CHALMERS
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A more resilient aftermarket supply chain

A case study at Volvo Service Market Logistics

Master's thesis in Supply Chain Management

ANDREAS SANDBERG
OLOF SVENSSON

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT

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Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

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SUMMARY

Supply chain resilience has gathered significant attention in recent years due to escalating frequency and severity of disruptions affecting supply chains' performances. Disruptive events, including the COVID-19 pandemic and geopolitical conflicts, have highlighted the need for companies to establish more resilient supply chains. Despite increased awareness, many organizations, including the case company Volvo Service Market Logistics, are struggling to bridge the gap between awareness and implementations of resilience strategies. Thus, this thesis aims to map and evaluate the case company's current resilience capabilities, identify areas for improvement and propose strategies that could strengthen the resilience further.

In order to conduct this thesis and answer the set research questions, a qualitative research approach was utilized, including interviews, a workshop and a literature review. The study was initiated by an exploration within the field of supply chain disruption and resilience. Then an analysis follows, using a theoretical framework from literature as a starting point in order to map and evaluate the current resilience capabilities of the case company.

Notable findings from the study include the case company's strengths in terms of redundancy, facilitated by effective safety stock management, and cross-functional collaboration, by forming agile task forces during disruptions. In general, the case company possessed most of the capabilities found in the literature, and no significant gaps were identified. Nevertheless, opportunities for improvement still exist in several areas, including enhancing end-to-end visibility, developing a more mature Sales and Operations Planning (S&OP) process, and by introducing scenario planning, in order to become more resilient.

The study concludes by emphasizing the wider applicability of the findings beyond the case company, by offering insights for other companies in the aftermarket as well as for organizations across industries. While the adopted resilience framework provides a structured approach, aftermarket entities might face unique challenges in establishing certain resilience capabilities due to the unpredictable demand characteristics. Nevertheless, the resilience capabilities proposed in literature are still essential to enable an organization to prepare for, respond to, as well as recover from disruptions and maintain operational excellence.

Keywords: Supply chain resilience, Resilience capabilities, Aftermarket, Capability framework, Resilience phases, Supply chain disruptions.

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Firstly, we would like to direct a big thank you to Chalmers and Volvo Service Market Logistics, as well as the Advanced Analytics team for giving us the opportunity to write our master's thesis with you. Then, we would like to show our sincere gratitude to our supervisors at Volvo Service Market Logistics, Joakim Andersson and Yash Shrimali, for providing us with valuable feedback and guidance along the way. Without your continuous support as well as your help to connect us with Volvo Service Market Logistics coworkers in various departments, it would not have been possible to conduct this study.

We would also like to express our gratitude towards the employees at Volvo SML for their helpfulness, openness and for letting us participate in various meetings. An additional thankfulness to all the employees who participated in the interviews and workshop that were conducted during the thesis. Without your valuable insight, this research would not have been possible.

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Andreas Sandberg & Olof Svensson
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Table of contents

1
Introduction

The introduction includes a background, where the topic of the research is presented and some context as to why it is a relevant area to study. Furthermore, the connection the research has to Volvo Service Market Logistics (SML), the case company, is presented. Additionally, the purpose and delimitation of the study as well as the research questions that the thesis aims to answer are introduced.

1.1 Background

During recent years, the topic of supply chain resilience has risen on many companies' agendas. The main reason for this is that supply chain disruptions have become more frequent and the consequences from the disruptions have been more severe in recent years (Asafo-Adjei et al., 2023). Since the start of this decade, various types of disruptions such as the COVID-19 pandemic, semiconductor shortages, geopolitical conflicts, and shipping crisis in the Red Sea region have increased the logistics cost and lead times. Thus, having an immense effect on supply chain performance, including material shortages, transport delays and closed borders (Asafo-Adjei et al., 2023). According to Tukamuhabwa et al. (2015), supply chain resilience could be described as the supply chain's adaptive capability to prepare for, respond to, and recover from disruptive events to the original or an even better state. Furthermore, Ali et al. (2017) explains that organizations need to develop certain strategies or capabilities in order to achieve supply chain resilience. Such resilience capabilities could be redundancy, flexibility, collaboration, and visibility (Ali et al., 2017; Tukamuhabwa et al., 2015; Münch & Hartmann, 2022).

According to Katsaliaki et al. (2022), lean supply chain management practices, based on strategies such as maintaining low inventory levels, and enabling just-in-time deliveries have increased in popularity. Furthermore, the competitive landscape driven by globalization has shifted more emphasis to outsourcing of production to low-cost countries in order to cut costs. All of these trends are dependent on unaffected operations and stable external conditions, but still increases the supply chain's vulnerability to disruptions (Katsaliaki et al., 2022). This is in line with Tukamuhabwa et al. (2015) findings that strategies such as single-sourcing and lean initiatives may enable companies to cut costs, but at the same time leaves the organization exposed to supply chain disruptions. Given the fact that, according to Katsaliaki et al. (2022), more than half of all organizations suffer a supply chain disruption annually as well as that the number of disasters has increased continuously over the last decades, firms have started to put more emphasis on creating resilient supply chains.

The Economist Intelligence Unit (2021) states that supply chain disruptions could account for considerable financial costs, between six and ten percent of annual revenues on average. In addition to the financial cost, the reputational cost was also significant since firms struggled to deliver to the customers, which resulted in complaints and bad reviews. Despite a relatively high awareness of supply chain risks, and over 80 percent of organizations being concerned of supply chain resilience, merely 40 percent of all firms believe they have developed and implemented some kind of supply chain resilience capabilities (Katsaliaki et al., 2022). This

visualizes the gap between organizations' awareness of potential risks and their adopted practices, as well as highlights the potential for improvement by establishing certain resilience capabilities in order to be better prepared for future disruptions. Nevertheless, since there are plenty of resilience strategies to pursue, this thesis originates from Volvo SML's perspective and what resilience capabilities that would be suitable to prioritize and develop in order to increase their supply chain resilience.

Volvo SML, which is from here on also referred to as the case company, is used to study supply chain resilience in the specific conditions that apply to the aftermarket. Aftermarket is also referred to as after-sales services and includes offering spare parts and maintenance in order to maximize the value for the end-users (Cohen et al., 2006). Furthermore, the aftermarket is characterized by a complex planning environment due to attributes such as low and intermittent demand as well as a high number of stock keeping units (SKUs) (Andersson & Jonsson, 2018). This entails difficulties in achieving supply chain resilience compared to traditional manufacturing business, which do not have the same characteristics. Additionally, there is a gap in literature when it comes to research on how to create resilience in an aftermarket context.

1.2 Case study at Volvo SML

This study of supply chain resilience took place at Volvo SML's headquarters in Arendal, Sweden. Volvo SML is responsible for the distribution of spare parts to all the brands supplied by Volvo Group, including trucks, buses, construction equipment, as well as marine and industrial engines, and power systems. Volvo SML is a subdivision of Volvo Group Trucks Operation (GTO), which in turn is a department of Volvo Group (see Figure 1.1). Volvo Group was founded in 1927, in Sweden, but at that time Volvo was mainly producing cars (Volvo Group, 2024). However, since then, Volvo Group has split from Volvo Cars and their current product portfolio includes all the products mentioned above. Volvo Group has also undergone extensive expansion by acquiring brands such as Renault Trucks, Mack Trucks and Nova Bus. Apart from the physical products, Volvo Group offers a variety of services aimed at increasing the operation time as well as the productivity of their products (Volvo Group, 2024). Volvo Group is one of the leading actors on the global market, and as such try to leverage their position to shape the future towards more sustainable transport and infrastructure solutions (Volvo Group, 2024). The organization currently has over 100 000 employees worldwide. Furthermore, Volvo Group has production facilities in 18 countries and serves customers all over the world in 190 different markets.

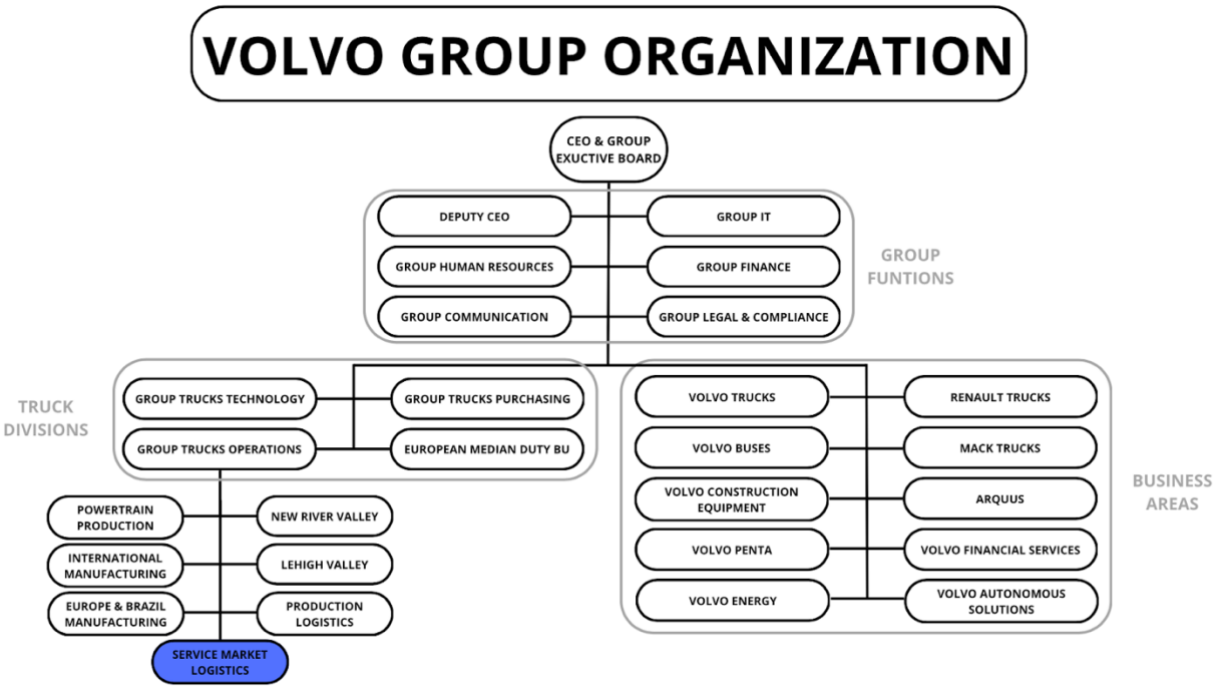

Figure 1.1: Volvo Group organization, from CEO to SML.

During recent years, the number of disruptive events, affecting companies' supply chains, have increased in frequency and effect (Asafo-Adjei et al., 2023). Volvo Group is no exception, and the challenges from major disruptions such as COVID-19, the war in Ukraine, and blockages in the Suez Canal have succeeded each other before the organization had time to recover from previous events. This is visible in the annual report from 2022, where disruptions in the supply chain have resulted in increased costs and thus lower profitability (Volvo Group, 2023). Furthermore, other issues caused by the disruptions are lack of transport capacity and material shortages, which has negatively impacted Volvo Group's ability to deliver according to agreement.

1.3 Purpose and research questions

The purpose of this study is to map the case company's current supply chain resilience, as well as to identify and evaluate areas of improvement. Furthermore, the research aims to provide additional understanding of supply chain resilience in an aftermarket context.

Based on this purpose, as well as the provided background above, the following two research questions have been formulated:

1. What supply chain resilience capabilities are currently possessed by the case company?
2. What supply chain resilience capabilities are currently lacking and needs to be improved or adopted by the case company?

1.4 Delimitations

This case study within supply chain resilience is based on the perspective of Volvo SML. Volvo SML manages the aftermarket and distribution of spare parts for several brands, such as Volvo Trucks, Volvo Buses, Volvo Penta, Renault Trucks, Mack Trucks and Volvo Construction Equipment. Additionally, Volvo SML is a global supplier with a complex supply chain, involving partners and customers all over the world. However, due to the limited timeframe of

this research, the scope of the study has been narrowed down to focus solely on one brand, Volvo Trucks, as well as primarily analyzing the part of the supply chain that is connected to the main central distribution center (CDC), located in Ghent. The primary reason for choosing the CDC in Ghent is that the majority of the employees stationed in Arendal, Sweden, work with the material flow covering the European market. The CDC in Ghent is not only the main distribution center in Europe, but also globally, responsible for supplying other distribution centers of Volvo SML located all over the world. Therefore, the results and findings of this research are to a large extent considered to be generalizable and applicable to Volvo SML's entire organization. Furthermore, this thesis will not go into detail on how certain propositions, such as technical solutions, should be designed or implemented, but instead focus on what kind of capabilities that needs to be established.

1.5 Report outline

The outline below provides an overview of the thesis disposition and structure, where the respective chapters are shortly described.

1. *Introduction*
   The introduction provides a background and insights into the area of supply chain resilience, as well as a short description about the case company and its context. Furthermore, the purpose of the study as well as the research questions and the delimitation of the thesis are presented.

2. *Literature Review*
   In the literature review, the reader is provided with theory of relevance for the research, within the area of supply chain disruption as well as supply chain resilience, including resilience capabilities. This lays the foundation for the framework used in order to structure the empirical findings, the analysis and the discussion. Moreover, additional theory is presented on areas and subjects that can be related to enhancing supply chain resilience.

3. *Methodology*
   In the methodology chapter, the research methodology used for conducting this study is described. It covers, for instance, the data collection methods and how the literature review was conducted. The chapter is finally concluded with a discussion of the reliability, validity and ethics of the method and study.

4. *Empirical Findings*
   The empirical findings start with a further description of the case company as well as their supply chain. It is then followed by brief explanations of different departments relevant for the study. Thereafter, the case company’s supply chain resilience practices are presented during each phase of supply chain resilience.

5. *Analysis*
   In the analysis chapter, the empirical findings are analyzed and then compiled into the different supply chain resilience capabilities in the respective phases of supply chain resilience, by using an adopted framework from theory, and thereby answers research question 1.

6. *Discussion*
   This chapter provides a discussion regarding the case company's supply chain resilience capabilities, with the aim to identify gaps and areas of improvement, by combining the empirical findings and the result from the analysis with the literature review. This aims to answer research question 2. Thereafter, discussions regarding areas of improvements for the case company concerning the resilience capabilities within the adopted framework, as well as the application of the framework within an aftermarket setting are presented. In this chapter, a brief discussion regarding ecological and societal aspects is also included.

7. *Conclusion*
   In the conclusion, the authors conclude the findings from the research and answer the purpose as well as the research questions of the thesis. Finally, this section ends with suggestions for future research.

2
Literature Review

In this chapter, a literature review regarding relevant subjects for the study, such as supply chain disruptions, supply chain resilience, and resilience capabilities, is performed. Furthermore, the adopted framework on supply chain resilience, which is later used to structure the findings, is introduced. Finally, practices to improve supply chain resilience are also presented. The literature review is used as the foundation for the study, to evaluate and identify areas of improvements when it comes to the supply chain resilience.

2.1 Supply chain disruptions

According to Bode and Wagner (2015), supply chain disruption can be defined as the combination of unintended and unexpected events that occurs in the supply network that constitutes a severe threat to organizations' ordinary business activities. Furthermore, the authors explain how the risk of supply chain disruptions originates from the vulnerabilities caused by complex flow of material, information, and capital in extensive supply networks. All firms are to a certain degree dependent on external resources and inter-firm relationships, thus no one is insusceptible to this kind of risk (Bode & Wagner, 2015). Additionally, Sudan et al. (2023) describes how recent unpredictabilities, such as COVID-19, geopolitical uncertainty, as well as extreme weather, have exposed vulnerabilities in companies supply chains, which is manifested by their ability to significantly impair the performance within supply chain networks.

Supply chain disruption can be divided into internal disruptions, which originates from within the boundary of the organization, and external disruptions, such as natural disasters or geopolitical conflicts (Tukamuhabwa et al., 2015). Some of the more common types of disruptions mentioned by Sudan et al. (2023) are interruptions during transportation, material shortages and insufficient availability of labor. In recent years, supply chain disruptions have increased in both frequency as well as severity and reached its height during the COVID-19 pandemic, which revealed major weaknesses in organizations' supply chains (Asafo-Adjei et al., 2023; Sudan et al., 2023). According to Shen and Sun (2021), pandemics can be distinguished from other disruptions, due to their scale of impact. This is further elaborated upon by Ivanov and Das (2020), who states that pandemics are characterized by their long-term nature as well as significant geographical spread, whereas other disruptions tend to be more temporary and local.

According to Bode and Wagner (2015), increased complexity is one of the main challenges related to organizations' supply chains, and the authors describe how supply chain complexity increases the supply chain vulnerability, thus also the risk for disruptions. Furthermore, the supply chain complexity increases with the number of nodes and geographical distance within the supply chain. According to the authors, long spatial distances to suppliers means longer transportation paths and lead times, which normally results in, for instance, greater reliance on infrastructure and less transparency, which in turn increases the uncertainty and risks for disturbances. Additionally, a large number of suppliers requires high information-processing

and monitoring costs (Bode & Wagner, 2015). The correlation between increased supply chain complexity and increased supply chain vulnerability is in line with Katsaliaki et al. (2022) findings that traditional management strategies, such as outsourcing of production, has left organizations more exposed to disruptions.

2.2 Supply chain resilience

According to Sá et al. (2020), the concept of supply chain resilience has received greater attention due to the increasing impact and frequency of disruptions and unexpected events. The definition of supply chain resilience varies in the literature, and there is a lack of consensus regarding the definition of the concept of supply chain resilience (Tukamuhabwa et al., 2015). Some of the more common characteristics of existing definitions regarding supply chain resilience include a supply chain's ability to return to its original state, or an even better state, after a disruption (Tukamuhabwa et al., 2015). However, according to the authors there is one important element that is absent in these definitions, namely the ability to manage disruptions in a cost-effective way, in order to increase the competitive advantage and make the adaptations more feasible to implement. In order for the proposed resilience strategies in this report to be of value for the case company, the following definition of supply chain resilience from Tukamuhabwa et al. (2015) has been adopted.

> *"The adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost effective recovery, and therefore progress to a post-disruption state of operations – ideally, a better state than prior to the disruption."*
> (Tukamuhabwa et al., 2015, p. 8)

According to Ali et al. (2017), establishing a resilient supply chain can be considered a strategic capability, and thus a source to achieving and maintaining a competitive advantage. A resilient supply chain should have the ability to anticipate, to adapt, to respond, to quickly recover, and to learn from disruptive events (Ali et al., 2017). Furthermore, Sá et al. (2020) explains how the main purpose of supply chain resilience is to form strategies to maintain the core function of delivering goods and services to the customers, even during more turbulent and uncertain times. Organizations with a more resilient supply chain are less vulnerable to disruptions, by being better prepared to manage and allocate internal resources, such as routines and systems, during unexpected disruptions (Sá et al., 2020). Additionally, according to Polyviou et al. (2020) and Chowdhury and Quaddus (2016), organizational culture and learning are important factors in order to build and increase supply chain resilience.

Supply chain resilience originates from supply chain risk management and supply chain vulnerability, which have been on organizations' agendas for several decades (Jüttner & Maklan, 2011). According to the authors, supply chain vulnerability can be defined as a supply chain's susceptibility to risk. Whereas supply chain risk management refers to an organization's ability to identify risks as well as to adopt strategies to reduce the supply chain vulnerability. However, during recent years companies have come to realize how little control they have over several of the risks that they are exposed to (Jüttner & Maklan, 2011). This has created a need for companies to increase their supply chain resilience, by developing adaptive capabilities in order to be better prepared to manage unexpected disruptions. Furthermore, Ali et al. (2017) explains that supply chain resilience is a way to manage complex supply chains in a way that avoids the limitations of supply chain risk management and other traditional strategies of risk protection and prevention.

