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COVID-19 effects on supply chain risk management in the Swedish automotive industry.

Master's thesis in Supply Chain Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2021
www.chalmers.se
Report No. E2021:031

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Abstract

The COVID-19 pandemic has caused disruptions in supply chains in most industries worldwide. The automotive industry has a complex supply chain and is characterized by just-in-time and small inventories, making it extra sensitive to disruptions. As the automotive industry has an important role in the global economy and affects many people, is it interesting to investigate how COVID-19 has affected the supply chains in the automotive industry and how companies have handled the risks and disruptions during this time. Therefore, the aim of the thesis is to investigate how COVID-19 has affected the supply chain risk management (SCRM) approaches of manufacturing companies in the Swedish automotive industry and to compare it with the theoretical findings on how to structure SCRM successfully.

This thesis is a multiple case study where data has been collected through semi-structured interviews with representatives from three different companies within the Swedish automotive industry. Before the interviews were conducted, literature on SCRM was analyzed to gain insight into how to best design SCRM in a company and which activities should be included in the process. This literature background has resulted in a SCRM framework highlighting four crucial steps of SCRM: risk identification, risk assessment, risk mitigation, and risk monitoring. The SCRM framework was used to analyze the empirical findings to understand how the case companies have worked with the risks and disruptions that have arisen during the COVID-19 pandemic.

The case companies have experienced several supply chain disruptions during the pandemic, and it has affected how these companies have handled their SCRM. All cases experienced a similar demand pattern during the pandemic where the demand went down in the early stages of the pandemic to see a drastic increase in demand from the summer of 2020 until the end of Q1 2021. A major disturbance that has surfaced for the automotive industry during the beginning of 2021 is a semiconductor shortage. The shortage will affect the production volume at OEMs in the coming 24 months, which will also affect the subcontractors. Supply shortages have highlighted the importance of visibility and transparency in the supply chain during the pandemic. Post-pandemic, the case companies see a need to improve their supply chain abilities in visibility and transparency along with implementing learnings that have been attained during the COVID-19. It has also been shown that the SCRM framework is a good tool for analyzing SCRM approaches in a structured and generalized way to get an overview of the SCRM process.

Keywords: Supply chain risk management, COVID-19, Swedish automotive industry

Acknowledgments

The journey while writing this master's thesis has been long and instructive in many ways. Therefore, we would like to emphasize our gratitude to the people who were involved in the process and who contributed in so many ways.

We would like to start by thanking our supervisor and examiner, Professor Frida Lind, who, through her expertise in research and her commitment to our project, has contributed with invaluable insights throughout the entire master thesis.

We would also like to forward our appreciation to Professor Patrik Jonsson and his associates, who have been involved in the early stages of this master thesis project. Lastly, this research could not have been conducted without the interviewees' participation from the three case companies, so we would like to express our gratefulness for their contribution.

Gothenburg, May 2021

Halil Garcevic

Erik Lidberg

Content

1. Introduction

Supply chain management (SCM) incorporates planning, management, and coordination of all activities in an organization to procure and manage supplies to meet the demand both within the own organization and across the company's borders (Jonsson & Mattsson, 2016). Many parties are involved in a modern supply chain, such as, suppliers, intermediaries, service providers, and customers. The management of this network is a crucial aspect of an efficient and successful organization (Fonseca & Azevedo, 2020)).

Globalization and industrial trends that focus on cost reductions in the supply chain, such as reduced supplier bases, outsourcing, and lower inventories, have resulted in longer supply chains with increased complexity that involves more parties (Fan & Stevenson, 2018). These trends have made the supply chains more exposed to risks, and thus has supply chain risk management (SCRM) been given much attention in the literature. SCRM has also become a highly prioritized topic in business because of the strategic importance of companies' supply chains (Sharma & Bhat, 2016; Khojasteh-Ghamari & Irohara, 2018; Black & Glaser-Segura, 2020).

Supply chain risks are defined by Black and Glaser-Segura (2020) as unplanned and unexpected incidents that cause disruptions in the material and service flow within a supply chain. SCRM aims to develop and implement strategies to create a more resilient supply chain by identifying, assessing, mitigating and monitoring supply chain risks by using analytical tools and techniques as well as by collaboration and coordination with other stakeholders in the supply chain. A successful SCRM-strategy might lead to a competitive advantage by being less affected by supply chain disruptions than competitors (Fan & Stevenson, 2018). Several studies present a wide array of events that can cause supply chain disruptions, for example, factory fires and superstorms (Simchi-Levi, Schmidt, & Wei, 2014), financial crises and natural disasters (Moritz, 2020), political instability (Simchi-Levi, o.a., 2015) and tariff wars between powerful nations (Ishida, 2020).

The latest significant disruption affecting global supply chains in entire industries and markets is the outbreak of the corona virus (SARS-CoV-2), causing the COVID-19 disease (Belhadi et al., 2020). Supply chains experienced an unprecedented level of disruptions during 2020 due to the breakout of COVID-19 that has resulted in a global pandemic (Ivanov, 2020). As of May 6th, 2021, there are approximately 154 million confirmed cases of COVID-19, over 3,2 million fatalities, and the virus is present in 223 countries (WHO, 2021). Governments have imposed restrictions and lockdowns to reduce the spread of the virus. This has also created changes in consumer behaviors, with peaks and declines in demand, production downtimes and shortages in supply (Capgemini Research Institute, 2020).

Supply chain disruptions as a phenomenon have received much attention during the pandemic both in the academic literature and among business leaders and professionals worldwide (Belhadi et al., 2020; Shih, 2020; Ishida, 2020; Black & Glaser-Segura, 2020; Xu Z., Elomri, Kerbache, & El Omri, 2020). In a report by Capgemini research institute (2020), 1000

international companies were surveyed about if they experienced a negative impact of COVID-19 and 80% of the companies experienced a negative impact, and 66% believed that their supply chain needs to change significantly post-pandemic.

The automotive industry is a significant contributor to many nations' economies, e.g., in Sweden, the automotive industry composes approximately 13% of the total value produced in the Swedish manufacturing sector and employs around 153,700 people (Statistiska Centralbyrån, 2020). In the light of the COVID-19 pandemic, the automotive industry has faced an abrupt drop in vehicle demand. The decline in demand caused disruptions for most actors in the supply chain, such as, original equipment manufacturers (OEM's), suppliers of materials, and services, car dealers, and end-consumers (Belhadi et al., 2020).

In short, as the supply chains are getting longer and more complex, SCRM has become an increasingly important part of creating a robust supply chain strategy that can withstand disruptions. The emergence of COVID-19 has exposed weaknesses in supply chains and further stresses the importance to handle disruptions effectively. The automotive industry saw the demand for new vehicles vanish at the beginning of the COVID-19 pandemic. Still, some automotive manufacturers managed to restore their operations and supply chains accordingly as demand for new vehicles recovered (Volvo Cars, 2020). Consequently, the supply chains in the automotive industry are of interest to study to understand and learn more about disruptions and how to manage and prevent them in the future.

1.1 Aim

The thesis aims to evaluate and analyze the effects of COVID-19 on supply chain risk management of manufacturing companies within the Swedish automotive industry. Furthermore, the aim is to address the risks and disruptions the Swedish automotive industry has been affected by throughout the COVID-19 pandemic. The aim will be achieved based on selected literature about supply chain risk management and studies on the current COVID-19 pandemic, and empirical case studies of selected companies in the Swedish automotive industry.

The study focuses on addressing the impacts that COVID-19 has had on Swedish manufacturing companies in the automotive industry and examining the effects the pandemic has had on supply chain risk management at the companies.

1.2 Research questions

2020 will, in many aspects, be a year that humanity will remember for a long time forward because of the disruptions caused by the COVID-19 pandemic on our society. From a business perspective, companies have been struggling to match supply with demand and the other way around. Considering the difficulties of matching supply and demand, it has become more important than ever before for companies to monitor and manage their supply chains to mitigate the risks of similar and other disruptions in the future. By reading Fan & Stevenson's (2018) definition of Supply Chain Risk Management, one can understand the benefits and

objectives of monitoring and managing the supply chain with a proactive approach. The authors' definition is as follows:

"*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 advantage."*

Sweden as a nation has a big exposure towards the automotive industry, with companies, such as Volvo Cars, AB Volvo, Scania, NEVS, Koenigsegg Automotive, and thousands of subcontractors and service providers. It is interesting to examine the effect that COVID-19 has had on supply chains in the Swedish automotive industry and learn from their experiences and actions.

Research questions have been formulated to facilitate the execution of the study and to help the authors to reach the aim of the study by presenting clear conclusions on the studied subject with related analysis. The literature background will be the foundation to answer RQ1, while the literature on COVID-19 and the empirical findings will contribute to answering RQ2. For RQ3a and RQ3b, the analysis will support the authors to understand and conclude how supply chain risk management is applied in actual practice and what paths manufacturing companies in the Swedish automotive industry have taken due to the turbulences caused by the COVID-19 pandemic.

RQ1: *In accordance with the literature, how should companies structure and define the supply chain risk management process to handle risks and disruptions in their supply chains?*

RQ2: *How has the COVID-19 pandemic disrupted the supply chains of manufacturing companies in the Swedish automotive industry?*

RQ3a: *How has COVID-19 affected the supply chain risk management approaches of manufacturing companies in the Swedish automotive industry?*

RQ3b: *How will the effects of COVID-19 influence the direction of supply chain risk management approaches at manufacturing companies in the Swedish automotive industry in the future?*

1.3 Structure of the thesis

The structure of the thesis following this introduction chapter will be as follows.

2. Methodology

This chapter will describe the methods used in the study to answer the research questions and also discuss the quality aspects of the conducted research.

3. Literature background

This chapter presents the theoretical background of the studied subjects and ends with a theoretical framework that is constructed from the theoretical findings.

4. The impact of COVID-19 on supply chains

This chapter presents the effects of the COVID-19 pandemic on supply chains in general and supply chains in the automotive industry.

5. Empirical data

Data collection from three case companies in the Swedish automotive industry is presented in chapter 5.

6. Analysis of actions and strategies to mitigate the disruptions caused by COVID-19

In the analysis chapter, the authors will analyze the empirical findings, such as evaluating what actions and strategies the case companies have applied during the COVID-19 pandemic.

7. Discussion

In the discussion section, the authors will discuss, compare, and evaluate the literature and empirical data findings.

8. Conclusion

In this last chapter, the authors conclude the findings from the study and answer the research questions.

2. Methodology

The following chapter describes the methodology of how the aim has been addressed and how to answer the research questions. First, the research design will be presented to gain an overview of how the study will be carried out, followed by descriptions of how the literature background was conducted and how the empirical data was collected. The methods of how the theory from the literature background and the empirical data will be analyzed and discussed will also be addressed in this chapter. Lastly, the ways of assuring high quality in the study will be presented.

2.1 Research design

To answer the formulated research questions requires a combination of theoretical understanding and empirical data. Therefore, the research design is constructed to follow a linear and consecutive process that begins with acquiring theoretical knowledge through the literature background. Figure 1 below illustrates the approach used to complete this study. The literature background will consequently provide a theoretical basis for constructing a theoretical framework that will assist the authors in answering RQ1. The empirical data is collected from each case company that is involved in the study. The data collection carried out among companies in the Swedish automotive industry will be used for answering RQ2, RQ3a, and RQ3b, which are more industry and COVID-19 related research questions. After the previous steps have been completed, the study analyzes and discusses the empirical findings before formulating the conclusions.

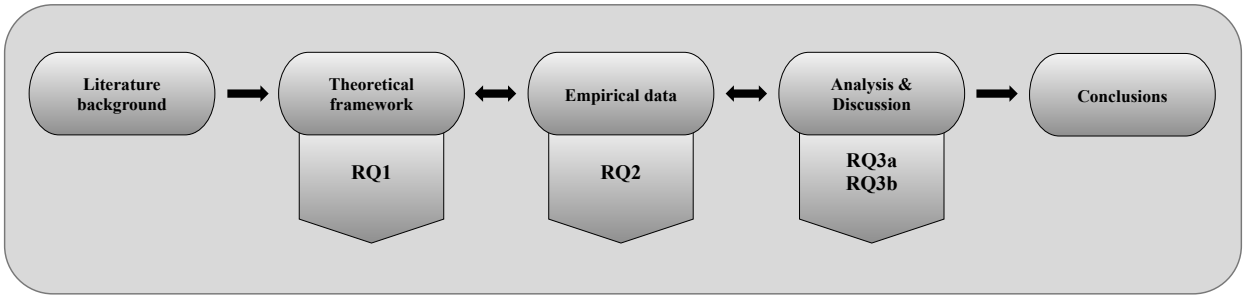

Figure 1. Illustration of the research design through a linear and consecutive approach.

2.2 Literature background

To be able to answer RQ1, there was a need to compose a literature background. This was done to provide a context and an understanding of the subject of Supply Chain Risk Management and summarize the strategies and processes identified within the academic literature into a SCRM framework. The literature reviewed in this study was academic articles, books, and other published sources such as news articles and conference material. The literature background was then used to guide the empirical data collection at the various companies within the automotive industry.

The search for literature has been conducted with different search engines, databases, and academic journals to find as relevant literature as possible. The search engines used to find literature and sources for this study are Google Scholar, Scopus, and Chalmers Library. In addition to the mentioned search engines, literature has also been retrieved from the International Journal of Physical Distribution and Logistics Management.

The literature background contains several topics, such as Supply Chain Management, Supply chain management within the automotive industry, and Supply Chain Risk Management, so that a broad understanding of the subject can be obtained. Different search words have been used to find relevant literature for each segment, and the literature found has been methodically filtered to focus on the context of the study.

The most frequently used search words for searching literature connected to each section of the literature background are presented in table 1.

Table 1. Search words used for each section of the literature background.

Sections of the literature background	**Search words**
Supply Chain Management	Supply chain management, Supply network, Supply chain + relationships
Supply Chain Management in the automotive industry	Supply chain management + automotive, risk management + automotive, supply chain risk management + automotive
Supply Chain Risk Management	Supply chain risk management, supply chain risk
SCRM process	Supply chain risk management + risk + identification / assessment / mitigation / monitoring + process

The retrieved literature was reviewed and summarized, which is intended to briefly introduce SCM in general and in the automotive industry and create a deeper understanding of SCRM and the processes in it. At the end of the literature background will a SCRM framework be presented on how to structure the work with handling risks and interruptions in the supply chain based on the literature.

2.3 COVID-19

To answer RQ2, a literature search was first conducted to give insights into how COVID-19 has affected supply chains in general and, more specifically, in the automotive industry internationally and the Swedish automotive industry. Since the COVID-19 pandemic is a relatively new phenomenon and most academic journals published on the subject were written in the early stages of the pandemic, very few focused on the automotive industry. To find relevant literature, has the Google search engine been used, in addition to Google Scholar and Chalmers Library, to find news articles and business reports to get as relevant and current information as possible. The most frequently used search words for the COVID-19 chapter, chapter four, are presented in table 2.

Table 2. Search words used for the data collection on COVID-19 in chapter 4.

Sections of the COVID-19 chapter	Search words
The impact of COVID-19 on Supply Chains	Supply chain risk management + COVID / pandemic / corona, Supply chain + COVID / pandemic / corona
COVID-19 and the automotive industry	COVID + automotive, Supply chain + COVID + automotive, COVID + Sweden + automotive, COVID + Global + automotive

2.4 Case studies and data collection

The second part of answering RQ2 and also RQ3a and RQ3b was an empirical data collection done through a multiple case study using qualitative methods with semi-structured interviews. The purpose of the multiple case study was to gain insights into how companies in the Swedish automotive industry have acted to handle disturbances in the supply chain due to the COVID-19 pandemic and if the pandemic has changed these companies' strategies regarding SCRM.

This master thesis was done in collaboration with another research project conducted by Professor Patrik Jonsson at Chalmers University of Technology. Professor Jonsson's study investigates planning and manufacturing data from producing companies in the Swedish automotive industry (OEM's & subcontractors). That research project also has an interest in qualitatively investigating the impact COVID-19 has had on companies within the automotive industry regarding decisions and actions during the pandemic, but mainly from an operations planning perspective.

Initially, a total of nine companies were invited to participate in the study, of which four declined to participate. Of the five remaining companies that agreed to participate, two companies dropped out due to high workload and coronavirus infection. Contacts with two subcontracting companies were attained through the collaboration with Professor Jonsson, and the interview guide was constructed to fulfill the purpose of both studies at once. The companies involved in the study are one OEM and two subcontractors in the automotive industry. Communication with the interviewees was mainly done through e-mail to give them the research context and decide when the interviews would be held. The interviewees had the chance to read the interview questions before the interview to be able to prepare their answers. The three participating companies have requested to be anonymous in this report because parts of the information shared during the interviews are confidential. Therefore, the three companies are referred to in the study as Alpha, Beta, and Gamma.

A multiple case study means that data is collected from several case companies with the intention to compare the individual companies with each other to identify differences and similarities to draw broader industry-specific conclusions (Marrelli, 2007). The methodology applied to collect data and information from the individual case companies will be through semi-structured interviews. According to Rowley (2012), semi-structured interviews are best employed in situations where it is important to understand processes, opinions, and values. For this study, this will be valuable to get insights into specific companies' processes, opinions, and

values, especially in the context of the COVID-19 and what impact the pandemic had on the individual companies' supply chains. Rowley (2012) further emphasizes that semi-structured interviews are characterized by more flexibility than structured interviews, which allows the interviewer to ask follow-up questions to the predetermined questions.

The interviews were held through the video conferencing tool Microsoft Teams, and each interview was scheduled to take approximately 60 min. The interviews lasted between 35 and 70 minutes, which varied because of different levels of insight in SCRM strategies at the company, depending on the interviewee's role at the company.

Several ethical considerations have been made in the handling of the empirical data in this study. Before the interviews took place, the interviewees were informed of the nature of the study, that the data from interviews would be published with open access, and they were asked if they approve of having the interview recorded. The interviewees were also informed about the possibility for them and the company to be anonymous in the report. They will also have the chance to comment on the parts of the report where their company will be discussed to make sure that the information written is correct. These ethical considerations are aligned with Allmark et al. (2009) view on how to ensure confidentiality and informed consent in interviews.

2.5 Analysis and discussion

A combination of the theoretical knowledge gained during the study and the empirical data collected through interviews will, in its entirety, form the basis for addressing research questions 2, 3a, and 3b. In the analysis and discussion sections, the intentions are to make comparisons between the three case companies to find similarities and differences in their approach and experience of COVID-19 from an SCRM perspective to generate sufficient and representative conclusions of SCRM in the Swedish automotive industry. By analyzing the companies individually and collectively with an SCRM framework, the hope is to capture the application of SCRM in actual practice and address the differences and similarities between actual practice and academic literature.

