important dimensions that do not show any significant changes, such as the variables regarding lean, collaboration and information sharing. Lean manufacturing SC is suitable for normal operations and does not react well to unpredicted major disruptions. Moreover, the results from the variables regarding collaboration and information sharing indicates that there have not been any notable measures in order to improve the respondent's inbound collaboration and information sharing. However, the results indicate a change in Norwegian companies towards a more attentive risk management focus.

4.1 Managerial implications

As one of the first researches, this study aims to examine the changes in inbound SCRM within Norwegian manufacturing companies before and after the COVID-19 pandemic. The findings show an increasing awareness towards external risk factors. However, there are little or no indication that the companies in question plan to implement sufficient measure to reduce or tackle the potential risks. This research addresses the potential for improvement regarding inbound SCRM, where the level of collaboration and information sharing processes do not meet the required level to manage the different dimensions of risks.

4.2 Limitations of the study

One important limitation of this study is the number of respondents. The study aims to investigate the changes within inbound SCRM in Norwegian manufacturing companies, where the previous study conducted by Sørland and Wembstad (2016) had a total of 92 respondents. Due to the uncertainty in the current market, many organizations did not have time to answer to the survey, which resulted in a total of 39 respondents.

4.3 Suggestions for further research

This research was limited to the inbound SCRM in Norwegian manufacturing companies. The subject of COVID-19 and SCRM has created many possible areas for further research. As this study has investigated the inbound SCRM it lays the premises for further comparison to the outbound SCRM as well. Moreover, it is not only the Norwegian manufacturing sector that would benefit from such an analysis, but the research may be transferred to other counties and industries. As the stakeholders and consumers in the world are becoming increasingly more focused on sustainability, it opens the field of SSCRM.

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6.0 Part II: The Research Paper

A comparative case study of inbound supply chain risk management (SCRM) in Norwegian manufacturing companies before and after COVID-19

A comparative study of inbound supply chain risk management (SCRM) in Norwegian manufacturing companies before and after COVID-19

Abstract

Purpose: The purpose of this research is to analyze changes in inbound supply chain risk management (SCRM), before and after the COVID-19 pandemic.

Methodology: The collection of primary data was conducted through an online survey. Secondary data from a previous master thesis was accessed through Molde University Colleges database. The sample size of each dataset was 39 companies.

Findings: Results from this research indicated an increased awareness of external risks. No further measures were implemented in order to tackle the risks identified, or to increase collaboration and information sharing in the inbound logistics.

Originality/value: This research is one of the first empirical studies to compare the effects of the COVID-19 on manufacturing firms.

Keywords: Supply chain risk, supply chain risk management, sustainable supply chain management, COVID-19, collaboration, information sharing, flexibility.

Introduction

For many years, supply chain risk management (SCRM) has been an important topic within the field of supply chain (SC) management. The topic has recently been receiving more attention, due to the COVID-19 pandemic. Causing disruptions of a kind never seen before, the pandemic illustrated how vulnerable global SC are with regards to disruptions that affect both demand and supply simultaneously (Fonseca and Azevedo 2020). Closed borders and containment policies created great difficulties in the transportation of raw material and goods, resulting in higher lead times and delays (Raj et al. 2022). As an industry that is dependent on raw material in many operations, the manufacturing sector was heavily impacted by the pandemic. El Baz and Ruel (2021) describe how Fortune (2020) reported that the pandemic affected around 94% of the top 1,000 companies in a negative way.

Authors have yet to agree on a definition for supply chain risk or SCRM, but they do agree on the importance of the subject. Ho et al. (2015) divided risks into macro and micro risks, while Jüttner, Peck, and Christopher (2003) classified risks as environmental-, organizational- and network-related risks. A conceptual framework was developed by Ho et al. (2015), emphasizing on risk identification, assessment, mitigation and monitoring.

Despite the fact that SCRM is a well-researched topic, there seems to be potential for improvement in the implementation of strategies within many organizations. Varzandeh, Farahbod, and Zhu (2016) investigated how different sized companies took advantage of risk management, showing that smaller firms did not have the necessary strategies to either avoid or mitigate risks caused by global SC disruptions. On the other hand, larger firms had partially implemented risk management and tried to avoid risks instead of rearranging their operations after a distruption.