2.2.1 Phases of supply chain resilience

Supply chain resilience can, according to Ali et al. (2017), be divided into three different phases: *pre-disruption phase*, *during-disruption phase*, and *post-disruption phase* (see Figure 2.1). The pre-disruption phase is before disruptions occur and includes preparation for and anticipation of disruptions and its potential consequences. Furthermore, according to the authors, the during-disruption phase is between the start of a disruption until its end and includes responding and reacting quickly upon the disruption. Finally, the third and last phase of supply chain resilience is the post-disruption phase and is the time after the end of a disruption until business and operations have recovered to the original or an improved state (Ali et al., 2017). According to the authors, the post-disruption phase includes mainly recovery and growth, but also to learn and take experience from the disruption. Additionally, Tukamuhabwa et al. (2015) explains that all these areas are of importance for, and have an impact on, supply chain performance.

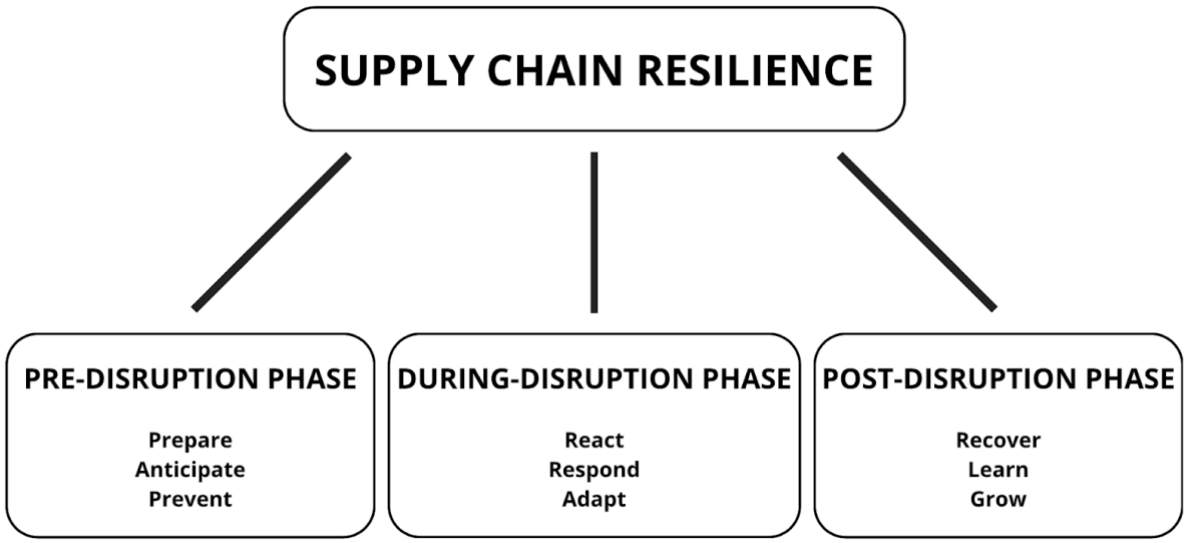

Figure 2.1: Supply chain resilience phases and key objectives related to each phase.

According to Ali et al. (2017), the pre-disruption phase is mainly about preparedness and readiness, but can also include processes to resist, avoid, and alert. Additionally, Han et al. (2020) states that the pre-disruption phase also includes the abilities to recognize, anticipate, and prevent disruptions before any damages occur. The importance of the pre-disruption phase for supply chains and the management of disruptions is, as explained by Han et al. (2020) as well as by Chowdhury and Quaddus (2016), to be prepared and ready for disruptive events in order to reduce the supply chains susceptibility to disruptions. Furthermore, forecasting, identification, and assessment of risks, as well as continuous monitoring of deviations, are crucial processes and factors in the pre-disruption phase of supply chain resilience (Han et al., 2020; Chowdhury & Quaddus, 2016). Nevertheless, Ivanov and Dolgui (2021) explains that, for instance, data analytics and scenario planning are activities that can be used in the pre-disruption phase in order to visualize supply chain risks, predict different types of disruptions and clarify their potential consequences. This would allow for the creation of back-up plans, also known as contingency plans, which could reduce the impacts of disruptions (Ivanov & Dolgui, 2021). In addition, according to the authors, knowledge and experience gained from previous disruptions should be utilized and act as input to the pre-disruption phase of resilience. Thus, employees with many years of work experience are particularly valuable for a firm when it comes to increasing the supply chain resilience, since they have more knowledge when it comes to managing, or preferably avoiding, disruptions (Polyviou et al., 2020).

The during-disruption phase includes activities to respond to, cope with, and adapt to a supply chain disruption (Ali et al., 2017). This is in line with Chowdhury and Quaddus (2016) findings that the ability to respond quickly to uncertainties and disturbances is an important aspect of supply chain resilience. Since, according to the authors, a late response during disruptive events in a complex supply chain might end up being very costly for all the stakeholders involved. However, on the contrary, if a firm possesses the ability to take an informed decision quickly, they have the opportunity to conquer large market shares and improve their market position (Han et al., 2020). Furthermore, according to Chowdhury and Quaddus (2016), the ability to swiftly reconfigure resources, both internal and external, is an essential capability in the during-disruption phase. Finally, data analytics and additional technology can be utilized also in this phase in order to spot any deviations at an early stage, and thus be able to react quicker and take more informed decisions (Ivanov & Dolgui, 2021).

According to Ali et al. (2017), the post-disruption phase of supply chain resilience can be described by activities to recover, survive, restore, return, and learn from disruptions and the damages that they cause. One of the initial activities in the post-disruption phase is normally to recover, which refers to restoring and returning to a normal state of business and operations after a disruptive event (Han et al., 2020). Furthermore, the authors emphasize the importance of quickly being able to return to the original state. Another aspect, highlighted by Sá et al. (2020), is the importance of learning from previous disruptions in order to improve the supply chain resilience. For instance, by using knowledge and experience from past events in the preparation of new contingency plans (Sá et al., 2020). According to Lin et al. (2022), learning can be divided into internal and external learning, where internal learning refers to a firm's ability to share information within and between various departments, in order to apply best practices in all parts of the organization. Whereas external learning instead refers to knowledge acquired from other companies, either within the same industry, or in some cases from the wider society (Lin et al., 2022). Further, according to Chowdhury and Quaddus (2016), learning can be seen from two different perspectives: *exploration of new possibilities* and *exploitation of old certainties*. Meaning that in order for a firm to increase their supply chain resilience they need to find a balance between learning from previous experience, but at the same time finding new ways to manage disruptions (Chowdhury & Quaddus, 2016).

Based on the previous sections, it is evident that all three phases of supply chain resilience are connected and interdependent on each other (see Figure 2.2). Meaning, that if improvements are made in one phase that will in turn impact all phases, and thus improve the overall supply chain resilience of an organization. For instance, if a firm improves their ability to anticipate disruptions and prepare for potential disturbances in advance, then the effects of the disruptions will be limited or perhaps even avoided, which later on will reduce the efforts required to recover from the disruption. A similar connection can be seen between the post-disruption phase and the pre-disruption phase. This was exemplified by Ali et al. (2017), who states that knowledge and experience from previous disruptions can be used as inputs for the pre-disruption phase in order to be better prepared if similar events were to occur in the future.

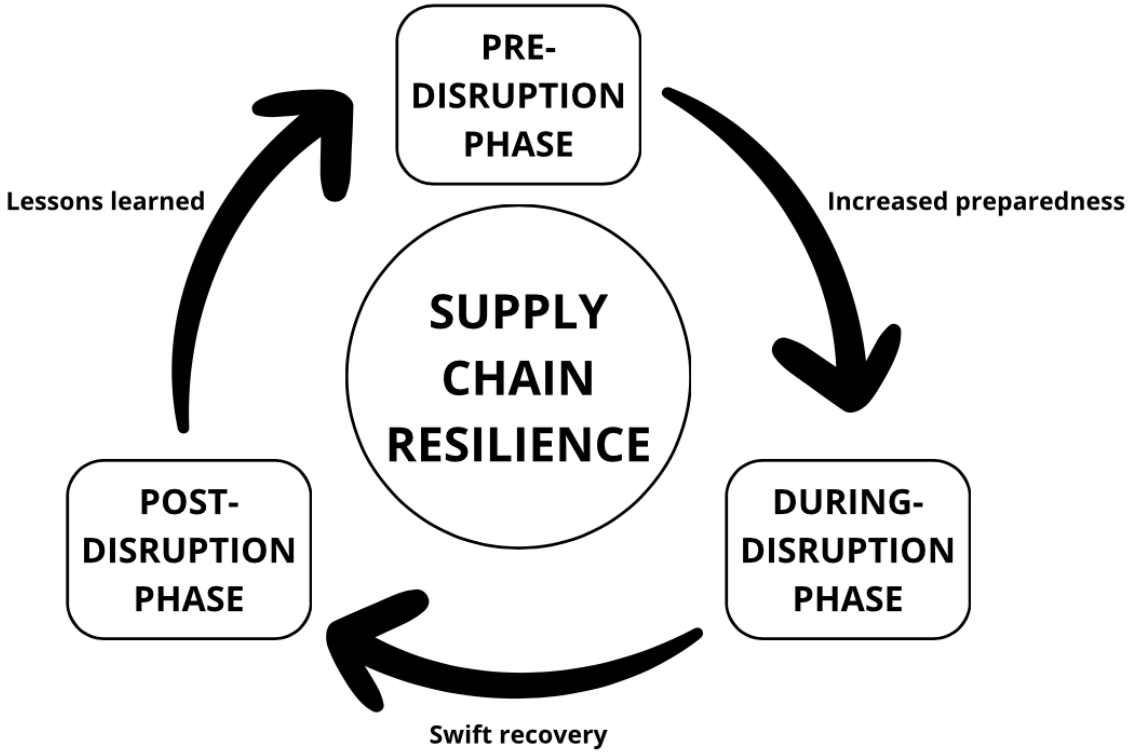

Figure 2.2: Connection and interdependence of the supply chain resilience phases.

2.3 Supply chain resilience capability framework

In this section, a supply chain resilience capabilities framework adopted from Ali et al. (2017) is presented (see Figure 2.3). The reason for adopting this framework in this study is that it is a comprehensive and well renowned framework within supply chain resilience and that there is a gap in literature regarding supply chain resilience in aftermarket settings. The framework includes all three resilience phases as well as the most prominent supply chain resilience capabilities connected to the respective phase. The pre-disruption phase contains five capabilities: *visibility*, *security*, *knowledge management*, *robustness*, and *situational awareness*. The during-disruption phase consists of four capabilities: *redundancy*, *agility*, *collaboration*, and *flexibility*. Whereas the post-disruption phase includes the following four capabilities: *building social capital*, *knowledge management*, *contingency planning*, and *market position*. Sá et al. (2020) further cement the framework by Ali et al. (2017), by explaining that the different phases of supply chain resilience require different capabilities and strategies. The adopted framework is used to structure the empirical findings and the analysis when evaluating the case company's current resilience practices as well as areas that can be improved.

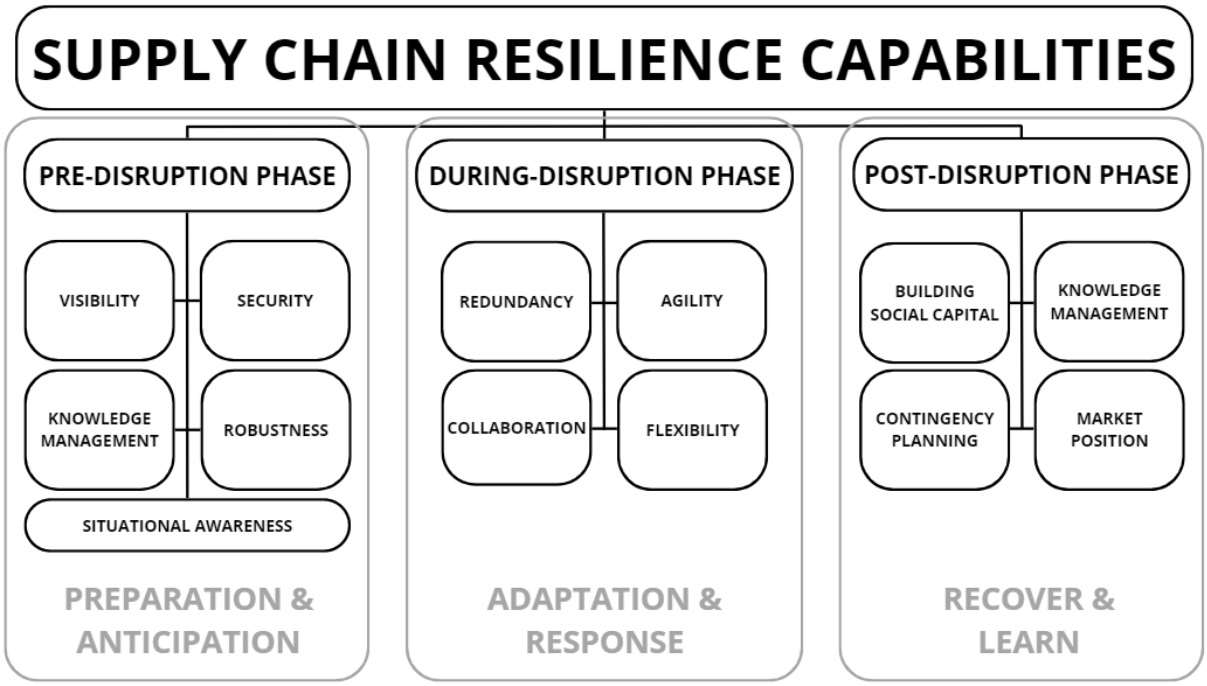

Figure 2.3: Adopted supply chain resilience capability framework based on Ali et al. (2017).

In order to achieve resilience, it is necessary for firms to develop certain strategies or capabilities, henceforth regarded as *resilience capabilities* (Ali et al., 2017; Tukamuhabwa et al., 2015). Based on a thorough review of literature on the topic of supply chain resilience, including two comprehensive literature reviews, the most common resilience capabilities were identified as the following: *redundancy*, *flexibility*, *collaboration*, *visibility*, and *agility* (Ali et al., 2017; Tukamuhabwa et al., 2015). These capabilities are further explained in more detail below.

2.3.1 Redundancy

One of the most common resilience capabilities applied by firms is redundancy (Ali et al., 2017; Tukamuhabwa et al., 2015). Building redundancy in the supply chain implies that an organization has excess capacity in strategic locations such as production, transportation, or by holding inventory (Ali et al, 2017). The purpose of creating redundancy in the systems is to be better prepared for sudden changes in the surroundings, that otherwise might have caused a disruption in the supply chain (Ali et al., 2017). However, according to the authors, one significant drawback with this concept is that it requires an extensive capital investment in order to create and maintain redundancy in the systems. Nevertheless, Münch and Hartmann (2022) explains that redundancy can increase the ability to deliver and the flexibility towards customers, by for instance increasing inventories and safety stocks, and argues that this in many cases outweighs the drawback of extensive capital investments. Furthermore, according to Tukamuhabwa et al. (2015), another pitfall to avoid when building redundancy is geographical location. Meaning that if redundant suppliers or warehouses are located in close proximity to each other, they may also be affected by the same disruption (Tukamuhabwa et al., 2015).

2.3.2 Flexibility

Flexibility can be defined as the ability of an organization to adapt to changing conditions in the market in order to meet the stakeholders' expectations, using as few resources as possible (Tukamuhabwa et al., 2015). According to Ali et al. (2017), flexibility contributes to creating a

more resilient supply chain by enabling quick adaptation to changes during turbulence, in addition to facilitating and enhancing operational efficiencies in stable conditions. Flexibility can be developed in several ways, for instance by having flexible supply and demand management, but also by supporting flexible order fulfillment or utilizing different means of transportation (Ali et al., 2017). Furthermore, Chowdhury and Quaddus (2016) explains that flexibility is especially important when there is high volatility and uncertainty in demand and supply. Although flexibility shares several similarities with redundancy, it can be achieved in other, more cost-efficient ways, which does not require any excess capacity (Tukamuhabwa et al., 2015). For instance, by hiring multi-skilled personnel or establishing more flexible contractual arrangements.

2.3.3 Collaboration

According to Tukamuhabwa et al. (2015), supply chain collaboration refers to an organization's ability to work together with other actors in order to achieve mutual benefits in various business areas. Information exchange is one important aspect related to collaboration, since it can reduce uncertainty and increase transparency, thus facilitating better and more informed decision-making (Tukamuhabwa et al., 2015). This is in line with Chowdhury and Quaddus (2016) findings that trust and open communication between supply chain actors are important in order to increase resilience. Furthermore, Ali et al. (2017) states that both vertical as well as horizontal collaboration between stakeholders has proven to increase the supply chain resilience. Apart from information sharing, other resources and complementary skills that are required to prepare for, respond to, or recover from disruptions can be shared and utilized by all the actors in the supply chain (Tukamuhabwa et al., 2015). To conclude, Sá et al. (2020) emphasizes the need to have collaboration and information sharing in place within the supply chain prior to any disturbances in more vulnerable nodes.

2.3.4 Visibility

Visibility, as a supply chain resilience capability, can function as a strategy to in early stages detect warning signs, and thereby allows organizations valuable time to align their resources in order to minimize the negative consequences and effects of disruptions (Ali et al., 2017). Furthermore, the authors explain that visibility also creates awareness and knowledge about the operations and its performance. This is vital since approximately 90 percent of the supply chain data is going practically unused, and the lack of visibility makes it extremely difficult to plan for and handle disruptions (Berti, 2021). According to Ali et al. (2017), monitoring of key performance indicator (KPI) metrics is a common way to achieve visibility, and that by investing in information and communication technology, the supply chain visibility and transparency can be enhanced. This is supported by both Asafo-Adjei et al. (2023) and Han et al. (2020), who state that firms should utilize technology in order to increase the awareness and control over the supply chain network. Additionally, the adoption of digital technology can also increase the end-to-end visibility in supply chains, which has proved to be an effective way to enhance supply chain resilience (Ivanov, 2021; Lin et al., 2022). Nevertheless, Polyviou et al. (2020) states that collaboration between supply chain actors can increase end-to-end visibility as well, thus enabling companies to react quicker to fluctuations in supply and demand.

2.3.5 Agility

According to Shekarian and Parast (2020), agility can be defined as the ability to rapidly change operating states in order to cope with environmental uncertainty or volatile market conditions. Furthermore, the author states that agility is one of the most effective ways to achieve a resilient supply chain, enabling it to quickly respond to potential changes in the external conditions.

Other authors see agility as a composition of visibility and velocity, where increased visibility allows an organization to take more informed decisions and avoid sub-optimizations, whereas velocity refers to the pace of the decisions (Ali et al., 2017; Tukamuhabwa et al., 2015). By combining these two practices, into supply chain agility, firms can improve their ability to respond to disruption, and thus minimize the impact from disturbances (Ali et al., 2017).

2.3.6 Remaining capabilities

The supply chain resilience capabilities that are not described above are briefly explained below, based on the article by Ali et al. (2017). Building security refers to a firm's ability to design processes to prevent or mitigate effects from disruptions before they occur, for instance by establishing strategic partnerships. Knowledge management and developing a deep understanding of the supply chain and the human resource structure are crucial aspects in the pre-disruption phase, when building a resilient supply chain. Furthermore, internal education and training as well as establishing a supply chain resilience culture can contribute to enhanced supply chain resilience. Meanwhile robustness refers to a supply chain's ability to mitigate the effects from disturbances, by proactively designing the supply chain in a way that enables sustained operation during disruptions. For instance, by adapting the sourcing strategy and by avoiding certain geographical locations that are more prone to various disturbances, such as extreme weather and geopolitical tensions. Nevertheless, situation awareness relates to having an understanding of the supply chain as well as its vulnerabilities by, for instance, using continuity planning.

