UNIVERSITY OF GOTHENBURG

SCHOOL OF BUSINESS, ECONOMICS AND LAW

Master of science in Logistics and Transport Management

Supply Chain Disruptions as a Consequence of Covid-19

A case study to investigate how a global pandemic affects a multinational manufacturing company from a supply chain perspective

Master Degree Project in Logistics and Transport Management - 30 credits

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Executive Summary

Master thesis in Logistics and Transport Management, University of Gothenburg School of Business, Economics and Law, Spring Term 2022

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Background and problem description: The business landscape becomes increasingly more uncertain and competitive which requires organizations to adapt and configure their operations in more complex ways. After the Covid-19 pandemic, it has become clear that the entire world is susceptible to crises of substantial magnitudes. The pandemic caused major damage to an array of economic sectors and industries throughout the world. Supply chains that are built to be lean and efficient and are reliant on single sourcing of materials are more vulnerable to disruptions. Thus, it is of great interest to study larger companies like AB Volvo which tend to have more complex supply chains and a longer logistics pipeline.

Purpose: The purpose of the study is to analyze and evaluate how different parts of Volvo's supply chains have been affected by the Covid-19 pandemic's disruptions. In addition, one important part is to see which types of actions have been taken by the organization in order to mitigate the negative impacts caused by the pandemic.

Delimitations and methodology: The focus of the study is the Swedish production plants and excludes aftermarkets, third tier-suppliers and sales due to the logistics focus of the report and the complexity of the organization. In terms of methodology, the study is of an interpretivist nature as findings mainly are derived from the empiric material gathered. The empiric material was gathered from seven interviews conducted with respondents associated with the organization and the findings were then examined in contrast to the theoretical framework in order to gain a deeper understanding of the phenomenon.

Findings and conclusions: The study shows that the most prevalent effects were component shortages from suppliers, disturbances in the transport network and overall capacity issues both internally and externally due to certain material overflow. In turn this required AB Volvo to actively work closer with their suppliers and support them whenever it was necessary. Additionally, the crisis called for increased collaborative efforts internally to ensure that everyone was on the same page and had as much information as possible.

Keywords: Supply Chain Management, Covid-19, Crisis Management, Supplier Management, JIT, Disruptions.

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Lastly, we would like to thank our supervisor Johan Woxenius for his engagement and high involvement during this whole thesis period. Johan helped us both with finding valuable respondents for the interviews as well as provided us with continuous ideas and suggestions for our further research.

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Gothenburg, 27 may 2022

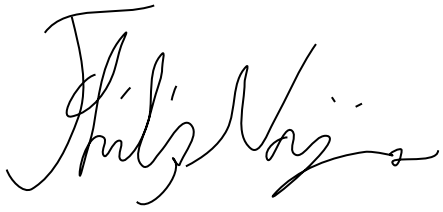

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Table of content

List of tables

List of figures

Abbreviations

LSP	Logistics Service Provider
MC	Material Controller
PTP	Powertrain Production
JIT	Just in Time
JIC	Just in Case
SC	Supply Chain
SCM	Supply Chain Management

1. Introduction

The chapter begins with a brief background regarding the fragility of modern global supply chains and the uncertainty that follows when a major crisis emerges. Thereafter, a problem description is introduced which is followed by the purpose and research questions that lay the foundation of the report. Ultimately ending the chapter with the delimitations that have been made in order to make the report more focused and impactful.

1.1 Background

In a world that is becoming increasingly more turbulent and uncertain, businesses who want to stay competitive in this globalized landscape have to adapt and configure their operations in complex ways. As the Covid-19 pandemic has shown, the entire world is susceptible to crises of this magnitude and within the business world there are no exceptions. The trend among many firms has been to minimize non-value added activities and implement Just in Time manufacturing which often includes working with lower inventory levels and warehouse-related costs (McLachlin, 1997). Thus, the margin of error and disruption sensitivity within these vast supply chain networks has been affected greatly. In other words, the advancement of additional global presence within many large corporations and the intricate nature of their supply chains naturally raises efficiency but simultaneously leaves them more vulnerable to disruptions. Globalizing the supply chain can indeed prove beneficial through economies of scale and establishing production in regions with lower factor costs (Van Hoek, 2020). However, it also lengthens the logistics pipeline which in turn introduces risks associated with delivery delays and dependencies on suppliers.

Covid-19 made its first appearance at the end of 2019 and resulted in lockdowns, material losses and supply chain disruptions all over the world. Despite having two years passed since it first became a major topic and part of people's everyday life, it is still prevalent to an extent even if some of its effects are becoming less noticeable Dwiedienawati et. al (2020). Despite Sweden not enforcing the same restrictions as many other countries such as the lockdowns in China for example, large organizations that are based in Sweden are still affected due to the global nature of their supply chains. An industry giant such as AB Volvo has material suppliers located throughout the entire world and their supply chain stretches beyond country borders. Hence, a question that arises is how a large organization such as Volvo, chooses to act in order

to mitigate any negative impacts caused by the pandemic while remaining competitive and not losing sight of their company goals. Due to the high uncertainty that followed from the Covid-19 pandemic and its scale, everyone was caught off guard as it caused a global crisis unprecedented in modern times (Dwiedienawati et. al, 2020). Major disruptions such as the Covid-19 pandemic threatens business continuity for any organization and thus requires effective crisis management. The function of management is to make decisions based on a combination of knowledge and experience but crises are at the same time unexpected with few managers possessing first-hand knowledge or practical experience (Parsons, 1996). In order to survive a crisis such as Covid-19, companies therefore need to have effective crisis management in order to maintain the company's reputation and ensure its survivability (Dwiedienawati et. al, 2020).