2.6 Quality of the thesis

The evaluation of the quality of the thesis is done with the help of the validity and reliability criteria, which are relevant and common criteria used in the academic field to evaluate the quality of the empirical data.

Due to the nature of the research, the validity criterion is an important quality aspect to demonstrate the trustworthiness of the studied phenomenon (Golafshani, 2003). The validity of the research determines whether the studied phenomenon is described in such a way as it was originally intended to do and considers the used research design, methodology, and conclusions (Bush, 2007). A common criticism of validity in qualitative research is that validity is not applicable as a quality criterion because there may be an inherent bias from the researchers that have affected the results of the research (Golafshani, 2003). Bias can arise from the impressions that the researchers received during the course of the study, e.g., through interactions with respondents used in data collection or the iterative process, where the researchers constantly are exposed to new impressions and knowledge from theory and

empirical data (Andersen, Dubois, & Lind, 2018). Therefore, the validity concept has been extended by researchers to better fit qualitative research by using more appropriate terms, such as quality, rigor, and trustworthiness, that evaluate the validity of the research (Golafshani, 2003). With regard to the approach used to collect data for the empirical findings, the semi-structured interviews are a way of obtaining credible data from respondents in the Swedish automotive industry. The semi-structured interviews make it possible for the researchers to collect information about the studied phenomenon, as the respondents are allowed to openly recapitulate their experience of reality without the influence of the researchers' values. During the empirical data collection, the authors have applied precautionary measures to prevent misinterpretations of the empirical data or simple human errors, such as forgetfulness, by video recording the interviews. Consequently, to argue in the same spirit for the validity of the thesis, the authors have received continuous feedback on the writing progress from a supervisor with solid experience in academic research and publication. The researchers have also received feedback from the interviewees, who have had the opportunity to read the material concerning their company and correct eventual misconceptions or errors. However, there was a large variation among the interviewee's positions at the companies, which may have affected the validity of the data collection because they may not have had an adequate insight into all processes of interest in this study.

Reliability is quality criteria that determine the study's reproducibility, briefly described, which means that a study must generate the same or equivalent results over time, regardless of who conducts the study (Amaratunga, Baldry, Sarshar, & Newton, 2002). This study has high reliability because it is well documented in the methodology section of this thesis. This supports reproduction of the research, as other researchers can firmly follow the approaches documented to follow the same research path. On the other hand, as the interviews are semi-structured, the reliability of achieving the same results is less likely to happen due to the nature of not following a strict questionary throughout the interviews. According to Bush (2007), this is one of the drawbacks of conducting semi-structured interviews because the respondents usually retell their experience and are allowed to do so freely, without the researchers directing the interview in one direction. The feedback from the respondents is also very dependent on the follow-up questions that arise during the interview. One way to increase the reliability is to triangulate, which infers to collect and compare data from several sources in the same subject (Bush, 2007). Supply chain risk management is a small area within the case companies, which made it difficult to interview several respondents as there are not many available candidates to gather information from. Although a triangulation has not been made in accordance with the academic description of the process, the authors have obtained data from secondary sources, such as, annual reports, to compensate for the low availability of respondents that can validate the data in order to improve the quality of the thesis.

3. Literature background

The following chapter will address relevant literature on Supply chain risk management (SCRM) and will constitute the theoretical base for the study. The chapter will touch upon general Supply chain management (SCM), the networks and relationships it constitutes, and an introduction of how SCM is conducted in the automotive industry. The literature background will also present an overview of the subject of SCRM and go deeper into the processes of SCRM with identification, assessment, mitigation, and monitoring of risks. In the last part of the literature background, a framework of the SCRM processes will be presented to summarize the literature on the subject.

3.1 Supply Chain Management

In this subsection will a definition of Supply Chain Management be presented to give a contextual understanding of what aspects are involved within the field of SCM. The last part of this section links SCM with the automotive industry and provides a general description of SCM in the automotive industry.

3.1.1 Definition of Supply Chain Management

The term Supply Chain Management (SCM) was introduced at the beginning of the 1980s. It was primarily used to shed light on the integration of companies' internal business functions, such as purchasing, manufacturing, sales, and distribution (Dubois, Hulthén, & Pedersen, 2004). In recent years, companies have needed to cope with complex flows of products, services, and information in the lights of the ongoing globalization while demand is volatile and nonlinear (Christopher, 2012). The scope of supply chain management has evolved from focusing on logistics to including other business functions equally important and has also widened from having an intra-organizational focus to concentrate on inter-organizational issues across the entire supply chain (Dubois, Hulthén, & Pedersen, 2004). The authors recognize some similarities identified in the SCM literature: several stages of intra- and inter-organizational integration and coordination that spans across several layers on both the supplier and customer side of the company.

Consequently, this requires management of intra- and inter-organizational relationships as the flow of products, services, and information is bi-directional. Lastly, the authors recognize the importance of providing high customer value through the appropriate use of resources and building a competitive chain advantage (Dubois, Hulthén, & Pedersen, 2004). In the context of SCM, there is no universal definition of the term and the scope of SCM, though this report will use the Global Supply Chain Forum's definition presented in Dubois, Hulthén & Pedersen (2004) to describe it;

"*Supply chain management is the integration of key business processes from end user through original suppliers that provides products, services and information that add value for the customers and other stakeholders"*

3.1.2 Supplier relationships and networks

Relationships are an essential foundation within SCM's scope and have gained much attention in the literature (Gadde & Snehota, 2000; Dubois, Hulthén, & Pedersen, 2004; (Gadde, Huemer, & Håkansson, 2003; Gadde & Snehota, 2019).

Firstly, the industrial network approach includes the three dimensions resources, activities, and actors (Gadde, Huemer, & Håkansson, 2003). The resource dimension infers to the usage of resources dedicated to a relationship. However, a company is often part of a collective entity with several relationships utilizing the resources (Gadde, Huemer, & Håkansson, 2003). Dubois, Hulthén, and Pedersen (2004) also highlight that companies are simultaneously members of several supply chains. Each relationship affects the available resources, which creates interdependence between companies and forms supply chain networks. According to Gadde, Huemer, and Håkansson (2003), this interdependence requires adaptations and combinations of resources to enable different technologies across the boundaries of each company.

The activity dimension infers to the interaction between actors in a supply chain by coordinating information, products, and services (Gadde, Huemer, & Håkansson, 2003). The activities that constitute a chain are interdependent and related through loose or tight links composing a network that can be valuable for companies to rationalize operations that are important and extend beyond the ownership boundaries.

The networks containing the resources and activity links dynamically change over time and do not have any particular center or borders. This implies that the networks are loosely connected systems of relationships with other actors that no company can dominate (Gadde, Huemer, & Håkansson, 2003). This brings up the last dimension of the industrial network approach, which is the actor dimension. The actors are the facilitators who coordinate and combine activities, utilizing and reconfiguring the resources in cooperation and competition with other companies (Gadde, Huemer, & Håkansson, 2003).

Managing relationships within the own organization and with suppliers is a complex task. It requires effective interaction, monitoring of interdependencies within the supply chain networks, and the ability to flexibly cope with dynamics (Gadde & Snehota, 2019). Gadde and Snehota (2019) further emphasize the importance of learning, developing skills and capabilities to exploit business opportunities through relationships.

3.1.3 Supply chain management in the automotive industry

The demanding and competitive environment surrounding the automotive sector has driven the industry to optimize its supply chains (Zhu & Zhang, 2018). The industry has grown to be a significant contributor to the world economy, and there are over 95 million vehicles produced globally every year (International Labour Organization, 2020). The European producers stand for roughly 20 million of the produced vehicles, and the automotive industry employs 14.6 million people, directly and indirectly, representing 6.7% of the European employment (European Automobile Manufacturers Association, 2020). The European automotive industry

directly contributes with 11.5% of the manufacturing jobs and 7% of the total Gross Domestic Product (GDP) in Europe (European Automobile Manufacturers Association, 2020). Sweden is one of the countries where the automotive industry is topping the list of significant industries for the nation's economy (BilSweden, 2021). The automotive industry is the largest source of export in the country and constitutes 15% of the total exported goods (BilSweden, 2021; Edgren, 2018). and 13% of the produced value from manufacturing (Andersson, Poldahl, & Widegren, 2017).

The fiercely competitive market in the automotive industry has forced companies to streamline their supply chains and operations and adopt Lean thinking. Lean thinking originates from Toyota and has become a common practice in the industry since the 1990s. The lean approach focuses on reducing waste, non-value-adding activities, and redundances to reduce costs tied to inventory (Ciano, Dallasega, Orzes, & Rossi, 2021). Some methods for creating a streamlined supply chain are just-in-time, outsourcing parts of the production to emerging countries, and single sourcing. Just-in-time allows for keeping low inventories, outsourcing to emerging countries will allow for lower labor cost and allow the company to focus on the core capabilities such as R&D, marketing and design, and single-sourcing will give the benefit of scalability in orders and economy of scale (Thun & Hoening, 2011; Van Weele, 2018; Zhu & Zhang, 2018). Still, these methods also expose the supply chain to more risks and vulnerabilities. The supply chains in the automotive industry are complex because a car comprises over 20,000 parts, which creates a vast and complex network of suppliers in multiple tiers for OEMs (Zhu & Zhang, 2018). If even one of those parts is not available when needed, it can cause a standstill of the production (Zhu & Zhang, 2018). Because of this complexity, has SCRM become an important part of SCM in the automotive industry.

One trend in the industry to manage these risks is to reduce some of the cost focus and give importance to resilience and continuity in the supply chains by using multiple sources and keep some safety stock (Zhu & Zhang, 2018). Supply chains must be robust to be proactive and resist negative impact events. Still, it must also be agile to react to unforeseen events that might influence the supply chain performance negatively (Wieland & Wallenburg, 2012).

The automotive industry has faced major disruptive events over the years that severely have impacted companies' operations negatively. In some cases, the whole industry has been negatively impacted (Ivanov, 2020). Two examples of major disruptions that have affected the automotive industry are the Tsunami that hit the coast of Japan in 2011 that crippled the supply chains globally and made Toyota lose $72 million in profits per day (Ho, Zheng, Yildiz, & Talluri, 2015). The second is the terrorist attack in New York in 2001 which caused massive shutdowns in Ford and Toyotas production plants in the USA when sourced material from abroad got delayed (Thun & Hoening, 2011).

3.2 Supply chain risk management

Globalization of the supply chains in the automotive industry and other industries has led to benefits such as reduced cost, a wider variety of suppliers accessible, and a broader international market (Chu, Park, & Kremer, 2020). As important as globalization has been to shape the current market, it also comes with some drawbacks (Thun & Hoening, 2011).

Globalization and industry trends such as reduced supplier base, lower inventories, and outsourcing have resulted in increased complexity and length of the supply chains (Fan & Stevenson, 2018; Black & Glaser-Segura, 2020). When the supply chains or supply networks become longer and more complex, they often involve more parties, making it harder to control the performance since the supply chain is as strong as its weakest link. This makes that supply chains have smaller margins of error and makes the supply chains highly vulnerable and exposed to risks (Kern, Moser, Hartmann, & Moder, 2012). The disruptions caused by supply chain risks have become more common with the globalization of the supply chains and often negatively affect the company's performance (Kern et al., 2012).

Supply chain risk management (SCRM) has emerged as a countermeasure for the risks that potentially can affect the supply chain negatively. The subject has gained much attention both in supply chain research and in the corporate sector over the last decades (Wieland & Wallenburg, 2012). Companies need to apply both reactive and proactive management approaches to reduce the vulnerability and negative impacts that the risks impose to improve the supply chain performance from a financial business perspective (Wieland & Wallenburg, 2012). According to Sharma, Bhat & Routroy (2014) is the proactive strategies to some extent of the greater importance of the two. Several definitions of SCRM are presented in the literature, and four of them are presented in table 3 to give an overview of different views of what SCRM entails.

Table 3. Supply chain risk management definitions

Author	**Supply chain risk management definition**
Fan & Stevenson, 2018	*"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 advantage."*
Jüttner, Peck & Cristopher, 2003	*"The identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole."*
Ho, Zheng, Yildiz & Talluri, 2015	*"an inter-organisational collaborative endeavour utilising quantitative and qualitative risk management methodologies to identify, evaluate, mitigate and monitor unexpected macro and micro level events or conditions, which might adversely impact any part of a supply chain."*
Wieland & Wallenburg, 2012	*"the implementation of strategies to manage both everyday and exceptional risks along the supply chain based on continuous risk assessment with the objective of reducing vulnerability and ensuring continuity"*

The development of the definitions has evolved from Jüttner, Peck, and Christopher's (2003) definition, which was one of the earliest to gain attention and is broad and concise, to Fan & Stevenson's (2018) definition that is more detailed in terms of strategies and how the business might be affected. The definitions of SCRM in table 3, except for Wieland and Wallenburgs (2012) definition, view that coordination and collaborations among the parties in the supply chain are a vital part of SCRM. In addition to collaboration (and relationships) in the supply

chains are also the processes and strategies concerning how to reduce the vulnerability of the supply chains a common theme of these definitions. The process of SCRM has been given much attention in the literature on SCRM and will be further explored in the next part of the literature background.

Even though the definitions state similar views on SCRM, Ho et al.'s (2015) definition is used in this report when referring to SCRM. This definition has a broad view of collaboration, the SCRM processes, and a separation of different risk types and events that impact the supply chain, which resonates well with the authors' collected interpretations of literature on the subject.

3.3 The Supply chain risk management process

As the popularity of the subject of SCRM, in general, has gained attention in the supply chain literature over the last decades, so has also the SCRM process (Fan & Stevenson, 2018). There is no unified way of defining the process of SCRM, and several authors present their views on the matter. Kern et al. (2012) and Kirilmaz and Erol (2017) have focused on Risk identification, risk assessment, and risk mitigation as the key steps in the SCRM process. Mandal (2011) states that the steps in the process are risk identification, risk analysis, risk estimation, and filtering of risks. The process of SCRM contains risk classification, risk identification, risk calculation, and implementation/validation, according to Wu, Blackhurst, and Chidambaram (2006). The most common way of describing the steps of the SCRM process is by the four individual steps of risk identification, risk assessment, risk mitigation, and risk monitoring, which has been discussed by authors such as Olson (2011), Ho et al. (2015), Wieland and Wallenburg (2012) and by Fan and Stevenson (2018). This last description of the SCRM process, with four individual steps, is the one that will be used in this report. It can be visualized as a continuous process that needs to be constantly revisited because of the high volatility in the supply chain (Kern et al., 2012), see figure 2.

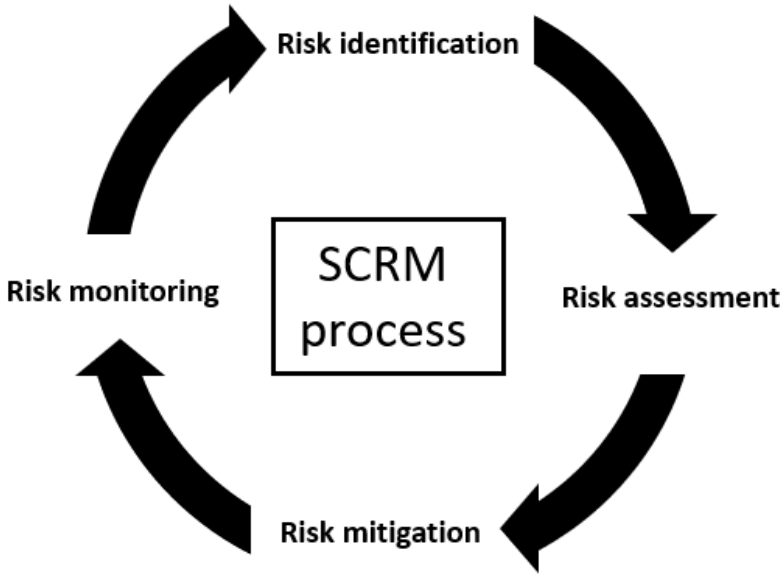

Figure 2. The supply chain risk management process based on a figure by Kern et al. (2012)

In the following text will literature on the four steps in the SCRM process, risk identification, risk assessment, risk mitigation, and risk monitoring be evaluated to better understand what purpose they have and which methods and tools could be used to have a successful SCRM strategy.

3.3.1 Identification of risks

The first step in the SCRM process is to identify what kind of risk types are relevant for the company and potentially cause disruptions (Fan & Stevenson, 2018). Only by first identifying the risks and vulnerabilities in the supply chain can steps be taken to hinder the risks from developing into disturbances (Kern et al., 2012). There are two phases of risk identification: listing risks and categorize them (Fan & Stevenson, 2018), so to be able to list relevant risks, there is a need to define what a supply chain risk is.

Supply chain risk definition

Several authors present their definitions of what a supply chain risk is, as can be seen in Table 4. These definitions of supply chain risks go from general and broad (Garvey, Carnovale, & Yeniyurt, 2015; Jüttner et al., 2003) to more comprehensive, regarding specific negative impacts that span across the whole supply chain (Ho et al., 2015; Tummala & Schoenherr, 2011).

Table 4. Supply chain risk definitions

Author	**Supply chain risk definition**
Jüttner, Peck, and Christopher, 2003	*"Any risks for the information, material and product flows from original to the delivery of the final product for the end user."*
Tummala and Schoenherr, 2011	*"Supply chain risk is defined as an event that adversely affects supply chain operations and hence its desired performance measures like cost, chain-wide service levels and responsiveness."*
Garvey et al., 2015	*"the likelihood of an adverse and unexpected event that can occur, and either directly or indirectly result in a supply chain disruption."*
Ho, Zheng, Yildiz & Talluri, 2015	*"the likelihood and impact 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."*

Based on these definitions, can a supply chain risk be described as an unexpected event that negatively affects the performance of the supply chain in terms of increased cost, operational disruptions, and strategic level failures.

Supply chain risk categorization

As stated by Fan & Stevenson (2018), is the categorization of risk one of the main phases of identifying risks. The purpose of categorizing risks is to separate risk factors into groups to help managers get an overview of areas that are exposing the company to context-specific risks (Wu et al., 2006).

The literature on supply chain risk categorizes the risks in different ways. Still, several studies categorize the supply chain risks into two main categories, but the categories are named differently throughout the literature. The first category is referred to as 'macro-risks' (Ho et al., 2015), external risks (Wu et al., 2006), disruptions (Tang, 2006), value-at-risk (Ravindran, Bilsel, Wadhwa, & Yang, 2010). The second category is referred to as 'micro-risks' (Ho et al., 2015), internal risks (Wu et al., 2006), operational risks (Tang, 2006), miss-the-target (Ravindran et al., 2011). In this report will the terms macro-risks and micro-risks be used when describing these holistic main categories of risks in the supply chain.