As a consequence of the negative effects the pandemic has had on many organizations, this might be an impetus towards a shift in focus towards SCRM. However, this has not been documented by other researchers. This paper therefore analyzes the changes in inbound SCRM in Norwegian manufacturing companies, before and after the COVID-19 pandemic.

Literature review

The recent COVID-19 pandemic disrupted global SC in an unpredictable manner, shedding light on how vulnerable SC are, especially when unforeseen distributions affect supply and demand simultaneously (Fonseca and Azevedo 2020). The current market has been growing increasingly more dependent on global SC: it is a quickly changing environment characterized by a complex network of SC partners, resulting in a higher level of vulnerability (Munir et al. 2020). Ivanov and Dolgui (2020) describe the effects of the pandemic as the worst disruption in history to global SC. The disruptions affected every link of organizations' SC, all the way from upstream to downstream logistics. As new governmental containment policies such as closed borders and travel restrictions (Castka et al. 2021) were set in motion, global SC's were heavily affected. The policies, especially those affecting the inbound transportation of raw material and goods, contributed to delays in the production of goods and materials. The delay of incoming deliveries led to higher lead times, affecting the manufacturers' ability to meet customers' demands of short delivery times (Raj et al. 2022). The delay of inbound supply may result in a ripple effect, delaying operations and flow of materials all the way to the end customer.

Siagian, Tarigan, and Jie (2021) describe how the manufacturing industry was heavily impacted by the pandemic. This sector relies heavily on raw material, with India and China as two of the main providers. Consequently, a 50% decrease in the industry's productivity was reported while running at a capacity level of 49% as a result of the new containment policies. Moreover, Fortune (2020), as cited in El Baz and Ruel (2021) stated that the outbreak affected around 94% of the top 1,000 companies in a negative way. Transportation delays, higher lead times and inability to run operations at the desired capacity may result in financial consequences for both a firm itself and their partners in their SC. As stated by Ivanov and Dolgui (2020), both local and global economies have been substantially affected by the COVID-19 outbreak.

Many SC have successfully implemented the lean principle in order to reduce waste, (e.g., reducing costs in unnecessary movement along organizations' operations, yet securing a final product that meets the end customers' demands). Other benefits from a lean production include a shorter lead timer, lower production costs, and increased output (Agus and Shukri Hajinoor 2012). As Fonseca and Azevedo (2020) describe, these SC are suitable for normal operations, and not for disruptions such as the COVID-19 pandemic. Castka et al. (2021)

also point out how lean SC work well in stable operations yet struggle in environments characterized by uncertainty and disruptions.

Supply chain risk management

For many years, SCRM has been an important subject, but it is only in the recent years and especially after the COVID-19 pandemic, that the topic has gained momentum. Still, there is no consensus among authors and researchers regarding a common definition of SCRM, Fan and Stevenson (2018, 210) provide a definition based on their literature review and former definitions:

> The identification, assessment, treatment, and monitoring of supply chain risks, with the aid of the internal implementation of tools, techniques and strategies and of external coordination and collaboration with supply chain members so as to reduce vulnerability and ensure continuity coupled with profitability, leading to competitive advantages.

Among authors, there are different ways of classifying risks and three groups of authors in particular have drawn much attention for their risk classifications. Jüttner, Peck, and Christopher (2003) categorized risks into three main groups, organizational risks, environmental risks, and network-related risks. Manuj and Mentzer (2008) divided risks into four categories (demand, supply, operational, and security risks), while Ho et al. (2015) divided them into macro- and micro risks. Furthermore, Ho et al. (2015) developed a conceptual framework for the SCRM process consisting of four steps: (1) risk identification, (2) risk assessment, (3) risk mitigation, and (4) risk monitoring. The first step is to identify all relevant present and potential risk factors that may disrupt SC operations (Norrman and Jansson 2004). Once risks are identified, they must be assessed to understand their possible impact on the SC (El Baz and Ruel 2021).

Risk assessment concerns two essential factors, the likelihood of occurrence and the potential severity level of the identified risks (Ferreira et al. 2018). The next step aims to apply the most suitable measures to the risks assessed, preferably before a disturbance occurs (El Baz and Ruel 2021). The fourth step in this process, monitoring, is considered to be a continuous process where the risks identified are monitored and evaluated (Fan and Stevenson 2018). Hallikas et al. (2004) point out the possibility of new risks occurring as well.