1.2 Problem description

During recent years, earthquakes, economic crises or worker strikes have disrupted supply chain operations repeatedly and have had significant impacts on firm's performances (Tang, 2006). However, in early 2020 the world was introduced to a disruption greater than any experienced in current time and which brought catastrophic results with it (Dwiedienawati et. al, 2020). Unlike crises such as worker strikes or earthquakes, this crisis was not contained within a single geographical area or industry but affected the entire global landscape. The Covid-19 pandemic has caused widespread damage to an array of economic sectors and industries throughout the world, including Sweden. A crisis of this scale is unlike anything that the modern world has experienced and is therefore difficult to navigate in an optimal way (Nikolopoulos et al, 2021). It affects the entire world economy and thus the organizations and industries that the world economy consists of. For example, many firms implement initiatives such as outsourced manufacturing or product variety in order to gain cost advantages and market shares. In a stable environment it may prove effective, but it also makes their supply chains vulnerable to various types of disruptions like a global pandemic (Tang, 2006). Firms that are actively working with Just in Time practices are at even higher risk due to their goals of achieving on-time deliveries and simultaneously minimizing inventory costs (Jadhav et.al, 2015). Supply chains that are built to be lean and efficient and are reliant on single sourcing of materials are more vulnerable to disruptions as a crisis can render critical material suppliers useless which in turn creates a need to quickly find alternative solutions in order to maintain production and time schedules (Yu et.al, 2009). If a critical supplier fails to deliver within an

organization that has implemented Just in Time manufacturing, disruptions can lead to complete production stops and ultimately costs associated with the halted production. Larger companies like AB Volvo tend to have more complex supply chains and a longer logistics pipeline which in turn creates additional difficulties in managing supply chain risks due to more variables being involved. Covid-19 has taught firms that the main factors involved in business survival and prosperity is not only limited to low costs, high quality or short delivery times, but now includes their ability to effectively respond to supply chain disruptions (Nikookar & Yanadori, 2022). Furthermore, how does a large company properly assess what is the most effective action and what should be prioritized when a crisis has become a fact and different departments have opposing goals that have to be taken into account?

For a company such as AB Volvo, who are working with Just In Time principles and were therefore affected in the ways described above, the year of 2020 was very demanding in terms of flexibility and adaptability. In addition, during this first stage of the pandemic in the beginning of 2020, AB Volvo decided to put all their employees in Sweden on short-term layoffs and closed all their Swedish production plants (SVT, 2020). The reasons behind the lay-offs were, according to the press manager at Volvo AB, a combination between supplier capacity and the government restrictions placed to avoid spread of the Covid-19, which made it impossible to work in a production plant (Expressen, 2020). However, during 2021, Volvo experienced a recovery in terms of increasing transport volumes and improved construction opportunities but the overall situation within their global supply chain has continued to be a challenge as the shortages of semiconductors and other components remained (AB Volvo, 2021). Due to the nature of the crisis it is something that was difficult or nearly impossible to predict and led to widespread damage on different industries and the overall global economy. The crisis management as well as the supplier management has therefore been of high importance for AB Volvo during this crisis and its different phases. Furthermore, to better understand the company, AB Volvo divides their value chain in six different sections being customers, product development, purchasing, production & logistics, retail & services and reuse (Volvo Group, 2022).

However, the primary focus in this report will be on production & logistics as well as purchasing. This is because these parts are the ones most closely related to the issues with

supplier capacity and production shutdowns. To conclude, what will be examined in this report will therefore be how a large industry such as AB Volvo approached this crisis in terms of crisis and supplier management as well as from a purchasing, production and logistics perspective.

1.3 Research purpose and questions

The purpose of the study is to analyze and evaluate how different parts of Volvo's supply chains have been affected by the Covid-19 pandemic's disruptions. In addition, one important part is to see which types of actions have been taken by the organization in order to mitigate the negative impacts caused by the pandemic. A further analysis will then take part with the purpose of understanding if and how these actions will affect the future of Volvo's supply chain.

Furthermore, the purpose is also to get a greater understanding of how a complex organization like Volvo Group handles a global crisis like Covid-19, a crisis where all departments are affected in one way or another.

Research questions:

a) What type of effects has the Covid-19 pandemic had on Volvo's supply chain?
b) In what way have Volvo Group handled these effects and what actions have been taken to mitigate the negative impact of the pandemic?
c) How will these effects and actions influence the future of Volvo's supply chain?

1.4 Delimitations

The focus of this report will be on the Swedish production plants, even though Volvo Group is a global organization with a wide spread of plants over the globe. This is motivated by the differences that may be between the countries and how every country handled the pandemic. However, as the transport networks and material suppliers are located globally, a global perspective will still be applicable. As the Tuve plant is the largest of the Swedish plants, an extra focus will be on their supply chain.

In addition, as Volvo is a large company with a complex supply chain, that is limited as well in order to focus the analysis. In this report the supply chain includes first and second-tier material suppliers, transport suppliers and production plants. This is motivated by the logistics

focus in the report as well as the complexity of the organization. Furthermore, as mentioned during the problem description, the primary focus in this report will be on the departments within AB Volvo that manage production & logistics as well as purchasing.

2. Theoretical Framework

This chapter presents the relevant literature and studies that are available on the research topics of supply chain disruptions and its effects. In addition, a part of the theoretical framework also

consists of studies on crisis and supplier management in order to supplement the case study. Hence, the theoretical framework consists of five main topics which were chosen based on the topics covered during the conducted interviews as well as the authors' pre-knowledge about the case study object being AB Volvo. These five main topics are Just in Time, Supply Chain Disruptions, Supplier Management, Crisis Management and Trade-offs.