Macro-risks

The macro-risks are relatively rare and unexpected situations caused by external events characterized by a very high business impact on the supply chain (Ivanov, 2020; Ho et al., 2015; Tang, 2006).

Much of the literature concerning macro-risks subcategorize it into two major risk types: man-made disasters and natural disasters (Ivanov, 2020; Tang, 2006). Chu, Park, and Kremer (2020) use another name to describe the categorization of macro-risks, political and environmental risks. In this study, the terms man-made disasters and natural disasters will be used in the Supply chain risk categorization model to categorize macro-risks (see figure 3).

Man-made disasters

Man-made disasters are a risk type consisting of risk factors influenced by mankind that might affect supply chain performance negatively, such as war, political instability, terrorist attacks, etc. (Olson, 2011)

Natural disasters

Natural disasters are caused by environmental events such as floods, hurricanes, earthquakes, epidemic outbreaks, etc. Epidemic outbreaks have not been widely covered as a risk factor in the supply chain risk literature (Ivanov, 2020). They are not mentioned as a factor of natural disasters either in Ho et al. (2015) or Chu et al. (2020), which are two comprehensive studies addressing risk categorization in supply chains. Still, epidemic outbreaks are now identified as a top concern for the global economy (World Economic Forum, 2021), and it has gained increasing interest due to several epidemic outbreaks since the beginning of the 21st century with diseases such as SARS, Ebola, Swine flu, MERS and the current COVID-19 pandemic (Ivanov, 2020). The magnitude of the supply chain disruption caused by COVID-19 is unprecedented (Nagem, 2021) and will be given a separate chapter after the literature background.

Micro-risks

Micro-risks are more common risks connected to the everyday operational management of the supply chain (Kern et al., 2012). The disturbances caused by these micro-risks do not usually have a significant impact on the supply chain. Still, since they are more common than the macro-risks, much of the focus in the literature is made towards the micro-risks (Olson, 2011).

The categorization of micro-risks varies between the literature, but some of the most comprehensive categorizations are presented by Ho et al. (2015) and Chu et al. (2020). Ho et al. (2015) conducted a literature review where a categorization of supply chain risks was compiled from 20 other articles on risk categorization, resulting in four subcategories of micro-risk types: demand risks, supply risks, manufacturing risks, and infrastructure risks. Infrastructure risks were in turn subcategorized into three types of risks: information risks, transportation risks, and financial risks. Chu et al. (2020) conducted a text-mining method based on supply chain risk management framework literature. They created a risk categorization that does not have any holistic main categories, such as macro-risks and micro-risks. Still, five risk types suit well to be categorized as micro risks: supply/demand risks, financial risks, logistic risks, operational risks, and system risks.

The subcategories of micro-risk types used in the supply chain risk categorization model used in this study are the same as stated by Ho et al. (2015). A presentation of what risk factors constitute the different types of micro-risks are presented below. A more elaborate list of risk factors, which mainly uses definitions from the framework by Ho et al. (2015), is presented in the Supply chain risk categorization model in figure 3.

Supply risk

The supply risks in a company refer to risk factors regarding the company's upstream partners, such as inability to handle volume changes, single sourcing, inability to meet quality requirements, etc.

Demand risk

Demand risks refer to events with a negative impact on downstream partners as customers and consumers in the supply chain, for example, demand uncertainty, inaccurate forecasts, short lead times, etc.

Manufacturing risk

Manufacturing risks refer to events caused by a company's internal operations, for example, working conditions, lean inventory, production disruptions, etc.

Information risk

Information risks refer to factors regarding the flow of information internally and to supply chain partners. Examples of information risks are lack of information transparency, IT-system compatibility between supply chain partners, internet security.

Transportation risk

Transport risks occur in the transportation of goods to and from the company, such as accidents during transports, handling of goods, few transport alternatives, etc.

Financial risk

Financial risks concern events regarding the monetary flow of the company, for example, exchange rates, interest rate levels, price fluctuations, loss of contracts, etc.

	Supply chain risks							
	Macro risks		Micro risks					
Risk types	Natural disasters	Man-made disasters	Supply risks	Demand risks	Manufacturing risks	Information risks	Transportation risks	Financial risks
Risk factors	• Earthquake • Flood • Tsunami • Epidemic outbreaks	• War • Terrorism • Political instability • Economic downturns	• Inability to handle changes in volume demand • Cannot provide competitive pricing • Quality deficiencies • Single sourcing • Global outsourcing	• Inaccurate demand forecasts • Demand uncertainty • Demand variability • Customer fragmentation • High level of service required by customers • Short lead times • Order fulfilment errors	• Labor disputes • Accidents • Lack of experience in employees • Inventory ownership • Lean inventory • Production capacity • Production disruptions • Design changes	• Lack of visibility and transparency internally and externally • Information delays • Lack of IT compatibility among supply chain partners • Internet security	• Excessive handling due to border crossings or change in transportation modes • Fragmentation of transport providers • No transport alternatives • Damages of goods during transport • Accidents • Long working hours • Transportation breakdowns • Port strikes • Congestion	• Currency exchange rates • Interest rates • Price fluctuations • Low profit margin • Market size • Market growth • Insurance • Loss of contracts • Credit periods

Figure 3. Supply chain risk categorization model.

Methods and tools for risk identification

According to Fan and Stevenson (2018), there is no unified method for identifying risks, but several quantitative and qualitative methods are mentioned in the literature. A quantitative method of identifying risks in the supply chain is a text-mining process (Chu et al. 2020) that utilizes data analysis to process unstructured text published on the internet, both academic journals and news websites, to gain a structure of relevant risk factors. Another quantitative method mentioned in the literature is the analytical hierarchy process (AHP), a multivariate analysis method that organizes and reduces the randomness of the risk factors to help managers identify the relevant risk factors (Gaudenzi & Borghezi, 2006).

Much of the literature on risk identification has focused on more qualitative risk identification methods (Ho et al., 2015). Some of the qualitative methods mentioned in the literature are brainstorming, the Delphi method, scenario planning (Gaudenzi & Borhezi, 2006; Mvubu & Naude, 2020), and value stream mapping (Fan & Stevenson, 2018).

Even if there is not a unified method of how to identify the risks in the supply chain, there is a consensus that this first step of the SCRM process is of great importance for the efficiency of both risk assessment and risk mitigation strategies (Kern et al. 2012; Fan & Stevenson, 2018; Gaudenzi & Borghezi, 2006).

3.3.2 Assessment of risks

The second step of the SCRM process is to assess the identified risks to evaluate and understand the relevance of each of these risks (Kern et al., 2012). The two most common objectives in the literature regarding the assessment of supply chain risks are to determine the probability of occurrence of an event and what degree the impact might have on the supply chain (Kern et al., 2012; Ho et al. 2015; Blackhurst, Scheibe, & Johnson, 2008). Fan and Stevenson (2018) also state that the inter-relationships between the supply chain risks are important to analyze to get a comprehensive understanding of the threat a risk imposes. The risk assessment should also take intangible consequences into account, such as loss of reputation and damaged trust if the risk develops into a disturbance (Fan & Stevenson, 2018).

Methods of risk assessment

Ho et al. (2015) present a comprehensive list of assessment methods in their literature review on Supply chain risk management. Still, the methods can roughly be divided into qualitative and quantitative methods. Two commonly referenced qualitative and two quantitative methods of supply chain risk assessment will be presented below.

Qualitative risk assessment methods

The most popular method to assess the probability and impact of risks is a probability-impact matrix (Fan & Stevenson, 2018; Blackhurst et al., 2008; Thun & Hoenig, 2011), shown in figure 4. This method is a qualitative method that requires a ranking process that will give an overview in the matrix of which risks need to be addressed immediately, which ones need to be observed and which risks require no actions (Thun & Hoening, 2011). There is some criticism of the probability-impact matrix that implies that there is no objectively correct way to conduct such matrix since the knowledge about the potential risks is possessed by people in different positions in the company

(Cox, 2008). Cox (2008) also states that the arbitrary use of risk matrices even might lead to worse-than-random risk management decisions.

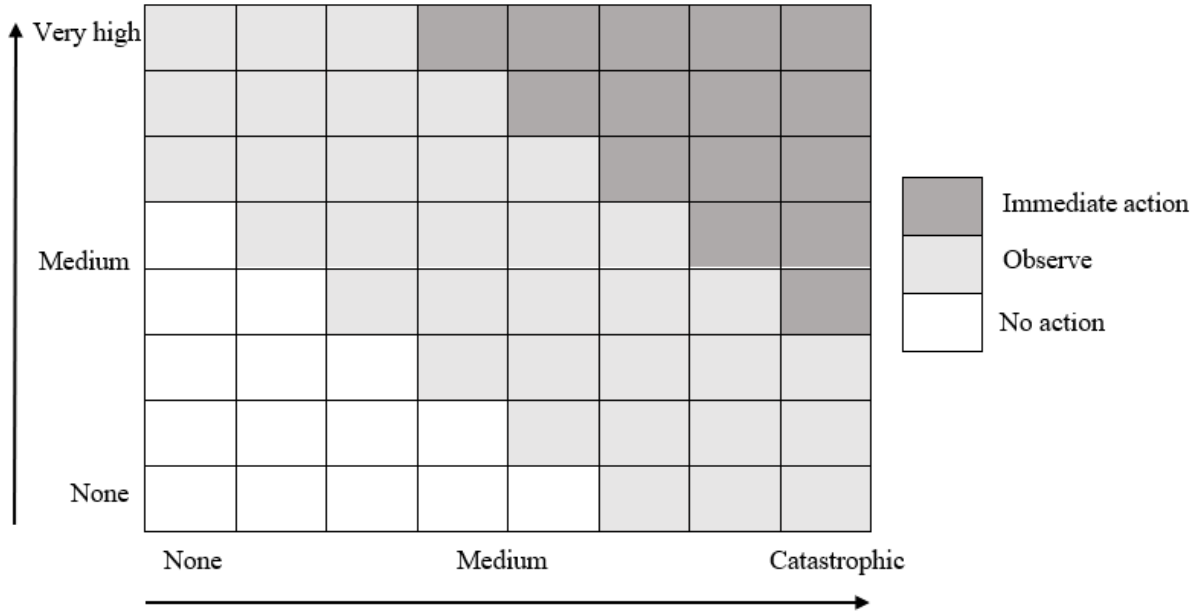

Figure 4. Probability-impact matrix

Ho et al. (2015) mention that fuzzy-based failure mode and effect analysis (FMEA) is a method of assessing risks. Fuzzy-based FMEA is a qualitative method to rank the severity of a risk, the occurrence rating, and chance of detection on a scale between 1-10, and to get the risk priority number (RPN), the three values are multiplied (Immawan, Sutrisno, & Rachman, 2018). As for the risk matrix, there are downsides with FMEA: it is subjective, and the inter-relationships between risks are disregarded.

Quantitative risk assessment methods

Some more quantitative methods of assessing risks in the supply chain are discussed in the literature, such as Bayesian belief networks (Fan & Stevenson, 2018; Ho et al., 2016) and analytical hierarchy process (AHP) (Wu et al., 2006; Gaudenzi & Borghezi, 2006).

The Bayesian belief network method is a formalized tool to assess risks in the supply chain. The method computes the probability of risk occurrence by using incomplete information, which will help in the decision process in how to manage the risks. Bayesian belief networks are well suited for handling and allow definitions of the inter-relationships between different risks, especially where the risks are not definite (Ahmed et al., 2005).

As mentioned in the risk identification segment of the literature review, AHP is a multivariate analysis technique that helps to break down, organize and prioritize

problems to reduce the randomness of risks that the supply chain is exposed to (Gaudenzi & Borghezi, 2006; Ahmed et al., 2005). AHP also helps the risk managers to make trade-offs between conflicting risk factors and give them a rational foundation for decision making (Wu et al., 2006). The method is ideally used in situations where the relative importance of a risk needs to be prioritized between risks to take actions against them.

Just like the positive correlations between the risk identification activities and the results from the risk assessment, is there also a correlation between risk assessment and risk mitigation, according to Kern et al. (2012). Companies working with proper risk assessment tools and activities to assess the probability, impact, and interrelationships between risks have been shown to excel with their mitigation strategies to a higher degree than companies that do not (Kern et al., 2012).

3.3.3 Risk mitigation

In supply chain risk management, the risk mitigation process is the part of the framework that counteracts and treats immediate and potential disruptions or risks (Kilubi, 2016) that can lead to business discontinuity of a company's operational activities (Fan & Stevenson, 2018), or affect both the supply chain performance and financial targets (Ho et al., 2015; Kern et al., 2012). Mitigating risks and disruptions is therefore crucial to a company's business continuity in terms of ensuring the supply of materials and components to maintain the production of products or services and to fulfill the customer demand and requirements (Fan & Stevenson, 2018; Ho et al., 2015; Um & Han, 2020). Data and information collected in the risk identification and assessment process are utilized in the risk mitigation process. The data and information are evaluated accordingly to the potential size of damage that the risks or disruptions can cause to the company (Kern et al., 2012), the probability that the risks will occur, and the organizations budget (Fan & Stevenson, 2018), before taking appropriate actions by applying corresponding countermeasures. This includes mitigating the risks before it has taken place, during ongoing events and after risks have occurred through a contingency plan (Kern et al., 2012). Risks that appear at the macro-level have, according to Ho et al. (2015), a larger negative impact on companies than risks at the micro-level. At the same time is the probability of macro-risks occurring extensively lower than for micro-risks (Fan & Stevenson, 2018). Micro-risks are recurrent events entirely associated with internal activities of companies within a supply chain network in comparison to macro-risks that are rare external events or situations causing disruptions within the supply chain (Ho et al., 2015). In Kern et al. (2012), the authors emphasize the importance of inter- and intra-company collaboration to mitigate supply chain risks successfully. Senior executives need to support collaboration by enabling holistic thinking, joint decision-making, and fast implementation activities (ibid).

According to Fan & Stevenson (2018), different companies treat risks differently, as the companies have a different level of risk acceptance and avoidance. There are always risks imposing on every company's operations, which means that the consequences of the risk must

exceed a certain threshold for the risks to be dealt with. The level of risk acceptance can vary among organizations, individuals, industries, and contexts. Risk avoidance seeks to eliminate the types of events that could trigger a risk, e.g., discontinuing certain products, suppliers, or geographical markets if the supply is unreliable. Additionally, the companies can also choose to share risks with other supply chain members or transfer them to others to minimize the company's risk exposure. Risk-sharing implies that the risks are shared with another company in the supply chain network, e.g., through contracts between buyers and sellers that address prerequisites for managing relationships and volume fluctuations under volatile circumstances. Risk transfer refers to the movement of risk exposure from a company to another party, for example, by transferring disruption risks through a business interruption insurance (ibid). Fan & Stevenson (2018) suggest risk sharing and risk transfer for macro risks and mitigation strategies for micro risks with high probability and low impact on the business. Ho et al. (2015) present nine risk mitigation strategies at the macro level, which intend to help companies manage inherent fluctuations before, during, and after a major disruption. Micro risk mitigation is divided into four subcategories in Ho et al. (2015) extensive literature review of supply chain risk management. The four categories are demand risk mitigation, manufacturing risk mitigation, supply risk mitigation, and infrastructure risk mitigation.

Demand risk mitigation

Demand risk mitigation strategies focus on mitigating risks occurring from stochastic demand, minimizing demand risks through forecasting techniques, and risk-sharing contracts that intend to minimize the losses due to uncertain demand.

Manufacturing risk mitigation

Manufacturing mitigation strategies aim to mitigate quality risks, lead time uncertainties, random yield risk, non-conforming product design, capacity inflexibility, and machine failures.

Supply risk mitigation

Supply risk mitigation strategies enable implementing behavior-based management techniques, strategic supplier relationships, early supplier involvement, and single-, dual- and multiple-sourcing.

Infrastructure risk mitigation

Infrastructure risk mitigation is divided into three subcategories; transportation-, financial- and information risk mitigation.

- Transportation risk mitigation strategies intend to determine the optimal production and order quantities and minimize the recovery duration in transportation disruptions.
- Financial risk mitigation strategies aim to reduce the supply chain vulnerability through natural hedging of currency and commodity price fluctuation.
- Information risk mitigation strategies intend to enable a free information flow with upstream and downstream supply chain partners without leaking information to competitors.

The risk mitigation strategies identified in the literature are presented below in table 5.

Table 5. Risk mitigation strategies

Risk mitigation strategy	**Description**
Postponement	Delays the customization of the end-product until the customer-order-point through standardization, commonality, and modular design. Is a cost-effective mass customization strategy (Kilubi, 2016; Tang, 2006; Ho et al., 2015).
Strategic stock	Safety stock inventories of critical components at strategic locations that can perform order-fulfillments for several supply chain partners. By these means, the risk of over-stocking and obsolesce is mitigated (Tang, 2006; Ho et al., 2015).
Flexible supply base	Utilizing more suppliers in order to reduce the risk of stock-outs caused by high-capacity utilization or other disruptions at the supplier. Exchanging lower purchasing prices per unit for a more reliant supply of goods (Tang, 2006; Ho et al., 2015).
Make-and-buy	Division of manufacturing activities or processes by retaining parts of the production in-house while other parts are outsourced to external suppliers (Tang, 2006; Ho et al., 2015).
Economic supply incentives	Incentivizing suppliers to enter a certain industry or segment in situations when there is a shortage of viable suppliers that can fulfill the company's demand of supply (Tang, 2006; Ho et al., 2015)
Flexible transportation	Enabling various transportation modes and routes to increase flexibility and minimize the risks of disruptions for goods-in-transit (Tang, 2006; Ho et al., 2015).
Revenue management	Applying dynamic pricing and promotion to sell perishable goods or services. An effective approach to managing demand when supply is disrupted (Tang, 2006; Ho et al., 2015)
Dynamic assortment planning	Influencing the consumers' product choice and customer demand through the set of products on display, the location of each product on the shelves, and the number of facings for each product (Tang, 2006; Ho et al., 2015).
Silent product rollover	Introducing new products to the market silently. It eliminates the uniqueness of the product and leaves the consumers to choose among available products in the assortment (Tang, 2006; Ho et al., 2015).
Visibility and transparency	Information sharing among supply chain members may occur through process management, IT systems, and service provider management to improve the responsiveness towards disruptions (Kilubi, 2016).
Partnerships/relationships	Reduction of supply risks through supplier relationship management (SRM). It can also improve the quality and ratio for on-time deliveries (Kilubi, 2016).
Redundancy (Inventory)	Implementing external safety stocks to minimize storage costs, the risk of obsolescence and capital waste caused by internal surplus stock, and protecting from unforeseen disruptions and demand fluctuations. It can be managed through vendor-managed inventory (VMI) or co-managed inventory (CMO) (Kilubi, 2016).
Joint planning and coordination	Experienced cross-functional teams that jointly solve problems are beneficial because risks are usually spread across the supply chain (Kilubi, 2016).