Collaboration and information sharing

SCRM is described by Munir et al. (2020) as an information sensitive process that is dependent on the level of collaboration and information sharing processes amongst SC partners. SC collaboration can be divided into vertical and horizontal collaboration, where vertical collaboration connects the upstream and downstream supply and horizontal integration includes other companies and competitors within the sector (Raweewan and Ferrell Jr 2018). Furthermore, Munir et al. (2020) refer to internal integration as the connection between functions within an organization such as purchasing, manufacturing and sales, whereas external integration connects suppliers and customers to the focal firm.

The benefits achieved by implementing SC integration have been discussed by several researchers, and are considered to exceed the possible risks it may involve (Raweewan and Ferrell Jr 2018; Chaudhuri, Boer, and Taran 2018). Moreover, Siagian, Tarigan, and Jie (2021) discuss the benefits of both upstream and downstream integration, as they allow the partners in a SC to access information quickly. Integration may also be part of a company's strategic business plan to benefit from sharing information with its partners. This creates an opportunity for an overview of the upstream as well as the downstream logistics, making it possible for a company to forecast production based on information they otherwise not would have access to.

A successful integration amongst partners in a SC is dependent on their willingness to share valuable information about their operations with each other. Many companies hesitate to share this information with their SC partners, and without a level of trust between the actors, they may be even more reluctant to share information. According to Munir et al. (2020) information sharing allows a company's partners to gain access to information about their processes, capabilities, and constraints.

Collaboration and information sharing have gained much attention in recent years due to the many benefits they bring, such as improved flexibility. Siagian, Tarigan, and Jie (2021, 4) defines flexibility as "a company's ability to adapt the SC practices following environmental changes to improve performance." The flexibility of manufacturing companies is to some extent related to their suppliers' ability to be flexible with regards to delivery, volume and order size. Without a flexible supplier, a firm could not be flexible enough to make changes in their production, thereby failing to meet the customer's demands (Siagian, Tarigan, and Jie 2021).

Research methodology

This comparative case study is based on research conducted by Sørland and Wembstad (2016), and thus the questionnaire they used was also used in this research, with a few modifications. The observations were collected using a Likert scale ranging from 1 to 5. First, the secondary data was accessed through Molde University College's database. The respondent companies from the 2016 dataset were used as a template for the primary data collection, and so the new survey was sent out through email to the same companies. The emails were sent to key personnel within the purchasing or logistics departments and contained necessary information about the project and a link to the online survey platform Nettskjema.no (2022) provided by the University of Oslo. The platform ensures secure data collection and anonymity to the respondents.

The database consisting of Norwegian Manufacturing firms was compiled by the research conducted by Sørland and Wembstad (2016). The data collection was conducted between the 2nd of March and the 6th of April 2022. The final response rate was 42%, 39 out of 92 possible respondents. Table 2 displays the responses rate for each industry.

Industry	2016	2022	Response rate
Electronics	9	4	44,44%
Fisheries	17	7	41,17%
Rubber and plastic	6	3	50%
Machines and equipment	12	10	83,33%
Food and drink	21	6	28,57%
Metal goods	5	3	60%
Furniture and textile	5	1	20%
Paper and paper products	2	1	50%
Ships and equipment	12	3	25%
Lumber and equipment	1	1	100%
Total	92	39	42,39%

Table 4: Questionnaire response rate 2022

Analyzing tool

The methods applied in this research were the Wilcoxon rank sum test, factor analysis, and Cronbach alpha. First, the Wilcoxon rank sum test – also referred to as the Mann-Whitney U test was conducted. As a non-parametric test that does not assume a normal distribution (Harpe 2015; Bergmann, Ludbrook, and Spooren 2000), this method was perceived to be appropriate for the data collected. The observations obtained were then calculated by the rank sum. This method generates the p-value, which determines whether the differences are significant between the two groups (Marx et al. 2016). The p-value was set at ≤ 0.1 or ≤ 0.05 due to the small sample size.

The Wilcoxon rank sum test detected which variables showed a significant change between the two years. From this point forward, factor analysis was used. Factor analysis is one of the preferred methods for analyzing data collected via a questionnaire because of its structure as a multivariate statistical procedure and ability to reduce a large number of variables into different factors (Williams, Onsman, and Brown 2010).