2.1 Just in Time

Just in Time manufacturing is not only something that affects the operational part of the organization but is also something that affects all departments within the organization. One crucial relationship to achieve the goals of JIT manufacturing is therefore the one between the suppliers and the purchasers. This is because they are the ones being able to ensure that goods are delivered not only in time but most preferably on time, in order to eliminate waste (De Toni & Nassminbedi, 2000). This means that the company prefers to have the goods delivered right when needed (on time) and not too early (in time) to avoid additional warehouse costs and to secure a smooth unloading process. Another important factor within the JIT principles is to get everyone within the company on board and get them to believe in the ideas behind JIT. To achieve this, top management involvement is of high importance (Swanson & Lankford, 1998). As a part of this, according to Holl et al (2007), the inventory holding costs, transport costs and procurement costs are often seen as trade-offs when working with JIT practices.

Because of the wide coverage of this topic the authors have decided to divide this section into three different subsections being JIT purchasing, JIT management and JIT manufacturing & transportation. This was done in order to study the details behind the phenomenon and to later on be able to relate the theories to the practical findings from the interviews.

2.1.1 Just In Time: Purchasing

According to Gunasekaran (1999) working with JIT purchasing is often a part of the JIT management principles within a company. However, there are a lot of different purchasing processes within the scientific literature which acknowledge that there are no best practices within the subject (Bäckstrand et. al, 2019). On the other hand, there are still some things that should be included in the purchasing process when working with JIT. Gunasekaran (1999) describes the supplier as an extended operator for the manufacturing process to work, which

makes the internal purchasing processes and the supplier-criteria matrix crucial. With this in mind, De Toni & Nassimbeni (2000) highlights the importance of having more of a strategic partnership with the supplier rather than a simple buyer-seller relationship to be able to work with JIT and supplier development. Furthermore, De Toni & Nassimbeni (2000) divide JIT purchasing into two different practices; operational and supplier development. Here, operational aims to work with deliveries, batch sizes, standard packaging, planning schedule etc while the supplier development practice aims for supplier integration, incentives, assistance and training.

According to Foerstl et. al (2013), a well performing purchasing department is highly dependent on the collaboration with the production department as well as the logistics and marketing departments. In addition, Schleper et. al (2017) explains the cross-functional collaboration between the purchasing function and the other functions as a key to establish a good supplier relationship as well as an increased operational performance. This positive effect of JIT purchasing on operational performance as well as agile manufacturing is also confirmed by Inman et. al (2010). When working with JIT, there is always a risk of having a mismatch between the customer's demand and the supplier's capacity (Memari et al, 2018), which support the purchasing company´s goal of achieving agile manufacturing in order to mitigate the effect of the mismatch (Inman et. al, 2010). One way of handling the goal towards agile manufacturing for the purchasing department is to aim for geographic proximity when working with suppliers as this results in decreased lead time from the supplier to the production plant (Holl et al, 2007).

2.1.2 Just in Time: Management

One success factor that has been found within companies that work actively with JIT is company-wide commitment towards the JIT practices (Swanson & Lankford, 1998). Company-wide commitment means that all departments within the company have a great knowledge of the practices and how they affect their own department as well as the company as a whole. It also includes the belief and vision that comes with the idea. To be able to get everyone on board, top management has a great responsibility (Swanson & Lankford, 1998). This is also confirmed by Hussein & Zayed (2021) who ranked top management commitment as the most important critical factor for a successful JIT work. Top management commitment gives the employees the possibility to get the required resources that are needed both on short-term and long-term when working with JIT and it can also increase the motivation and

willingness to adapt to the changes (Hussein & Zayed, 2021). Furthermore, JIT can be seen as an organizational phenomenon where JIT practices in itself does not increase manufacturing efficiency but has the possibility to do so if combined with great management (Sakakibara et. al, 1997). This is because JIT provides the company with disciplines and targets and by working with great management, the company is given the possibility to work together towards these targets. As a part of great management, Sakakibara et al (1997) mentions the development of flexible and problem-solving team players who are willing to be at the place within the organization where they are most needed at the specific time.

2.1.3 Just In Time: Manufacturing and Transportation

Just in Time manufacturing mainly seeks to eliminate waste and non-value added activities by aiming to get each product processed, produced and delivered right when needed (Swanson & Lankford, 1998). By working with minimizing non-value added activities, Just in Time manufacturing often includes working with minimizing inventory levels and warehouse-related costs (McLachlin, 1997). Another factor of JIT manufacturing is the transportation of raw materials or components. According to Holl et al (2007) there is an increased focus on flexibility in the order of output, reliability of scheduled transport flows and cost of time when discussing the transportation part of JIT. Furthermore, geographic proximity is a benefit when working with JIT as it enables higher flexibility in terms of less time consuming transports (Holl et al, 2007).

Falsafi et al. (2018) divides JIT transportation risks in three main parts being supplier issues, means of transportation and dock issues. The supplier issues, they explain, might be due to delayed delivery of the orders or quality issues. This in turn leads to delays in the transportation to the final destination, since pickup is being postponed. The means of transportation on the other hand refers to the disturbances that occur during the actual transportation, like weather or traffic (Falsafi et al, 2018). Lastly, the dock issues include issues like loading, unloading or staff issues at the different cross-docks (Falsafi et al, 2018) . Schwerdfeger et. al (2018) describes the use of cross-docks within the automotive industry and JIT as common. A cross-dock is often located close to the production plant with the aim of serving the plant with goods as lean as possible, even though the supplier might be located far away from the plant (Schwerdfeger et. al, 2018). In other words, cross-docks might work as a stopover for the goods moving from origin supplier to destination plant. Furthermore, Dörnhöfer et al (2016) visualize the most common inbound logistics processes within the automotive industry, see Figure 1.