Building social capital refers to establishing partnership and building trust within the supply chain as well as with other stakeholders, which in turn can result in an improved ability to learn. Knowledge management in the post-disruption phase refers to a supply chain's ability to learn from previous disturbances and increase the preparedness for future disruptions by developing and implementing new solutions. Furthermore, contingency planning is another important resilience capability that can be used in order to speed up the recovery process after a supply chain disruption. Developing effective contingency plans requires certain processes, such as scenario planning in the pre-disruption phase, which will enable a firm to be better prepared, and thus act quicker in order to restore the original state of the supply chain. The last resilience capability included in the framework by Ali et al. (2017) is the market position. Having a strong market position is a vital element for enhancing the supply chain resilience, since it will enable an organization to recover from disturbances due to their financial strength and organizational efficiency. Additionally, a strong market position will allow a firm to invest more in supply chain resilience, which in turn will strengthen customer relations.

2.4 Trade-offs in creation of resilient supply chains

Traditionally, companies have prioritized achieving cost benefits, for instance by outsourcing activities to actors that operate on the other side of the planet, in so-called low-cost countries (Heese, 2015; Katsaliaki et al., 2022). Furthermore, various lean supply chain management practices, such as just-in-time production while maintaining low inventory levels in order to reduce cost, have become increasingly popular. All of these strategies rely on a stable environment, since any disturbances will have a significant effect on the supply chain performance (Katsaliaki et al., 2022). However, in recent years the market conditions have been volatile and characterized by numerous significant disruptions (Asafo-Adjei et al., 2023). This has led to a shift, where companies move away from traditional supply chain management strategies, towards establishing a more resilient supply chain that is better posed to deal with turbulence (Katsaliaki et al., 2022).

However, building a resilient supply chain often implies additional work, and thus also additional costs. According to Rajesh (2021), flexibility in supply chains is a common way to mitigate the effects from disruptions. The author explains that flexibility often is achieved by installing various buffers in the system, which comes at a certain cost. Thus, firms need to find the optimal balance between resilience and cost (Rajesh, 2021). Tukamuhabwa et al. (2015) also emphasizes the importance of cost-effectiveness when it comes to creating resilience. According to the authors, resilient supply chains might entail more extensive costs compared to traditional supply chains, however, it is still crucial to minimize any excess cost related to supply chain resilience strategies. Nevertheless, according to Katsaliaki et al. (2022), the cost of disruptions is higher than the cost of creating and maintaining a resilient supply chain by allowing slack in the system as well as ensuring end-to-end visibility. This is in line with Dormady et al. (2022) findings, that organizations can avoid over four dollars in losses, due to interruptions in operations, for every dollar invested in resilience.

2.5 Aftermarket supply chain characteristics

According to Cohen et al. (2006), aftermarket, or after-sales services, can be seen as a kind of servitization of an original equipment manufacturer (OEM). The authors explain how this concept has grown in popularity in recent decades, due to the fact that companies have changed their business idea to deliver solutions rather than mere products. This change is primarily down to the increased competition and has switched the emphasis from producing as many products as possible to creating as much value as possible for the customers, by for instance offering spare parts and maintenance (Cohen et al., 2006). Additionally, according to the authors the aftermarket is a very lucrative market, with high profit margins. However, the authors explain how this transition towards offering complete solutions has increased the complexity of supply chains, by increasing the number of nodes and stakeholders involved in the value delivery process. This statement is further reinforced by Andersson and Jonsson (2018), who states that the management of aftermarket supply chains is both challenging and complex, due to the unpredictable demand characteristics. Furthermore, the authors declare that the demand for spare parts is both low-frequent and has a high variability at the same time, meaning that there can be extended periods of time without any demand for certain parts.

Additionally, to increase the complexity further, an aftermarket does not only have to support the latest products and models, but also previous models that no longer are in production but still require maintenance and spare parts in order to function as intended during the expected lifetime (Cohen et al., 2006). According to the authors, this results in after-sales services having to manage extensive numbers of suppliers and parts, and the number of SKUs is approximately 20 times higher compared to a traditional manufacturing unit. Another aspect that contributes to the complexity of demand and inventory management of spare parts is the high responsiveness required due to the significant cost during downtime for the end-users (Bacchetti & Saccani, 2012; Huiskonen, 2001). Thus, finding a balance between cost related to supply chain activities and providing a high availability of spare parts towards the customers is one of the key challenges in the aftermarket (Andersson & Jonsson, 2018).

One thing that stands out in regard to the aftermarket is how the demand is generated, namely through the need for repair or maintenance, which can be divided into two types of maintenance, preventive as well as corrective maintenance (Andersson & Jonsson, 2018). According to the authors, preventive maintenance is much easier to plan for since the demand is based on service intervals, which the authors exemplify by taking the perspective of a vehicle that normally is scheduled for service periodically. Corrective maintenance, on the other hand, is very hard to

foresee, for instance, since the demand is known first after a vehicle has already broken down and is in immediate need of service (Andersson & Jonsson, 2018). According to the authors, these two types of maintenance can be used to classify spare parts, depending on which type of maintenance they are used for. Other common classifications of items are criticality, part cost, and demand volume (Bacchetti & Saccani, 2012). Cakmak and Guney (2023) describes how classification of spare parts can help companies improve their inventory management, improving the service level and decreasing the cost simultaneously. The authors continue by explaining how classification of the spare parts can help an organization separate the most critical parts from the rest of the assortment. Thus, allowing a company to pursue different strategies depending on what category an item belongs to, where critical items can be prioritized, to minimize disturbances during crisis and disruptions (Cakmak & Guney, 2023).

According to Andersson and Jonsson (2018), another challenge regarding the aftermarket and managing spare parts is to manage the different phases of the life cycle. The authors divide the life cycle into three phases: *phase-in*, *prime*, and *phase-out*. Furthermore, Dekker et al. (2013) explains that during the phase-in period, the demand for spare parts is low and that it really starts to take off during the prime phase, with a relatively rapid increase. Finally, the phase-out period is where the demand starts to decrease and fade out. According to the authors, it is important to hedge against uncertainty, which for instance could mean that spare parts need to be in place from the beginning of production. However, due to the fact that the demand for spare parts in the phase-in stage usually is low and with a low frequency, this may result in excessive inventory costs (Andersson & Jonsson, 2018; Dekker et al., 2013). In addition, Dekker et al. (2013) explains that having higher levels of inventory is also a risk due to the common challenge of obsolescence regarding spare parts in the aftermarket. This challenge is amplified by the fact that it is more difficult to predict the decline of the demand related to spare parts compared to an increase in demand, since an increase in demand is normally preceded by a growth in the installed base of new vehicles (Dekker et al., 2013).

2.6 Practices to strengthen supply chain resilience

In this section, practices or strategies in order to improve the supply chain resilience are presented. The different topics that are included below are sourcing strategy, sales and operations planning, as well as scenario planning.

2.6.1 Sourcing strategy

During recent decades the trend has been for companies to outsource an increasingly large share of its operations, partly to achieve cost benefits and be able to focus on core competencies (Heese, 2015). Previously, it was mainly simple and standardized parts that were outsourced, however this has changed and nowadays it is common for companies to outsource more complex tasks as well (Heese, 2015). According to the author, this change has contributed to shifting the balance of power from the OEMs towards the suppliers that now enjoy a stronger bargaining position. Regarding the procurement of material or complete components, an organization can choose between various sourcing strategies depending on the context and what strategic objectives they aim to achieve. According to Yu et al. (2009), the most frequently used sourcing strategies can be divided into three types: single sourcing, dual sourcing, and multiple sourcing. Heese (2015) explains that single sourcing is when a firm chooses to work with just one supplier, whereas multiple sourcing is when the firm allocates the work between two (dual sourcing) or more suppliers.

One of the main reasons for adopting a single sourcing strategy is to promote closer collaboration with the supplier and achieve shared benefits (Burke et al., 2007). The authors continue by stating some of the benefits related to the single sourcing concept, such as lower purchase price as well as logistics cost through extensive consolidation enabled by economies of scale. This is in line with Zeng (2000) findings that cost reductions for both parties is one of the main benefits related to single sourcing strategy. Furthermore, other advantages related to single sourcing is improved communication as well as long-term stability of supply (Zeng, 2000). This can be compared to multiple sourcing strategies that instead aim to reduce a firm's dependance on a single supplier (Heese, 2015). Thus, the focal firm will be less exposed to certain types of risk that might cause supply disruptions, for instance, labor strikes, natural disasters, or material shortages (Heese, 2015). According to Silbermayr and Minner (2016), dual sourcing is a way to mitigate the risk of supply disruptions, however, this comes at the cost of losing the full potential to benefit from economies of scale. Thus, dual sourcing can be seen as a strategy to optimize the trade-offs between the pros and cons related to both single and multiple sourcing respectively (Silbermayr & Minner, 2016).

Outsourcing can also be divided into local sourcing and global sourcing, based on the geographical location of the suppliers (van Hoek & Dobrzykowski, 2021). During recent decades, firms have put a lot of emphasis on achieving cost benefits, by utilizing a global sourcing strategy where material and components are procured from low-cost countries. However, according to the authors, this has decreased firms' supply chain resilience during disruptions. The authors further explain how digitalization and new technologies can compensate for higher labor costs in more developed countries. Additional cost savings can be obtained through reduced freight and logistics costs due to the reduced delivery distances, which also contributes to shorter lead times (van Hoek & Dobrzykowski, 2021). Overall, extensive disruptions, such as the COVID-19 pandemic, combined with diminishing cost benefits from global sourcing has made firms reconsider their choice of sourcing strategies.

2.6.2 Sales and operations planning

Current challenges amplified by the competition on a global market has increased pressure on firms to renew their business strategies and internal processes in order to succeed (Seeling et al., 2021). Furthermore, an increased supply chain complexity combined with turbulent external conditions, caused by for instance the COVID-19 pandemic, has forced companies to evaluate and improve their supply chain planning processes, where sales and operations planning (S&OP) plays a crucial role (Seeling et al., 2021). According to Danese et al. (2017), the S&OP process is an important tool in order to facilitate cross-functional coordination and integration. The primary objective with an S&OP process is to balance supply and demand, both internally, but also externally together with other supply chain actors (Seeling et al., 2021). The authors continue by explaining that a successful S&OP implementation can enhance the company's supply chain as well as the overall performance.

According to Danese et al. (2017), the S&OP process can be divided into five steps: *data gathering*, *demand planning*, *supply planning*, *pre-meeting*, and *executive meeting*. The frequency of the meetings can vary between on a weekly basis to on a monthly basis, depending on the specific needs of the company (Danese et al., 2017). The planning horizon for the supply and demand can also vary between various companies and industries, but a common span is 3-18 months (Dittfeld et al., 2021). The first step of the S&OP process includes collecting relevant data from the previous periods and monitoring certain KPIs in order to identify and analyze trends (Danese et al., 2017). Based on this data, a demand plan and a capacity plan are created in step two and three respectively. Finally, the fourth and the fifth steps include a pre-meeting

to adjust and align the plans, and then a concluding executive meeting, where issues are resolved and the plan confirmed (Danese et al., 2017).

Normally, the state or how developed a firm's S&OP process is, is classified as how mature the S&OP process is. Danese et al. (2017) proposed a maturity model that is well used and referred to (see Table 2.1). The model is based on four categories that are evaluated and divided into five stages or levels. The categories are: *people and organization*, *process and methodologies*, *information technology*, as well as *performance measurement*; and the five stages are: *no S&OP process*, *reactive*, *standard*, *advanced*, and *proactive*. Furthermore, the authors explain the importance of a balanced improvement in each of the four key dimensions in order to increase the overall S&OP maturity, and that strides in one dimension alone are not sufficient. For instance, merely prioritizing improvements in one area, such as information technology, will yield limited results (Danese et al., 2017). The increased interdependence between each dimension in order to reach higher maturity levels is, according to the authors, one of the underlying reasons preventing organizations from advancement to higher stages. Worth mentioning is that the highest maturity level is almost unobtainable for most companies, since it requires seamless coordination, not only internally but also externally within the entire supply chain (Danese et al., 2017).

Table 2.1: A S&OP process maturity model by Danese et al. (2017).

	Stage 1 No S&OP process	**Stage 2** Reactive	**Stage 3** Standard	**Stage 4** Advanced	**Stage 5** Proactive
People and organization	• Lack of sponsorship from business executives • No team of S&OP • Silo culture domination	• Some collaboration between demand and operations • No definition of responsibilities	• New planning culture with non-dedicated S&OP team • Clear roles and responsibilities • Excellent commitment	• Formal S&OP team with executive participation • Collaboration with main customers and/or suppliers • Development of new skills and personnel training	• The S&OP process owner becomes coordinator of the entire network • Participation of top management of all partnering companies
Process and methodologies	• No formal S&OP process • Frequent re-planning and revenue focus	• Emerging but still inconsistent process • No financial integration	• Formalized and structured process • Regular meetings • Financial integration	• Process balanced with the external network partners • Demand and supply plans jointly aligned	• Dynamic process • Event-driven meetings
Information technology	• Individual managers keep own spreadsheets • No consolidation of information	• Many spreadsheets or functional solutions • Some consolidation but done manually	• Integrated demand and supply planning software • Improved data rationalization and integration capability	• Technology to access external partner data and share information with them	• Innovative technology to support decision- making (e.g. on risk management and scenario analysis for profitable trade-offs) using information dispersed in the supply network and beyond
Performance measurement	• Basic measurements	• Functionally specific metrics • Measure of how well Operations meets the sales plan	• Integrated internal supply chain metrics to manage trade-offs	• External supply chain metrics to support decision-making at the supply network level. • New product introduction metrics • S&OP effectiveness	• Assessment of the impact on company profitability • Measurement of the impact on the ecosystem (e.g. social impact, global environmental impact, etc.)

Finally, according to Dittfeld et al. (2021), the S&OP process can also be used as a risk management tool, in order to balance the supply and demand during more turbulent times. Traditionally, S&OP has had a more proactive role in risk management by enabling organizations to identify, assess, monitor, and treat risk in the monthly S&OP meetings (Dittfeld et al., 2021). However, the authors demonstrate a more reactive role for the S&OP process, by providing an established structure and communication channel to use during disruptions, to facilitate quick and efficient decision-making. This requires some temporary changes to the S&OP design, such as adaptations to the planning frequency and planning horizon, through so-called crisis meetings (Dittfeld et al., 2021). This is in line with Jonsson et al. (2021) findings that supply chain disturbances require a more dynamic S&OP process in order to be resilient. One way to achieve this is by complementing the traditional S&OP meetings with more frequent decisions, on a weekly or sometimes even a daily basis (Jonsson et al., 2021). The industry term for this short-term planning is sales and operations execution

(S&OE), and a successful integration between the short-term S&OE and the mid- to long-term S&OP process can result in a competitive advantage (Hainey, 2022).

The S&OE process has a shorter planning horizon of 0-12 weeks and tends to focus on a SKU level as well as on individual orders or shipments, compared to the S&OP process, which instead looks at a more aggregated level of supply and demand (Rodrigues et al., 2023). The authors continue by stating that the aim with S&OE is to evaluate and enable plans developed during the S&OP meetings. Furthermore, the processes are closely interlinked, but work best as a complement to each other and should remain separated (Rodrigues et al., 2023). According to the authors, the primary reason to develop a S&OE process is to enable a firm to meet the demand even during more volatile external conditions. To conclude, reduction of inventory and improving service level are some of the benefits that can be realized by the introduction of a S&OE process (Rodrigues et al., 2023).

2.6.3 Scenario planning

According to Olivares-Aguila and Vital-Soto (2021), scenario planning is a tool that companies can use in order to increase their supply chain resilience, by developing and evaluating scenarios in order to prepare for potential disruptions. According to the authors, scenario planning covers a gap that has previously been overlooked and ignored by decision makers, namely low probability and high impact disruptions. Although, scenario planning might not be able to prevent these kinds of events from occurring, knowing how the supply chain behaves, as well as being aware of and understand certain consequences when facing major disruptions is a way to mitigate the impacts from disruptive events (Olivares-Aguila & Vital-Soto, 2021). According to Ivanov and Dolgui (2020), a digital version of a supply chain, a so-called digital twin, can enhance the effectiveness and realism of scenario planning. A supply chain digital twin can be used to simulate various disruption scenarios, in order to identify bottlenecks within certain parts of the supply chain, and thus be able to fortify them (Ivanov & Dolgui, 2020). Furthermore, contingency plans can be developed, based on possible scenarios, to facilitate a swift recovery process in the post-disruption phase.

3
Methodology

In the following chapter, an overview of the methodology for the research is presented. The aim of this part is to provide insights into, and understanding of, how the research was conducted. Furthermore, it includes how information and data are collected through interviews, a literature review, conducting a workshop or focus group, reading internal documents and continuous observations. Finally, the chapter is concluded with an evaluation of the quality of the research.

3.1 Overview of the methodology process

Initially, an introductory phase to the study was carried out, where one part was to explore the subject. This was conducted through an initial literature review, consisting mainly of scientific papers, previous master theses as well as books, which were studied to increase the overall understanding of the research's topic. Simultaneously, onboard meetings with the case company, Volvo SML, as well as the supervisor and examiner from Chalmers were held to support the process of formulating the research's scope and delimitations. Furthermore, the case company held kick-off meetings and company presentations in order to lay the foundation for the project and give the required knowledge about the structure and organization within the case company.

After laying the foundation for the project through a literature review on the subject as well as a company description, the project proceeded to the second phase consisting of interviewing employees at the case company. The insight gained from the interviews was used as the basis to answer research question 1, namely, to identify and map current resilience practices adopted by the case company. The respondents were selected together with the supervisors at the case company, where the authors suggested which departments and roles that might be of relevance to interview, in order to get a full picture of the work processes. Then the supervisors from the case company assisted in making sure experienced employees within the respective departments were chosen as respondents, in order to maximize the value of the interviews.

Thereafter, when the theoretical as well as the empirical findings were collected, the data were combined to answer research question 2, and identify areas of improvement by comparing the case company's current practices and capabilities with supply chain resilience capabilities found in literature. Finally, a discussion regarding the applicability of these capabilities in the specific context of the aftermarket, as well as the topic's connection to sustainability was provided. A simplified overview of the research process, from start to finish, is visualized below (see Figure 3.1).