The objective of this method is to discover the "underlying dimensions between measured variables and latent constructs" (Williams, Onsman, and Brown 2010, 2). Additionally, to determine what latent variables affect the different factors in the analyses, the level of correlation between the two is used. The level of correlation between the variables loading on the same factor should preferably be ≥ 0.50 to ensure the highest possible loading values, but in some cases where it is deemed necessary, loadings at ≥ 0.4 may be applicable, thus reducing the reliability of the factor (Williams, Onsman, and Brown 2010). This research will approve values ≥ 0.50.

Lastly, the Cronbach alpha was used to measure the internal consistency between variables loading on a factor (Bonett and Wright 2015). The Cronbach alpha result indicates whether the measurement accuracy is sufficient. Bonett and Wright (2015) state that the lower bound for the Cronbach value should be $\alpha \geq 0.80$ to ensure a high internal consistency. Nevertheless, this research accepted an alpha value at $\alpha \geq 0.7$ due to the small sample size. Every statistical method was analyzed through STATA.

According to Flannelly, Flannelly, and Jankowski (2014) the objective of any research is to examine and understand the source to a phenomenon, whereas the independent variable is believed to influence another variable, e.g., the dependent variable.

This research aims to see how the independent variables as listed in Table 3 affect the dependent variable: inbound SCRM. Two variables, information sharing 2.14 (2) and collaboration 2.14 (1), were deleted from the analysis due to their low factor loading.

Variable	Question / statement
Dependent variables	
Inbound SCRM	2.14 (6), 2.14 (7), 2.14 (8)
Independent variables	
External factors	3.1 (3), 3.1 (4), 3.1 (5), 3.1 (6), 3.1 (7), 3.1 (8), 3.1 (9)
Financial consequences	3.2 (7), 3.2 (8), 3.2 (9)
Information sharing	2.14 (4), 2.14 (5)
Collaboration	2.14 (3)
Inbound delay	2.4
Lean	2.11

Table 5: Variables used in the analysis

Table 3 displays an overview of the descriptive statistic of the data collected.

		2016 / 2022				
Question	**No. of observations**	**Min**	**Max**	**Mean**	**Median**	**Std.dev.**
2.4: Inbound delay	38 / 39	1 / 1	3 / 4	1.84 / 2.56	2 / 2	0.82 / 0.85
2.11: Lean	24 / 39	1 / 1	5 / 6	3.12 / 3.84	3 / 4	1.36 / 1.88
2.14 Statement 3	39 / 39	1 / 1	5 / 5	3.23 / 3.25	3 / 3	1.42 / 1.14
2.14 Statement 4	39 / 39	1 / 2	5 / 5	3.33 / 3.53	4 / 3	1.08 / 0.99
2.14 Statement 5	38 / 39	1 / 1	5 / 5	2.84 / 2.76	3 / 3	1.38 / 1.01
2.14 Statement 6	39 / 39	1 / 1	5 / 5	3.28 / 3.10	3 / 3	1.25 / 1.07
2.14 Statement 7	39 / 39	1 / 1	5 / 5	3 / 2.84	3 / 3	1.29 / 1.06
2.14 Statement 8	39 / 39	1 / 1	5 / 5	3.17 / 3.25	3 / 3	1.55 / 1.27
3.1 Statement 3	35 / 39	1 / 1	3 / 5	1.08 / 2.92	1 / 3	0.37 / 1.49
3.1 Statement 4	35 / 39	1 / 1	3 / 5	1.17 / 2.02	1 / 2	0.51 / 1.11
3.1 Statement 5	35 / 39	1 / 1	3 / 5	1.28 / 2.76	1 / 3	0.57 / 1.18
3.1 Statement 6	35 / 39	1 / 1	3 / 4	2.05 / 2.43	2 / 2	0.72 / 0.96
3.1 Statement 7	35 / 39	1 / 1	4 / 4	2.17 / 2.23	2 / 2	0.89 / 0.95
3.1 Statement 8	35 / 39	1 / 1	4 / 4	2.05 / 2.46	2 / 2	0.96 / 0.78
3.1 Statement 9	34 / 39	1 / 1	4 / 5	2.52 / 3	3 / 3	0.82 / 0.88
3.2 Statement 7	35 / 39	1 / 1	5 / 5	3.34 / 3	4 / 3	1.39 / 1.19
3.2 Statement 8	35 / 39	1 / 1	5 / 5	3.2 / 2.89	3 / 3	0.96 / 1.07
3.2 Statement 9	35 / 39	1 / 1	5 / 5	3 / 3.17	3 / 3	1.21 / 1.09