Among those, Dörnhöfer et al (2016) emphasize the increased use of cross-docks processes as well as the direct deliveries in terms of warehouse on wheels (WOW), Just In Time and Just In Sequence. In addition, if there are supplier issues or issues at the cross-dock, Falsafi et al. (2018) suggest the use of express transports to speed up the delivery process and therefore, be able to deliver on time. This can be connected to Figure 1, meaning that the use of express transport or speed-up alternatives can be used to avoid a cross-dock or another stopover in order to reduce lead time and deliver on time.

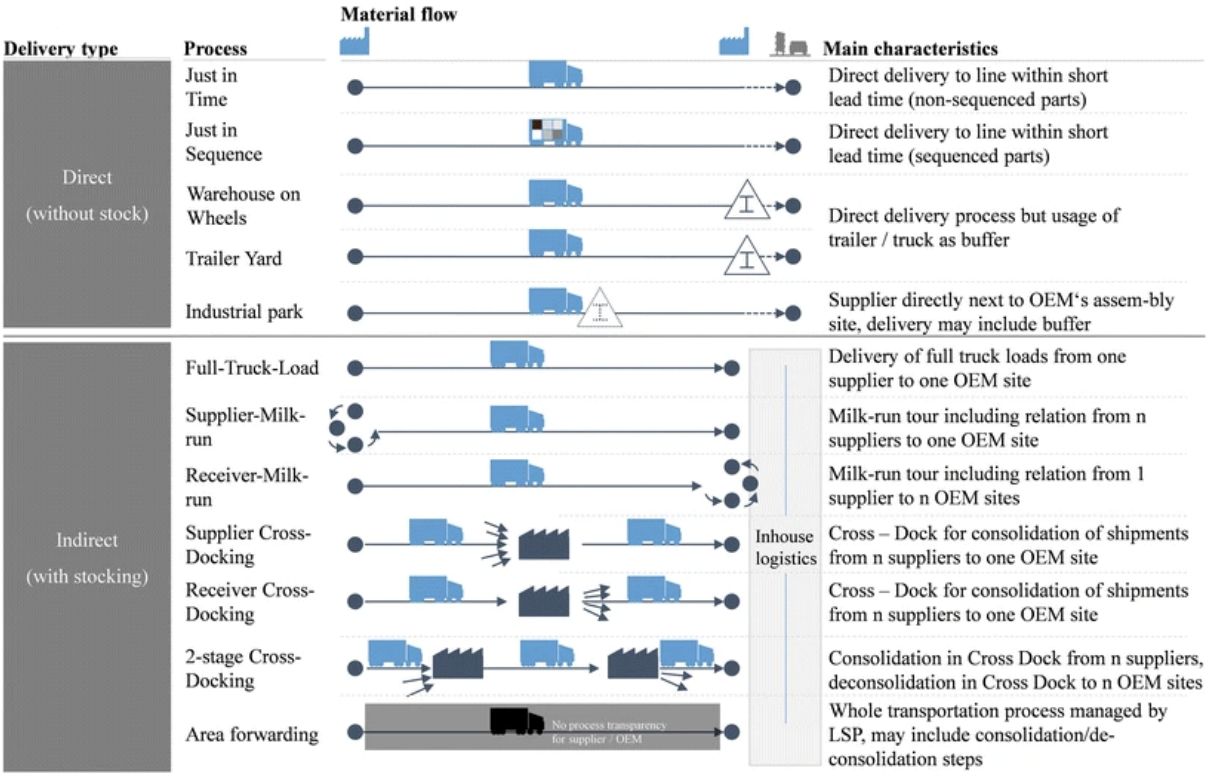

Figure 1: Inbound logistics processes within the automotive industry (Dörnhöfer et al, 2016).

2.1.4 Post Covid-19: Move from Just In Time to Just In Case?

As Covid-19 has challenged the idea behind JIT and its principles due to the extensive disturbances and consequences on firms' more global and optimized supply chains, a new strategy has emerged. This is the idea of Just In Case (JIC) which seeks to use larger buffers and borders with the aim of making the supply chain more resilient but still utilize the advantages associated with JIT in terms of supplier-relationships, transparency through the supply chain and lean manufacturing (Brakman et. al, 2020). Another one that highlights the aim of moving to a more resilient supply chain as a result of Covid-19 is Van Hoek (2020) who

listed supply chain risks as well as potential actions to be taken to mitigate these risks, see Table 1. These mitigation strategies go in line with what Brakman et. al (2020) mentions increased buffers and more local suppliers and can therefore be perceived to support JIC. In addition, both Van Hoek (2020) and Brakman et. al (2020) agrees that Covid-19 has resulted in an increased focus on risk management and the potential drawbacks related to globalized supply chains.

Table 1: Supply chain risks and efforts related to Covid-19 (Van Hoek, 2020).

		Selected risks reported by participating supply chain executives	Resilience efforts targeted and pursued by participating supply chain executives
Supply risk	**Supply disruptions resulting from plant closures**	1) Shortage of supply and extended leadtimes 2) Slow ramp up after factories reopen 3) Logistical bottlenecks as a result of rush supplies 4) Lack of preparedness to respond to disruptions and limited applicability of existing plans	Rebalance supply-lines to include more local and nearshore suppliers and plants Reduce reliance on single plants and single locations Accept inventory level increases for the sake of agility
Demand risk	**Demand spikes leading to product shortages and logistical bottlenecks**	5) Shortterm peaks in certain categories 6) Reductions in demand in other categories 7) Shortterm peak in transportation demand followed by surplus capacity in transportation 8) Need to speed up online and IT capabilities	Accelerate digitization initiatives for greater visibility Introduce new types of automation Adopt a relationship approach to help suppliers and grow relationship capital for the long run
Control risk	**Need to engage suppliers in crisis response**	9) Need to focus on ensuring supplies and getting priority with disrupted suppliers 10) Seeking inventory and improved terms with suppliers as part of coping with (financial) pressure on the company	Focus on critical supplies and resist the temptation to opportunistically benefit from softness in the supply market. Only seek savings and payment support from selected suppliers