Collaboration	Through collaboration, the company can better respond to environmental changes as a result of the knowledge generated through joint product design, collaborative research, or collective process innovation (Kilubi, 2016).
Flexibility	The flexibility strategy can be achieved by outsourcing activities that enhance the supply chain capacity or by building responsive production processes that respond quickly to external changes (Kilubi, 2016).
Multiple sourcing and flexible contracts	Increasing the supplier base by dual- or multiple-sourcing to minimize supply risks (Kilubi, 2016).

3.3.4 Risk Monitoring

The fourth and final process within the SCRM framework identified in the literature is risk monitoring (Fan & Stevenson, 2018, Ho et al., 2015; Kern et al., 2012). Risks are changing over time and are not a static phenomenon, making it important to continuously monitor and evaluate the development of risk sources that are posing a potential risk to the company's supply chain and its operations (Fan & Stevenson, 2018). Consequently, risk management activities, including previous supply chain risk management processes, must be repeated regularly and frequently, even after successful mitigation strategies have been implemented (Kern et al., 2012). The risk monitoring process is vital to control the risks by continuously analyzing the effectiveness and outcomes of applied mitigation strategies (Kern et al., 2012). It is also important to implement active changes in the supply chain risk management processes based on generated knowledge to improve the ability to obtain new information (Fan & Stevenson, 2018).

Fan & Stevenson (2018) present four important aspects that companies need to incorporate to improve the risk monitoring process. These four are, developing monitoring capabilities, early-warning management processes, designing tools to identify trends, and establishing specific data management systems for risk monitoring. According to Fan & Stevenson (2018), risk managers tend to combine the monitoring process with other existing management routines, e.g., in combination with risk assessment activities, through key performance indicators (KPI's) and various performance measurement systems.

3.4 SCRM process framework

The circular model of the SCRM process presented in figure 2 in section 3.3 gives an understanding of the continuous nature of SCRM. Still, it does not give a broader understanding of the process. Presented in figure 5 is a more detailed model of the SCRM process based on the literature where the risk types, assessment points, and mitigation strategies are incorporated. Risk monitoring is in this model represented as an activity that goes along the other three steps in the process to visualize that monitoring is a constant task to be performed in the SCRM process. This framework contributes to answering RQ1 by presenting a structured approach for SCRM. The framework will be used in the analysis to categorize the empirical data.

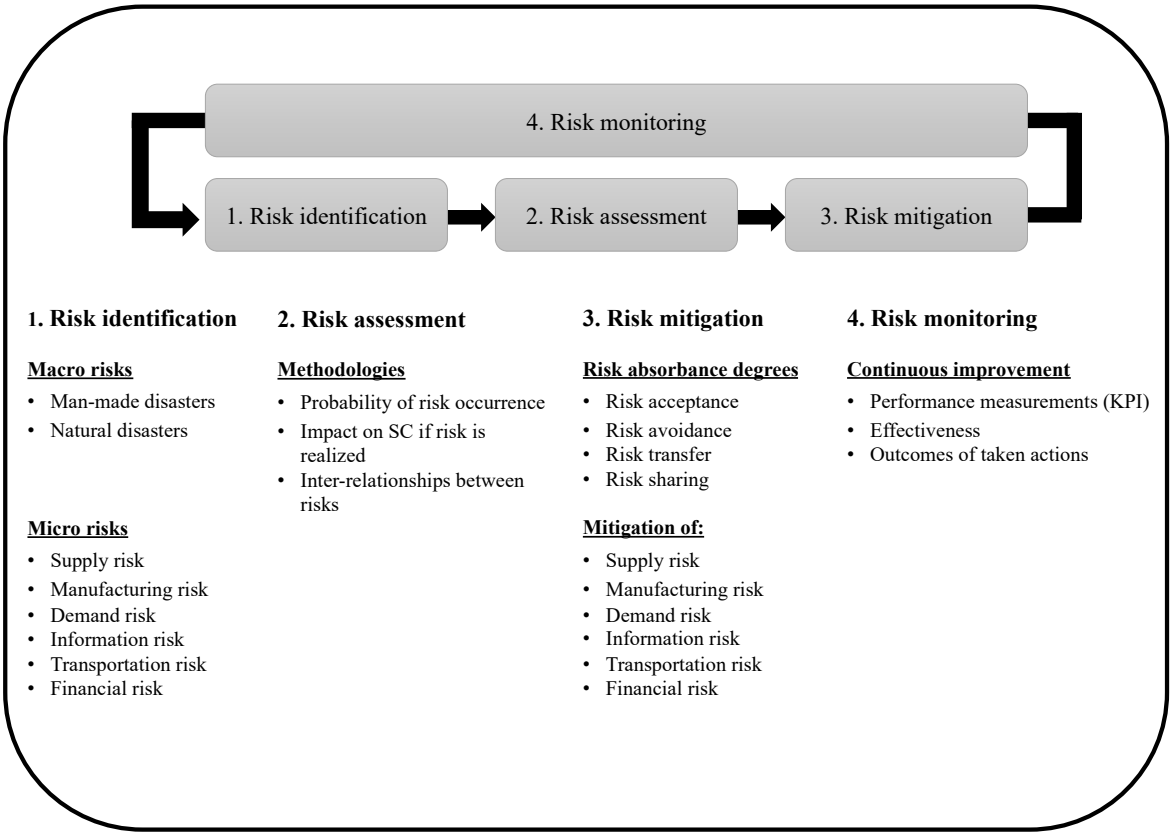

Figure 5. Supply chain risk management framework

4. The impact of COVID-19 on supply chains

In December 2019, the Coronavirus (SARS-CoV-2) and the disease COVID-19 first appeared in Wuhan, China (WHO, 2021). Approximately 94% of the fortune 1000 companies have tier 1 or tier 2 suppliers located in the Wuhan area (Paul & Chowdhury, 2020; Ivanov, 2020). This affected material supply and production globally due to lockdowns and closed borders. By March 11th, 2020, the virus had spread across the globe to the extent that WHO declared COVID-19 as a pandemic (WHO, 2021). As of May 6th, 2021, approximately 154 million cases of COVID-19 have been confirmed in 223 countries or territories globally, resulting in over 3,2 million deaths (WHO, 2021).

In addition to the negative health effects, the pandemic has also led to a devastating social and economic downturn (Fonseca & Azevedo, 2020; Pato & Herczeg, 2020). Governments have been closing borders, banning travels inside and outside the individual country, and imposed lockdowns, in part or totally, in society to reduce the spread of the virus.

Epidemic outbreaks are characterized by an unpredictable and long-term disruption that causes disruption in all parts of the supply chain as supply, demand, and logistics simultaneously (Ivanov, 2020). Supply chains have previously encountered several epidemic outbreaks historically, with 1438 reported only between 2011 and 2018 (Chowdhury, Paul, Kaisar, & Moktadir, 2021), including SARS in 2002-2003 (Ivanov, 2020) and the avian flu (H1N1) in 2009 (Paul & Chowdhury, 2020) that influenced the performance of the SC negatively. Still, the effects of the COVID-19 pandemic are unprecedented in modern times, with expectations of great negative outcomes on trade and the economy (Chowdhury et al., 2021).

Problems that have emerged during the COVID-19 pandemic are hitting all supply chain members and areas of the supply chain simultaneously (Chowdhury et al., 2021). A literature review on COVID-19 related supply chain research by Chowdhury et al. (2021) has listed eight areas of the supply chain that the pandemic has impacted. These areas are the management of demand, supply, production, transportation and logistics, relationship, finance and sustainability, and the supply chain-wide impacts. Some of the more specific impacts are demand fluctuations, shortage of material, production disruptions, delays in transportation, and extended lead times (Chowdhury et al., 2021; Van Hoek, 2020).

The main focus in the literature on the impact of COVID-19 has been towards the food and healthcare sectors since those sectors might be seen as especially essential in a pandemic (Chowdhury et al., 2021). Since the automotive industry is a vital part of the global economy, see chapter *3.1.3* for more information. It is also of interest to further address how the COVID-19 pandemic has affected that industry.

4.1 COVID-19 and the automotive supply chain

The following chapter begins with a short overview of the years previous to COVID-19 in the global automotive industry and is followed by presenting the impact the pandemic had on the global and Swedish automotive industry.

4.1.1 The global automotive industry in the years before COVID-19

In recent years, the global automotive industry has witnessed a reduced demand for new vehicles, much because vehicle sharing has become a viable option among the younger population (MarketLine , 2020). The combined value of the global automotive industry decreased by 1.6%, reaching a value of $1604,5 billion in 2019. Total volume of produced vehicles decreased by 4.9% to reach a volume of 146,4 million units during the same period (MarketLine , 2020). During the five years 2015-2019, the compound annual growth rate (CAGR) for revenue was modest, with a growth rate of 1% annually and 0,5% CAGR for production volumes.

4.1.2 COVID-19 impact on the global automotive industry

According to an industry report from MarketLine (2020), the COVID-19 pandemic had a significant impact on the global automotive industry. The profits and cash flow from automakers did decrease dramatically in connection with the spread of the pandemic (Chowdhury, Paul, Kaisar, & Moktadir, 2021). This is supported by figures presented in MarketLine's (2020) report, e.g., Toyotas production volumes were cut in half, with a decrease by over 53% during the beginning of April and end of June 2020. Simultaneously, Toyotas revenues fell by 43% for the same period. This scenario is reflected from other automakers in the global automotive industry; for example, Volkswagen saw a 32,5% drop in vehicle production, sales down by 30%, and revenue declined by over 23% during the first half of 2020 (MarketLine , 2020). Other brands, such as Hyundai and General Motors, had similar figures for the first six months of 2020, with a 47% and 33,2% decline in revenues respectively for the companies. Automotive producers globally entered a halt for reasons such as supply chain disruptions, reduced demand, or precautionary actions from the companies to protect their workforce (MarketLine, 2020). In addition, the automotive industry was hit hard when the transportation capacity decreased significantly as a result of the COVID-19 pandemic, which caused significant increases in transport prices for air-, train- and sea transports. This led to a shortage of materials and components among the manufacturers, as prices skyrocketed by several multiples, and available transport capacity was prioritized for food and medicine transports (Pato & Herczeg, 2020).

4.1.3 COVID-19 impact on the Swedish automotive industry

The automotive industry is one of the cornerstones of the Swedish economy. The industry employs approximately 74.600 people directly connected to the manufacturing of motor vehicles. However, if the purchases of components and services from suppliers are included, the automotive industry indirectly employs 153.700 people (Statistiska Centralbyrån, 2020). At the end of March 2020, most Swedish vehicle manufacturers, such as AB Volvo, Volvo Cars, and Scania, announced that they would temporarily suspend all production in the country due to the pandemic (Svenska Dagbladet, 2020). The main reason for the decision to shut down production was that companies wanted to protect the health of their employees, difficulties in accessing materials and components safely from subcontractors, and a significant reduction in demand (NyTeknik, 2020). On 2 April 2020, the Swedish parliament voted in favor of increasing the subsidy for short-term layoffs. The state accounted for three-quarters of the employee's remuneration at the same time as the employees reduced working hours (KPMG, 2020). From the major manufacturers in the Swedish automotive industry, AB Volvo, Volvo

Cars, and Scania, approximately 60,000 employees were laid off on short-term leave. In addition to that, another 80,000 employees from Swedish subcontractors within the automotive industry (NyTeknik, 2020). Regarding sales of vehicles during 2020, the Swedish automotive market as a whole, including passenger cars, trucks, and busses, suffered an 18,1% decrease in sales from the previous year (BilSweden, 2021). Despite this, the Swedish automotive industry had a strong recovery during the second half of 2020, where the car manufacturer Volvo Cars achieved the highest half-year sales in the company's history (Volvo Cars, 2021).

5. Empirical findings

The empirical findings consist mainly of the answers given during the interviews with each of the three case companies, Alpha, Beta, and Gamma. To complement the interviews has information from the companies' annual reports been collected in some cases. The empirical findings from each case will be presented in four parts, general information about the company and its operations, disruptions and risks faced due to the COVID-19 pandemic, countermeasures taken to prevent disruptions and risks, and key learnings from the COVID-19 pandemic.

5.1 Alpha

Alpha is a market-leading company producing fastening elements and has nearly 150-year experience in the field. The company has the headquarter in Sweden, where production and development take place, but production is also made in other locations in Europe, Asia, and America. In total does Alpha have approximately 1600 employees globally.

Two persons from Alpha were interviewed together during the interview, A1, and A2. Interview person A1 works in the position Manager Logistic Analytics with leading logistical studies and projects, follow the forecast processes and demand changes in the company. Interview person A2 works as a logistician comprising monthly statistics and is responsible for forecasting data and adjusting these if needed.

Alpha works mainly as a tier 1 supplier to OEM's in the automotive industry but also as a tier 2 supplier by supplying products to other companies in the automotive industry. Approximately 99% of the produced components are believed to be designated for the automotive industry, while the last one percent has been available on the general market. Formal business relations are managed with Alpha's tier 1 suppliers and with their customers, mainly OEM's. There are also codes of conduct that are required to be followed by tier 2 suppliers as well.

Alpha's annual report describes how the company's management views the risks that the company is exposed to, including operational risks, financial risks, conjuncture- and external risks, and sustainability risks. In the annual report are the risk factors analyzed in a probability-impact matrix, and the strategic actions to mitigate these risks are further described for a one-to-three-year horizon.

5.1.1 Disruptions and risks faced due to the COVID-19 pandemic

Alpha has experienced significant challenges during the last year, mid-March 2020 until late March 2021 (when the interview took place), due to the COVID-19 pandemic. The first problems following the COVID-19 breakout were that the communication between the customers and Alpha was lacking. There were considerable differences in how the customers (OEM's) chose to communicate the demand during this time, where some had to shut down operations due to lockdowns in some countries. When the shutdowns happened, the demand orders were left in the electronic data interchange (EDI), and delivery plans never were updated, so the actual demand was hard to find out.

At the start of the second quarter of 2020, the demand got heavily reduced and stayed that way until July. Still, in August/September, the demand took a turn around and kept increasing

during 2020 to a record-breaking quarter in Q4. The market volatility has been extreme, which has made the planning of operations hard to perform accurately. This also has to do with disturbances further upstream in the supply chain at the steel suppliers who have difficulties delivering products in time or even producing in some cases. The details of what has caused these disturbances at the steel suppliers are unknown but could be because of personnel shortage or production shutdowns.

An unbalanced flow of containers in sea transport has caused disturbances in the transport flow and has led to longer lead times. Brexit has also contributed to the unbalance in the container flow when Great Britain has bought many containers pre-COVID-19, and it has also caused longer times in customs. This has spiked prices of container transport, but how this has impacted the company's overall result is not known.

There have been very high levels of sick leave at Alpha during the pandemic, but that has to do with precautionary sick leaves where the employees have minor symptoms and then stayed at home. This has instead led to very few outbreaks of COVID-19 in the production facilities. It still has been possible to manage the production without using external workforces.

A looming threat of future demand that has been identified is the semi-conductor shortage that has hit the automotive industry. Even though Alpha does not depend on any semi-conductors in its products, it will influence how many vehicles the customers can produce, which will impact the demand for Alpha’s products.

5.1.2 Countermeasures taken to prevent risks and disruptions

Supply Chain Risk Management is not a concept that is used in Alphas operational activities. Still, risk management is driven at the logistical department by constantly analyzing the changes in the customers' delivery schedules and forecasts and trying to react to potential disturbances in an agile way. Strategic forecasts are also a source for identifying potential risks in a long-term perspective (2-5 years) and planning the mitigation strategies more proactively. According to the annual report, the proactive approach is important for risk management at a managerial level at the company since it is an important factor in strategic planning. Even if there is no formal collaboration regarding planning between the departments, the ERP system is used fully transparently, and the current demand situation is shared in real-time with all relevant departments within the supply chain of company Alpha.

To counteract the dependability issues of the delivery plans received through their EDIs, Alpha sought additional information from other channels like newspapers and the internet. This gave Alpha more accurate information regarding the demand of the customers. To keep relevant information and clear the inaccurate order-in database, Alpha internally developed a tool to manage this. This tool was used between March and June until the customers could make the corrections themselves.

The following decrease in demand required Alpha to reduce production and implement short-term layoffs during the summer, and this was possible with some financial aid from the government. A decrease in demand is easier to manage from a planning perspective than an increase, but it still led to some additional stocking of some products.

When the demand turned around in the third quarter, there was a need to increase the production. To manage the planning when the demand steadily was increasing did Alpha implement more frequent planning meetings. The increase in production required few external workers and was mainly covered by the employees who were given the possibility to work overtime.

Alpha handled the situation with the lower availability of steel by reserving as much capacity at the suppliers as possible. What type of steel and which dimensions are not exactly known, but they need to reserve as much as possible to get the material required to keep up with production. The company has chosen to work with the existing suppliers to get the material and has not broadened the supplier base to source steel from other suppliers.

5.1.3 Key learnings from the COVID-19 pandemic

During the COVID-19 pandemic, Alpha has made some important learnings. Firstly, it is essential to act quickly when a large disruption in the supply chain happens and not wait for some customer or supplier to solve anything. Secondly, it is also important to be vigilant and collect information from other sources than only through formal communications tools, such as EDIs. It has become clear that the received delivery plans cannot be trusted in turbulent times, and more information about supply chain members is required.

5.2 Beta

Case company Beta is a Swedish manufacturing company with roots dating back to the early 1800s. The company has since its establishment grown to become an industry leader with a global presence within the process industry. The company has 18 manufacturing facilities worldwide and employs 2,400 people globally. The company has operations or customers in 75 markets around the world, and the product portfolio consists of over 3,500 unique product types. The customers are located within three main regions, which are EMEA (Europe, Middle East & Africa), APAC (Asia-Pacific), and Americas (North and south America). The group has an annual production capacity of 500,000 tons, of which 300,000 tons are produced in the Swedish production facilities. Thus, the Swedish manufacturing sites are fundamental to the group's revenues.

From the 300,000 tons that are produced in Sweden, 99% of the goods are exported and sold abroad. The Swedish production facilities supply approximately 100,000 tons of goods to customers in EMEA, 165,000 tons to APAC, and the remaining 35,000 tons to the Americas. Approximately 70% of the manufactured volumes are sold to customers in the automotive industry, which is the biggest industry segment the company is supplying with its products. Therefore, it is an industry that the company is highly dependent on. The company has no formal or standardized framework for supply chain risk management. Still, each individual production site applies different methods to identify, assess, mitigate and monitor risks to prevent disruptions within the supply chain. At a company group level, Beta has composed a Supply Chain Excellence team consisting of managers and white collars from different subsidiaries within the group’s operations and supply chain divisions.