Table 6: Descriptive statistics from 2016 and 2022

Factor Analysis

The factor analysis was conducted using data from both 2016 and 2022. The analysis resulted in five factors for the 17 variables included. The total number of observations in the final matrix is 61, with all but one variable loading on a factor. Nevertheless, the variable 2.11(lean) is included in the matrix due to its significance in the Wilcoxon rank sum test. To ensure the applicability of the factors, all used factors had an eigenvalue >1 (Stevens 2012). Furthermore, all variables but one had a loading value above 0.5. Variable 2.14 (4) had a loading factor of 0.4753 but was included in the analysis because of its importance regarding information sharing and proximity to the boundary value of 0.5. Each factor in the generated model had at least two or three variables loading.

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
2.4	**0.6529**	-0.2146	0.1552	-0.0825	-0.2821
3.1 (3)	**0.8586**	0.0138	0.0039	0.0760	-0.0511
3.1 (4)	**0.8191**	-0.0130	0.1243	0.1183	0.0210
3.1 (5)	**0.8580**	0.0021	-0.0127	0.1732	0.0354
2.14 (3)	0.0317	**0.7638**	-0.0937	-0.0959	0.0395
2.14 (6)	-0.1107	**0.7659**	-0.2405	0.0882	0.1887
2.14 (7)	-0.0127	**0.7464**	-0.1987	-0.0564	0.1361
2.14 (8)	-0.0112	**0.6471**	-0.0878	0.0438	-0.1340
3.2 (7)	0.0122	-0.0378	**0.6829**	0.0746	-0.4006
3.2 (8)	0.0103	-0.1858	**0.8504**	0.0565	-0.0424
3.2 (9)	0.1999	-0.2727	**0.7354**	0.1162	0.1155
3.1 (6)	0.1565	0.1151	0.2288	**0.6592**	0.0391
3.1 (7)	0.0419	0.1273	0.0552	**0.7289**	-0.2361
3.1 (8)	0.2048	-0.1918	-0.0265	**0.6828**	0.1548
3.1 (9)	0.4199	-0.1971	0.1550	**0.5838**	0.0199
2.11	-0.0815	-0.0333	0.0883	0.3334	-0.3411
2.14 (4)	-0.0485	0.3762	-0.0546	0.0238	**0.4753**
2.14 (5)	-0.1743	0.4062	-0.1622	-0.0582	**0.5807**

Table 7 - Factor Analysis results

The results from the internal consistency test are presented in Table 5 below. Factor 1, which consists of three external variables and one variable regarding inbound delays, shows the highest alpha value achieved in this analysis, $\alpha = 0.8757$. This indicates that the variables that load on Factor 1 has a high internal consistency, and it is accepted as a factor. The next factor generated in the factor analysis concerns the variables of inbound SCRM and collaboration, with an alpha value of $\alpha = 0.7710$, which is acceptable. Financial consequences of an external event form the third factor also met the required level of internal consistency with $\alpha = 0.7712$. The fourth factor, which concerns the external risks regarding suppliers, also met the required level, $\alpha = 0.7575$. However, the information sharing factor shows a lower alpha value than desired. At a level of $\alpha = 0.6815$. it is in the borderline of what may be accepted, and thus it was be accepted with reservations. The requirements for internal consistency between variables loading on the same factor were met. The variable measured by question 2.4 (lean) does not load to any factor, and therefore it is not included in any alpha measures.

Factors	Cronbach's Alpha
Factor 1	0.8757
Factor 2	0.7710
Factor 3	0.7712
Factor 4	0.7575
Factor 5	0.6815

Table 8: Cronbach's Alpha results

Results

The Wilcoxon rank sum test shows whether there are any changes between two independent groups. Consequently, the decision to extract the external factors variable was made due to the variable's low p-value, implying a significant change from 2016 to 2022. As presented in Table 5, significant changes were observed in the variables referring to external factors, economic consequences, inbound delay, and lean. The latter describes the extent to which companies' most important suppliers practice the lean principle, and the rank sum for this observation in 2016 is much lower than the corresponding rank sum for 2022. This can be explained by the small sample size in 2016 of 24 observations. The variables concerning inbound collaboration, information sharing, and SCRM did not undergo any significant changes.