2.2 Supply Chain disruptions and its consequences

Supply chain disruptions can be defined as “An event that interrupts the material flows in the supply chain, resulting in an abrupt cessation of the movement of goods” and can arise from, among other, natural disasters, wars or dependence on a single supplier (Wilson, 2007). Another way of defining supply chain disruptions are by saying that “disruption risks concern mainly events with low frequency and high impacts” where a pandemic is an even more special disruption based on the fact that it's a long term disruption causing uncertainty in both supply and demand (El Baz & Ruel, 2021). A disruption can arise everywhere in the supply chain and

since this report focuses on supplier, transportation and production this is also how this section is divided. In addition, a last subsection will discuss supply chain disruptions in relation to the Covid-19 pandemic.

2.2.1 Supplier-related disruptions

Supplier-related disruptions include disruptions that are connected to the supplier and this can be for instance lack of labor, dependence on a single supplier and supplier bankruptcy (Wilson, 2007). In addition, there are disruptions related to today's more vulnerable and optimized supply chain which result in a negative impact on the supply chain as a whole (Yu et. al, 2009). Some of these factors behind supplier disruptions connected to today's supply chain are the lack of buffers and flexibility connected to the distance between supplier and buyer (Yu et. al, 2009). Another issue that can be identified as a supplier causing disruption is the issue with second-tier suppliers including lack of raw material or components, lockdowns or machine breakdowns (Durach et al, 2020). As confirmed by Durach et al (2020), a disruption at the second-tier supplier affects all downstream parts of the supply chain.

2.2.2 Transportation-related disruptions

Disruptions connected to the transportation of goods do jeopardize the whole supply chain and affect the supply chain performance, service level to customers and company reputation (Alberetzeth et al, 2019). Some of the risks of disruptions associated with transportation are delayed transports (Zhen et al, 2016), damaged goods or goods stuck in transit (Alberetzeth et al, 2019). In addition to this there are also disruptions caused by lack of staff or mechanical failure (Wang et al, 2018). The negative effects of transportation-related disruptions on the overall supply chain are, according to Wilson (2007), greater if the disruption occurs during the transport from tier-one supplier to the production plant. Even though these risks are associated with transportation in general, there are also some increased risks of disruptions related to express transportation and air freight. As an example, Wang et al (2018) mentions the complex aviation issues related to airfreight as well as the huge financial losses that often comes with disruptions as air freight companies often use high-value cargos.

Another issue that is related to the transportation part of the supply chain is when a contracted transport supplier experiences capacity issues (Pellegrino et. al, 2018). This issue is also highlighted by Lindsey & Mahmassani (2017) who state that capacity issues for a dedicated transport supplier is a result of supply chain uncertainty. This goes in line with what Pellegrino

et. al (2018) describes that during times of uncertainty it is hard for all supply chain partners to provide each other with reliable demand forecasts, which in turn increases the risk of capacity issues. On the other hand, both Pellegrino et. al (2018) and Lindsey & Mahmassani (2017) address a potential solution to the transport supplier-related capacity issues being the use of spot-market to quickly be able to find an alternative transport supplier that has the possibility to manage the transport. The spot bid market is described by Figliozzi et. al (2005) as an auction based market where pre-chosen transport suppliers get an enquiry for a specific shipment moving from point A to point B. After receiving the enquiry, the transport suppliers are asked to offer their best solution for this shipment. This is a flexible way of ensuring capacity in order to avoid supply chain disruptions caused by the transportation network (Lindsey & Mahmassani, 2017). However, using the spot-market for transportation often comes with a higher price (Pellegrino et. al, 2018; Lindsey & Mahmassani, 2017).

2.2.3 Production plant-related disruptions

When discussing supply chain disruptions one does also need to consider the potential disruptions that emerge from events related to the production plant itself. As an example of this, Bai et al (2016) discuss the disruptions originating from an individual workstation in a manufacturing plant where workstations are connected. The production plant-related disruptions can be based on both individual mistakes as well as machine breakdowns or system errors (Bai et al, 2016). Furthermore Darmoul et al (2013) choose to divide disruptions in different clusters where three of the clusters related to manufacturing performance are resource failure, product failure and customer failure. Here, resource failures include machine breakdowns, labor issues, material shortages etc. while product failures include rejects, scraps and quality issues. In addition to this the customer failures focus more on canceled orders, order modifications or rush orders (Darmoul et al, 2013). With this in mind, one can conclude that a potential outbreak of Covid-19 at the plant, a lockdown due to governmental decisions or other restriction that prohibits the employees to go to work is covered under the resource failure cluster provided by Darmoul et al (2013) as labor issues. To strengthen this reasoning, Belhadi et. al (2020) also mentioned the forced closure of production plants in the automotive industry within Europe as a result of the government-imposed lockdown restrictions related to Covid-19.

2.2.4 Global Supply Chain disruption: Covid-19

The Covid-19 pandemic is to be classified as a global supply chain disruption as it affects all parts of the supply chain in one way or another (El Baz & Ruel, 2021). According to a study conducted by ISM (2020), nearly 97% of the companies reported that their supply chain has been negatively affected by the Covid-19 pandemic. Some factors that cause these disruptions are the mismatch between supply and demand (Ivanov, 2020) as well as over-optimized and global supply chains that makes the companies even more vulnerable to disruptions (Nikokaar & Yanadori, 2022). These factors do in turn negatively impact the supply chain in terms of material shortage and delayed deliveries (Nikokaar & Yanadori, 2022). To better understand the extent to which the pandemic has affected the global supply chains, Heidary (2022) classifies the Covid-19 pandemic as a force majeure event and visualizes how an event like this affects different parts of the supply chain, see Figure 2. Force majeure is defined by Kiraz & Üstün (2020) as "Force majeure gives rise to the exemption from the liability for non-performance in the case of an unforeseen or unexpected event beyond the control of the parties". Furthermore, Kiraz & Üstün (2020) discusses the question of legal responsibility of the different parties involved in contracted businesses during Covid-19. These responsibilities and legal aspects can be of high importance for manufacturing firms or other supply chain members as the disruptions have huge economic consequences on the supply chain and therefore someone has to be responsible for it.