The representative at Beta who has been interviewed works as a Supply Chain Manager at one of the Swedish production plants and has worked approximately 20 years for Beta under various positions.

5.2.1 Disruptions and risks faced due to the COVID-19 pandemic

As for many other companies, the year 2020 has been a turbulent year for Beta, with unprecedented volatility swings in demand and major disruptions in their logistics flow.

Around the Chinese New Year 2020, the company received indications that Chinese ports would be closed as a result of COVID-19, which in turn led the company to increase exports to China to secure the supply of goods to its customers in the APAC region. Just a couple of weeks after the decision to increase export volumes, demand more or less disappeared completely. The following period consisted of short-term layoffs for the company's employees, where the degree of layoffs varied between blue and white collars. Beta took the dramatic decision at the beginning of May to shut down the complete production at the Swedish site during July month for the first time in the company's history.

Shortly after the decision was made, an unanticipated swing in demand took place, as the demand in the Americas region recovered quickly, followed by the other regions also recovering. The increasing demand in the Americas put the company in a dilemma. The decision to shut down the entire production in the Swedish site was final because there were no possibilities to withdraw such a decision on short notice that affects around 500 employees. The shutdown of production caused delays for certain product types and product groups, but in general, the company managed to supply their customer orders well from the other production facilities worldwide, even though approximately 60% of the entire production capacity is located in the Swedish production facility. The company has struggled to keep up with deliveries since the production in Sweden started running again in August because a small backlog was built up due to a steady increase in demand during the autumn of 2020.

This steadily increasing demand has resulted in an all-time high demand during March 2021. In terms of production capacity, the company has in periods utilized maximum capacity during the pandemic, which has created an imbalance between demand and production capacity. The forecast reliability has also been low during the pandemic, which made it more important for the company to receive customer orders in time to be able to deliver on time. Simultaneously as the demand has been increasing during the autumn, Beta has been faced with difficulties in maintaining their export volumes due to the low availability of shipping alternatives.

The supply of transports, particularly maritime shipping, which Beta is so dependent on in its exports, has been causing problems for the company as the availability for vessels going from Scandinavia/Europe to Asia has been low. Additionally, there has been an imbalance in the flow of empty containers. There was a low availability of empty containers in periods because the shipping companies relocated all empty units to China and other ports in Asia. The ports in the European content were given noticeably smaller priority from the shipping companies as they prioritized providing empty loading units to ports in Asia. As a result, the company was forced to use different transport routes and modes to get the goods transported to customers.

With different transport modes, the company also faced the challenge of learning how to load other units safely because Beta usually loads 20-foot containers due to the characteristics of the goods. In turn, Beta had to use 40-foot containers, which are much more difficult to load safely due to the weight of goods. Another transport issue that the company was faced with was the complete halt in the Suez Canal, which stopped all bypassing vessels to and from Europe.

5.2.2 Countermeasures taken to prevent risks and disruptions

Disruptions and risks in Beta's supply chain have been noticeable during the COVID-19 pandemic. To minimize the damage and maintain continuity in the production facilities, the company has had close contact with key customers worldwide. Internally and externally, the company has increased the information exchange and transparency between the demand and supply side to improve responsiveness and flexibility towards changes in demand caused by the COVID-19 disruptions. In some cases, the company applies Vendor Managed Inventory (VMI) for some key accounts, where the company has full access to inventory levels and sales data of the customers. From a production planning point of view, the frequencies between meetings have been shorter, and the input from other stakeholders has increased.

Furthermore, the company has established a forum for professionals in supply chain and operations, where the main focus has been to identify and assess risks and find solutions that are in line with the company's objectives. During the critical period when the Swedish production facility was closed, the Supply Chain Excellence team generated a solution in how the company could continue supplying customers, despite lacking approximately 60% of the total production capacity for a month. The solution was to consolidate all finished goods and semi-finished inventories across all production units and take into account existing capacity. The inventories were then distributed among the three regions, EMEA, APAC, and Americas. Beta has also applied several other strategies to maintain flexibility towards customers and volatility in demand, e.g., ship semi-finished products from Sweden to Asian production facilities to reduce lead times for customer orders. By delaying the customer order point to a later stage in the manufacturing process of a finished product, the company has been able to react quickly to received sales orders and thus maintain acceptable lead times in production and transportation with high service levels.

Regarding transportation, Beta's strategy has been to negotiate shipping rates and tariffs directly with the shipping companies. This was done mainly to secure transport capacity, benefit economies of scale by consolidating the total shipping volume of the company to few operators and bypassing intermediaries and related transaction costs. During the COVID-19 pandemic, the company has had a close dialog with the shipping companies, focusing mainly on sharing their projections of demand in transport capacity at sea for the coming month or two. The close dialog aimed to prepare the shipping companies for their transport needs and secure transport capacity. Beta has also been exploring other transport routes and modes when the performance of maritime shipping has been insufficient in terms of availability of maritime transports and transportation lead time. In these situations, the company mainly used rail transports, but there were also situations when they were forced to transport goods by air freight. The rail freight offered the company several benefits, mainly by reducing the

transportation lead time by up to three weeks. The company kept up with the high demand even though the capacity utilization was at high levels. In periods, the company had to transport goods from Sweden by truck to southern European ports, which offered departures to Asia.

Concerning the access of raw materials for the own production facilities, the purchasing department of Beta has actively worked to secure a supply of key materials to mitigate the risk of stock-outs that could shut down production lines. Extra attention has been put into raw materials with a long lead time with a limited number of suppliers. When the company received indications that there might be disruptions in their logistics flow to Asia, the strategy was to increase the inventory levels abroad in case the Chinese ports would be closed for a period due to the COVID-19 virus.

5.2.3 Key learnings from the COVID-19 pandemic

During the COVID-19 pandemic, it has become clear to Beta that to cope with major supply chain-related disruptions and risks; the company needs to extend the degree of applying risk management principles, particularly supply chain risk management, and formalize the processes company-wide. The outcome is that Beta will in the near future focus on developing its working methods in the supply chain risk management context and expanding the application of working more proactively to reduce its exposure to risks and disruptions in the supply chain.

Another part of Beta's transformation is that the company has introduced an S&OP program currently being implemented and will be fully integrated at the company over a 3-5 year period. The S&OP program will contribute positively to the company's long-term and strategic work with SCRM and integrate all independent production facilities and subsidiaries into one big unit that can offer much greater flexibility to their customers in the future. Finally, it has emerged that Beta needs to expand its efforts to ensure sufficient long-term production capacity, as the company has been touching its capacity constraints during large parts of the COVID-19 pandemic.

5.3 Gamma

Gamma is a Swedish original equipment manufacturer (OEM) of commercial vehicles. The company is a global player in the automotive industry with branches in Europe, Asia, and the Americas. From an operational perspective, the company's supply chain is very complex and resource-intensive to manage. The supplier base consists of more than 4,000 suppliers who supply the company with components, products, and services. Like most other companies in the automotive industry, Gamma applies Lean methods such as Just-In-Time, which means that the assembly lines are very sensitive to shortages of materials and components in the supply chain that can stop production. To mitigate the risk of disruptions in the assembly lines and assure high quality of components, products, and services, the company has a Global Supply Chain Risk Management department whose main task is to identify, mitigate and monitor disruptions in the procurement area. The global supply chain risk management department consists of 12 people located in different countries close to production plants and major suppliers.

The representative at Gamma, who has been interviewed, works as the manager of the Global Supply Chain Risk Management department and has a very good overview of the company's line organization. The manager defines the Global Supply Chain Risk Management department as an independent bridge between procurement, suppliers, and the production plants. The risk management department takes the lead in complex situations and cannot be handled by the line organization or suppliers and if the supply chain disturbance is sustained long-term.

The Supply Chain Risk Management process

The working methods and approaches applied within supply chain risk management at the OEM are formalized and constructed to continuously monitor and measure the performance of suppliers as regards parameters such as quality, delivery, manufacturing (backlog issues), and transports. Suppliers are scanned every week on normal occasions to identify if some suppliers need greater attention to decrease the occurrences of risks and disruptions. Cases are built around the identified risks, and teams are formed accordingly. The case team appointed a case consists of a project leader from the Global Supply Chain Risk Management department, various stakeholders from internal departments (e.g., procurement, manufacturing & quality department within the line organization), and representatives from the affected supplier(s). According to the interviewed manager, collaboration with internal and external stakeholders is an important success factor to mitigate risks and disruptions. Under normal circumstances, the department has direct business relationships with tier 1 and tier 2 suppliers and, on rare occasions, even tier 3 suppliers.

5.3.1 Disruptions and risks faced due to the COVID-19 pandemic

Given that Gamma has production facilities in mainland China, the management realized in December 2019 that the Chinese production plants were at risk of being exposed to disruptions from the COVID-19 virus. A short period after that, the company had to close down production at the Chinese plants due to the spread of COVID-19. The management did not anticipate that the COVID-19 virus will spread and become a global pandemic, nor were it any indications pointing in that direction. Instead, it was treated as a local or regional risk affecting the APAC region temporarily. By mid-March 2020, the pandemic also became a reality in Europe as the second continent to be hit by the spread of the coronavirus. Due to the velocity of the COVID-19 spreading on the European continent, Gamma was forced to close down the production facilities in Europe at the beginning of April 2020.

During the second half of 2020, Gamma started to recover from the losses in sales and production volumes experienced during the first half of 2020, and by mid-May, the assembly lines were up and running at full capacity. The second half of 2020 was characterized by high production rates and strong market demand, which resulted in the company breaking a historical sales record in terms of the number of vehicles sold between July and December. On a full-year basis in 2020, Gamma managed to navigate through the disruptions with minor revisions on the planned production volumes, a total decline of 6%. The strong demand in the automotive market has also continued during the first quarter of 2021. During the first half of 2020, Gamma was affected by disruptions in demand and manufacturing, while supply disruptions started becoming apparent during the end of the second half of 2020. In December, the company started receiving indications that there is a shortage of semiconductors in the

automotive industry. Semiconductors are critical components in vehicles and are needed for several technical features modern vehicles are equipped with. The early indications that Gamma was receiving were confirmed in January. The shortage quickly became a major problem for the OEM since the surplus of semiconductor capacity that arose during the decline in production volumes in the automotive industry during the first half of 2020 was sold out to the consumer electronics industry that saw an increase in demand during the same period. There is also an inherent problem in addition to the shortage of semiconductors, which is, the suppliers of semiconductors are tier 4 or tier 5 suppliers to Gamma with arms-length relationships at best, which makes the situation harder to cope with. Early estimations show that there will be a short-term shortage of semiconductors for the coming 12-24 months due to the long lead times in the manufacturing process of semiconductors. Due to the shortage of semiconductors, Gamma has revised its production plan for the first half of 2021. In addition to the shortage of semiconductors, Gamma also experienced disruptions in the supply of raw materials used, such as steel and plastic.

5.3.2 Countermeasures taken to prevent risks and disruptions

Gamma has actively handled disruptions since the first outbreak of COVID-19 in the Wuhan area in December 2019. The first action the company had to take was to close the factories in China for a total of three weeks at the end of January-beginning of February 2020.

When the virus hit Europe in March, it became clear that actions had to be made to manage the drop in demands that followed. This resulted in that at the end of March/beginning of April, the company was forced to close all plants, where both the major Swedish factory and the plant in Belgium were closed for approximately 2-3 weeks. During this time, substantial layoffs of white-collar employees and consultants were implemented at Gamma.

During COVID-19, the Global Supply Chain Risk Management department started to work in a task force set up, in order to manage to act upon risks and potential disturbances in a better way. This task force consists of cross-functional teams that follow up on the situations at the plants and with the suppliers. Right now, the company has over 180 suppliers that have reported issues and require increased monitoring, but of those 180 suppliers, does the taskforces focus on approximately 70 suppliers. For these 70 suppliers, daily to weekly meetings have been implemented where the task force, which includes the suppliers, constructs and works on an action plan. Every taskforce team is then reporting the progress during daily meetings, and the information is shared with management so strategic actions can be taken.

When the semiconductor shortage was identified as a major issue in January 2021, a task force team was implemented to solve the short-term problems. A strategic decision following this is that 30,000 vehicles will be taken out of the production plan because there is not enough supply of semiconductors for now. This reduction in production is spread globally and will be made during a nine-week period. During this period, the production shift focuses on the most profitable models to maximize profitability. The 30,000 vehicles are still planned to be made, and the production will hopefully recover the volumes during the third and fourth quarters.

In addition to handle the situation with the semiconductor shortage with taskforces to solve the short-term disturbances, the company is also working on a long-term solution to the problem.

For the longer perspective have Gamma hired two consultancy firms to help them find a way to mitigate this kind of disturbance better in the future. One possible solution they are exploring is to establish close business relations with the semiconductor manufacturers or suppliers, even if they are tier 4 or 5, or even further away in the supply chain, to find ways to allocate the volumes of semiconductors better. A pilot project of this kind with suppliers of semiconductors will most likely be carried out in the near future.

5.3.3 Key learnings from the COVID-19 pandemic

Compared to many other automotive OEMs have Gamma managed to handle the disturbances during the COVID-19 pandemic without losing much volume in the production, according to the interviewee. Several factors have been identified as important for this, but one particular success factor has been the unique setup of the Global Supply Chain Risk Management department. It is believed that the way the department works with handling risks is not how any other OEMs in the automotive industry does it. This led to Gamma holding out longer without shutting down the production than most other OEMs. Not being tied to any line organization but flexible and agile to act wherever there is a need creates a better overview of the production plants and the cooperation within the supply chain and presents a possibility to act more quickly to mitigate potential disturbances.

The new setup of using taskforces has also been a factor that has helped Gamma handle the disturbances that have come with COVID-19. During the last year, it has been proven that it is a time-efficient way of working and cost-efficient by avoiding costs connected with disturbances in a better way. The taskforces have been so successful, and this work setup will be continued in the future beyond the current COVID-19 related crisis.

Having the risk managers located in proximity to the factories and suppliers is also something that has contributed to better handling of the risks and disturbances during the pandemic. Having good connections with the factories and suppliers has helped the cross-functional collaborations in the task force teams.

According to the interviewee, there are also improvement possibilities in the process of risk management learned during the course of the COVID-19 pandemic. Firstly, the need for being more proactive in scanning the supply chains has become apparent during the pandemic. This can be seen in the current semiconductor shortage because it has been known that semiconductors are important parts of vehicles and that there are long lead times for the product, but still have there not been enough actions taken to secure the supply. This goes for several components and materials that are produced in higher tiers of the supply chains. So, there is a need to implement a cross-check of the supply early and establish direct communication with the suppliers that have not been there previously. By screening for risks deeper in the supply chain, could the company identify them and take better strategic decisions early enough to lower the impact of that potential disruption. It all comes down to the correlation between impact, probability, and cost regarding risks in the supply chain. The automotive industry in general needs to be more proactive to balance these factors.

6. Analysis

The analysis is conducted using the four steps in the SCRM process according to the Supply Chain Risk Management framework, presented in chapter 3.4, to categorize the empirical findings presented in the previous chapter. Each case will be analyzed individually based on which challenges were faced and how they were handled. COVID-19 is seen as a macro-risk on a global scale that led to the exposure of micro-risks in the supply chain. It is the micro-risks that will be one of the subjects of the analysis. The last section of the analysis is a cross-case analysis where the motive is to compare similarities and differences in the risks and disruptions the companies have been exposed to and compare the approaches and strategies applied in their supply chain risk management during the COVID-19 pandemic.

6.1 Alpha

Even though Alpha's supply chain risk management process is not specifically defined or applied in the daily operational work, the different steps of the SCRM framework can help visualize how the company has worked with identification-, assessment-, mitigation- and monitoring of risks during the COVID-19 pandemic.

6.1.1 Identification of risks

The empirical findings imply that Alpha works with risk identification both proactively and reactively. Alphas annual report mentions that identifying risks is important to prevent the eventual disruptions caused by these risks. This can be seen as a proactive approach to risk identification. On the other hand, the interview suggests that operationally, at least in the logistical department, is not the work with identifying risks done proactively in the same way. The risks are instead identified when it starts to impact the operations or when information of potential disruptions is received from other departments, i.e., in a more reactive fashion.

In the SCRM-framework is the micro-risks categorized into six different risk types, and the risks that Alpha has faced during the pandemic can be sorted with the help of them.

Supply risk

The main supply risk that Alpha has encountered during the pandemic is that the lead times of steel have become long. COVID-19 has likely caused production problems at several producers, which could have influenced the shortage of steel. Another factor of the steel shortage might also be an increasing demand for steel, and the suppliers do not have the capacity to handle this.

Demand risk

When it was declared a global pandemic and forced Alpha’s customers to shut down production in March, there was a big drop in the demand. This also exposed Alpha for inaccurate demand forecast because the customer did not update the joint IT systems with revised and accurate demand before they shut down their production.

There has been a demand uncertainty since mid-March 2020 with drops in demand during Q2, but since August 2020, there have been steady increases in demand, which is harder to plan for.

Another demand risk that has come to Alpha's attention is that the semiconductor shortage probably will affect the OEM's and it is unclear how that will affect the demand for their products.

Manufacturing risk

A decrease in demand requires production to be reduced so that the inventories do not become too big and costly. But by reducing the production, a redundancy of production workers then become another manufacturing risk.

During the second half of the year, it became harder to plan the production to keep up with the steady increase in demand. The difficulties in planning production and high sick leave rates, which is a result of following governmental guidelines regarding staying home if showing any symptoms of COVID-19, exposed Alpha to a shortage of workforce and risk not being able to produce according to the plan.

Information risk

Lack of adequate visibility and information both from customers but also further away with suppliers of steel. Alpha has acknowledged that the suppliers are having delivery issues, but the reason behind the problem is not fully known.

Transportation risk

Alpha has experienced disturbances in transports during the COVID-19 pandemic as there has been a shortage of containers. It has become difficult to get hold of containers, leading to increased cost and longer lead times for the transports. Brexit has amplified this problem because Great Britain has gathered many containers to lower their dependability on the rest of the EU.

Lead times have also increased during the COVID-19 pandemic due to more complicated customs controls, closed borders, and quarantined shipments.

Financial risk

What financial risks Alpha faced during the pandemic is not explicitly stated in the empirical findings. One financial risk is that the price for transport has increased a lot which could affect the profitability. Another financial risk for Alpha is that when the demand has reached high levels, and there is a shortage of material, steel prices might increase.

6.1.2 Assessment of risks

How risks are assessed at Alpha was not mentioned during the interview. In Alpha's annual report, the risks are presented in a probability-impact matrix where the risks are assessed by how probable it is for a risk to occur and how significant impact this occurrence would have on the company.

6.1.3 Mitigation of risks

Based on the risks and disturbances that Alpha faced, specifically due to the COVID-19 pandemic, has certain actions been taken to mitigate them. The SCRM framework is used to describe these mitigation strategies.