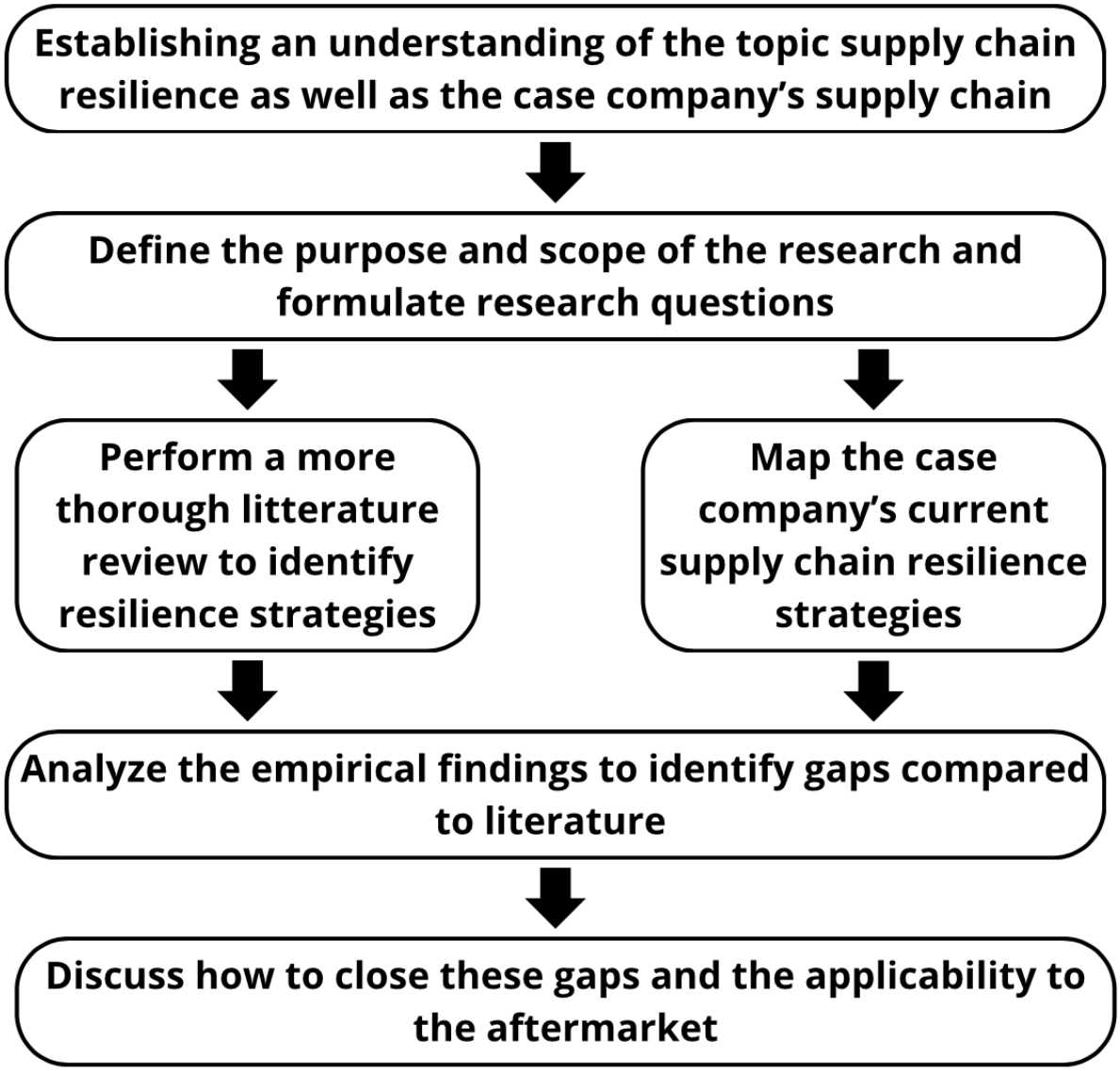

Figure 3.1: Overview of the research process.

3.2 Research approach

According to Höst et al. (2006), there are mainly two different types of research methodologies, quantitative as well as qualitative studies. The authors explain quantitative data to encompass more about numbers and calculations. Whereas qualitative data consists of words and descriptions, and are often more detailed. The research strategy of this study is of a qualitative nature, where the data and information used to provide insights were collected through observations, but mainly through interviews. Furthermore, Höst et al. (2006) explains that the data which is analyzed in qualitative studies usually consist of transcribed interviews and the authors also point out the importance of the existence of words, concepts, and descriptions. According to Bell et al. (2022), a qualitative research approach allows to in an efficient manner present the respondents view and perspective on situations. Furthermore, it is also cemented by Tenny et al. (2022), who explains that a qualitative research approach is suitable to use in order to obtain a more detailed insight into a specific problem. Then continues by stating that qualitative research is best suited to answer the questions "how" and "why", by gathering the experiences and perceptions of various stakeholders (Tenny et al., 2022). This supports that a qualitative research approach is appropriate to use in order to fulfill the purpose of this research. In addition, since resilience in the aftermarket is a largely unexplored area, an abductive

approach has been taken to the research, namely by moving back and forth between theory and empirical data in an iterative manner (Bell et al., 2022). Further, as the information gathered during the interviews forms the basis to answer the set research questions, an abductive approach, where a theoretical framework is used to structure the input from the interviews, was deemed appropriate.

3.3 Literature review

The literature review for this research was divided into different phases. Initially, the introductory phase was performed in order to get a greater understanding and insight into the area and topic of supply chain resilience. Later on, the literature review entered a more thorough phase, where it laid the foundation for the theoretical framework in this research. Finally, complementary literature was used in order to close gaps and adjust to new insights mainly from interviews. Additionally, in order to ensure that the reviewed literature had high credibility, mainly scientific and peer-reviewed articles, as well as educational books and previous master theses were used in the literature review. This is supported by Höst et al. (2006), who states that this type of literature usually possesses high credibility and can be useful in this kind of research.

Bell et al. (2022) proposes, in order to identify appropriate literature, to for instance use the database EBSCO, which was reached most frequently through Chalmers Library and Google Scholar. Additionally, Bell et al. (2022) explains that the use of relevant keywords and the combination of these makes the process of searching literature in databases more efficient. For the literature review, common keywords were *Supply chain resilience*, *Supply chain resilience capabilities*, *Supply chain disruption*, *Aftermarket*, *Service market*, *After-sales services*, *Spare parts*, *Sourcing strategies*, *Sales and operational planning*, and *Scenario planning*. Furthermore, another concept used to find additional relevant literature is snowballing, which refers to the process of identifying further literature on the topic by exploring the references used in the current literature (Bell et al., 2022).

3.4 Data collection

According to Patel and Davidsson (2011), there is no optimal data collection method, instead it varies depending on the situation. This is supported by Bell et al. (2022), who explains that it is common in qualitative research to use more than one data collection method. Therefore, for this study, several different data collection methods have been used during the information gathering process, in order to establish a more comprehensive picture of the case company's supply chain and its processes. Furthermore, a combination of primary and secondary data has been used. Primary data was mainly gathered through interviews, observations and through conducting a focus group session. This was done by interviewing people from numerous departments that had experience from working with supply chain disruptions, by participating in meetings, as well as by gathering a focus group consisting of experienced employees and managers to discuss the topic and findings of the thesis. On the other hand, the secondary data come from reviewing internal documents that have been provided by the case company, regarding for instance internal processes and their supply chain structure.

3.4.1 Interviews

To gain insight into the case company's current resilience practices and identify organizational structures, such as communication channels or meeting structures, several interviews with employees from various departments were performed. To get a more accurate visualization of how the processes looked, employees with expertise within the supply chain resilience area

were chosen as interview objects. Furthermore, at least one employee from all relevant departments for this study was interviewed in order to provide a more holistic picture of the current situation and not miss out on any vital aspects. This was achieved together with the supervisors at the case company, who were in possession of that company specific knowledge. At the beginning of the interviews, the research and its purpose were presented in order for the respondent to grasp the intention of the interview. Additionally, a template was created with questions for the interviews (see Appendix A.1), in order to direct the conversation towards supply chain resilience.

Interviews are, according to Bell et al. (2022), flexible and allows the respondents the opportunity of conveying what they think is of importance. Interviews can be conducted in different ways and have different structures, where the most common division of interviews is into unstructured, semi-structured, and structured (Bell et al., 2022). Furthermore, semi-structured interviews normally consist of a combination of pre-prepared questions as well as giving the respondents the opportunity to freely formulate their own response to the open questions asked (Patel & Davidson, 2019). Due to the fact that the purpose of the interviews was both to increase the general understanding of the organization and its structure as well as how it managed different types of disruptions, semi-structured interviews were deemed to be the most suitable in this case. Bell et al. (2022) further cement that semi-structured interviews are appropriate to use during these circumstances. A summary of the interview objects and their respective roles are presented below (see Table 3.1).

Table 3.1: Table over the respondents' roles and the date for the respective interview.

Interview nr.	Position	Date
1	Digital Driver, Operational Planning/Refill	2024-01-25
2	Manager Operational Planning/Refill	2024-01-30
3	Head of Operational Planning/Refill	2024-01-31
4	Service Center Coordinator	2024-02-01
5	Director Supply Planning & DIM SML	2024-02-05
6	Manager Product Projects & Quality	2024-02-05
7	Exploration Mode Development Lead	2024-02-06
8	Supplier Relationship Manager	2024-02-06
9	Senior Specialist Unnumbered Orders	2024-02-06
10	Continental Material Planner	2024-02-06
11	Continental Material Planner	2024-02-06
12	Manager Service Center Ghent	2024-02-12
13	Head of Demand & Inventory Planning	2024-02-29
14	Head of Dealer Inventory Management	2024-02-29
15	Director Sales & Operations Planning	2024-03-01
16	Supply Chain Design Specialist	2024-03-05
17	Manager DIM Analysis	2024-03-07
18	Head of Advanced Analytics	2024-03-13
19	Head of Uptime Vehicle Purchasing	2024-03-19

To conclude, all the information gathered from the interviews were recorded and transcribed in order to be able to analyze the content afterwards, without missing out on any essential information. According to Höst et al. (2006), transcription of interviews is a good method to preserve all the information that appears during the interview.

3.4.2 Focus group

Focus groups, or workshops, are one type of method primarily used for qualitative research (Bell et al., 2022). According to the authors, a focus group is a good way to complement other data collection methods, such as interviews. Bell et al. (2022) explains that a focus group normally consists of a group of people that are brought together to discuss a certain topic of interest. These types of sessions are led and guided by moderators and are usually performed

in an open and friendly manner, in order to welcome thoughts and promote discussions (Bell et al., 2022). Furthermore, according to the authors, focus groups offer the possibility for participants to explore and discuss other people's views, meaning that the perception of a participant can change after having heard the thoughts and reasoning from other participants. Bell et al. (2022) explains that in interviews, the respondents' views are rarely challenged, leading to less nuanced answers, which might not represent the reality. Therefore, a focus group can be seen as a good complement to interviews by allowing the participants to discuss and challenge each other in order to come up with a more realistic picture of the situation (Bell et al., 2022). Finally, the authors state that a focus group is a common means to establish trustworthiness and respondent validation, that enables triangulation of collected data from other methods. A focus group was arranged to support this study with two primary objectives. Partly, to validate the findings from the interviews, but also to get further insights into the topic, by inviting experienced employees and managers to discuss and evaluate potential improvement areas. Furthermore, the authors of this thesis acted as moderators for the focus group and below is a complete list of the focus group's participants (see Table 3.2).

Table 3.2: Table over the focus group's participants' respective roles.

Participant nr.	Position	Date
1	VP Supply Chain Optimization	2024-04-17
2	Head of Advanced Analytics	2024-04-17
3	Head of Dealer Inventory Management	2024-04-17
4	Head of Demand & Inventory Planning	2024-04-17
5	Manager DIM Analysis	2024-04-17
6	Continental Material Planner	2024-04-17
7	Supply Chain Data Modelling Expert	2024-04-17
8	Excellence Expert	2024-04-17

3.4.3 Observation

A main reason for including observations as part of the methodology in this research has been to complement the interviews and the focus group, as well as giving the authors an own perspective and opinion of the case company and their processes of dealing with disruptions. According to Bell et al. (2022), observations are a suitable complement to an interview study, which constitutes the foundation of the empirical data gathering within this research. Furthermore, Bell et al. (2022) explains that observations only should be used as complements and not as the primary source of data, due to the difficulties of ensuring a high level of reliability. However, an advantage with observations compared to other data collection methods is that it does not require the individuals to memorize certain situations in order to be effective (Patel & Davidsson, 2011).

The observations that have taken place in this project have mainly been by attending meetings. This allowed the authors of this thesis to get a better and broader perspective of the case company and how they work. During the observations, notes have been taken and the materials used for and during the meetings have been explored, in order to better utilize the observations

as a complementary source of data. The meetings that have been attended are more formal, larger, and less frequent meetings (see Table 3.3).

Table 3.3: Table over the conducted observations and attended meetings.

Observation nr.	Meeting	Date
1	Supply Chain Optimization Info Meeting	2024-01-23
2	SML Unpacked - Dealer Survey 2023 results - Session 1	2024-02-06
3	SML Unpacked - Dealer Survey 2023 results - Session 2	2024-02-07
4	Demosession: Analytics Exploration mode development	2024-02-14
5	DMT Weekly Meeting	2024-02-28
6	SML Unpacked - Data access and competence development in SML	2024-04-18

3.4.4 Documentation

To further increase the understanding of the case company's organizational structure and its processes, internal documents were studied and analyzed. Furthermore, the internal documents worked as complements to the interviews and observations by preparing the authors for the sessions but also by validating the information provided during those sessions.

3.5 Data analysis

During the research, the collected data were of a qualitative nature, where interviews with the employees of the case company were the primary data source. In order to not miss out on important information or aspects that came up during the interviews, notes were taken as well as that all of the interviews were recorded. In the initial part of the research process, the gathered data were used in order to decide on the direction of the research, for instance to develop the research questions and identify relevant areas to include in the literature review. Later on, the collected qualitative data were thematized into categories of the theoretical framework. According to Bell et al. (2022), a thematic analysis approach is one the most common ways to analyze data of qualitative nature. This thematic approach was, for instance, used to separate information related to different phases of supply chain resilience and find commonalities between various interview objects as well as internal departments. Finally, the analyzed data will build up the sections regarding empirical data as well as the analysis and discussion in this research.

3.6 Research quality

According to Bell et al. (2022), the concepts of reliability, validity and ethics of a research is important to consider in order to assess and ensure the quality of a research. Therefore, reliability, validity and research ethics of this study will be evaluated below in the following sections.

3.6.1 Reliability

According to Bell et al. (2022), reliability can be defined as to which degree the study can be repeated, without any significant changes to the result. As interviews constituted a considerable part of the information gathered regarding the case company, there is a risk for misunderstandings or distinctions in interpretation of the answers. Nevertheless, in order to reduce this risk, both authors were always present during the interviews. Additionally, all the interviews were recorded, and notes were taken, leading to a more accurate interpretation of the content as well as reducing the risk of missing out on important information. Furthermore, multiple interview objects from several of the main departments were chosen in order to further increase the reliability of the study. Moreover, standardized questions were used in order to guide the interview process and ensure consistency in the topics covered. Therefore, the method's reliability can be considered high since the information gathered would most likely be of similar nature if the research were to be replicated.

3.6.2 Validity

Validity can be divided into two aspects, namely internal as well as external validity (Säfsten & Gustavsson, 2019). Internal validity refers to how well the results correspond to what is intended to be investigated, whereas external validity aims to determine in which contexts the results are valid (Säfsten & Gustavsson, 2019). According to Bell et al. (2022), the external validity refers to whether or not the findings from the research can be generalized and applicable in another context. In order to enhance the internal validity of the study, the interview questions were sent to the supervisors for revision before the interviews took place to make sure the answers were relevant to the research.

A triangulation of methods has been used, which is a research strategy that combines several data collection methods with the aim to cross-validate findings and improve both the internal as well as the external validity of the study (Säfsten & Gustavsson, 2019). The methods used for this study are primarily interviews, complemented by a focus group, observations, and a document study. According to Säfsten and Gustavsson (2019), the main advantage with triangulation is that the weaknesses related to a certain method can be compensated for by another method. This is in line with Crowe et al. (2011) findings that triangulation is a way to increase the validity of a study. Crowe et al. (2011) elaborates on this and states that data collected through various methods should result in similar conclusions, and that the utilization of different methods provides a more nuanced picture of the reality. Additionally, another way to further increase the validity of a study is to interview multiple stakeholders in order to validate the information gathered (Quintão et al., 2020).

3.6.3 Research ethics

Bell et al. (2022) explains the importance of ethics when people impact a research and its result by participating. Therefore, from the initiation of this research until its end, ethics has been taken into account. For instance, ethics were considered in regard to privacy, consent and to avoid exposing participants to any risks or harm. To ensure the privacy of the participants, all names are omitted and anonymized by only sharing the roles of the respondents. This applies both externally as well as internally at the case company, in order to not expose the respondents to any risks or harm by being open and honest. Furthermore, permission was requested from the respondents to give their consent to recording of the interviews. Finally, in order to not endanger the case company by exposing sensitive or confidential information, the report was sent to the case company and the supervisors for review before being published.

4
Empirical Findings

This chapter includes a short background of the case company as well as a description of the supply chain, including relevant stakeholders for this study. Then, the case company's current supply chain resilience activities are presented and divided into the three phases of supply chain resilience, based on the structure of the adopted framework. The empirical data is mainly based on the conducted interviews with employees working in various departments. In addition to the interviews, a workshop as well as internal documents and observations have been used as complements.

4.1 Case description

The case company is a multinational actor, delivering spare parts to several markets all over the world, with its headquarters located in Gothenburg. Furthermore, the supply chain of the case company is extremely complex, with thousands of dealers and suppliers scattered across the globe. To increase the complexity further, the case company mainly inherits their suppliers from the OEM Volvo Group, which severely limits their ability to choose sourcing strategy. The reason behind this is that as a spare part provider, the case company has difficulties in reaching sufficient purchasing volumes for an independent supplier to sign any contract. Thus, the original contracts towards the suppliers' state that the supplier should be able to deliver spare parts for at least 15 years from when the production of new vehicles ceases. The vast majority of the parts are then delivered from the suppliers to a CDC. Additionally, the case company has distribution centers present in markets around the world in order to provide their customers with short lead times (see Figure 4.1).

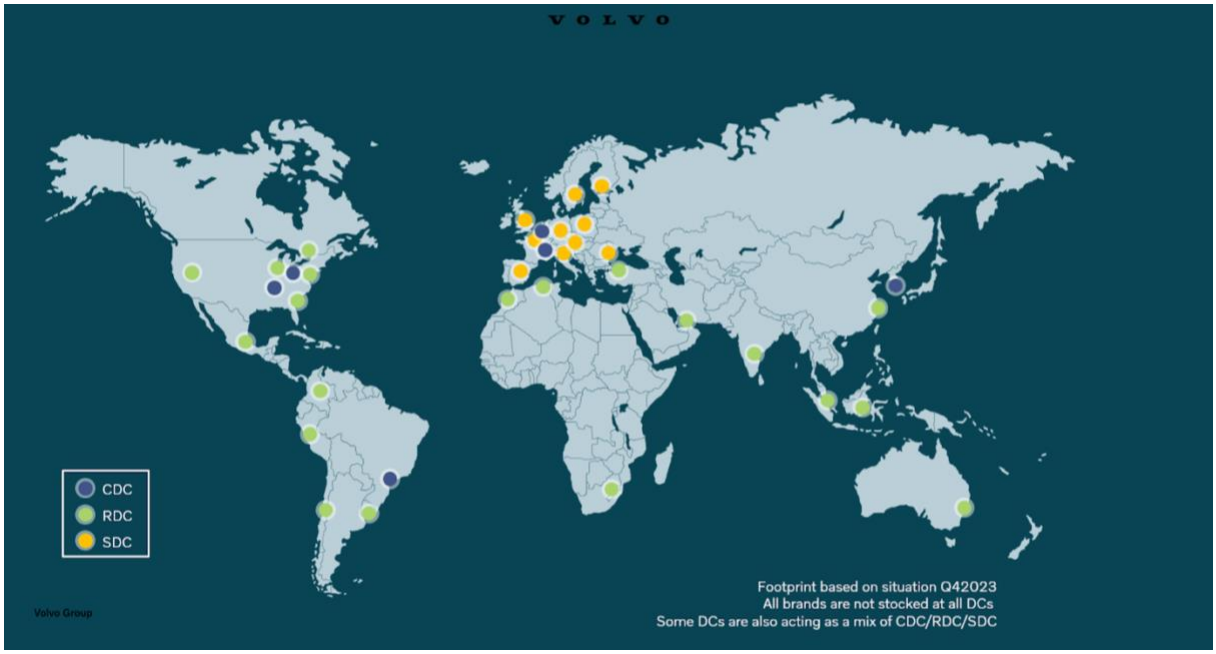

Figure 4.1: Map showing the location of Volvo SML's distribution centers globally.