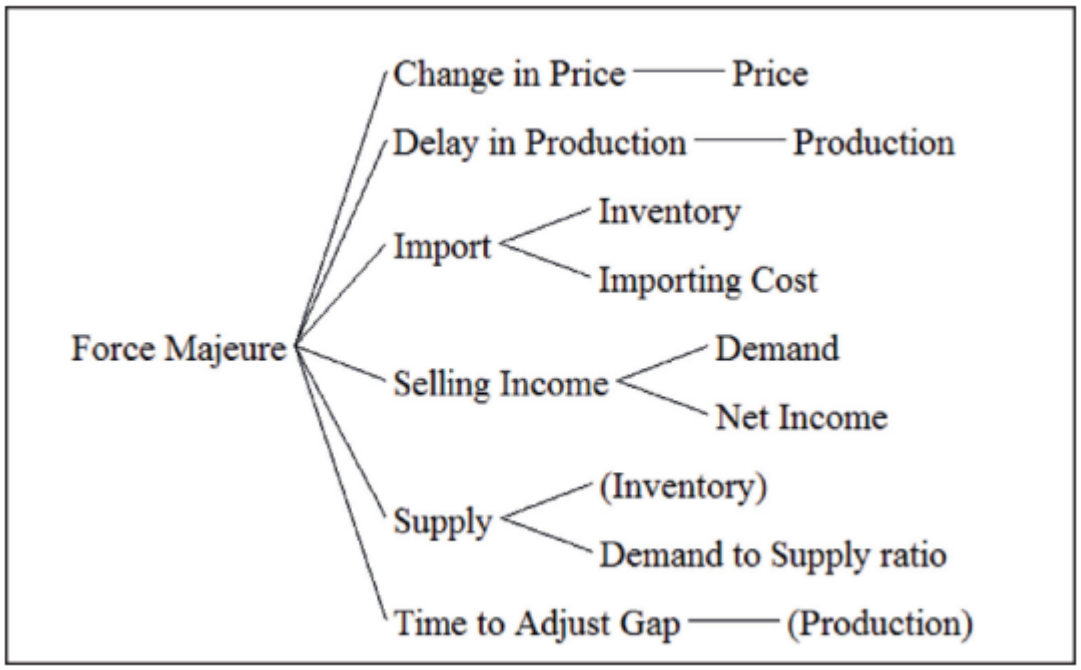

Figure 2: The impact of the Force Majeure event Covid-19 on global supply chains (Heidary, 2022)

The disruptions caused by Covid-19 have had an enormous impact on fundamental thinking about SCM and JIT principles. To quote the CEO for Council of Supply Chain Management Professionals (SCMP) ``To say that everything changed is an understatement. Before the COVID-19 pandemic struck, supply chains were lauded for their ultra-efficient, single-source and just-in-time capabilities. Now, the logistics field will need to construct entirely new levels of supply chain resilience.'' (Van Hoek, 2020). The CEO is far from alone in his thinking that the disruptions related to Covid-19 have put an explosive focus on supply chain resilience in order for companies to avoid these disruptions in the future. As an example, Nikobaar & Yanadoori (2021), Ivanov (2021), Ozdemir et. al (2020) and Hobbs (2020) all describes the need for a change towards more resilient supply chains as a result of the global and overlapping supply chain disruptions that emerged as a result of the pandemic.

To conclude, as stated by Nikolopoulos et al. (2021) "Our generation has never met anything remotely similar to this pandemic." This goes in line with what Dwiedienawati et. al (2020) mentions about this pandemic being unprecedented in modern times due to the scope and uncertainty that follows with it. This rareness, scope and uncertainty that is characterized by the pandemic have therefore led to extensive, global disruptions on our supply chains.

2.3 Supplier management

The recent trends of optimizing, and in many cases also minimizing, the supplier base has put an increased importance on supplier management (Theodorakioglou et al, 2006). According to Theodorakioglou et al (2006) the trend can be perceived to be a combination between the increased level of outsourcing and the increased focus on total quality management (TQM). Hence, these factors create an increased mutual dependence between suppliers and buyers in order for the buyer to deliver high quality services and goods to the end customer (Schiele et. al 2012). When you establish a dependence on one supplier, you are also put into a higher risk if the supplier chooses to serve your competitors, which also creates a greater need for a mutual and collaborative supplier management to stay competitive on the market (Schiele et. al, 2012). According to Kannan & Tan (2002) the trends of SCM have forced companies to view their supplier rather as an extension of their company than as an external company. By doing so, Kannan & Tan (2002) stress that a company may need to develop the internal management processes and apply these on the external suppliers as well. In other words, they highlight the

importance of effective supplier management as suppliers' performance is directly connected to buying firms' performance today.

2.3.1 Supplier sourcing strategies

The decisions taken by the management related to sourcing strategies are decisions that affect the firm in different ways. It has therefore been widely discussed whether it's preferable to work closely with a limited number of suppliers (Spekman et. al, 1999) or to work with dual or multi-sourcing strategies (Hittle & Leonard, 2011). Furthermore, as a result of the more globalized supply chains, the question regarding global or local sourcing has emerged over the last years. One crucial factor for effective sourcing is, however, to make sure that both internal and external perceptions, goals and objectives are aligned (Spekman et. al, 1999). This is also because sourcing strategies are objects to a numerous of trade-offs where the buying company needs to have a clear picture of the business and its needs (Yu et. al, 2009).