Variable	Question/statement	Rank sum	P-value
External factors	3.1 (3)	812 / 1962.5	0.0000**
	3.1 (4)	984 / 1791	0.0000**
	3.1 (5)	834.5 / 1940.5	0.0000**
	3.1 (6)	1166 / 1609	0.0930*
	3.1 (7)	1301 / 1474	0.8957
	3.1 (8)	1137 / 1638	0.0446**
	3.1 (9)	1078 / 1623	0.0347 **
Financial consequences	3.2 (7)	14428 / 1347	0.2000
	3.2 (8)	1457 /1318	0.0982*
	3.2 (9)	1281 / 1494	0.7249
Inbound SCRM	2.14(6)	1598/1483	0.5534
	2.14(7)	1588/1493	0.6239
	2.14(8)	1530.5/1550.5	0.9218
Information sharing	2.14(4)	1471.5/1609.5	0.4740
	2.14(5)	1480.5/1522.5	0.9874
Collaboration	2.14(3)	1542.5/1538.5	0.9836
Inbound delay	2.4	1168/1835	0.0008**
Lean	2.11	651.5/1364.5	0.0938*
P-value: *≤ 0.1 and ** ≤ 0.05			

Table 9: Results from the Wilcoxon rank sum test

Discussion

The purpose of this research is to compare the changes in inbound SCRM between 2016 to 2022.

External risk factors

The results from the Wilcoxon rank sum test show that there is a significant difference in how the respondents evaluated the likelihood of an external risk in 2016 and 2022. The external variables 3.1(3), 3.1(4), 3.1(5), regarding armed conflict, terrorism, and unstable political circumstances, all had p-values of 0.0000, indicating a significant change in how companies assessed the likelihood of such an event occurring. Wu, Blackhurst, and Chidambaram (2006) mention political issues and governmental regulations as factors that may increase uncertainty. Furthermore, the external variable referring to accidents, 3.1(6), shows a p-value just below the predetermined significance level $p \leq 0.1$, with a value of 0.0930. This indicates that companies assessed accidents to be more likely to happen in 2022 compared to 2016. It is difficult to determine what this change may have been influenced by; it might be due to the increased uncertainty in the market.

The next external variable showing significant change is variable 3.1(8), measuring how a company assesses the likelihood of their suppliers going on strike, which has a p-value of 0.0446. This variable may be affected by companies' rating of unstable political circumstances. Such political circumstances may affect the working conditions within an organization, as well as law and regulations on a larger scale. Furthermore, the external variable referring to transport problems, 3.1(9), also shows a significant change with a p-value of 0.0347. This may be explained by the injunctions implemented to prevent the spread of the virus, such as closed borders, quarantine, and travel restrictions. By increasing the possibility of an unexpected event occurring to the transportation, the lead time and delays of goods and raw materials are increased.

The only external variable whose p-value does not show a significant change is 3.1(7), referring to the likelihood of suppliers going into liquidation, with a p-value of 0.8957. One possible reason for this may be the trust the focal firms have in their suppliers, or their confidence that their supplier audits are performed using the right criteria, thus securing a supplier with financial stability (e.g., reducing the likelihood of going into liquidation). The pandemic may have increased the responding companies' awareness of external risks (e.g., influencing companies to rate the likelihood of an external event higher after the pandemic).

Financial consequences

The financial consequences manufacturing firms face if an external risk occurs are described next. Out of the three variables, only one variable, 3.2(8), shows a significant change in the Wilcoxon rank sum test. This variable is related to suppliers or subcontractors going on strike. When the results of financial consequences in the current variable are seen in the context of the external factors, both show a significant change. As companies rate the likelihood of their suppliers going on strike higher, the financial consequences of this event occurring also increase. One possible explanation for why the financial consequences are rated higher in 2022 may be connected to the difficulties of finding a new supplier in an unstable market. Many of the providers in the market are dealing with late deliveries and scarcity of raw material, which makes it even more difficult for manufacturing firms to find substitutes for their current suppliers. On the other hand, the financial consequences of their suppliers going into liquidation, 3.2(7), and transport problems, 3.2(9), do not show any significant changes. It is unclear to why the companies rated the likelihood of these events higher in 2022 than in 2016 but not the financial consequences.