Supply risk mitigation

To mitigate the shortage of steel has Alpha started to book as much capacity of the suppliers as possible for six months in the future, so they don't risk having too little material. By doing this, Alpha is transferring the risk from themselves to the suppliers.

Demand risk mitigation

Alpha's countermeasures to mitigate the uncertain delivery plans they received through EDI was to quickly develop a tool to clear the delivery plans from the customers in the EDI's, so they did not produce items without actual demand. Alpha also started to search for additional information outside the usual channels of communication to understand how the customers were hit by the pandemic and then to better estimate more accurate delivery plans.

Due to the variations in demand over 2020, Alpha increased its planning frequency to produce more accurate production plans and adapt faster to the real customer demand. This increased planning frequency will continue until the demand is not so volatile anymore.

Manufacturing risk mitigation

As the demand lowered in the second quarter of 2020 did Alpha reduce the production of products with the lowest demand, and the focus was on producing high commodities. The reduced production forced Alpha to make short-term layoffs to cope with the unused capacity. Still, Alpha needed to produce more than the demand to keep the production going, so they accepted the building of small strategic stock to keep the plant from shutting down temporarily.

The higher planning frequency that Alpha implemented helped manage the planning of using the existing workforce in the best way. This helped Alpha manage the increase in production without using external personnel, even considering the higher sick leave rates.

To avoid getting an outbreak of COVID-19 in the production, Alpha followed the governmental guidelines regarding that employees should stay at home if they have any symptoms of a cold. Alpha has accepted the risk of having high sick leave rates to keep the employees safe and not have to shut down production.

Information risk mitigation

The lack of visibility and transparency between Alpha and the customers has caused Alpha to improve the visibility by establishing more communication channels to get more accurate information. More transparent communications help Alpha to share the risks with the customers regarding the inaccurate delivery plans.

Transport risk mitigation

From the empirical findings, it is not established in detail how Alpha mitigates the transport risks other than that relying on their transport providers to manage the transports. The risk with transports is then transferred to some extent to the providers, so they solve issues with container shortage and custom disturbances.

Financial risk mitigation

There is little information from the empirical findings on how Alpha has mitigated the financial risks during the COVID-19 pandemic. In Alpha's annual report, there are some general mitigation strategies presented. Regarding material volatility, Alpha made agreements with

their customers to be partly compensated and share the risk with their customers. Alpha has signed insurances to hedge the risk that production should be shut down due to forces beyond Alpha's control.

6.1.4 Monitoring of risk

The structure of how Alpha monitors the risk after it has been mitigated is not stated in detail in the empirical findings and could be more elaborate than what is presented in this segment. In accordance with the information collected in the empirical findings, the logistics department works with monitoring risks in some ways. The ERP system allows for continuous monitoring of changes in delivery plans and operations. Another is that monthly reports of logistical statistics are produced to see if anything is out of the ordinary. Another way Alpha is monitoring the risks is by calibrating the forecasts when other departments experience events that can influence sales or supply or if other data imply changes in the forecast conditions.

6.1.5 Summary of the analysis of Alpha

The SCRM framework was used to summarize the SCRM approaches of Alpha during the COVID-19 pandemic, see figure 6. The priority level of the risk categories is only an estimation based on the authors perception from the empirical data collection.

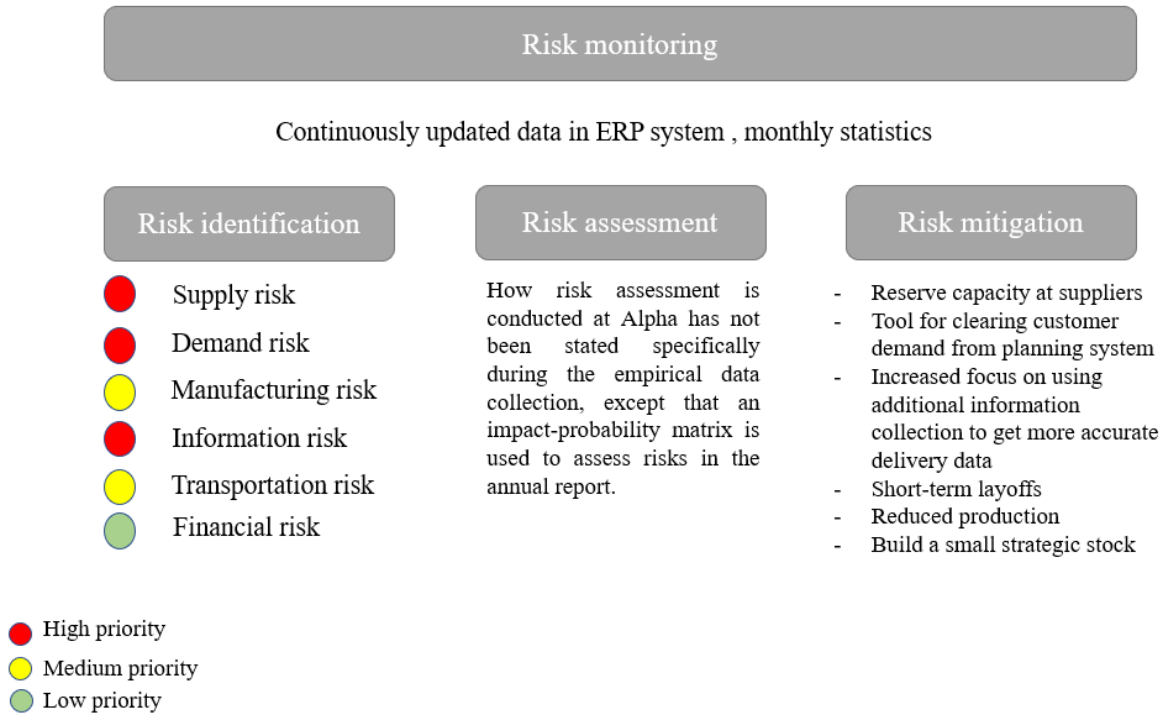

Figure 6. Summary of the analysis of Alpha

The risks that have gotten much attention at Alpha are supply risk, demand risk, and information risk. Manufacturing risk and transport risk have also caused disturbances at the company, while the financial risk is not something explicitly mentioned. The risk assessment tools and methods have not been mentioned more than that an impact-probability matrix is used to assess risks in the annual report. To mitigate the identified risks has actions such as creating

a tool for clearing customers' delivery plans in the planning system, booking as much capacity as possible at suppliers, and increasing the focus on using more sources of information than EDI when planning production. The monitoring of risks is done at Alpha by conducting monthly statistics on customers' delivery plans and having an ERP system that continuously updates changes in data received from customers.

6.2 Beta

Beta is currently lacking a formalized and defined supply chain risk management structure. On the other hand, it has emerged through the empirical data collection that Beta deals with supply chain risk management at a general level in its daily operational execution and long-term strategical horizon. The four SCRM processes from the framework in chapter 3.4, identification, assessment, mitigation, and monitoring, are applied at Beta, however, to different extents. In the following subsections below, will an analysis of the SCRM processes at Beta be conducted.

6.2.1 Identification of risks

The identification process at Beta is two-dimensional, which means that the company works proactively to identify risks and reactively on risks that bypassed unidentified. During the interview, it emerged that Beta works proactively to identify risks and disruptions that are inherent on the supply and manufacturing side of the operations. Otherwise, Beta applies a reactive approach to risks and disruptions by allocating resources once the risk event has taken place and affected the company’s operations.

During the COVID-19 pandemic, Beta has identified risk types and disruptions from the micro risk category in the SCRM-framework. These risks are listed below.

Supply risk

The supply of certain key materials used in the manufacturing of products at Beta has been affected by longer lead times. In general, the company has avoided any stock-outs or other supply-related risks, which has enabled them to sustain operations in the production facilities.

Demand risk

There has been a prominent fluctuation in demand during 2020, starting with an abrupt decrease in demand. Many of the customers in the automotive industry had to close down the production facilities as COVID-19 spread around the world and became a pandemic. During the second half of 2020, demand has turned around, a bit unanticipated, and since the beginning of the third quarter of 2020, the demand has been increasing to the point that the company reached its all-time-high in terms of outbound volumes from the production facilities in March 2021. Interestingly, Beta had its highest output in the company's history during a period where OEMs are suffering from shortages of semiconductors, which is disrupting the output from the OEMs.

Manufacturing risk

Throughout the entire period with the COVID-19 pandemic, Beta has been exposed to various types of manufacturing risks. The majority of the manufacturing risks are related to stochastic demand. During the first half of 2020, when the company suffered drops in demand, Beta implemented short-term layoffs to prevent redundancy and overproduction and cope with the current financial situation. Beta was forced to close down the Swedish production plant towards

the end of the second half of 2020 for one month due to low demand. When demand recovered during the second half of 2020, have Beta instead been utilizing maximum production capacity, resulting in difficulties in keeping up with the demand and delivery plans. Beta has the vision to implement a common manufacturing strategy for all the production plants, which implies that the company is able to produce all product types with the same quality standard across all manufacturing facilities. Beta has faced manufacturing disruptions to a certain extent due to not having a fully implemented common production strategy across the plants, which has prevented the company from reallocating production volumes between the subsidiaries.

Information risk

Disruptions in the information flow have been most prominent internally at Beta during COVID-19. Currently, the company is lacking an implemented Sales & Operations Planning program, which would enable a more efficient visibility and information sharing channel through common IT software and planning meetings within the group. The ability to reallocate production volumes from plants running on the maximum capacity to other manufacturing facilities with lower degrees of capacity utilization would have been easier with an implemented S&OP-program. When the demand dropped in the early stages of the COVID-19 pandemic, Beta intensified communication with key accounts and internal stakeholders from the sales department to understand the swings in demand better.

Transportation risk

Beta depends on high-performing long-distance transportation modes as the majority of the produced volumes are exported abroad within the EMEA region and APAC or Americas. Transportation is the subject that has been affected the most by the COVID-19 pandemic from an operational perspective at Beta. Beta procures transport capacity directly from the shipping companies, without intermediaries, to minimize transportation costs and secure high-performing transportation modes. Despite this, Beta has not been able to cover their transportation needs sufficiently due to low available maritime capacity from Europe to the APAC region in particular, but also other regions. This, in turn, has contributed to the company being forced to use other transportation modes and routes from the ones traditionally used. The global shipping companies have, during the COVID-19 pandemic, prioritized the Asian ports and the export from Asia to EMEA and/or Americas, which has created a shortage of shipping containers on the European continent. This has exposed the company to disruptions in transports, and at times the company has had to replace the 20-foot containers with 40-foot containers, which complicate the loading process in part because the company traditionally loads the 20-foot units full and meets the load securing and weight requirements.

Financial risk

During the turbulent first half of 2020, Beta witnessed how the revenues vanished while all the fixed costs remained. From a short-term perspective, this affected Beta's cash flow. In situations where Beta had to use transport service providers outside its contracts, the company has been affected by the significant increase in maritime transport rates. Other than these financial risks, there have not been addressed any other financial risks during the empirical data collection.

6.2.2 Assessment of risks

The Global Supply Chain Excellence team has during the COVID-19 pandemic, been a positive contributor who has been used as a forum to assess risks and disruptions. The team has also been utilizing the platform for scenario planning, where the representatives formulate and discuss different strategies and action plans for the risks and disruptions.

6.2.3 Mitigation of risks

Risks and disruptions that have been affecting Beta required different approaches and strategies to be mitigated or to reduce the impact which the risks and disruptions had imposed on the operations. These actions will be analyzed and described in accordance with the SCRM-framework.

Supply risk mitigation

In order to mitigate the supply risks during COVID-19 for critical materials suffering from long lead times, Beta's procurement department has extended the partnership/relationships with the affected suppliers through intensified information sharing. The objectives of increasing the information exchange are to be proactive by communicating the company's needs at an early stage and share projections of future demand to secure deliveries upfront. Through the transparency initiative, Beta has created space for its suppliers to act in a timely manner, thus establishing flexibility in the supplier's production plans.

Demand risk mitigation

To mitigate demand risks that have arisen during the COVID-19 pandemic has Beta intensified the collaboration on several fronts. Internally, Beta has worked extensively with the exchange of information between the company's supply and demand side to create an awareness of the current situation. The transparency between the supply and demand-side at Beta has made it possible for the organization to respond quickly to fluctuations in demand as a result of better visibility and understanding of the COVID-19 impacts. Externally, Beta has during the pandemic had a continuous dialog with key accounts in order to find common solutions that benefit both parties. The frequent exchange of information between Beta and key accounts has contributed to better visibility and transparency between the parties, which has consequently dampened or mitigated the negative effects of the COVID-19 pandemic. Internal and external collaboration with key stakeholders has contributed to a better foresight of actual risks encountering the supply chain and getting more accurate sources of demand information that can support production and capacity planning.

Manufacturing risk mitigation

During the first months with the COVID-19 virus, Beta implemented short-term layoffs in production to mitigate overproduction and large inventory build-ups that are costly to keep in stock. As time passed and the effects of COVID-19 became more apparent, Beta began to apply joint planning through collaborations with key accounts in order to create more reliable production plans. When the company reached its cap in terms of manufacturing capacity, Beta implemented a postponement strategy, which meant that the Swedish manufacturing plant began to supply the smaller production facilities abroad with semi-finished products in order to cut production and transportation lead times and to offer high service levels by a flexible manufacturing strategy. The postponement strategy allowed Beta to delay the customer order

point in the manufacturing process with small levels of inventory and quick responsiveness to customer orders. The manufacturing facilities also acted as order fulfillment centers with a strategic stock. Also, during the period when the Swedish manufacturing plant was closed for one month, Beta managed to supply customer orders from existing inventories at the other plants and existing production capacity. Additional solutions which were implemented to mitigate manufacturing risks during the second half of 2020 with COVID-19 was that Beta utilized flexible transportation solutions in order to cut transportation lead times which created timeslots for the highly strained manufacturing facilities. By these means, Beta could proceed to deliver customer orders according to the delivery plans that existed.

Information risk mitigation

Because there has been such volatile demand during the COVID-19 pandemic, production plans, delivery plans, and forecasts have been incorrect, which has exposed Beta to major information risks. A risk-sharing approach has been applied, as accurate information benefits all actors affected by information risks in the supply chain. Therefore, the company has actively worked to intensify the exchange of information internally and externally to create an increased understanding of the real customer needs. The expanded partnerships or business relationships have contributed to the company being able to visualize actual needs during the pandemic. This transparency has required full disclosure and trust between the partners due to confidentiality and the sensitivity of the exchanged information.

Transportation risk mitigation

Transportation risks were mitigated through collaboration with transport service providers (shipping companies and haulers). Beta constantly remained transparent and expressed upcoming needs to the transport providers to make sure there was a sufficient transport capacity available that fulfills Beta's needs. In situations where Beta did not get a hearing on its requested transport needs, the company sought other transport solutions to cover the needs. A major change that was implemented when maritime transport was not available or low performing was the change to rail transports from Europe to Asia, which also decreased to transportation lead time significantly compared to maritime shipping. Transports are important for Beta as the company is an exporting firm, much effort has been applied to avoid transportation risks.

Financial risk mitigation

How Beta mitigated financial risks during the COVID-19 pandemic has not been addressed in detail in the empirical data collection. One action taken to mitigate the financial risk in the early stage of the COVID-19 pandemic was to implement short-term layoffs to reduce the fixed costs during the period that Beta suffered from reduced revenues.

6.2.4 Monitoring of risks

Beta continuously monitors risks and disruptions in its day-to-day operations. Through the global supply chain excellence team, Beta has established an additional platform where risks and disruptions are monitored continuously. Changes in certain supply chain areas exposed to risks or disruptions and required some intervention or increased attention are compiled in KPIs that are monitored continuously to act quickly on deviations.

6.2.5 Summary of the analysis of Beta

The SCRM framework was used to summarize the SCRM approaches of Beta during the COVID-19 pandemic, see figure 7. The priority level of the risk categories is only an estimation based on the authors perception from the empirical data collection.

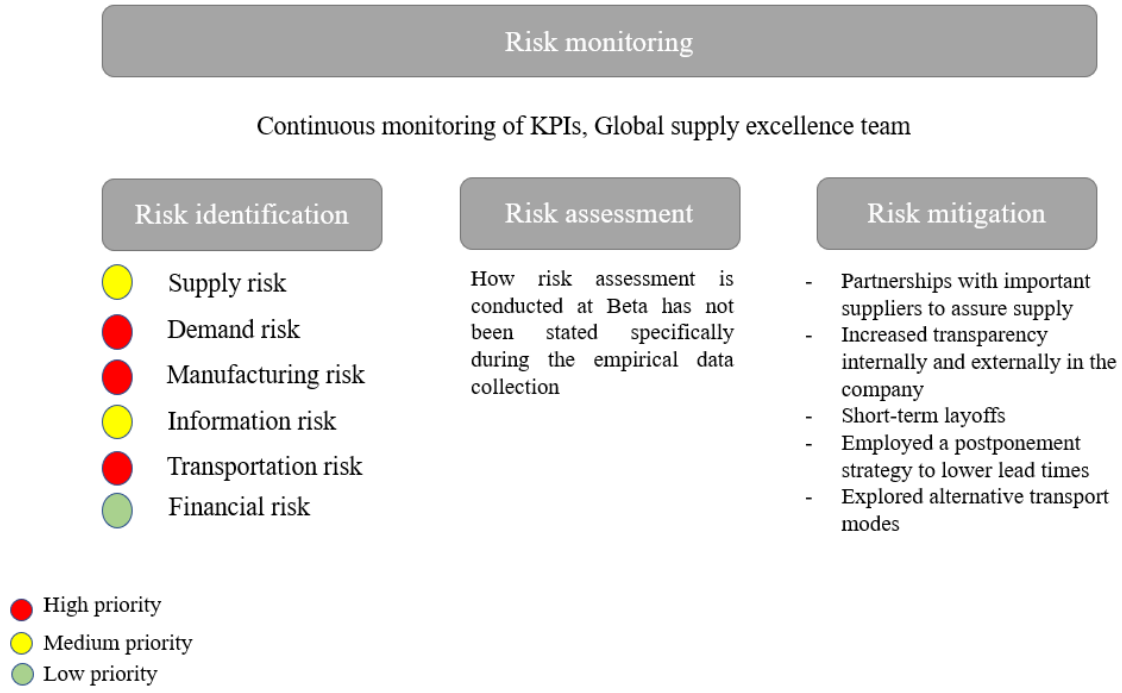

Figure 7. Summary of the analysis of Beta

The risk categories identified by Beta's high priority risks are demand risk, manufacturing risk, and transportation risk. Information risk and supply risk have also caused disturbances at Beta, while financial risk has not been a high priority. Risk assessment methods have not been specified more than that the global excellence team is working with developing the routines of how to do these assessments. Beta has taken actions such as developing partnerships with important suppliers, increasing transparency both internally and externally in the company, and exploring alternative transport modes to mitigate risks. Monitoring of risks at Beta is conducted by continuously monitor KPIs, and the global supply excellence team has an important role in screening for deviations.