Furthermore, Bagul & Mukherjee (2019) discusses the importance of taking even your tier-2 suppliers into consideration, especially within the automotive industry, when taking the decisions regarding sourcing strategies. This is because you are often a part of a multi-tier network where different actors have different goals and your tier-1 supplier does in many cases use the same tier-2 supplier. To illustrate this, Bagul & Mukherjee (2019) created an example of how a multi-tier supplier network looks like, see Figure 3.

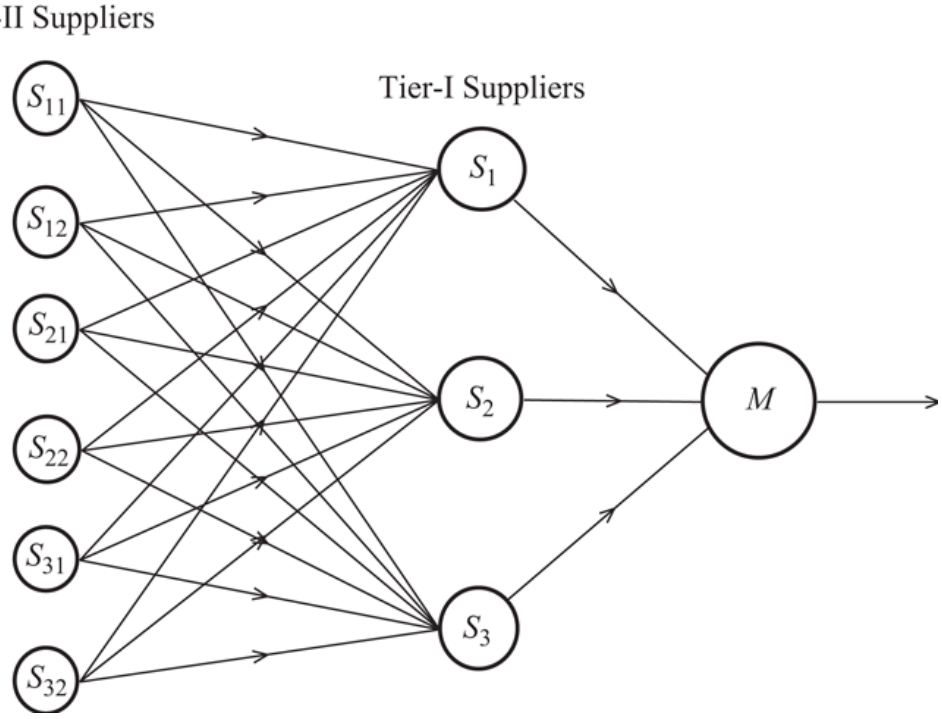

Figure 3: Example of a multi-tier supplier network (Bagul & Mukherjee, 2019)

As an example, Yu et. al, (2009) state that single sourcing is perceived to fit JIT organizations better due to the fact that it's easier to develop an effective supply chain and eliminate waste if you have more of a strategic partnership with your supplier than a buyer-seller relationship. On the other hand, multiple or dual sourcing mitigate the risks of supplier-related disruptions on the supply chain as the company often has a backup supplier when working with this sourcing strategy (Yu et. al, 2009). According to Whitney et. al (2014), the main argument behind single sourcing is that it is perceived to result in long-term benefits as product development, co-learning and a strengthened relationship. In other words, single sourcing is perceived to be more long-term beneficial while multiple sourcing is proven to be more beneficial during short-term crises (Whitney et. al, 2014). In addition, as seen in Figure 3, there are also risks with multiple sourcing. If your multiple suppliers use the same sub-suppliers and if that sub-supplier is the one affected by a crisis, multiple supplier strategy might not prove effective (Bagul & Mukherjee, 2019).

When discussing global or local sourcing strategies, the global sourcing strategies are often motivated by the low production costs in developing countries (Spekman et. al, 1999). According to Holweg et. al (2011) the benefits of global sourcing can be summarized in the following categories: (1) gaining access to cheaper resources and the intensification of international competition; (2) establishing a presence in new markets; and (3) obtaining access to distinctive resources. Golini & Kalchschmidt (2011) are also covering these categories by stating that some of the drivers behind global sourcing are access to foregign markets, low procurement costs but also increased access to new technologies, knowledge and high-quality products. With this in mind, Golini & Kalchschmidt (2011) mention that global sourcing can be used for two main purposes being (1) lower procurement and production costs or (2) greater access to high quality products and technologies. On the other hand, global sourcing does also mean longer lead times, increased transportation costs and more complex supply chains (Holweg et. al, 2011; Golini & Kalchschmidt, 2011). In addition, Bohnenkamp et. al (2020) also mentions the challenge connected to government policies and cultural differences when working with global sourcing. They refer to it as social capital and describe its importance and its implications as a driver for moving back to local or regional sourcing (Bohnenkamp et. al, 2020). Another reason for local sourcing is the possibility to carry less inventories and being

more flexible in the order and manufacturing processes due to shorter lead times as well as the decreased risks for strikes, weather-related disruptions etc (Han et. al, 2008).