Collaboration and information sharing

The variables of collaboration and information sharing does not show a significant change in the Wilcoxon rank sum test, indicating that the respondents have not taken any notable measures to increase their level of collaboration and information sharing to improve their inbound SCRM. This supports the statement from Sharma, Adhikary, and Borah (2020) that the effects of COVID-19 on the SC have created a new and obvious need for collaboration among SC partners.

The lack of change and focus on the information sharing and collaboration variables is ultimately reflected in the inbound SCRM variable. This variable shows no significant changes, meaning that companies treat the inbound SRCM similar to how they treated it before the pandemic, or at least had no increased focus on this area. When there is little focus on increasing collaboration and information sharing with their most important suppliers, the quality of inbound SCRM is reduced. One possible explanation for why the responding companies did not show a significant change in the variables of collaboration, information sharing, or inbound SCRM may be due to lack of knowledge within their organizations. Another possibility may be the short time from the pandemic to when the survey was conducted. Perhaps the companies are internally shifting their focus and planning to change their risk management in the future, but this was not reflected in the data collected.

Inbound delay

Moreover, the variable of inbound delay, 2.4, shows a significant change, with a p-value of 0.0008. This indicates that the companies experience delays from their most important suppliers more often now than before the pandemic. As Raj et al. (2022) point out, transportation restrictions have affected the flow of material and goods, resulting in higher lead times and longer delivery times to the end customer. This variable indicates that the focal firms are aware of external risks and delays are more frequent than before. Despite this, there is no indication that they have taken any notable actions towards reducing the external risks.

Lean

The analysis shows a significant change in whether suppliers follow the lean principle. As discussed by Fonseca and Azevedo (2020) and Castka et al. (2021), lean SC are designed for normal operations and are thus not suitable under disruptive conditions, such as the COVID-19 pandemic. In the wake of the pandemic, it is clear that lean manufacturing does not adapt well to major disruptive events. Accordingly, in situations where the supplier practices a high level of lean in their operations, the ability to be flexible with the manufacturing firm is reduced.

Conclusion

This paper investigates the changes in inbound SCRM in Norwegian manufacturing companies before and after the COVID-19 pandemic. The findings show that companies today are more focused on some factors concerning risk management. Still, there are several important SCRM dimensions that the companies do not emphasize in their risk management. This may be due to lack of knowledge within the organization or too short of a time from the COVID-19 outbreak to when the survey was conducted. However, the research found clear connections between several important variables and an increased level of significance in many variables, indicating a change in Norwegian manufacturing firms towards a more attentive relationship concerning inbound SCRM.

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Appendix

Questionnaire relating to risks and delays- Manufacturing companies
Part 1: General part

1.1 Company name_____

1.2 Position_____

1.3 How would you describe the production/products of your company?
Answer:
Standard product, make to stock _____
Standard product, make to order ____
Specialized product, make to order____
Customized product, engineered to order ____
Combination of two or more, which one? _ _ _ _ _ _ _ _ _ _

Part 2 Questions for suppliers
In this part of the questionnaire we would like you to base your answers on the most important or strategic products that you purchase.

2.1 How often do you have deliveries coming in?
Answer:
Several times per day
3 times per week
2 times per week
Once a week
Every 14.day/infrequent
Don't know

2.2 What are the approximate average delivery times of your most important suppliers?
Answer:
delivery times is ____ days
____weeks
____month

2.3 How often do you make use of urgent orders from your most important suppliers?
Answer:
2-3 times per week
Once a week
Every 14.day
Once a month
More infrequently
Don't know

2.4 How often do goods arrive late from your most important suppliers?
Answer:

1 = very rarely 2 3 4 5 = almost always Don’t know

2.5 How long could a delay last for, on average?
Answer:
1day 2 days 3 days 4 days More than 4 days Don’t know

2.6 How often do you receive damaged goods from your most important suppliers?
Answer:

1 = very rarely 2 3 4 5 = almost always Don’t know

2.7 What are the consequences for your company if deliveries arriving from your most important suppliers are delayed or damaged?
Answer:
None___
Production stops___
Larger economic loss for our company ca in EUR_____
Delay for the rest of the supply chain ____
Economic compensation from the supplier as day tickets (payment), ca in EUR_____
Loss of sale for our customers____
Hiring extra workers on evenings/weekends___
We have to organize faster and more expensive transportation to reduce the delay___
Other (specify)_____
Don’t know ___