6.3 Gamma

Gamma has a well-established supply chain risk management department that works strategically to identify, assess, mitigate, and monitor risks that are potential threats to the company. Smaller risks and disruptions are being managed in the line organizations, and the more complex and sustainable long-term risks are being managed by the Global supply chain risk management department. The department is a fluid and agile entity that is not connected to specific line organizations or plants and work as a bridge between the suppliers, procurement, quality, and the plants.

6.3.1 Identification of risks

The automotive industry is characterized as a reactive industry due to being tailored to be Just-in-time, that will say low inventories and short lead times. This makes it harder to be proactive in identifying risks in the supply chain. Gamma is trying to be as proactive in identifying risk as possible by continuously monitoring the supply chain performance and screening the supply chain for potential risks.

Supply risk

Of Gamma's 4000 active suppliers, are 188 experiencing some sort of disruption. This causes several potential risks that need to be assessed. Of these 188 suppliers are approximately 70 of them are exposing Gamma to more direct risks that require active mitigation.

During the COVID-19 pandemic has a variety of component- or material shortages affected the supply for Gamma. The supply of steel and certain plastics are some of the materials that have been affected during the pandemic. If there are any shortages in material, the production volume will be affected since they are crucial materials in a vehicle.

Gamma received the first indications of a shortage in semiconductors in December 2020. In late January 2021, it became clear that the semiconductor shortage will be affecting Gamma's operations in the coming 12-24 months. The relatively long recovery of this shortage has to do with the complexity of the products and the long lead times due to extensive testing of the semiconductors. This shortage will thus affect the volumes of what can be produced in a negative way.

Demand risk

Gamma has experienced both drops and spikes in demand during the pandemic. The variability in demand causes uncertainty and makes it harder to plan the production.

The company saw troubles in the supply of material to the Chinese plants at the beginning of 2020, and during the first half of March did Gamma see a big drop in demand in the rest of the markets, which lasted until May.

During the second half of May did the demand start to recover. The recovery in demand and production at Gamma, and in the automotive industry in general, happened faster than anticipated, and the second half-year in 2020 was the best in Gamma's history, in terms of number of vehicles sold.

Manufacturing risk

The disruptions in both supply and demand have caused additional risks in the production of Gamma. The lower demand and supply shortages led to lower production volumes, which led to a high cost in labor compared to what was being produced. Due to disturbances in the supply chain and reduced demand, resource utilization was at low degrees during the first half of 2020.

During the COVID-19 pandemic, Gamma has experienced additional manufacturing risks at its production facilities. The problem has been to provide a safe workplace despite the prevailing pandemic with minimal impact on the production output. Following the governmental and company guidelines regarding how to act in public and more rigorous sick leave instructions lowers the risk of getting an outbreak of COVID-19 in the assembly facilities.

This causes higher sick leave rates but getting this virus outbreak would threaten the employees' health and risk a shutdown of production.

Information risk

As business relationships are held mainly with tier 1, and sometimes with tier 2 suppliers, Gamma needs to rely on them to manage suppliers further upstream. This creates a lack of visibility in the supply chain and might result in delays in the information flow or information being lost on the way.

In a complex supply chain, which Gamma has with approximately 4000 active suppliers, is transparency important for quick identification and mitigation of disruptions, so it does not affect the customers.

Transportation risk

Specific transportation risks that Gamma has faced during the COVID-19 pandemic is not clearly stated in the empirical findings. Still, premium transports are continuously being monitored by the global supply chain risk management department. In an industry characterized by Just-in-time is the lead times and delivery accuracy important factors to consider. Transport risks in general during this time have been that the transport prices have increased and that closed borders have caused more excessive handling when crossing borders.

Financial risk

Gamma's year-on-year revenue for 2020 decreased by 6% in comparison to 2019. The majority of the financial risks associated with the losses in sales were prominent during the first half of 2020, when the first wave of COVID-19 hit the company. The latter half of 2020 contributed to a strong financial recovery, as Gamma had its best half-year sales in the company's history. At present, in 2021, Gamma has not been able to meet the demand volumes due to the semiconductor shortage that has created a bottleneck in production and thus limits the number of vehicles that the company can currently produce and sell.

6.3.2 Assessment of risks

The Global Supply Chain Risk Mitigation department surveillance the supplier performance continuously to ensure continuity in the supply of materials and components from the suppliers that can cause production stoppages at Gamma's production plants. When indications of deviations in the supply chain are detected, the Global Supply Chain Risk Mitigation team at Beta quickly appoints a supply chain risk manager whose main task is to assess the impact and probability of the risk or disruption. Initially, the supply chain risk manager's priority is to map the situation that has arisen to be able to rectify the risk or disruption affecting the production plants quickly. The second phase of the risk assessment process at Beta is finding the root cause of the disturbance affecting the operations and constructing an action plan that defines what measures must mitigate the problem permanently. The main topics being assessed at the suppliers are quality-, delivery- and financial issues.

6.3.3 Mitigation of risks

Depending on how the risks are assessed, the risks will be mitigated differently. If the risk is deemed a complex nature or sustained long-term during the assessment, a task force will be assembled to mitigate the risk directly and minimize the short-term disturbances. The task force

consists of a risk manager from the Global SCRM department, who works as a project leader and representatives from the supplier, the plant, procurement, and other relevant departments. The Global SCRM department continues to work with long-term action plans to handle the root cause of the problem, so it does not return. If the risks or disruptions are deemed to be of a simpler nature, would the problem be left to the line organizations to be managed.

Supply risk mitigation

To handle the risks connected to the identified 70 suppliers who were experiencing disturbances due to COVID-19 have task forces been assembled to mitigate the risks. The team has weekly, and sometimes daily, taskforce meetings to follow up and implement action plans. This setup is done for both the shortage in steel and plastics as well.

A special task force has been assembled to work with the acute disruptions concerning the semiconductor shortage. A short-term action plan to mitigate this has been to reduce the volume of produced vehicles by 30,000 during a nine-week period in the second quarter and instead focus on the most profitable models. Hopefully, the semiconductor suppliers will be able to produce some more so that the volume can be recovered during the second half of 2021.

The long-term strategy to mitigate the semiconductor sourcing is that two consultancy firms have been appointed to create sustainable mitigation strategies to reduce the possibility of something similar happening. One of the possibilities these consultancy firms are looking into is establishing direct business relations with the semiconductor producers to provide better transparency both ways in the supply chain so the risks could be shared or completely avoided. Another possibility is to explore multiple sourcing.

Demand risk mitigation

Gamma received financial support by the Swedish government to mitigate the drop in demand, which helped the company recover faster than anticipated. The vigilant work by the taskforces to “stop the bleeding” of acute disruptions also helped Gamma avoid shutting down the production longer than most competitors.

Actions taken to handle the increases in demand that Gamma experienced during the second half of 2020 and the beginning of 2021has been to work at a higher capacity than normal. The supply shortages have made it hard to continue to produce in the takt of the demand.

Manufacturing risk mitigation

The variation in demand and supply shortages made Gamma first shut down production in China in January 2020 for three weeks. In March, the production facilities in Europe shut down for approximately two to three weeks as well. The main reason for closing down the production plants was to protect employees' health and reduce the occurrence of large stock build-ups of finished vehicles.

Information risk mitigation

The information risk mitigation actions that Gamma has made are connected to the supply chain risk mitigation actions. The company needs to create transparency in the information flow between semiconductor suppliers and other high-tier suppliers that are supplying bottleneck items and Gamma.

Transportation risk mitigation

Mitigation of transportation risk is not specifically stated in the empirical findings.

Financial risk mitigation

During the COVID-19 pandemic, Gamma has prioritized producing the most profitable vehicle models to maximize its revenues. Since the beginning of 2021, when the shortage of semiconductors became evident, the vehicle manufacturer has revised its forecast and removed 30,000 vehicles from the production plan for the second quarter of 2021. To reduce the consequences of the reduced sales volumes, Gamma has given priority to producing vehicle models that generate the greatest profit per unit sold to maximize its earnings under prevailing conditions. This can be considered a risk transfer strategy, where consumers who demand less profitable vehicle models suffer from delays in deliveries.

6.3.4 Monitoring of risks

The risk monitoring process at Gamma is continuous, and the company works very proactively to prevent risks or disruptions affecting its operations as production stoppages are very costly due to the magnitude of operations. Gamma uses KPIs to detect deviations in quality, deliveries, and delays (production backlogs).

6.3.5. Summary of the analysis of Gamma

The SCRM framework was used to summarize the SCRM approaches of Gamma during the COVID-19 pandemic, see figure 8. The priority level of the risk categories is only an estimation based on the authors perception from the empirical data collection.

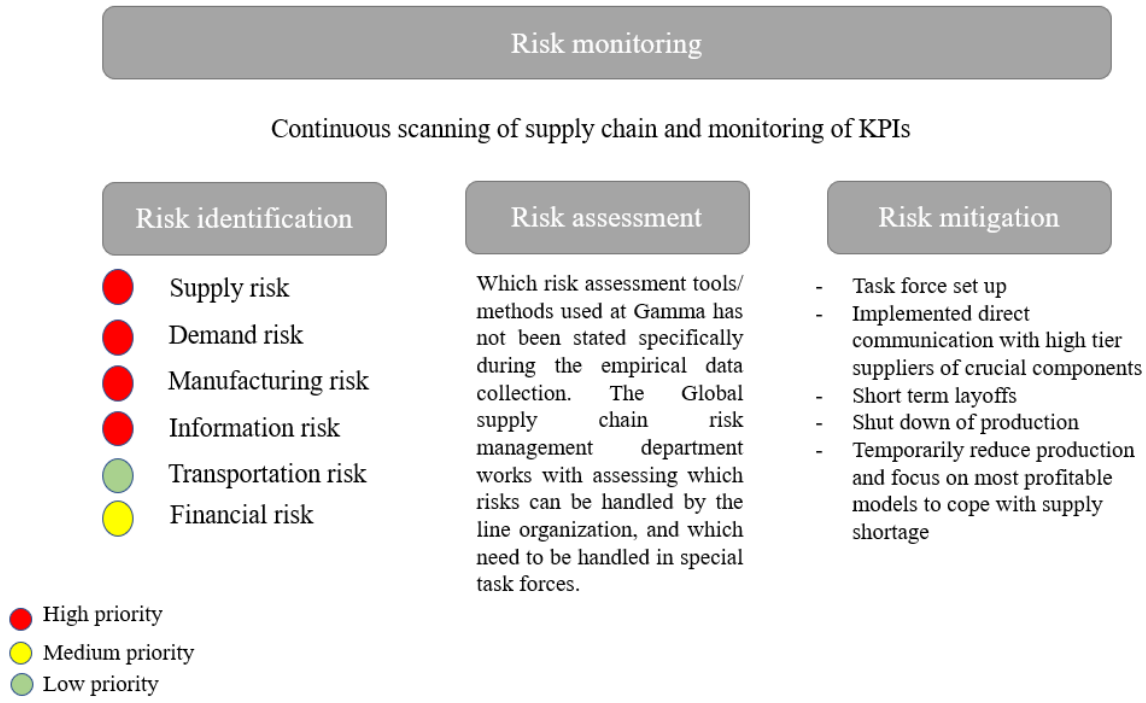

Figure 8. Summary of the analysis of Gamma

Four out of six risks were considered to be of high priority. These risks were supply risk, demand risk, manufacturing risk, and information risk, while transportation risk was not

addressed as a particular disturbance of Gamma. An analysis of how impact, probability, and how risks interconnect cannot be made due to little information on which methods and tools are used during the risk assessment. Several mitigation actions have been taken by Gamma, including implementing a unique task force setup to manage more severe risk, temporarily shutting down production in several plants, and improve focus on visibility and transparency with crucial high tier suppliers. The monitoring of risks is continuous by monitoring KPIs frequently and actively scanning the supply chain for improvement areas.

6.4 Cross-case analysis

During this section is an analysis conducted based on the collective empirical data from the three cases and the four steps in the SCRM framework. The focus of the analysis will be to address the similarities and differences in experiences and actions at the case companies.

6.4.1 Supply chain network positions of the case companies

Initially, the three case companies will be placed in a supply chain network in figure 9 below, to visualize their network position which in turn can lead to increased understanding of the actions taken by each individual case company during the COVID-19 pandemic.

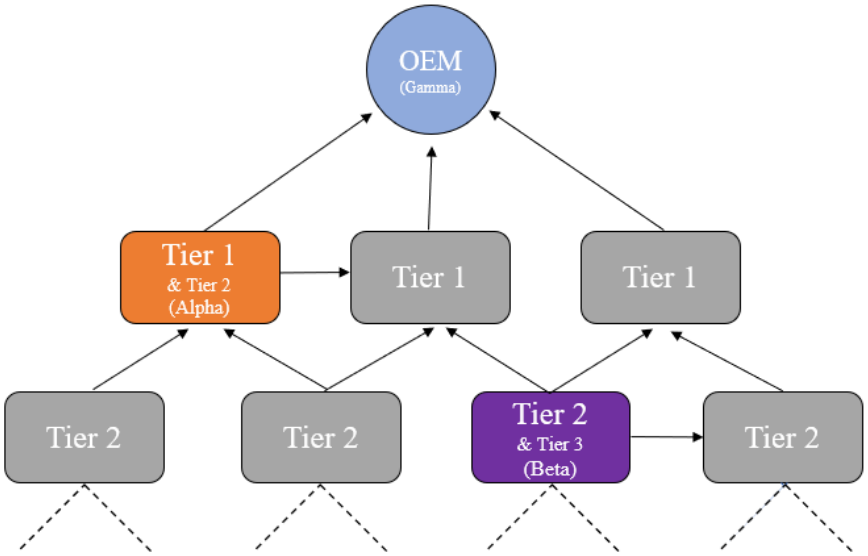

Figure 9. Visualization of the case companies supply chain positions from a network perspective.

Gamma is the company with the strongest supply network position, much thanks to its size and purchasing power, the company has a large influence on other actors in the network. The company has more financial and human resources to devote to the supply chain risk management process, but is also more or less forced to work more proactively and preventively against risks and disruptions in its supply chain due to the scope of its operations compared to Alpha and Beta. Based on these observations, it is natural that supply chain risk management is a central part of Gamma's organization and that the company is working very dedicated to manage supply chain risks and disruptions. Beta's position in the supply network is as a tier 2 and tier 3 supplier, which decouples or distant them from close collaboration or interaction

with OEM's. Instead the company has much closer relationships with customers who in turn are more attached to OEM's. The relational distance to the OEM's may contribute to the company having to act more independently or freely towards risks and disruptions in the supply chain. Lastly, as regards Alpha's supply network position, the company acts as a tier 1 supplier for the most parts, but in some situations also as tier 2. The relational proximity to the OEM's may contribute to the company being able to rely on support from OEM's when supply chain risks or disruptions occur.

6.4.1 Identification

The automotive industry is characterized by just-in-time, lean inventories, and short lead times, which forces the supply chain to be agile and reactive to changes and disruptions. It is not easy to be proactive and avoid these risks in a fast-changing environment, but it is something the case companies are striving for in different ways, which also became clear in the interview with the representative from Gamma who put it: "*We try to be proactive in a reactive world*."

Alpha has a proactive identification process on a managerial level of risks that could potentially affect the company's operation. Still, the most risks that are faced in the departments are identified in a more reactive way when the risks already have started to impact the operation. Beta also works both proactively and reactively to identify risks in the supply chain. Gamma focuses on working as proactively as possible to avoid risks from happening. Gamma has a dedicated department for SCRM that identifies potential risks through continuous monitoring and active scanning of the supply chain. This gives the company the possibility to assess and act upon the risks before they affect Gamma's operation. This approach allows the SCRM department to be proactive and have plans for handling risks in place, being reactive, and identifying the risks as soon as there is a possibility that it could lead to disruptions.

The case companies have been faced with the different kinds of risk types mentioned in the framework during the COVID-19 pandemic. The risks that were given the most attention in the empirical findings were supply risk, demand risk, and information risk. Financial risk, in terms of how it is defined in the literature, i.e., exchange rates, interests, price fluctuation, etc., was given the least attention.

All the case companies experienced a drop in demand in the middle of March 2020, when the virus spread through Europe and was classified as a global pandemic. After that followed a quick recovery so that all three of the companies experienced a record-breaking second half of the year and a continued high demand during the first quarter of 2021. Connected to the drop in demand at the end of the second quarter of 2020 did the production at the case companies face disruptions.

The shortages in steel supply have directly affected all the case companies, but Gamma, who has a more complex supply chain than Alpha and Beta, also has experienced shortages in plastics, and most prominently, semiconductors. This semiconductor shortage has proven to be a major problem for Gamma and will affect the demand for items from its subcontractors such as Alpha and Beta even if they do not use semiconductors in their products.

Information risks have been identified by the case companies and have in some cases caused major disturbances. The information flow through EDI's between Alpha and their customers

was disturbed, and the delivery plans became inaccurate. This was a major issue not getting the right information regarding the demand, which caused extra work in planning and clearing the systems from faulty delivery plans. Beta, on the other hand, has experienced mot internal information disturbances. Since the implementation of S&OP in the company is under work and not established yet, has the information between departments and plants been lacking. The information risk that Gamma has faced is a lack of visibility at high-tier suppliers of crucial products. This has become a clear problem now with the semiconductor shortage where Gamma has not had any direct relations historically and the information has had to flow through several tiers of suppliers before reaching them.

The transportation risks that have been stated in the empirical findings focus on the container shortage that has spiked in sea transport during the pandemic. Both Alpha and Beta have experienced a difficulty in obtaining containers during this time which creates longer lead times.

Information about financial risks is scarce in the empirical findings apart from price increases in transport and general financial loss due to decreased production.

6.4.2 Assessment

Through the empirical data collection, it has emerged that risk assessment is a part of the supply chain risk management framework at all of the three case companies. The degree of how the process is formalized and applied, on the other hand, is differing between the three case companies. Beginning with Alpha, who has the lowest degree of formalization and application of the risk assessment process. The risk assessment process is to a certain extent detached from the operational level of the company, as it is performed at a higher managerial level which then culminates in the operational level at Alpha. Beta, on the other hand, assesses risks through two layers. The first one is at the operational level, which implies that each manufacturing plant and subsidiary performs its own risk assessment. Regarding the low degree of formalization and standardization of risk assessment at Beta, there is a large variation in the execution. The second layer of risk assessment at Beta is performed on a more strategic level and includes assessing risks affecting the whole company. At a strategic level, the risk assessment process is a fairly new concept that the company has implemented in connection with the introduction of the Global Supply Chain Excellence team and is starting to become formalized. Gamma has a very formal and defined risk assessment process through its proactive approach, where the company continuously assesses risks that arise. Because the company works so preventively, they can act at an early stage on emerging risks and thereby reduce the effect or completely mitigate them.