A CDC is a larger warehouse where most of the spare parts are stored. The CDC in Ghent is the main CDC in the case company's supply chain for the brand Volvo Trucks, to which most of the deliveries from their supplier are delivered to. Then the Ghent CDC refills other CDCs, regional distribution centers (RDCs), support distribution centers (SDCs) as well as dealers (see Figure 4.2). The other CDCs then also supply RDCs and dealers. RDCs are strategically placed local warehouses used to increase the presence in certain markets around the world, in order to decrease lead times and transportation costs. SDCs are also local warehouses, but with the main purpose of supplying dealers with critical and urgent orders, so-called Vehicle Off Road (VOR) and day orders, and not the standard refilling of dealers' shelves, so-called stock orders. VOR orders are receiving higher priority in order to maximize the uptime for the end consumers, in case their vehicle has broken down during operations. The SDCs are only present in Europe, where the CDC in Ghent is supposed to provide the dealers with stock orders. Elsewhere in the world, the RDCs are responsible for performing all different types of orders. Finally, dealers are the customers of the case company and act as service points for end consumers of Volvo vehicles across the globe, where services, maintenance and repairs are performed.

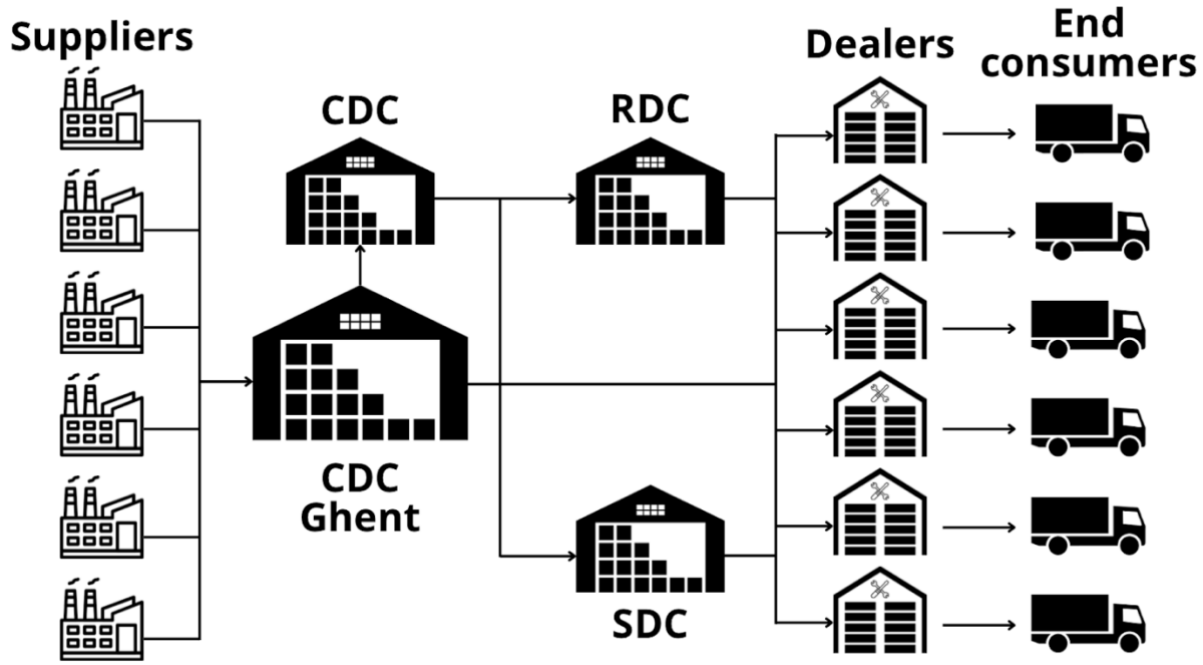

Figure 4.2: The supply chain structure of the case company.

4.1.1 Organization

In this section, the primary internal departments of the case company who were subjects to the interviews are listed and their respective roles are briefly explained. The departments are *Demand & Inventory Planning*, *Material Planning*, *Supplier Relationship Management*, *Refill* (*Operational Planning*), *Dealer Inventory Management*, *Service Center*, and *Advanced Analytics*. Nevertheless, the function of *Purchasing* is also included and briefly explained below, even though it is not a department within the case company and rather an overarching department of Volvo Group.

Demand & Inventory Planning

The demand and inventory planning (DIP) department is responsible for forecasting the demand within the EMEA and APAC regions. The forecasts are then used as initial delivery plans for

the suppliers. Thus, maintaining a high forecast accuracy is crucial for the DIP team, which is why continuous forecast evaluations are a central part of the department's responsibility. However, forecasts are primarily based on historical data, which means that the accuracy during disruptive events tends to be low. Due to this challenge, combined with the increased frequency of disruptions, the DIP department has started to utilize real time data from vehicles, through demand sensing, in order to increase the forecast accuracy even during more turbulent times.

Material Planning
The responsibility of material planners is to secure the availability of spare parts at the CDCs, by placing orders for spare parts towards the respective suppliers. Each material planner is in charge of a supplier assortment and the contact with their respective suppliers. The material planners describe that their main objective is to ensure that the right spare parts arrive in the right quantity, at the right place, at the right time and meet the quality expectations. In order to achieve this, they use certain tools, such as forecasts provided by the DIP team to decide on appropriate order quantities. The material planners are also responsible for root cause analysis and error coding concerning various supply or delivery failures, and then making sure that the information is available, by communicating it to affected stakeholders internally. However, if the material planners are not able to sort out the issues on their own, they involve the responsible supplier relationship manager.

Supplier Relationship Management
The supplier relationship management (SRM) department works proactively together with the suppliers in order to enhance the suppliers' performance. This is achieved by working closely together with the suppliers and by taking actions as soon as any deviation is spotted in order to deal with the situation before it derails. Furthermore, it is the SRM department's responsibility to classify the suppliers, by conducting audits at the supplier sites and gathering supplier data from forms, in order to make sure all the suppliers that deliver spare parts to the case company live up to set standards. Finally, the SRM department also supports the material planners and are responsible for the supplier communication in case an issue in the procurement or call-off process occurs.

Refill or Operational Planning
The refill function, also referred to as operational planning, is responsible for maintaining proper inventory levels in both the RDCs as well as the SDCs respectively. This is done by monitoring the stock levels in the warehouses and then deciding upon what is to be shipped from the CDC in Ghent to each individual RDC and SDC, in order to ensure a satisfactory availability of spare parts.

Dealer Inventory Management
The dealer inventory management (DIM) department works in close collaboration with the dealers. The DIM team is responsible for monitoring, managing, and optimizing the inventory levels of dealers according to a logistic partner agreement (LPA), in order to ensure that the right parts are available for the end consumers at the dealers. The LPA concept of Volvo SML is a so-called vendor managed inventory system, where the case company is responsible for the dealers' inventories. However, apart from managing the forward orders towards the dealers, DIM is also responsible for the return flow in case the wrong parts are delivered or if certain parts do not sell out.

Service Center
Service centers exist on the different markets of the case company, where there are both more local service centers as well as a central one in Ghent. The local service center department handles the contact with the dealers in case they have questions or need any kind of support related to spare parts. They are also responsible for booking transports of returns from dealers as well as invoicing. The service center in Gothenburg is responsible for the markets and dealers of Northern Europe, including for instance the Nordic countries and the Baltic States. Nevertheless, the service center in Ghent acts both as a local service center for the markets and dealers of Central Europe as well as a service center towards internal stakeholders, such as CDCs, RDCs and SDCs. The service center then communicates and provides information regarding, for instance, shipments leaving the CDC in Ghent.

Advanced Analytics
Advanced analytics (AdA) is the department at the case company that is responsible for innovating, partly when it comes to the exploration of new technologies, such as AI, but also by finding new and improved ways of working. Then it is the AdA team's responsibility to make sure that these innovations are implemented in the rest of the organization, by making sure that the inventions are accessible for all the departments. Thus, AdA are involved in various projects in order to come up with cutting edge solutions to stay ahead of the competition.

Purchasing
The case company does not have their own purchasing function, instead, there is one common purchasing department for the entire organization of Volvo Group, in order to achieve scale benefits. However, there are people within the purchasing team that are dedicated towards the aftermarket and the procurement of spare parts, who work closely with other departments within the case company, such as DIP, material planning and SRM. The purchasers are responsible for initiating the supplier relations and signing the contracts. Furthermore, deciding on what sourcing strategy to develop for various spare parts is another important part of their responsibilities.

4.2 The case company’s supply chain resilience practices
In recent years, supply chain disruptions have increased in both frequency as well as severity, where a few of them are mentioned in the first subsection below. Thus, companies have started to put more emphasis on creating a more resilient supply chain in order to be better prepared to handle these disturbances. In the following sections, the case company’s current supply chain resilience efforts and related practices are presented.

4.2.1 Experienced disruptions
Since the start of this decade, supply chain disruptions have continuously replaced one and other. No matter which department or roles within the organization, every one of the respondents had experienced some kind of supply chain disruptions. The disruptions could be of completely different nature, where some affected the entire organization, whereas others merely affected certain parts of the supply chain. The former will be referred to as macro disruptions, and the others as micro disruptions. Common examples of macro disruptions mentioned by the respondents were, the COVID-19 pandemic, the war in Ukraine with sanctions towards Russia, semiconductor shortages as well as the ongoing crisis in the Red Sea region, with rebels preventing the ships from passing through the area and the Suez Canal. All

of these disruptions have had a significant impact on the case company's operations and also affected their bottom line as well as their ability to deliver to their customers. However, the most common type of disruption are minor disruptions, such as transport delays or supplier failures, meaning that the supplier fails to deliver the agreed upon quality or quantity.

4.2.2 Resilience phases

In order for an organization to be truly resilient it needs to be able to both anticipate and prepare for, respond and react to, as well as recover and learn from a disruption. Thus, this section describes how the case company works with resilience in all three phases, prior to disruptions, during disruptions, and finally, after disruptions.

4.2.2.1 Pre-disruption phase

According to the respondents, it is very difficult to be able to prepare for a disruption in advance, at least if no similar disruptions have occurred previously, and experience on how to best manage the situation has been gathered among the employees. Nevertheless, according to the participants of the workshop, a resilience culture has been developed at the case company in recent years. The participants expressed that since the COVID-19 pandemic, the organizational culture has evolved into a more cooperative and solution-oriented environment. Additionally, during interviews as well as the workshop, some respondents and participants referred to a "*can-do attitude*" and "*let's get together and fix it*" approach to new challenges caused by supply chain disruptions.

SRM is a department that works more proactively, by following up on any deviations that they spot by keeping track of relevant KPIs. If they see anything out of the ordinary, they immediately reach out to the supplier concerned to try to prevent, or at least mitigate, a disruption before it occurs or escalates. Furthermore, the SRM department also performs audits at potential new suppliers and occasionally on existing ones, in order to confirm that the required standards, certifications as well as operational and logistic capabilities are in place. The audits are also conducted in order to classify the suppliers based on their performance. The classification is on a scale from A to C, where A is a high performing supplier, whereas C is a lower performing supplier that consequently are more susceptible to risks. This classification is, for instance, used when choosing suppliers, where suppliers with higher grades are prioritized. This is another way to decrease the risk of disruptions, by minimizing the use of underperforming suppliers.

Another way, in which the case company tries to increase their preparedness for potential disruption, is by having a continuous dialog with the suppliers. Furthermore, according to the respondents, there are some suppliers that are relatively good at communicating in advance, as soon as an issue is realized. This gives the case company more time to take appropriate actions, and most of the time a disruption can be avoided if relevant stakeholders are informed prior to the event and involved in early stages. This is similar to internal disruptions, such as a strike in one of the organization's warehouses. Since strikes can be announced in advance, which enables the company to prepare for, and thus mitigate the effects of the disruption.

DIP is another department that works more proactively, by trying to anticipate where and when spare parts will be needed, in order to avoid potential disruptions in their deliveries to the customers. Continuous forecasting, as well as forecast evaluation in order to constantly improve their forecast accuracy, are central parts in ensuring availability of spare parts. However, traditional forecasting methods are based on historical data and work best during stable external conditions, whereas the accuracy during disruptions tends to be poor. This was clarified by a

respondent that explained that one of the first measures during the COVID-19 pandemic, which was a macro disruption that affected both supply and demand, was to shut down part of the systems, since the forecasted demand was misleading, and would have resulted in overstocked warehouses. Therefore, in order to complement the forecasts and get a more accurate picture of the future demand, they have started to utilize demand sensing, where they use real time data, such as driving distance of their sold vehicles, in order to better predict the future demand. Demand sensing worked well during the pandemic, where there was a distinct correlation between an increase in driving distance and an increase in demand for spare parts. However, one important limitation with merely looking at, for instance, the mileage of sold vehicles, is that it does not provide any information regarding where the vehicles are used, and thus where the spare parts are most likely to be needed. Another proactive measure taken by the DIP team is the dimensioning of the safety stock based on attributes such as criticality, cost, and lead times, but also which phase of the life cycle the spare part belongs to in order to find an optimal balance between inventory cost and availability during uncertainties and sudden changes in demand. Furthermore, previously there have been some attempts to try to establish a scenario planning structure within the DIP department, however, it was unsuccessful, and no scenario planning is actively used today.

One element in the pre-disruption phase that is missing in Volvo SML's organization, which was mentioned by some of the respondents, is a developed S&OP process. Currently, there are so-called flow planning meetings, which are monthly cross-functional meetings, where updates regarding the supply chain status is discussed and deviations can be reported. The one who participates in the meetings are the majority of the departments mentioned in *Section 4.1.1* as well as representatives from different markets and distribution centers. This cross-functional meeting structure enables the organization to inform relevant parties and communicate over department boundaries in a structured way. Before the flow planning meetings, each department has their own preparatory meetings, where they discuss what to bring up during the flow planning meetings. Some of the respondents draw similarities between their flow planning meetings to the structure of an S&OP process, but on the other hand, some respondents also expressed that it is far away from a S&OP process. However, Volvo Group has an established S&OP process, but this is outside of Volvo SML, and although Volvo SML are informed and invited to decision-making forums, they rarely attend these meetings due to a production focus.

Additionally, there has been an increase in awareness of resilience and the effect of supply chain disruption in recent years, due to all the turbulence and uncertainties in the world. Consequently, the experience and knowledge among the employees regarding how to manage various types of disruptions have increased. There has also been a switch in focus from mainly relying on their ability to react, towards being more proactive, by trying to anticipate and prepare for certain events. A recent example of this was when cyber security appeared on the agenda since a cyber-attack occurred in another organization and severely affected their operations. It was a manager who had read about the cyber-attack and its consequences in an article and then took the initiative to organize a meeting regarding cyber security. During this meeting, cyber security was discussed as well as what type of information and data each department requires in order to perform their work if a cyber-attack were to happen and evaluate how the level of preparedness was. The conclusion from this meeting was that a small amount of data would go a long way in mitigating major negative effects. Thus, this risk could be mitigated by making sure that certain data was protected during a potential cyber-attack. Finally, since 95 percent of all cyber-attacks are caused by human errors, recurring company wide education is performed in order to educate employees on how to, for instance, spot malicious mails and prevent a potential data breach.

Another area where proactive measures were taken in order to increase the resilience, by avoiding disruptions, was in the choice of sourcing strategy. The priority is to source as many parts locally as possible in order to avoid transport related issues, but also other issues related to certain geographical locations, such as natural disasters or geopolitical conflicts. Furthermore, for suppliers located on the other side of the world, for instance in Asia, Volvo SML has a requirement that the supplier needs to have a local hub or a pick-up point in Europe. Preferably close to the CDC in Ghent, where they can perform deliveries with relatively short lead times, less than three days and preferably within 24 hours. Apart from trying to maintain a relative proximity to the suppliers, another important aspect, according to the purchasing department, is that the suppliers have more than one production facility. Preferably in a separate location, in order to ensure continued shipments even during a local disruption affecting the primary site used to supply the case company.

A compilation of the case company's supply chain resilience measures in the pre-disruption phase is presented below (see Table 4.1).

Table 4.1: Resilience measures of the case company in the pre-disruption phase.

Summarization of resilience measures in the pre-disruption phase
Internal resilience culture and "can-do" attitude
Monitor supply chain partners KPIs
Performing supplier audits
Performing supplier classifications
Continuous supplier communication
Utilizing demand sensing and vehicle specific data
Utilizing strategic inventory planning
Flow planning structure and meetings
High degree of internal competence and experience
Conducts training and education of employees
Prioritizing to source from nearby suppliers
Requirement of having local pick-up-points for suppliers far away

4.2.2.2 During-disruption phase

During the interviews, respondents explained that the case company works more reactively than proactively, where several of the respondents also clarified that there was no structured way on how to anticipate or prepare for various disruptions. Instead, due to the nature of disruption and their vastly different scale and scope, the majority of disruptions are handled ad-hoc. Furthermore, the size of the organization as well as the lack of clear communication channels and visibility have contributed to departments working in silos, which increases the risk of suboptimization. For instance, some of the respondents clarified that some of the recent

stockouts could have been avoided by utilizing the resources in a more efficient way, since there were spare parts available within the organization, although in the wrong location. However, this is something that employees from several departments are aware of and there is currently work ongoing to mitigate this problem. For instance, by trying to establish better end-to-end visibility in order to facilitate the planning process and avoiding silo-planning, by visualizing the stock levels in all the nodes simultaneously, which currently is not the case. Several respondents reasoned that this would be useful in all phases of supply chain resilience, meaning prior to disruption, in normal times, as well as during disruptions and afterwards.

When it comes to micro disruptions, such as minor transportation delays or suppliers with temporary lack of capacity, it generally does not influence the customers. Since smaller disturbances like this are to a large extent mitigated by the safety stock in the respective nodes. It is first after several days, or in some cases a few weeks, when they start to run out of stock and their customers might be affected. But to prevent this from happening, and ensure a high availability for the end users, there are several measures that can be taken. One way is to use expedited deliveries, by flying critical parts to certain nodes in order to avoid stockouts. However, this is not feasible on a larger scale due to the financial as well as environmental constraints. Another way to prevent a stockout in certain nodes is by performing some kind of rebalance of material or by changing the safety stock levels. For instance, one respondent explained that by decreasing the safety stocks in each node, it might be possible to prevent a complete stockout in another part of the supply chain. Furthermore, during uncertainties they tend to try to keep the stock centralized, in their CDC in Ghent, in order to decrease the risk for stockouts. By keeping a centralized stock they can avoid suboptimization, for instance by having to return some of their parts from one RDC just to send it to another RDC, which can be quite time and resource demanding.

Regarding delivery disturbances from various suppliers, there is a structured process on how to handle the situation, a so-called escalation ladder. The process is initiated by the material planners, who perform a root cause analysis together with the contact person at the supplier site. The objective within this step is to come up with an action plan for how to proceed and solve the issue, if this is achieved the case can be closed. If no solution is found, the material planners have to involve the responsible supplier relationship manager, who then will set up a crisis management team together with the supplier, involving all the relevant stakeholders in order to get to the bottom of the problem. The final step, if the problem cannot be solved by the crisis team, is to escalate the issue to the purchasing management.

For disruptions that affect the lead times within key transportation routes used by the case company, such as the Suez Canal and the Red Sea region, that has been a recurring issue during the last few years, the organization has improved their ability to manage these kinds of disruptions. One important aspect is to immediately change the lead time parameters in their systems for certain nodes that are affected by the transportation delay. This enables the responsible planner to adapt to the situation by, for instance, increasing their order quantity to match the new demand during a prolonged lead time, in order to ensure a satisfying availability towards the customers. For disruptions within Europe, it is easier to manage a potential disturbance in a supply route, since the local transports primarily are performed by trucks and by nature are more flexible compared to longer transports by sea.