2.8 Do you have any reserve suppliers for the most important products that you purchase?
Answer: Yes ___ No____ Don’t know

2.9 How many suppliers are considered to be your company's most important suppliers?
Answer:: Number_____ Don’t know

2.10 In which countries are your company's most important suppliers located (several options)
Answer: 1) 2) 3) 4) 5) Don’t know

2.11 To what extent do your most important suppliers practice the "Lean Principle?
Answer: 1= limited extent 2 3 4 5 = Largely Don’t know

2.12 Do you have contingencies for late deliveries from your most important suppliers?
Answer: We have (one or more)
Buffer inventory___
Other suppliers____
Slack in the lead time____
Other product to substitute with ____
Working evenings and weekends____
Other (specify)_____
Don't know___

2.13 If you are informed about delays/disruptions, how do you receive such notifications?
Answer:
Telephone_____
Fax_____
e-mail _____
electronic order system _____
Other (specify)_____
Don't know_____

2.14 Please consider the extent to which the following statements describe the exchange of information between your company and your most important suppliers:

(scale 1= highly disagree 5=totally agree)

We cooperate with our suppliers on a regular basis in order to reduce the likelihood of delays	1=disagree	2	3	4	5= agree
We receive routine information when our suppliers have sent their goods	1=disagree	2	3	4	5= agree
We have the opportunity to track goods between the time when they leave our suppliers and when we receive them	1=disagree	2	3	4	5= agree
We receive routine, immediate notification from our suppliers when delays unrelated to actual transport occur	1=disagree	2	3	4	5= agree
We receive routine, immediate notification from the haulier when delays/disruption relating to transport occur	1=disagree	2	3	4	5= agree
We and our most important suppliers have procedures which are designed to identify any risks occurring in the value chain	1=disagree	2	3	4	5= agree
We and our most important suppliers have developed strategies for handling disruptions or delays in the value chain	1=disagree	2	3	4	5= agree
We have people with defined areas of responsibility for handling risks	1=disagree	2	3	4	5= agree

Part 3: External factors
In this part of the questionnaire we would like to ask you questions about external risk factors

3.1 Disruptions (external risks):

We would like you to assess the likelihood of any events occurring. On a scale of 1 to 5, how likely do you think it is that any of the following events will occur?
Where 1 = highly unlikely and 5 = highly likely

1.	Natural disasters	1= highly unlikely	2	3	4	5= highly likely
2.	Pandemic	1= highly unlikely	2	3	4	5= highly
3.	Armed conflicts	1= highly unlikely	2	3	4	5= highly
4.	Terrorism	1= highly unlikely	2	3	4	5= highly
5.	Unstable political circumstances	1= highly unlikely	2	3	4	5= highly
6.	Accidents (e.g. fire, explosions)	1= highly unlikely	2	3	4	5= highly
7.	Suppliers/subcontractors going into liquidation	1= highly unlikely	2	3	4	5= highly
8.	Suppliers/subcontractors going on strike	1= highly unlikely	2	3	4	5= highly
9.	Transport problems	1= highly unlikely	2	3	4	5= highly
10.	Import and export restrictions	1= highly unlikely	2	3	4	5= highly

3.2

If any of the events mentioned above actually occur, what would the consequences be? You can rank the degree of severity on a scale of 1 to 5, where 1 = minimum financial consequences and 5 = serious financial consequences.

1.	Natural disasters	1= min fin cons	2	3	4	5= ser fin cons
2.	Pandemic	1= min fin cons	2	3	4	5= ser fin cons
3.	Armed conflicts	1= min fin cons	2	3	4	5= ser fin cons
4.	Terrorism	1= min fin cons	2	3	4	5= ser fin cons
5.	Unstable political circumstances	1= min fin cons	2	3	4	5= ser fin cons
6.	Accidents (e.g. fire, explosions)	1= min fin cons	2	3	4	5= ser fin cons
7.	Suppliers/subcontractors going into liquidation	1= min fin cons	2	3	4	5= ser fin cons
8.	Suppliers/subcontractors going on strike	1= min fin cons	2	3	4	5= ser fin cons
9.	Transport problems	1= min fin cons	2	3	4	5= ser fin cons
10.	Import and export restrictions	1= min fin cons	2	3	4	5= ser fin cons