In general, it has been shown that the risk assessment process is more formalized and developed the larger the company is, which may be due to the company's willingness to allocate resources but also how sensitive the company is to disruptions and risks within its supply chain. What is in common for all three case companies is that all of them are using a mixture of qualitative and quantitative methods in the risk assessment process. Quantitative methods are used to detect deviating patterns and changes, while qualitative methods are used to assess the impact of the risks.

6.4.3 Mitigation

The risks and disturbances that the case companies have faced during the COVID-19 pandemic have been mitigated in different ways. Some risks have been mitigated similarly at the case companies, and some risk mitigations actions have been carried out differently.

Regarding the demand risk mitigation, have the case companies all received financial help from the government so that they could manage the drops in demand and implement short-term layoffs in the workforce.

There are some differences in how the case companies have mitigated the demand risks as well. To handle the inaccurate delivery plans from customers, Alpha developed a program to clear the delivery plans and relied on side information to create more accurate production plans. Alpha was able to keep the production going without shutting down, while Beta took a strategic decision to shut down production in Sweden for a month during the summer. Following the decision to temporarily suspend production, an unanticipated turn in demand started to recover faster than expected. But as the decision was final without the possibility to withdraw it, Beta solved it through collaboration with all other production plants to cover the lost capacity in Sweden. Gamma also shut down the production in China and Europe for approximately two to three weeks due to disruptions in the supply and lockdowns, aiming to reduce the spreading of COVID-19.

Gamma has the most elaborate supply risk mitigation approach. They have a task force set up that implements action plans to help suppliers solve problems that could cause disruptions. One of the actions taken to manage the semiconductor shortage is that Gamma has reduced production temporarily with 30,000 vehicles as a short-term solution together with establishing direct communication with semiconductor suppliers to get accurate information. For a long-term solution, Gamma has taken in external consultants to investigate the best solutions, one of which might be to establish direct relationships with semiconductor suppliers. Extending transparency and forming a partnership with crucial suppliers is also a strategy that Beta has used to mitigate supply risks. On the other hand, Alpha has used a strategy of booking as much capacity as possible at existing suppliers to make sure that their need for steel will be supplied.

Beta has, during the pandemic, been experiencing difficulties in providing the customer needs in time due to high-capacity utilization, which has made the company look for solutions to the capacity constraints outside of the manufacturing. Beta has partly solved the manufacturing disruptions with flexible transportation solutions that shorten the transportation lead time to create space in the delivery plans and keep up with demand. On the other hand, Alpha has intensified the planning meetings to be more flexible in production during the time period in which the demand was increasing. Gamma's manufacturing mitigation strategies have solely focused on preventing disruptions in the production plants by working preventatively to reduce the risks of COVID-19 infection spreading.

All case companies have mitigated information risks similarly by opening new communication channels to create better visibility and transparency. In the case of Beta, they focused both on internal and external collaboration, while Alpha and Gamma mainly focused on broadening the communication with external parties in the supply chain.

Regarding the transport risk mitigation, Beta explored new transport alternatives when the transport needs could not be fulfilled through sea transport. Besides that, has little information about how Alpha and Gamma have mitigated transport risks been found during the empirical data collection, which might indicate that the two companies have not witnessed as many transport disruptions as Beta has experienced.

Little information is found in the empirical findings on the financial risk mitigation at the case companies. All companies have gotten financial aid from the government to manage short-term layoffs. Some general mitigation strategies for financial risk are mentioned in Alpha's annual report. During the reduction in production due to the semiconductor shortage, Gamma focused on the most profitable models to minimize the financial loss.

6.4.4 Monitoring

The empirical results have shown similarities and differences in how risk monitoring is done among manufacturing companies within the Swedish automotive industry. The biggest difference identified is the interval in which risks are monitored and vary from daily to weekly or even monthly scans. On the other hand, the similarities are that the process is continuous and recurrent at all three companies. In addition, it has been shown that all three companies make use of KPIs to measure the performance of their supply chains. The three companies detect risks and disruptions through continuously monitoring the KPIs that keep track of the supply chain performance. As soon as deviations are detected, the companies can act upon them in a timely manner.

At Alpha, risk monitoring is carried out weekly and monthly, and due to the longer time intervals between the occasions in which Alpha is monitoring, it may imply that the company identifies deviations when the disruption is ongoing. This makes the monitoring process less efficient to identify risks in an early stage and proactively mitigate it. Beta has during the COVID-19 pandemic intensified the monitoring process. Previous to COVID-19, Beta was carrying out the risk monitoring process on a weekly basis, but due to high degrees of uncertainties during the pandemic, it was changed to be performed a few times each week. The change has made it possible to act proactively on deviations in the supply chain and prevent disruptions. Company Gamma also regularly carries out its risk monitoring process and has, due to the COVID-19 pandemic, intensified the intervals between the scanning's. Due to Gamma's disruptions in the supply chain, the continuous risk monitoring process was changed from once per week to several times per week.

6.4.5 Summary of the cross-case analysis

Both similarities and differences have been observed in the SCRM approaches between the case companies. The timeline of experienced disturbances at the case companies has been similar and is interconnected since the companies are members of the same supply chain. The fall and rise in demand followed a similar pattern during the pandemic, where there was a drop in demand during March 2020 and then a steady increase in demand from the summer until the end of the first quarter of 2021.

The risks and disturbances the case companies have faced during the COVID-19 pandemic, based on the information gathered in the empirical findings, are covered by the risk categories used in the SCRM framework.

The assessment methods used by the case companies have not been explicitly elaborated. Still, it is mentioned in the empirical findings that there has been a combination of quantitative and qualitative methods used to assess the risks that have been identified for all case companies.

One of the essential mitigation strategies for all of the case companies has been to increase the visibility in the supply chain to get more accurate information faster. Another has been to reduce production and compensate for the reduced revenue by short-term layoffs. Differences could also be seen in managing manufacturing disruptions where the companies all acted differently. Alpha increased the planning frequency, Beta searched for new transport solutions to compensate for longer lead times, and Gamma put a lot of focus on avoiding shutdowns of production.

Monitoring of risks has been highlighted as a continuous process for following up on KPIs regularly. One difference in how the monitoring of risks is conducted is in the interval in which risks are monitored. These intervals vary from daily to weekly or even monthly scans, where the more frequent monitoring is related to a more progressive SCRM approach.

7. Discussion

The discussion that follows will address the SCRM framework and its strengths, what aspects could be improved, and its weaknesses. After the discussion on the framework will a comparison of how the SCRM approaches applied during the COVID-19 pandemic, in reality, are comparable with the theoretical SCRM framework. Lastly, will the learnings from the study will be discussed.

7.1 The SCRM framework

Reviewing the SCRM framework, presented in 3.4, both several strengths and some questions appear. The SCRM framework is constructed to guide companies on structuring and applying the SCRM process based on the academic literature. Still, it can also be used as a practical tool to analyze and categorize risks and the process of handling risks at companies, as it is done in the analysis of this thesis.

The framework is based on a strong theoretical foundation based on mainly two extensive literature reviews, Fan & Stevenson (2018) and Ho et al. (2015), which has worked as a critical source in creating the framework, and other relevant articles on SCRM. This collection of literature has made that the framework and the risk categorization model (figure 3) have new dimensions to add to the existing literature. The risk categorization model has a wide and structured approach similar to the risk categorization done by Ho et al. (2015), and its risk categories have strong support in the literature. Still, more recently, sustainability and corporate social responsibility (CSR) has gained attention in the automotive industry and have been the subject in articles regarding SCRM (Azevedo, Govindan, Carvalho, & Cruz-Machado, 2013), and this is a risk category that has not been incorporated in the model. In hindsight is this missing risk category something believed to be a weakness in the framework since not having sufficient focus on sustainability and CSR could potentially companies' business be negatively affected.

The main four steps in the SCRM process, risk identification, risk assessment, risk mitigation, and monitoring of risk, have strong support in the literature as critical activities for having a successful SCRM structure at companies. It has been observed that risk identification and risk mitigation have gained the most attention in the academic literature, theoretical assessment methods have also gained some attention in the academic literature, while monitoring of risk has not been widely covered.

What can be seen as both a strength and a concern regarding the SCRM framework is that it is general. It is not specified for a specific industry and could, in theory, be used as well in the automotive industry as in healthcare, for example. It is neither specific in terms of the size of the company where it could be used since the steps in the SCRM process are quite universal and could be adapted to a variety of situations. The broad applicability can be seen as a strength since the SCRM framework is done in a simple way that is easily understood, and it can give a better understanding of which risks and how to structure the SCRM approach. At the same time, does this broad and general usage only offer the user an overview of the SCRM process. To be applied more extensively in a company, must the company and industry specific context

be taken into account. The framework does not provide information on how to apply the activities in the SCRM process.

To summarize, the SCRM framework has a strong theoretical foundation, and its use is to provide a clear overview of how the SCRM process should be and what activities should be included. It could also be used to analyze the existing SCRM approach of a company to clearer categorization of risks and better understand how to mitigate them best. The SCRM framework can be applied generally in various industries and by companies of different sizes, which also means that it is not specific enough to use without considering important contexts.

7.2 Comparison of framework vs. reality

There are indications in the results that the size of the company is decisive for how formalized and developed the supply chain risk management processes are. It is believed that the size of the business leads to varying degrees of complexity in each company's supply chain and resources that the companies have disposable to dedicate to supply chain risk management. The developed framework for SCRM is presenting clear definitions of each individual process and how they are executed. Still, in the automotive industry, it has been found that the four SCRM processes are not as clearly defined as in the framework, even at the OEM, which is the biggest one among the three companies. A perceived difficulty with the SCRM framework that has become apparent during the study is that it was difficult to categorize risk types because risks affect each other and trigger other risk events or disruptions, causing a ripple effect. During the empirical data collection, it has emerged that perceived risks often have other effects on the company, but on the other hand, it has been difficult to map the sequence in which the risks arise.

The importance of the continuous monitoring process in the SCRM framework has been shown to be consistent with the reality among the three companies in the automotive industry. It is believed to be the foundation of both risk identification and risk assessment processes due to the characteristics of continuity in the monitoring process. A prerequisite for being able to be proactive in a changing business and supply chain environment is that the SCRM work needs to be structured and uniform throughout the company. At Alpha, for example, the logistics department was unaware of the full extent of supply chain risk management and how it is applied at a company level, according to the company's annual report, which shows that SCRM has not gained traction in the entire organization. Beta's experience from the COVID-19 pandemic has, on the other hand, made the company aware that their SCRM work needs to be more structured and extended in the future to manage risks and disruptions in their supply chain better.

Relationships and collaborations in supply chain risk management have been shown to be important aspects for the automotive companies applying the more proactive approach, which more or less is lacking from the developed SCRM framework. The relationships and collaborations first become apparent in the SCRM-framework in the mitigation process to counteract risks or disruptions. Still, the reality has shown that some firms work with relationships and collaborations at earlier stages in the supply chain risk management work.

7.3 Learnings

COVID-19 has had an influence on Beta and Gamma's way of working with SCRM in the present and for the future. The respondents felt that changes would be needed to become even more effective in preventing supply chain risks and disruptions. This is partly due to the wider supply chain disruptions that have been apparent during the pandemic and a continuous improvement process. The respondents from Alpha did not believe that the COVID-19 pandemic will influence the work forward, and this might be because the SCRM work is not permeated throughout the whole company. To assume that SCRM will receive greater focus in the future among manufacturing companies within the automotive industry is not completely bold, as the findings show that the companies faced several challenges simultaneously, which can be difficult to manage without a proactive and well-structured SCRM process.

With the findings from the study, it has appeared that flexibility, visibility, and transparency within the supply chain have been gaining more attention during the pandemic. Traditionally, much communication is carried out through digital channels, which has been insufficient in times of a pandemic as there have been many uncertainties and rapid changes. Flexibility, visibility, and transparency have, according to the respondents, been the key to understand the rapid changes and align the manufacturing activities in accordance to actual demand.

There is an interconnection between risks, and in many situations, one risk type will trigger other risks or disruptions to occurs, which is in line with previous findings in the SCRM literature. In this study, the developed SCRM framework has shown that it is rather difficult to categorize risks as the risks often occur in the sequence of a chain effect.

Lastly, because the interviews were conducted with semi-structured principles, it may have affected the level of detail of the answers from the respondents. At times, the responses were comprehensive, which may have contributed to the data collection not capturing complete descriptions of the SCRM process or the disruptions the companies have faced and what actions were applied to counteract. In retrospect, the authors have wondered if a structured interview process would not have been more efficient to have a more uniform data collection. Additionally, the interviewees' roles at the company may also have affected the quality of the data collected, as it happened that the interviewees were not able to answer some of the questions.

8. Conclusion

This thesis has contributed to the SCRM area of research by constructing a clear and structured framework of a SCRM process consisting of four steps: identification, assessment, mitigation, and monitoring of risks. All four steps are important to incorporate in the SCRM process to achieve an effective SCRM in a company. The framework adds to the existing literature a clear risk categorization model, and the continuity of risk monitoring has been given a bigger focus than previously given. The SCRM framework could be used to guide activities that should be applied in the process and which risk categories and mitigation strategies could be used, but the development of a SCRM strategy at a company should be tailored after its specific needs, abilities and requirements. The SCRM framework is also suitable for analyzing and categorizing existing risks and SCRM strategies to understand better how it is conducted presently and if anything is missing in the process.

The COVID-19 pandemic has had a large impact on the Swedish automotive industry, with risks and disruptions affecting the case companies. In the early stage of the pandemic, the case companies experienced a drastic fall in demand for a period of time to later witness a strong recovery in demand that has been steadily increasing during the second half of 2020 and peaked at the end of the first quarter in 2021. Furthermore, the case companies have been experiencing supply disruptions due to the COVID-19 pandemic. There has been a shortage in the supply of critical materials for the manufacturers, and the industry is currently facing a shortage of semiconductors, which is expected to last for at least the coming 24 months ahead. Goods shipped in containers by the case companies have been experiencing disruptions by the COVID-19.

It has also been seen that the SCRM strategies of these companies in the automotive industry have been affected during the COVID-19 pandemic. The companies have put much effort to act upon the risks and disturbances that have occurred since no one anticipated the pandemic and had contingency plans in place for such disruptions. Gamma introduced an interesting concept, believed to be unique in the industry, of using cross-functional task forces to get faster assessments and mitigations. This concept is believed to have helped Gamma to have relatively short shutdowns of production and a faster recovery. The effects of the pandemic also forced the case companies to receive financial help from the government to apply short-term layoffs. An important action taken by all the case companies during the pandemic is to improve communications in the supply chain to get more accurate delivery plans and secure the supply of critical items. This improved visibility will be a continued area of focus at the companies to develop relationships and partnerships with critical suppliers so that supply can be continued with fewer disruptions. An important aspect mentioned for the continued work with SCRM is that there is a need to quickly implement a cohesive structure of SCRM and planning within a company to facilitate coordination between plants or departments, which Gamma has seen as one of their strengths during the pandemic.

There are certain limitations of the thesis: it is hard to make conclusions based on a small sample of three responding case companies, and the use of the SCRM framework for analysis could have benefited from having more structured interviews. Especially was the subject of

risk assessment not specified during the interviews, which made it impossible to draw any conclusions regarding that step in the process. Even though many patterns and different characteristics can be seen between the case companies, the results cannot be generalized for the entire industry. Instead, the risks and strategies used during the COVID-19 pandemic should be viewed individually for each company.

Finally, a gap in the literature has been identified regarding the risk monitoring process in the SCRM-framework. The monitoring of risks is a topic that should be investigated more thoroughly in the future because it has been shown in this research that it is a vital activity in the SCRM process. It is also believed that additional focus should be given to SCRM strategies to better understand which company and industry context is important for shaping SCRM strategies.

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A. Interview guide

Introduction

- Introduce ourselves.
- Presentation of the Master Thesis and the data collection for the S&OP-study
- Describe that we hope to both get a brief overview of the SCRM function, but also that we want to know the reason behind the decisions that has been made due to the COVID-19 pandemic.
- Ask for consent to record the interview and if the company wants to be anonymous in the report.
- Inform the interviewee that the report will be published, and that the information collected will be publicly available.

Interview

- Ask the interviewee to present himself/herself and state what role at the company he/she has.
- How long working experience does the interviewee have in the area of SCRM?
- How long has the company worked with SCRM?
- How large part of your production is designated for the automotive industry?

1. How has COMPANY X structured the supply chain risk management function? For example, what processes do you involve in your SCRM framework, what stakeholders/actors are involved and have the firm limited the SCRM to certain business areas?
    - Does COMPANY X apply same strategies and/or contingency plans to manage operational and external risks in the supply chain?

2. Does COMPANY X collaborate internally and externally with stakeholders to identify and monitor risks in its supply chain? For example, taking input from various departments internally, suppliers and customers externally.
    - How do you manage the relationships with the suppliers/customers from the SCRM function?
    - How many steps at the supplier level do you include in your SCRM? E.g. Tier 1, tier 2, tier 3 etc.

3. Have COMPANY X faced supply chain disruptions during the COVID-19 pandemic? If so, please describe the events that have disrupted your supply chain.
    - What kind of uncertainties have you experienced during the pandemic? (delivery plans, market estimations, supply chain capacity etc.)

- What kind of contingency plans did COMPANY X have regarding external disruptions previous to the COVID-19 outbreak? How did they work during the COVID-19?
- What have been the countermeasures from COMPANY X to mitigate these supply chain disruptions?
- Has there been any need to apply different strategies to deal with supply chain disruptions from the outbreak of the COVID-19 virus until now?

4. Considering the disruptions caused by the COVID-19 on COMPANY X's supply chain, will there be any adjustments and changes in SCRM strategies post-COVID-19?
    - In a short-term perspective (<24 months). Why? How?
    - In a long-term perspective (>24 months). Why? How?

5. Have the SCRM work received more attention during the COVID-19 pandemic than before at COMPANY X?

6. Can you describe the planning process of COMPANY X on the following S&OP horizons:
    - Long term (3-9 months)
    - Medium term (1-3 months)
    - Short term (daily operations)

7. Has the planning process changed during the COVID-19 pandemic? How, in terms of:
    - Planning frequency?
    - New types of data sources or planning tools?
    - Involvement of new staff functions?

Post interview

- Ask the interviewee if it is possible to contact him/her with complementary questions via e-mail if it is needed.

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