During uncertainties and disturbances, it is sometimes necessary to prioritize between various customer orders, in order to minimize the impact from disruptions on the end consumers. There is a distinct order of priority established when a lack of material occurs, where VOR orders

receive the highest priority. Volvo SML is even allowed to collect parts from the production facilities of Volvo Group if there are no spare parts available in any of the warehouses at that time. The second highest priority is Volvo Group's production of new vehicles, which means that Volvo Group's production, in turn, can take parts from Volvo SML's CDC in Ghent, for instance, in order to avoid a production stoppage. Thereafter comes the day orders, whereas lowest priority is given to the stock orders. Meaning that during a major disruption, it might be necessary to block all the stock orders temporarily, since that will not normally affect the end consumers, at least not in the short-term. Whereas VOR orders are very important to deliver to the customers as soon as possible, in order to ensure the promised uptime of the vehicles for the end consumers.

When a macro disruption, such as a pandemic or a geopolitical conflict occurs, which has a major impact on the case company's supply chain, an immediate action is to assemble a cross-functional team. To these meetings, stakeholders from the respective departments are invited in order to come up with solutions on how to proceed as soon as possible. Furthermore, the frequency of these crisis meetings are high, sometimes even on a daily basis for more severe disruptions, at least until the situation is under control. However, currently these meetings are of an ad-hoc nature and there is not a specific team assigned to work with this, as is the case within a structured S&OP and S&OE process. Therefore, the communication channels are a bit unclear in the beginning and it is difficult to know who is responsible, and thus who you should reach out to regarding certain matters. This tends to result in an extended information lead time, which further prolongs the decision-making process. Nevertheless, according to the respondents, there has been an improvement in the decision-making process in recent years, since some of the decisions have been decentralized, thus enabling faster decisions during critical periods. However, the respondents clarify that it is important to not rush decisions in order to avoid negative consequences in the future or for other stakeholders.

Finally, another action that might be necessary to take during a major supply disruption is to stop the LPA system, meaning the automatically generated orders to the majority of dealers. The reason for this is to avoid a stockout in the CDC in Ghent, which would have an immense impact on the entire supply chain, since it is the main warehouse where the majority of the spare parts passes through before it reaches the customers. However, this action requires a significant amount of manual work from the case company, which puts a strain on the available resources. Additionally, according to the respondents, it risks creating a bull-whip effect later on, once the system is activated again and several dealers are in need of stock replenishment. Therefore, the case company tries to prevent the shutdown of the automatic order system to the extent possible.

Below, a compilation of the case company's supply chain resilience measures in the during-disruption phase is presented (see Table 4.2).

Table 4.2: Resilience measures of the case company in the during-disruption phase.

Summarization of resilience measures in the during-disruption phase
Ad-hoc approach to manage disruptions
Utilizing safety stocks in multiple nodes and geographical locations
Possibility to switch transport mode in order to expedite deliveries
Possibility to adjust safety stock levels and rebalance materials between different nodes
Escalation process and cross-organizational collaboration during supply failure
Previous experience allowing for quicker decisions
Utilizing order prioritizations in times of shortages in order to ensure availability
Quickly establishing cross-functional teams when a disruptions occurs
Increasing meeting frequency during disruptions
Decentralized decision-making allows for quicker decisions during uncertainties

4.2.2.3 Post-disruption phase

After a disruption has occurred, it is important for an organization to recover the operations to a state similar or, if possible, better compared to the pre-disruption phase. For instance, by recovering depleted safety stocks to normal levels in order to ensure the availability of parts to the end consumers. Furthermore, being able to learn from the experience and implement changes to make sure the firm and all employees are better prepared to handle a similar disruption in the future if it were to occur again, is of utmost importance in order to increase the resilience. In addition to the internal learning within the company borders, another important aspect is the inter-organizational learning, where knowledge is acquired and shared over company borders with other stakeholders. This learning process is further facilitated by establishing long-term relations and building trust among supply chain partners, which the case company aims to achieve through a close collaboration process. Learnings are to a certain extent used to improve the supply chain resilience today, where employees at the case company utilize their knowledge from prior disruptions, so-called lessons learned, in order to mitigate the effect from similar disruptive events at a later stage.

A recent example of this is the crisis in the Red Sea region, where the first disruption occurred in 2021, when the Ever Given ship got stuck in the Suez Canal and blocked other ships from passing. Then more recently, at the end of 2023, another disruption occurred in the same region, although this time due to an armed conflict in the area, preventing ships from passing through the canal. However, both disruptions had the same consequence, namely that they prevented the ships from using the transportation route through the Suez Canal, and thus having to take a significantly longer route than usual. But during the second disruption, the case company was able to act much quicker since they had experienced a similar scenario before and knew how it affected various performance parameters, such as the lead times. This meant that they could change the lead time in their systems as well as inform all the relevant stakeholders of the changes and the reasons, and then continue their operation with up-to-date information. However, a distinct difference between the two disruptions is the uncertainty regarding the

duration of the disruption. The first disruption was caused by a ship that was stuck in the canal, but it was just a matter of days before it got removed. Whereas the second disruption has been ongoing for months and there is no sign of a resolution to the ongoing conflict in the region.

However, in order to make use of the lessons learned, and avoid dependency on certain people with experience from various types of disruption, it is crucial to document and communicate the learnings. Thus, the resilience can be sustained for a longer period of time, instead of being linked to a few people within the organization. This is especially important since the case company has had a relatively high staff turnover in recent years, which means there are new employees that need to acquire this knowledge. According to some of the respondents, this has been attempted in previous years, by the creation of some kind of whitebook, which are manuals where knowledge of how to manage different types of experienced crises has been documented. Still, the issue persists, since it is only a few departments within the organization that mentioned some kind of documentations of learnings from previous disruptions. Additionally, the utilization of whitebooks appeared to be limited or mostly non-existent, to the point where some of the employees had merely heard of it and never actually utilized it.

Finally, as an alternative to the whitebooks and documentations of learnings from past disruptive events in a manual, some respondents talked about continuous improvements. The idea is the same, namely, to gather experience and learn from previous disruptions by holding on to the things that worked well and dismiss the things that did not work. However, instead of gathering the knowledge in a separate manual, which was only used for specific disruptions, these respondents instead emphasized the importance of implementing these practices in the systems, processes, and daily work. For instance, by preparing multiple control parameters in the systems that are adapted to suit different levels of demand, they are now better prepared to handle abrupt changes in demand. According to some respondents, this is a way to ensure that previous experience and learnings are utilized, and not forgotten by the next time a similar disruption occurs.

A compilation of the case company's supply chain resilience measures in the post-disruption phase is presented below (see Table 4.3).

Table 4.3: Resilience measures of the case company in the post-disruption phase.

Summarization of resilience measures in the post-disruption phase
Having long-term relations and building trust with supply chain partners
Utilizing lessons learned from previous disruptions to increase the preparedness
Documentation of learnings in so-called whitebooks
Work with continuous improvements in order to maintain up-to-date systems and processes

5
Analysis

In this chapter, research question 1 is answered by evaluating and analyzing the empirical findings, through linking the identified resilience practices from the respective phases to the resilience capabilities in the framework by Ali et al. (2017). The adopted framework is used to create a consistent structure, and a summary of the complete classification is presented at the end of the chapter.

5.1 Pre-disruption phase

According to Ali et al. (2017), the pre-disruption phase requires a firm to develop five supply chain resilience capabilities, namely visibility, security, knowledge management, robustness, as well as situational awareness (see Figure 5.1), in order to increase the preparedness for, or in some cases even prevent, a disruption.

Visibility

Regarding the first capability, visibility, the case company has good visibility, in terms of available data, within specific nodes and departments, however, a more holistic picture appears to be lacking. Additionally, information regarding items in transit, such as ETA and partial orders, is not visible in the systems. Nevertheless, the case company has decreased the reliance on traditional forecasts in recent years, by increasing the visibility through demand sensing, which has enabled the organization to be better prepared for potential changes in demand during disruptive events. In addition, the case company strives to increase the visibility upstream by monitoring certain KPIs, such as delivery precision, at the supplier sites, in order to spot any deviations at early stages. Furthermore, regular supplier communication is another way to increase the upstream visibility by maintaining a good relationship. This can provide the case company, in early stages, with vital information regarding specific events which might result in a supply chain disruption.

Security

Looking at the second supply chain resilience capability, building security, which is primarily achieved in two ways by the case company. Firstly, by performing supplier audits before establishing new partnerships with suppliers. This is done to ensure that the supplier of choice meets and has certain standards and certificates, but also in other areas when it comes to risk management, such as data management and education in cyber security. Another focus area in the audits is to monitor the suppliers operational and logistic performance to minimize the number of disturbances. Based on the outcome of the audits, suppliers are placed in certain categories, between A and C, as described above in *Section 4.2.2.1*. Minimizing the use of C- and, to a certain extent, also B-classified suppliers, is a way for the case company to establish security and prevent regular supply disturbances.

Knowledge management

There is a vast amount of experience gathered within each department, since many of the employees have worked in the organization for several years, and thus been involved in

managing multiple severe disruptions, not least since the beginning of this decade. This has also contributed to the formation of a resilience culture at the case company, characterized by cross-functional collaboration, which entails a more holistic view of problems and solutions. Furthermore, in certain risk prone areas, such as cyber security, there has been company wide education and training in order to mitigate the risk of disruptions. Together, this constitutes the knowledge management in the pre-disruption phase at the case company.

Robustness
Robustness, for the case company, is mainly achieved in two ways, both through the choice of sourcing strategy as well as by maintaining strategically placed safety stocks. Regarding the sourcing strategy, the case company prioritizes more local suppliers in proximity to the central warehouse in Ghent. For certain parts that are not produced in Europe, the contracted suppliers need to establish a local pick-up point on the continent to facilitate a swift delivery process. Additionally, primarily suppliers with multiple production facilities were used, at least for more critical parts, to ensure continuous availability. A strategic inventory in each node is also built-up prior to potential interruptions, in order to maintain high availability towards dealers and end consumers during more turbulent times.

Situational awareness
Furthermore, in order to complement the traditional forecasts, which are unable to anticipate any future changes in demand and rely solely on previous data, the case company has tried to increase their situational awareness. This has been pursued through monthly flow planning meetings, where stakeholders from different departments are invited to participate and coordinate the operations to mitigate the risks for disruptions.

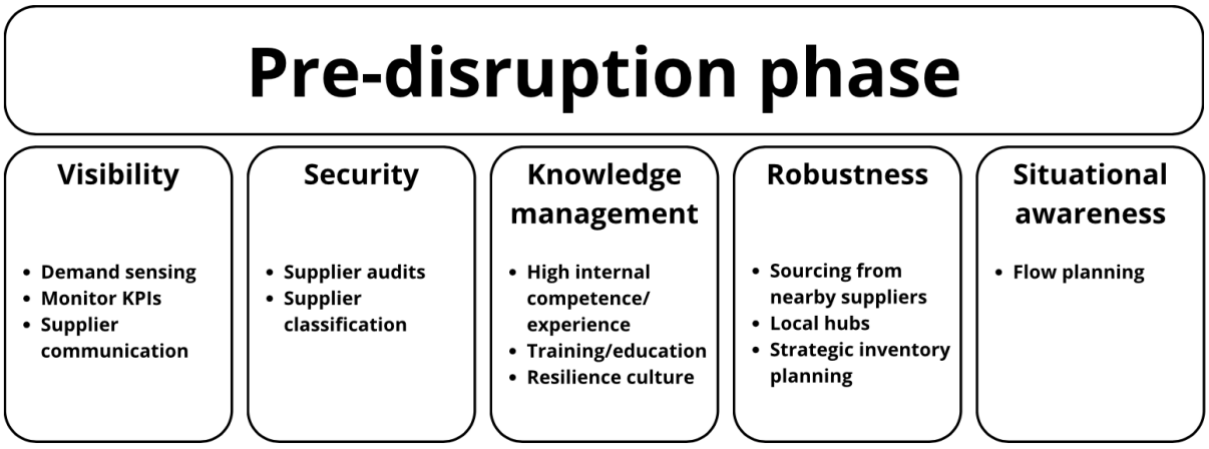

Figure 5.1: Summary of the supply chain resilience capabilities in the pre-disruption phase.

5.2 During-disruption phase
In this phase, there are other capabilities that are required in order to manage an ongoing disruption in the best possible way and prevent it from significantly impacting the end consumers. Redundancy, agility, collaboration, and flexibility are the four capabilities identified by Ali et al. (2017) to be the most prominent in this phase of a disruption (see Figure 5.2).

Redundancy
Starting with redundancy, which has been high on the case company's agenda, due to the nature of the aftermarket and the high requirements regarding availability of spare parts. Thus,

appropriate safety stock levels have been established in the respective nodes, which contributes to the prevention of stockouts, for small- to medium-sized disruptions, that otherwise would affect the availability for the end consumers.

Agility
The second supply chain resilience capability in the during-disruption phase, agility, have also been improved in certain areas during recent years. For instance, regarding the decision-making process, where some of the decisions have been decentralized, which enables the respective departments to act faster during uncertainties. Furthermore, in some systems there are several predetermined control parameters that are customized to suit different levels of demand, which enables quick changes during a disruption. Finally, there are also order prioritization rules in place, to facilitate swift decisions regarding resource allocation during uncertainties and shortages.

Collaboration
Collaboration is another central capability for a firm to possess during turbulent times when many complex decisions, spanning over several departments, need to be taken within a short time frame. Thus, the case company tends to organize cross-functional meeting structures during crises, often on a daily or at least on a weekly basis, until the situation is under control or averted. During a supplier related disruption, cross-organizational collaboration between the case company and the supplier in question takes place in order to find the root cause of the problem and prevent it from becoming a persisting problem.

Flexibility
Due to the nature of disruptions and their large spread in scale and scope, it puts a lot of emphasis on organizations to be flexible, in order to adapt to changes quickly. Thus, it is difficult to find a generalized solution on how to manage different types of disruptions. Therefore, the case company currently adopts an ad-hoc approach to manage disruptions, where temporary teams are established based on which departments that are affected, and what competencies that are required. Transportation is another area where the case company has developed flexibility, by utilizing flight transport for urgent deliveries in order to ensure up-time for the end consumers. Additionally, flexibility has been added in the order fulfillment stage by enabling deliveries from multiple nodes, both through the use of SDCs or RDCs, as well as directly from the CDC in Ghent to the dealers. Finally, there is a possibility to redistribute stock between various nodes in order to prevent shortages in certain parts of the supply chain.

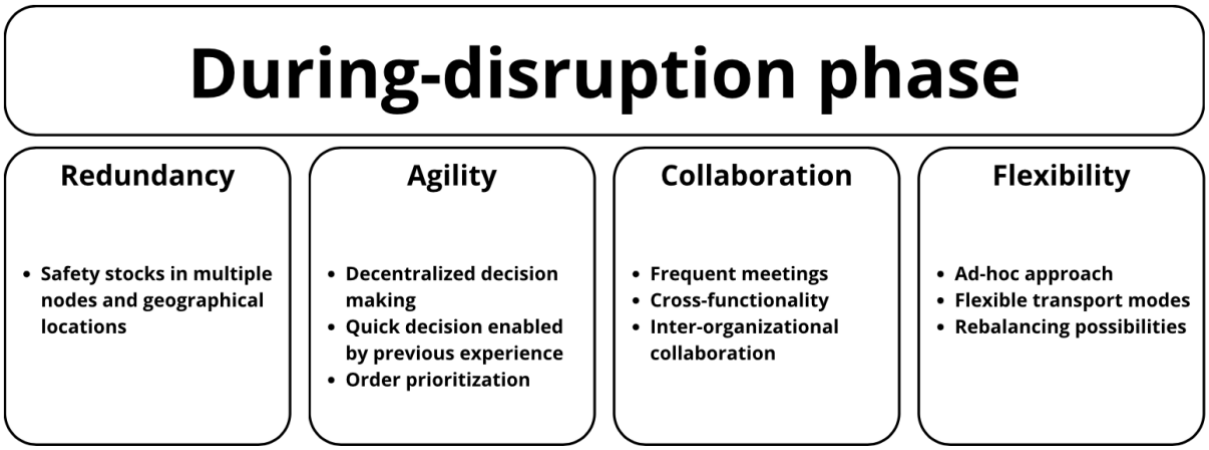

Figure 5.2: Summary of the supply chain resilience capabilities in the during-disruption phase.

5.3 Post-disruption phase

Finally, the post-disruption phase revolves around learning as well as recovering from prior disruptions, and includes four supply chain resilience capabilities, namely building social capital, knowledge management, contingency planning, and market position (see Figure 5.3).

Building social capital

Regarding building social capital, the case company tries to build trust as well as establishing strong and long-term relationships with suppliers and supply chain partners, through maintaining a continuous dialog with all their partners. Additionally, regular visits to suppliers and dealers are done, where the employees of the case company try to create personal connections to the responsible parties at the respective suppliers and dealers.

Knowledge management

According to several of the interviewees, whitebooks have been created during the COVID-19 pandemic, containing information regarding how to act during a major supply chain disruption. However, it seemed like each department had created their own whitebook, with lessons learned, but a more holistic picture was missing. Additionally, the utilization of these whitebooks appeared to be limited for the majority of the employees. For this reason, some departments chose to work more with continuous improvements instead, where changes were made and implemented to the daily processes and ways of working based on previous learning, thus mitigating the risk of losing out on valuable experience. These were the case company's two most structured ways to manage knowledge from past events.

Contingency planning

Regarding the supply chain resilience capability related to contingency planning, it was evident, based on the interviews, that the case company lacks in this area. During the interviews, contingency planning and scenario planning often came up and was discussed as something that could be beneficial to implement in the future, but currently does not exist within the company. Some respondents explained that there had been investigations or projects regarding scenario planning a couple of years back, but that faded away and did not result in any implementation or further explorations as far as the respondents were aware of.

Market position

Finally, looking at the last supply chain resilience capability in this phase, market position. The case company has a strong market position as a global actor, with customers located all over the world. Furthermore, Volvo Group is one of the largest truck manufacturers globally with a turnover of approximately 500 billion SEK and a profit of over 10 percent (Volvo Group, 2023). This strong financial position enables the case company to keep investing in different areas, such as resilience in order to maintain high operational performance also during more turbulent times. In addition to the strong financial position, the organization has been around for almost a century, meaning that it has created a strong brand and is well established on the market.

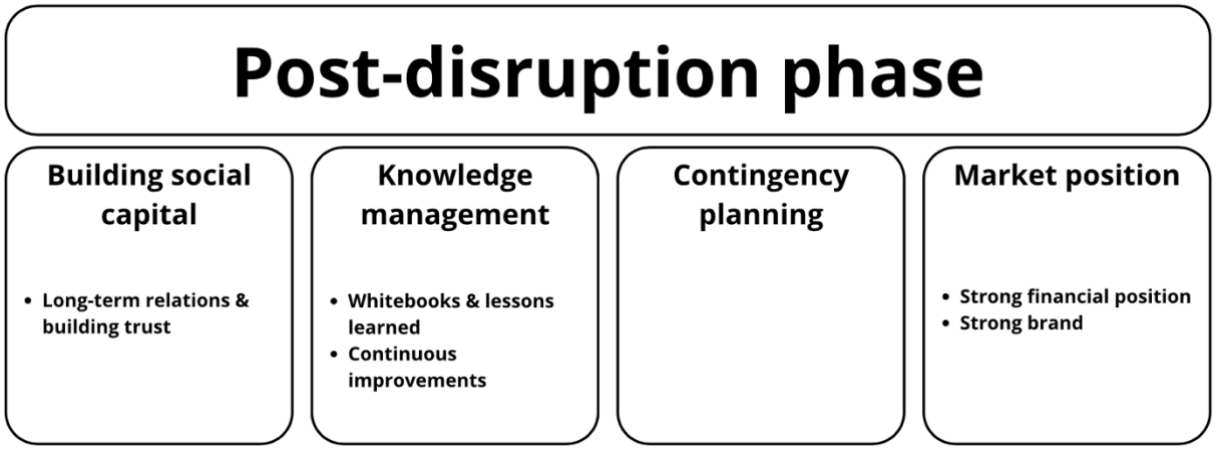

Figure 5.3: Summary of the supply chain resilience capabilities in the post-disruption phase.

5.4 Summary of the found resilience capabilities

The following table summarizes the found supply chain resilience capabilities along with related activities for each of the three disruption phases (see Table 5.1).

Table 5.1: Compilation of supply chain resilience capabilities found at the case company.

Pre-disruption Phase	During-disruption Phase	Post-disruption Phase
Visibility	Redundancy	Building Social Capital
• Demand sensing • Monitor KPIs • Supplier communication	• Safety stocks in multiple nodes and geographical locations	• Long-term relations & building trust
Security	Agility	Knowledge Management
• Supplier audits • Supplier classifications	• Decentralized decision-making • Quick decision enabled by previous experience • Order prioritization	• Whitebooks & lessons learned • Continuous improvements
Knowledge Management	Collaboration	Contingency Planning
• High internal competence/ experience • Training/education • Resilience culture	• Frequent meetings • Cross-functionality • Inter-organizational collaboration	
Robustness	Flexibility	Market Position
• Sourcing from nearby suppliers • Local hubs • Strategic inventory planning	• Ad-hoc approach • Flexible transport modes • Rebalancing possibilities	• Strong financial position • Strong brand
Situational Awareness		
• Flow planning		

6
Discussion

In this chapter, research question 2 is answered by combining the empirical findings and analysis with the findings from the literature review. It is based on the framework adopted from Ali et al. (2017) and structured according to the three phases of supply chain resilience. The different supply chain resilience capabilities in the framework are evaluated, analyzed, and discussed in the context of the case company, where gaps and areas of improvement are identified.

As visualized by the table in Chapter 5 (see Table 5.1), the case company has certain activities in place for all except one of the supply chain resilience capabilities. However, there is a distinct difference for a firm to have certain activities aimed at enabling a specific capability, compared to actually possessing that capability and being able to utilize it in order to increase the resilience of the supply chain. Furthermore, some of the capabilities are complex and require a combination of multiple activities in order to be fully developed. Thus, there still exists several areas of improvements and gaps that need to be filled in order for the case company to further strengthen its resilience, which are discussed below.

Thereafter, a discussion regarding the application of the adopted supply chain resilience capability framework in an aftermarket setting is presented. Finally, the chapter is concluded with a section regarding ecological and societal aspects in relation to the thesis.

6.1 Pre-disruption phase

In the following section, the activities related to the capabilities in the pre-disruption phase are discussed and evaluated in order to identify areas of improvement.

Visibility

Concerning the first capability in the pre-disruption phase, visibility, it was evident that the case company had an extensive amount of data available, both upstreams and downstreams from suppliers and customers respectively, but primarily internal information regarding what is available in each node. However, the primary challenge for the case company is to utilize this data to establish end-to-end visibility, since there is no common digital platform where all relevant information is gathered and accessible for the involved parties. Furthermore, additional data regarding items that are currently in transit between various nodes would be beneficial to increase the transparency of the supply chain and thus facilitate the planning. Instead, various systems were used by different departments, which meant that each department to a large extent relied on other teams for acquiring certain information. This lack of end-to-end visibility resulted in extended information lead times, which in turn can entail delayed or uninformed decisions, thus increasing the risk for sub-optimization. This is in line with Berti (2021) findings that lack of visibility increases the difficulty in planning for and managing disruptions. However, the case company is aware of this issue and are currently working on establishing a shared platform providing a more holistic view of the supply chain. This improvement is meant to make each department more self-reliant regarding access to information and reduce non-

value adding work, thus allowing the organization to become more resilient. This approach is supported by Asafo-Adjei et al. (2023) and Han et al. (2020) who state that firms should take advantage of technology in order to increase the awareness, and thereby the supply chain resilience.

Nevertheless, according to Polyviou et al. (2020), collaboration between supply chain partners is another way to increase visibility and resilience, by enhancing an organization's ability to react to changes in supply and demand. This is another area where the case company can improve, although the visibility downstream is extensive, due to the LPA solution, the communication and information exchange with certain suppliers can be further developed. However, this remains a challenge to solve due to the nature of the aftermarket, characterized by its low and intermittent demand (Andersson & Jonsson, 2018), which transfers the balance of power more towards the suppliers as well as reduces their willingness to collaborate and share information.

Overall, the case company's visibility of its supply chain is insufficient, where the main challenge lies in creating a more holistic picture and increasing the availability of the data for the different departments and functions, thus enabling them to take quicker and more informed decisions in order to avoid sub-optimizations. A distinct example of this is the stock levels in and between each node within the supply chain, which today is not easily accessible for each function, instead the planning of the respective nodes are often performed in silos. One way to tackle this issue, could be to change the planning structure to involve spare parts rather than warehouses, where one person is responsible for the planning of specific parts and their distribution worldwide, instead of different people being responsible for the same components albeit on different nodes and geographical locations.

Security

The case company tries to build security by performing comprehensive audits of suppliers before engaging in a long-term partnership. Generally, the contracts state that the supplier should be able to deliver spare parts for up to 15 years after the production of new vehicles has come to an end. Thus, this process plays an important role in making sure the case company chooses an appropriate business partner in order to minimize the number and effect of disruptions. According to Ali et al. (2017), establishing strong partnerships with supply chain partners is a way to create synergies and enhance the supply chain resilience. Nevertheless, this process could still be improved further, since most of the time an audit is merely performed before a new supplier is contracted, and not continuously within a set time interval, which increases the risk of sticking with non-compliant suppliers.

Knowledge management

It is evident that there is a vast amount of combined experience and knowledge within the case company regarding how to manage various types of disruptions. Furthermore, an organizational culture that promotes cooperation in problem solving has been established in recent years due to the high number of severe disruptions, which, according to Chowdhury and Quaddus (2016), is an important aspect in building resilience. However, the knowledge is often tied to certain people and structured ways to spread the knowledge, such as through education and training (Ali et al., 2017), are generally lacking, which could cause problems in the future if these employees were to leave the organization. Company wide education regarding cyber security is a good example of how to spread the knowledge within the organization, and thus increase the level of preparedness for and resistance towards those kinds of events.

Robustness
The complex planning environment of the aftermarket, which Andersson and Jonsson (2018) explains to be caused by, for instance, low and intermittent demand, results in that the capability of robustness is difficult to fully develop in an aftermarket setting. These traits make the spare part industry less lucrative for suppliers to work with, which means most of the suppliers used by the case company are inherited from Volvo Group, due to the nature of the long-term contracts established in the first place to ensure availability of spare parts for up to 15 years after production ends. Thus, the case company is to a certain degree limited to work with the suppliers chosen by Volvo Group. Consequently, utilizing multiple sourcing strategies, which, according to Heese (2015), leave a firm less exposed to certain risks and supply chain disruptions, is rarely feasible for the case company.

However, there are still certain measures being taken in order to increase the robustness, and thus the supply chain resilience. For instance, there is a group within the purchasing department who works towards the aftermarket and procurement of spare parts, and one of the priorities of this team is to ensure continuous availability of parts. Therefore, the majority of the suppliers used by Volvo Group are located in Europe, to facilitate shorter lead times and avoid disruption related to having geographically dispersed suppliers. This is in line with van Hoek and Dobrzykowski (2021) findings, that offshoring has proved to decrease supply chain resilience. Additionally, for suppliers located further away, there is a requirement for them to operate a local pick-up point, within 72 hours from the CDC in Ghent, in order to increase the robustness and resilience of the case company's supply chain. Another action being pursued with the objective of increasing the robustness against disruptive events, is the planning and maintenance of strategic inventories in various nodes of the supply chain, which enables the organization to better cope with volatile market conditions.

Situational awareness
Regarding the last capability in the pre-disruption phase, situational awareness, the case company performs their monthly flow planning meetings, with the aim to inform affected stakeholders of potential changes in the supply chain. This is in line with Dittfeld et al. (2021) demonstration on how an organization can utilize the S&OP process as a risk management tool by enabling a firm to identify, assess, monitor, and treat risk in a structured way. However, far from all the respondents even mentioned the flow planning meetings during the interviews, which shows a potential area for improvement in actually utilizing this meeting structure to prepare for, manage, as well as learn from disruptions. Nevertheless, the fact that there is a S&OP process within Volvo Group is an advantage, since Volvo SML can utilize that knowledge and experience when it comes to working with S&OP in order to facilitate their own implementation.

6.2 During-disruption phase
In the following section, the activities related to the capabilities in the during-disruption phase are discussed and evaluated in order to identify areas of improvement.

Redundancy
One capability that was well established at the case company was redundancy, which was evident since the majority of disruptions never affected the customers. Instead, those disruptions were managed with strategic use of several layers of safety stock that managed to absorb small- to medium-sized disruptions. It is first after a couple of weeks of continuous disturbances that the availability towards the customers starts to be affected, since extensive planning had taken place as a basis to classify the assortment based on criticality, cost, and

volume, in order to come up with appropriate service levels for each item. According to Rajesh (2021), installing buffers in the system is a common way to build resilience, but it comes at a certain cost, which puts pressure on firms to enhance resilience in a cost-effective way. Classification of spare parts is a method suitable for the challenging characteristics of the aftermarket, in order to optimize the inventory management, by improving the service level and decreasing cost simultaneously (Cakmak & Guney, 2023). Additionally, according to the authors, classification of spare parts has also proved to increase resilience and minimize effects from disruptions, by enabling specific strategies to ensure availability of critical items.

Agility

Agility was a capability that had been improved in recent years, for instance by decentralizing some of the decisions to the operative functions. However, one important lesson learned by several of the respondents was that it is important to avoid rushed and uninformed decisions, since that could backfire later on and result in an even worse scenario than status quo. This phenomenon is supported by Ali et al. (2017), who states that agility can be seen as a combination of visibility and velocity, and that both pieces are needed in order to be able to take informed decisions in a rapid manner. Therefore, the ongoing work to establish better end-to-end visibility of the entire supply chain via a common digital platform can help facilitate agility, and thus further strengthen resilience. Furthermore, other improvements in this area were the predetermined parameters set for certain demand levels, as well as the order prioritization rules, which facilitates quick adaptation to changes in supply and demand. This eliminated manual work for the employees, who then had more time to come up with a solution to the issue or perform other value adding activities. This is in line with Shekarian and Parast (2020) findings that agility is the capacity to change operating state in an efficient manner in order to manage fluctuations in supply and demand.

Collaboration

The third capability in the during-disruption phase is collaboration, which refers to a firm's ability to work closely with other stakeholders to achieve a common goal (Tukamuhabwa et al., 2015). According to the authors, information exchange and sharing of additional resources can help all involved parties to better prepare for, respond to, and recover from a supply chain disruption. According to Ali et al. (2017), both horizontal as well as vertical collaboration between supply chain actors has proved to increase resilience. The case company is good at solving problems after they have occurred, once a task force has been formed consisting of a cross-functional team in order to gather all the necessary information and expertise in one place to come up with the best possible solution. Nevertheless, there is still room for improvement in this area, since several of the respondents still mentioned the existence of a silo-culture, where each department prioritizes their own needs instead of looking at the bigger picture. An example of this is the planning of the various nodes, where each team aims to maximize their own KPIs and avoid stockouts. However, without proper visibility, either through a common digital platform or through inter-functional collaboration, there is a high risk of sub-optimization in the supply chain.

Furthermore, the daily communication during non-interrupted times tend to be mainly internal within the respective departments, which could mitigate the organization's ability to anticipate and prepare for a potential disruption in the future, due to lack of information. Moreover, communication and information exchange with external partners takes place as well, especially with the dealers due to the developed LPA solution, which is used by the majority of the dealers, providing the case company with full visibility of the dealers' inventory and demand data. Regarding upstream partners, the suppliers, the degree of collaboration and information sharing

is lower, although there is continuous monitoring of KPIs as well as that potential discrepancies are handled together with the suppliers. Having established communication channels and platforms for information sharing prior to a disruptive event, especially in more vulnerable nodes, is important to increase the resilience of the supply chain (Sá et al., 2020).

Flexibility

According to Ali et al. (2017), flexibility is the final capability a company can benefit from during a supply chain disruption. The authors highlight multiple ways to develop flexibility in the system, for instance by having flexible supply and demand management. However, achieving flexibility in terms of supply and demand is difficult for a company in the aftermarket industry, due to the demand characteristics (Andersson & Jonsson, 2018). The demand pattern in the aftermarket is quite unattractive for potential suppliers that generally want larger and more reliable volumes to benefit from economies of scale, which means that the case company often is stuck with one supplier inherited from the production of Volvo Group, as described in *Section 4.1*. This is a major issue for the case company since flexibility is especially important in a volatile market with high uncertainty in terms of supply and demand, as explained by Chowdhury and Quaddus (2016).

Still, there are a few areas where the case company has developed some flexibility, such as through their flexible order fulfillment, but also by utilizing air freight as a complement to slower means of transport for urgent deliveries in order to prevent stockouts. Worth mentioning is that these strategies entail additional cost and emissions for the case company, thus they are not feasible to utilize on a larger scale. This is in line with Rajesh (2021) findings that achieving flexibility often comes at a certain cost, and thus it is important to find a balance between creating resilience and limiting the cost. Nevertheless, the relatively high margins in the aftermarket (Cohen et al., 2006), combined with the fact that the cost for creating and maintaining resilience is lower compared to the cost of disruptions, as explained by Katsaliaki et al. (2022) and Dormady et al. (2022), means that these measures are justified by the case company.

6.3 Post-disruption phase

In the following section, the activities related to the capabilities in the post-disruption phase are discussed and evaluated in order to identify areas of improvement.

Building social capital

Regarding the first supply chain resilience capability in the post-disruption phase, building social capital, the case company tries to establish long-term relations, with a high degree of trust, with supply chain partners. The case company strives to work with building relationships and trust through maintaining continuous dialogs with all stakeholders as well as making regular visits to, and establishing personal relations with, supply chain partners, such as dealers and suppliers. According to Ali et al. (2017), creating partnerships and building trust in the relations within the supply chain and with stakeholders enhances the ability to learn. Furthermore, Sá et al. (2020) explains that learning is an important aspect in the post-disruption phase in order to improve the supply chain resilience. According to the definition of Lin et al. (2022), building social capital is connected to external learning, where knowledge is acquired from and shared between supply chain actors. Finally, by having good relationships, established trust and continuous dialog with supply chain partners and stakeholders, the case company can learn about how to be better prepared for disruptions. Both by getting access to how previous disruptions have been managed and what lessons have been learned by external parties, as well as being able to receive earlier warning signs and insights from external parties. This is

supported by Chowdhury and Quaddus (2016), who states that in order to increase the supply chain resilience of a firm, it is important to utilize the two perspectives of learning as described in *Section 2.2.1*.

Knowledge management

Post-disruption knowledge management is another supply chain resilience capability, which refers to an organization's ability to learn from previous disruptions, and thus be better prepared for similar events in the future by making use of experience and knowledge gathered during past disruptions (Ali et al., 2017). According to the authors, this can be achieved through training and education, as well as by having post-disruption feedback sessions, where good and bad practices from the previous event are discussed. There are a few examples of when the case company has utilized the experience and knowledge from previous disruptions, for instance by establishing multiple predetermined parameters for certain demand levels, in order to facilitate a swift adaptation in case of future fluctuations in demand. Changes similar to this one, where recent knowledge is applied directly in the systems and becomes a part of the daily work can be seen as continuous improvements. Nevertheless, a structured way to exploit previous learnings, such as through education or post-disruption feedback sessions, as proposed by Ali et al. (2017), is generally lacking, resulting in a high dependency on human capital and certain individuals as previously indicated.

Furthermore, several respondents mentioned the creation of whitebooks, where learnings from experienced disruptions, such as the COVID-19 pandemic, were written down in order to be able to rely on this knowledge for future disruptions. However, although this measure has the potential to increase the supply chain resilience, it requires the whitebooks to actually be used in order to benefit from it, otherwise it is merely a waste of time creating it. And as of today, it is evident that the majority of the employees barely know of its existence, rather than actually utilize it to draw from past experiences in times of uncertainties, which defeats the whole purpose of the documentation. Additionally, it appeared as various departments created their own whitebooks and that a limited amount of knowledge was shared between the departments. Lin et al. (2022) defined internal learning as an organization’s ability to share information within and between different functions, and due to the limited usage and sharing of the knowledge gathered from past events, it is evident that the case company has room for improvements in this area.

Contingency planning

Contingency planning was the only capability where no structured processes or measures were available or applied according to the respondents. However, in at least one department there had been talks and plans regarding adopting some kind of contingency or scenario planning, but no action was realized. According to Ali et al. (2017), contingency planning is crucial in order to prepare for various scenarios, and thus be able to act quicker during a disruption to restore the original state of the supply chain. Furthermore, Ivanov and Dolgui (2021) explains how an organization can utilize data analytics and scenario planning in order to visualize supply chain risks and identify vulnerabilities. According to the authors, this will facilitate the creation of contingency plans, which can reduce the impact from disruptive events and improve the supply chain resilience. Hence, by establishing contingency plans for various scenarios and thereby developing this capability, the case company can increase their supply chain resilience. Worth mentioning is that the set parameters for different demand levels can possibly be seen as one kind of contingency planning, which enables the case company to swiftly reconfigure their operations during uncertainties.

Market position
According to Ali et al. (2017), a strong market position facilitates a more rapid recovery from disruptions, since the high margins enables considerable investments in, for instance, strengthening the supply chain resilience. This was apparent for the case company, which was able to leverage its strong market position and significant financial surplus to proactively prepare for, and thus facilitate a swift recovery from disruptions. Examples of areas where proactive measures, enabled by the access to monetary and human resources, limited the effects from disruptions were in the establishment of safety stocks, the choice of sourcing strategy, as well as the access to a comprehensive knowledge pool due to the size of the corporation.

6.4 Improvement areas

In the following subsections, improvement areas for the case company in regard to supply chain resilience, as well as potential measures that could be taken or implemented in order to mitigate gaps related to the adopted supply chain resilience capability framework, are presented and discussed. The identified improvement areas that are included below are "*develop a more mature S&OP process*", "*establish end-to-end visibility*", "*introduce scenario planning*", and "*improve the knowledge management*" (see Table 6.1).

6.4.1 Develop a more mature S&OP process

S&OP has proved to be a key process in terms of balancing supply and demand even during more uncertain external conditions (Seeling et al., 2021), which has been the case during recent years. The case company currently has so-called flow planning meetings, which has a similar purpose as traditional S&OP meetings. However, the level of maturity of these meetings belongs in the lower end of the maturity model proposed by Danese et al. (2017), since the case company currently works more reactively than proactively, which is a common sign of the lower maturity levels. Nevertheless, the fact that the case company still has regular flow planning meetings on a monthly basis, although of a more reactive nature, means that stage two in the maturity model (see Table 2.1) is a just placement of their current S&OP process. Furthermore, the case company has no established roles in the flow planning meetings, and the commitment was limited as well, since some employees barely were aware of the existence of these meetings, much less their purpose. The long-term objective for all firms should be to reach stage five, however, as explained by Danese et al. (2017), this is close to an utopian state, which almost no organizations manage to achieve. Thus, a more realistic first step would be to establish a structured S&OP process with regular meetings, dedicated roles and increased commitment, preferably from top management as well. Then the next step is to create a digital platform with integrated demand and supply planning, from there on the involvement of external stakeholders, such as suppliers or dealers, can be evaluated in order to reach an even higher maturity level.

Additionally, our suggestion is to establish a S&OE process to complement the S&OP process, with the aim to align the day-to-day operational activities with the plans developed in the S&OP process. Further, another objective with integrating a S&OE process into the S&OP structure is to facilitate disruption handling, in order to achieve the objective of balancing supply and demand also during more turbulent times, as described by Dittfeld et al. (2021). By successfully integrating the S&OP and S&OE processes, the case company will have a more dynamic process, which, according to Jonsson et al. (2021), is necessary in order to be resilient.

By developing the current flow planning meetings to a more mature S&OP process, including an integrated S&OE process, the case company should be able to improve several supply chain

resilience capabilities. One of the primary resilience capabilities facilitated by this meeting structure is collaboration, since the cross-functional, or even cross-organizational, nature of these meetings enables a firm to balance supply and demand within the entire supply chain, thus increasing the overall performance (Seeling et al., 2021). Additionally, these meetings allow for, as well as to facilitate, information sharing across internal and external borders, which, according to Ali et al. (2017), has shown to increase the supply chain resilience. Furthermore, according to the authors this extensive information sharing and coordination between supply chain partners is a way to proactively develop and improve the level of situational awareness. Additionally, having an established S&OP process with defined meeting structures and responsibilities can also help an organization to act faster, by not having to set up new teams, forums, and communication channels in case of disruptive events, which would entail an improved agility. This is in line with Dittfeld et al. (2021) findings that the S&OP process can have a more reactive role, where it provides an established structure as well as clear communication channels during disruptions, which facilitates rapid and efficient decision-making. Finally, knowledge management is another capability which can be enhanced by having a mature S&OP process, since it can provide a structure for post-disruption feedback sessions.

6.4.2 Establish end-to-end visibility

Another capability with significant potential for improvement is visibility. Several respondents mentioned the lack of end-to-end visibility as an area that could be improved and stated that they currently plan in silos. Nevertheless, the amount of available data from various nodes within the supply chain is high, albeit in different systems, which limits its accessibility for other functions. Hence, by establishing a common digital platform, where relevant data regarding stock levels and items in transit is available for all internal stakeholders, the case company can decrease the information lead time within their organization, and thus avoid uninformed decisions which risk resulting in sub-optimizations. Establishing end-to-end visibility has proved to be an effective way to increase supply chain resilience (Ivanov, 2021; Lin et al., 2022). This should be the case for the case company as well, since, according to several of the respondents, during disruptions and stockouts in certain markets, there were often spare parts available in other geographical nodes within the supply chain. Meaning that by increasing the end-to-end visibility, and thus facilitating the planning and balancing of stock levels in the entire system, the case company can prevent some of the shortages and ensure higher availability towards the customers. However, the case company is currently working on a project to develop an integrated platform in order to increase the end-to-end visibility. If this platform works as intended, it should contribute to an enhanced supply chain resilience for the case company.

Another way to establish end-to-end visibility, described by Polyviou et al. (2020), is through inter-organizational collaboration, with other supply chain actors, such as suppliers and dealers for the case company. Close collaboration with supply chain partners can be used as a complement to digital technology in order to further increase the visibility. Close collaboration can also be seen as an enabler of technological solutions reliant on external data, since trust between supply chain partners is a vital element when it comes to extensive information sharing. Thus, a combination of closer collaboration with key supply chain partners and an integrated digital platform can increase the end-to-end visibility of the supply chain, and in turn contribute to enhancing its resilience.

6.4.3 Introduce scenario planning

Scenario planning is a tool that can be further exploited by the case company in order to increase their preparedness against certain disruptive events, as explained by Olivares-Aguila and Vital-Soto (2021). There have been internal discussions regarding the prospect of utilizing scenario planning as a proactive measure to prevent or mitigate disruptions, however, to the knowledge of the authors of this thesis, no practical application of a similar tool has taken place. Sudan et al. (2023) explains how recent disruptive events have exposed vulnerabilities in firms' supply chains, by significantly hampering their performance, and that both the severity as well as the frequency of disruptions have increased in recent years. This increases the value of scenario planning, which helps a firm to increase its situational awareness and prepare for disruptions by identifying weak spots in the supply chain and thus enable reinforcement before a potential disruption occurs, which can either prevent or, at least, mitigate the effect from the disruption (Ivanov & Dolgui, 2020). Furthermore, according to the authors, one way to increase the effectiveness of scenario planning, that the case company could benefit from, is by creating a digital twin of the supply chain, which can be used to simulate real life scenarios in a virtual environment. Based on the outcome of these simulations, effective contingency plans can be developed in order to facilitate a more cost-efficient recovery process. By utilizing scenario planning as a means to prepare for disruptive events, as well as for a foundation to create contingency plans, the case company can bridge their current gap in regard to the lack of contingency planning and increase their supply chain resilience.

6.4.4 Improve the knowledge management

Another area with potential to improve the supply chain resilience is knowledge management, in both the pre-disruption phase and the post-disruption phase respectively. From the interviews, it was evident that the employees possessed a significant amount of knowledge and experience gathered from previous disruptions. According to Polyviou et al. (2020), employees with many years of experience can be particularly valuable to a firm in regard to building resilience. However, in order to be able to fully leverage all the accumulated knowledge, certain structures or processes for how to spread the information, both within as well as between functions, needs to be established. This is supported by Lin et al. (2022), who states that information sharing within and between functions is crucial in order to attain the full benefits from previous learnings. Furthermore, finding ways to share the knowledge will decrease the dependency on certain individuals, and enable the case company to maintain the knowledge over time.

A common way to spread knowledge and preserve proven resilience practices is through education and training, as explained by Ali et al. (2017). This is something the case company has utilized to educate the employees in regard to for instance cyber security and could benefit from in other areas as well. Furthermore, whitebooks containing lessons learned have been created by several teams, which represents another potential source of unutilized knowledge for the case company to tap into. In order to align the operations of the entire company, it might be beneficial to create one common whitebook, where the main knowledge is consolidated and accessible for everyone within the organization. Another approach could also be to gather the whitebooks in one place, easily accessible for the entire organization. To conclude, the current cross-functional meeting structure within the flow planning meetings could be utilized to provide a platform for post-disruption feedback sessions, where good and bad practices are discussed and evaluated between involved stakeholders. If done correctly, this should enable the case company to better align operations during future disruptions as well as to avoid sub-optimizations.

Table 6.1: Summarization of the improvement areas and the affected resilience capabilities.

Improvement area	Affected resilience capabilities
Develop a more mature S&OP process	• Situational awareness • Collaboration • Agility • Knowledge management
Establish end-to-end visibility	• Visibility
Introduce scenario planning	• Contingency planning • Situational awareness
Improve the knowledge management	• Knowledge management

6.4.5 Generalizability of the improvement areas

The suggested improvement areas above originate from the case company's context and situation, but these actions are also applicable for other organizations. However, to what extent the different improvement areas will generate benefits varies depending on the respective organization as well as its situation and context. Below, the generalizability for each of the four improvement areas will be discussed.

Develop a more mature S&OP process

S&OP is a commonly used planning process (Seeling et al., 2021), which is adopted in some form by many organizations, although the level of maturity varies. Hence, by increasing the efforts to create a more mature S&OP process, preferably complemented by an S&OE process as well, organizations can improve their ability to balance supply and demand, enhance collaboration across functions, and increase agility in responding to disruptions. Thus, developing a more mature S&OP process is an area which is relevant for organizations across industries, for any company that manages material flows, since an effective S&OP process is crucial in order to optimize inventory levels, increase service levels, and improve overall supply chain performance.

Establish end-to-end visibility

Lack of visibility is a common challenge for companies, especially in recent years due to the increased complexity of supply chains as described by Bode and Wagner (2015), caused by a high number of nodes and large geographical distances. Therefore, establishing end-to-end visibility through integrated digital platforms and close collaboration with supply chain partners

has increased in importance and enables firms to track inventory, identify bottlenecks, and improve the response time to disruptions. This improvement is particularly relevant for organizations with global and complex supply chains, involving multiple partners all over the world.

Introduce scenario planning
Scenario planning is a proactive resilience strategy, which enables organizations to both anticipate and prepare for potential disruptive events. This is achieved by simulating various scenarios in order to identify vulnerabilities and develop adequate contingency plans that can be applied during a disruption to mitigate the impact, and thus improve the supply chain resilience (Olivares-Aguila & Vital-Soto, 2021). Scenario planning is a valuable process for any organization, especially those that operate in industries that are prone to supply chain disruptions, such as the transportation industry, where the ability to adapt to changing circumstances is vital in order to achieve, or maintain, a competitive advantage.

Improve the knowledge management
Having structures in place to facilitate the preservation and sharing of knowledge is essential for capturing and leveraging lessons learned from previous disruptions (Lin et al., 2022). By establishing processes for knowledge sharing and preservation, such as training and education, or documentation of best practices, firms can institutionalize resilience practices and enable employees to make informed decisions during disruptive events. This improvement is relevant for any organization, regardless of which size and industry they operate within, since effective knowledge management enables continuous improvement and adaptation to evolving challenges.

6.5 Application of the adopted framework in an aftermarket setting

The adopted supply chain resilience framework by Ali et al. (2017), used as a foundation for this study when evaluating the case companies supply chain resilience practices, is not tailored towards the aftermarket context. Thus, a few of the existing capabilities might be less feasible to achieve in the specific settings of the aftermarket, such as the robustness and flexibility, regarding establishing a robust supply base with dual or multiple sourcing capability. Since the low and intermittent demand, which characterize the aftermarket industry, as explained by Andersson and Jonsson (2018), decreases the bargaining power of the case company and other actors in the spare parts business. This tends to limit the choice of sourcing strategy to single sourcing, where the supplier is chosen by the OEM before being inherited by the spare part side of the business. Furthermore, single sourcing is less robust due to the reliance on one sole supplier, which leaves the firm more exposed to supply chain disruptions (Heese, 2015). However, there are still situations where dual sourcing, or even multiple sourcing, might be both feasible and beneficial to use for actors in the aftermarket as well. For instance, regarding certain components that are mainly used as spare parts, and thus sold in relatively high volumes and with a quite stable demand pattern, such as oil filters for conventional vehicles, that are changed during regular service intervals. Redundancy is another capability which requires certain workarounds before it is feasible to implement, due to the high number of SKUs for actors in the aftermarket (Cohen et al., 2006). For instance, by classifying the assortment based on criticality of spare parts as the case company has done, in order to find a balance between cost and resilience. According to Cakmak and Guney (2023) classification of spare parts can promote improved inventory management, and thus increase the service level while limiting costs, which is one of the key challenges in the aftermarket (Andersson & Jonsson, 2018).

Nevertheless, the majority of the capabilities are comprehensive and applicable in any industry, regardless of specific traits. Capabilities such as visibility, redundancy, agility and collaboration are mentioned by several researchers within the field of supply chain resilience, including in the extensive literature reviews on the topic by Tukamuhabwa et al. (2015) and Ali et al. (2017). Apart from the aforementioned capabilities, situational awareness and learning through a structured knowledge management process are both vital in order to build and maintain supply chain resilience. Situational awareness enables an organization to identify vulnerabilities in a supply chain, and thus develop strategies to avoid or mitigate the effects from a disruption (Ali et al., 2017). Whereas the ability to learn from previous disruptions and utilize the experience gained in order to develop better solutions for future disruption is another fundamental element of supply chain resilience, as described by Sá et al. (2020). Working with continuous improvements, by implementing lessons learned from prior disruptions in order to enhance the supply chain resilience, is important for any organization, regardless of the context in which they operate. Thus, the majority of the findings from this thesis should be applicable for other organizations as well.

Additionally, the importance of each capability can vary depending on the type of situation and disruption. In regard to more predictable disruptions, where early indicators are available, for instance through new EU-regulations, such as "Green Deal", where the union aims to be the first climate neutral region in the world (European Commission, 2023). This will naturally entail certain measures to reduce the emissions, for instance by prohibiting sourcing from certain companies that fail to live up to set environmental standards. This could potentially affect the case company, but also other actors all over the world, due to the nature of globalization, which has increased the competition and thus made firms more prone to outsource their production to less developed countries in order to cut costs (Katsaliaki et al., 2022). By establishing and maintaining a high level of situational awareness, companies can anticipate this risk and take action in order to prevent a disruption from occurring. However, other disruptions are more difficult to anticipate, such as the blockage of the Suez Canal or the occurrence of a natural disaster. In these cases, proactive measurements, such as the establishment of redundancy in the system, for instance by installing safety stocks, can provide a firm with more time to mitigate a disruption, while ensuring availability towards the end consumers.

6.6 Ecological and societal aspects

The case company is committed to be a part of, or even a leader in, the change towards sustainability, and are currently embarked on a journey to contribute to a net-zero society. Building a more resilient supply chain can contribute to this objective in multiple ways. For instance, by decreasing the need for expedited transports in order to ensure availability, since a more resilient supply chain is less susceptible to disruptive events, and thus less likely to have to resort to air freight in order to compensate for delays upstream in the supply chain. Furthermore, local suppliers are prioritized by the case company, which not only decreases the risk for transport related disruptions, but also entails decreases in the emissions from transportation due to the relatively short distances. Another resilience practice, applied by the case company, that can contribute to lower emissions is the supplier auditing and the classification of suppliers, where more sustainable suppliers are prioritized. This is both due to the fact that the case company wants to be a leader within the change towards sustainability, as well as in order to reduce the risk of disruptions when initiatives, such as the Green Deal goes through and sourcing from unsustainable suppliers is prohibited or restricted. Nevertheless, there are also certain resilience practices that can result in increased emissions and

environmental impact. For instance, by developing the capability of redundancy, a firm increases the risk of obsolescence and waste in case they have to dispose of parts. Further, maintaining higher inventory levels in order to ensure uninterrupted operations during disruptive events might require additional energy for storage, handling and processing of parts.

Although environmental sustainability is an important factor to consider, the importance of societal aspects should not be diminished. In general, organizations can, by being more resilient, relieve the levels of stress and pressure that occurs during the chaotic period when disruptive events first hit and start to affect the supply chain. Both by being better prepared by an improved ability to predict, anticipate and know the supply chains vulnerabilities, as well as to better know how to act. This in terms of having a proper structure and communication channels in place, as well as to have established contingency plans from testing different scenarios in scenario planning. Furthermore, from an external perspective, the supplier audits and classifications also contribute to more ethical sourcing practices, by eliminating the use of unethical suppliers. This can result in better working conditions and fair wages, and thus improved social well-being for the employees at the suppliers' sites.

7
Conclusion

The purpose of this study was to firstly evaluate the case company's current supply chain resilience, by identifying and mapping their current resilience practices and relate those to resilience capabilities proposed in the literature. Comparing the empirical findings with the theoretical framework from the literature review, it is evident that the majority of the resilience capabilities exists within the case company. Nevertheless, some of them are more developed than others. For instance, redundancy through pre-built-up safety stocks was utilized in an effective way in order to mitigate the effect from disruptions. Furthermore, cross-functional collaboration, enabled by temporary task forces formed in times of uncertainty, was another important capability for the case company.

Although the case company possessed many of the capabilities from literature and no significant gap was found, several areas of improvement were still identified. To further strengthen its resilience, the case company could benefit from developing a more mature S&OP process, establish end-to-end visibility, introduce scenario planning, and finally by improving the internal knowledge management. Strides in these areas would enhance the case company's supply chain resilience by improving its ability to prepare for, respond to, as well as recover from disruptive events.

To conclude, the adopted supply chain resilience framework was generic, which means that the findings from this study should to a large extent be generalizable for Volvo SML's other brands and markets, as well as for other firms in different industries. However, worth mentioning is that for actors that operate in an aftermarket setting, such as the case company, with its unique and challenging demand characteristics, might find it more difficult or cost-intensive to establish some of the capabilities, such as robustness, flexibility, and redundancy.

7.1 Further research

Based on the set delimitation for this study, the authors can see several interesting areas for future research. One of the primary areas of interest is regarding the design and implementation of certain propositions, which has not been explored in detail in this report. For instance, the proposition to develop a more mature S&OP process to establish a formal meeting structure, to facilitate cross-functional collaboration, and increase situational awareness among other things. Nevertheless, before this can be achieved, a great amount of planning needs to take place, in order to decide upon the structure of these meetings, including for instance which participants that need to partake and what type of data that is necessary for each department to share. The same applies when it comes to establishing end-to-end visibility. There is no doubt that this would facilitate the planning and help enhance the supply chain resilience, however, designing an integrated platform where all relevant data is available and accessible for the respective functions remains a challenge and an unexplored area.

Another interesting area of further research would be to investigate the connection between supply chain resilience and sustainability. These are both hot topics on supply chain managers'

agenda, since disruptions are increasing in both frequency and severity, while pressure from customers and regulations, such as the Green Deal initiative, are forcing companies to decrease their emissions and adopt more sustainable practices. Thus, if improvement in these two areas can be combined it would be very beneficial for organizations, such as the case company, who strive to drive the change towards sustainability while reducing their sensitivity towards disturbances. Based on the findings from this study some aspects of sustainability can be improved by strengthening the supply chain resilience, for instance by limiting the use of air freight as well as unsustainable suppliers. Nevertheless, this still remains a largely unexplored area which would be interesting and valuable for both researchers and industry professionals to investigate further.

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A
Appendix

A.1 Interview Guide

Interviews began with the authors asking the interview object if it was okay to record the interview, and all of the respondents gave their consent. Then the authors presented themselves as well as the thesis.

Introduction of the interview object:

1. Can you please describe your role at Volvo and your responsibilities in short and tell us how long you have been at the company?
2. What is your team's role?

Going into experienced disruptions:

1. Have you experienced any disruptions in the supply chain during your time here at Volvo?
    - What kind of disruptions?
2. What impacts and consequences have the supply chain disruptions had?
    - Where in the supply chain did the disruption have the largest impact and how?
3. How did you find out about the disruption?
    - How was it communicated?

Cross-functional & cross-organizational communication:

1. Was there any communication with other departments? If so, which departments and how did you communicate?
    - Did any new communication or information sharing channels evolve?
2. Did you also communicate with external actors/partners?

Disruption handling process:

1. How would you describe how disruptions are handled and how the disruptions handling process look like?
2. Are there any important parts that you think are missing or lacking, and what stages or parts of the current process do you think are especially important?
3. What type of data is used in the process of handling disruptions and are there any types of data that you think would be crucial but are usually missing in order to be able to draw good conclusions?
4. Which stage of the disruption were you involved in? (Preparation, response, recovery, or any other?)

Questions for the preparation stage:

1. What type of actions or what kind of methods did you use to prepare for any potential disruptions?
    - Do you perform any scenario or contingency planning?
2. How do you identify vulnerabilities in your supply chain?

3. Do you have any standardized ways of working, or structures in place, in order to know how to handle different types of disruptions?
4. What type of warning signs or indicators have you seen prior to previous disruptions? How do you work with identifying these indicators or signs?

Questions for the response stage:

1. How are disruptions identified and how quick are you in noticing disruptions?
2. Have you been prepared for the disruptions that have occurred in recent years?
3. What have been your immediate actions when disruptions occurred? Was there any established structures or processes in place on how to act?
4. Did you collaborate with other roles or departments within the organization and/or did you collaborate with any external actors?
5. Did the disruption negatively affect your customers?

Questions for the recovery stage:

1. Did you learn anything from the disruption? Have you taken any action to prevent it from happening again, or to mitigate the effect from a similar event?
2. Have you recovered to a similar state or better as before the disruption occurred?
3. Have you noticed any change within the company when it comes to working with resilience, such as new processes or guidelines on how to act during various types of disruptions?

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
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