2.3.2 Supplier management during crises

During supply chain crises it has been proven that a good supplier relationship is highly beneficial (Hittle & Leonard, 2011). One thing included in these supplier relationships is the level of effective communication between the supplier and buyer, which are directly connected to the chance of surviving a crise (Hittle & Leonard, 2011). Furthermore, Matook et al. (2009) describe the relationship between manufacturer and supplier as crucial in order to survive in today's business environment where there is an increased risk for disasters and crises. This is also confirmed by Yang et. al (2021) who stress the importance of long-term relationships between buyers and suppliers to achieve both an effective supply chain as well as effective communication and collaboration. Yang et. al (2021) mentions unplanned demand changes, which often is the case during a crisis that requires flexibility, as an example of where the partnership between the supply chain partners will be crucial in order to help each other. One can also connect this to what Kannan & Tan (2002) mention about suppliers being an extended part of the buying company, meaning that the buying company should treat their suppliers in the same way as they treat other departments within the company even during a crisis. This stresses the importance of working together during a crisis in order to reach the most beneficial outcome for both parties when the crisis is over, also since one is often equally dependent on suppliers today (Schiele et. al 2012).

2.4 Crisis management

The definition of crisis management is “A set of factors designed to combat crises and to lessen the damage inflicted by a crisis” (Coombs & Laufer, 2017). The function of management is to apply a mixture of applied common sense and experience while devoting their time to concentrating on the problem at hand (Parsons, 1996). Furthermore, crisis management efforts are deemed to be effective whenever core activities and operations are sustained or resumed, losses are minimized in terms of organizational and external stakeholders and knowledge is gathered which can then be used in future crises (Pearson & Clair, 1998). The organization should aim to quickly recognize any emerging threats and proceed with implementing mitigating actions as soon as possible while accentuating that a crisis can bring opportunities as well (Dwiedienawati et.al, 2021). In the aftermath of a crisis, collective adaptation and

replacement of old practices and relationships therefore often become an eventuality (Pearson & Clair, 1998). For an organization that operates in a single country, crisis management is very challenging at the best of times. Navigating through a crisis when the organization is operating in multiple countries introduces new complexities that create colossal challenges for them and solutions that worked in the home country may not necessarily work abroad (Coombs & Laufer, 2017).

2.4.1 Crisis groups

When a crisis is imminent, command and control has to be established while balancing limited resources, time and uncertainty as constraints (Dwiedienawati et.al, 2021). Hence, it is difficult for leaders to act alone and they therefore need to lean heavily on their crisis management team who plays a critical role during crisis situations. Dwiedienawati et.al (2021) emphasizes that a crisis management team is responsible for managing not only a firm's resources but also its people during critical events and that their effectiveness is a vital part in the resolution of any crises. Furthermore, an effective crisis management team can facilitate decision making and actions by accelerating the flow of information and resources during a crisis (Pearson & Clair, 1998). In addition to this, Parsons (1996) emphasizes that an ideal steering group in the times of crisis is diversified and consists of members from every department of the organization in order to fully assess the situation. Moreover, poor decision making in times of crisis is often a result of 'group thinking' as one dominant way of framing the problem without asking questions can become a tendency (Dayton, 2009).

2.4.2 Flexibility

In terms of flexibility, the purpose of crisis management planning is to consider entire scenarios while developing flexible plans that everyone involved in its implementation can understand and rehearse (Parsons, 1996). Moreover, crisis management plans are ideally meant to be flexible except in those cases where there are standard operating procedures in place for handling a specific crisis (Coombs & Laufer, 2017). In uncertain situations, different decision-makers approach and define problems in varying ways which makes it more difficult to come up with a suitable solution to the crisis situation (Dayton, 2009). In other words, uncertainty paired with the urgency to find viable solutions to the problem at hand makes it impossible to consider all options carefully. Thus, an organization may not always be as flexible as they ideally want to be as a result of them being forced to an urgent response when attempting to mitigate any negative effects (Dayton, 2009).

2.4.3 Collaboration

It is important for the organization to engage their organization members while putting emphasis on shared value in order for them to creatively develop solutions that will help the organization thrive and still satisfy its customers, even when faced with a crisis (Dwiedienawati et.al, 2021). Pearson and Clair (1998) suggests that group efforts are more likely to succeed when the responsibility of taking action and making decisions are collectively distributed among a group's members. The way in which a crisis management group communicates with each other, develops processes for making decisions and enforces these processes often becomes the key determinant of whether the crisis management is effective or ineffective (Dayton, 2009). Expanding further upon this, Parsons (1996) reiterates that all lines of communication should be open and that top management must be kept fully informed of any news, whether they are good or bad, in order to provide more transparency throughout the organization.

2.5 Trade-offs associated with Supply Chain Management

To summarize this chapter, there are a lot of trade-offs associated with SCM. However some of them are more current during a global pandemic like Covid-19 than others. As an example, when suppliers face difficulties and when transport suppliers have a hard time to respect written contracts, there will be disruptions. In order to mitigate these disruptions and at the same time minimize the economical effects of them, the trade-offs need to be carefully evaluated. One example of a trade-off that needs to be taken care of during the actual crisis is the one between low transportation costs and production disturbances. As described by Falsafi et al. (2018), companies sometimes use express transportations in order to secure production. This is because even though the costs for transportation may increase dramatically, the costs of production stops or disturbances are considered higher (Falsafi et al, 2018). Another trade-off that appears, if the crisis is supplier related, is the one regarding keeping a supplier or switching to a new one, mentioned by Holweg et. al (2011). Switching suppliers during a crisis forces the buying company to do market research, company evaluations and negotiations which come with higher costs in terms of time and resources needed (Holweg et. al, 2011).

Furthermore, there are also trade-offs related to long-term strategic decisions which means that these ones need to be considered before the crises appear or after in order to minimize the risk

of disruptions in the future. Sourcing strategies and use of manufacturing strategies are two of these. In order to distinguish between the more strategic trade-offs and the more ad-hoc trade-offs, Table 2 was created by the authors. This table is based on the theoretical framework but with the aim of connecting the different sections in it to the trade-offs that need to be carried out by companies in order to survive a crisis like Covid-19.

Table 2. List of trade-offs associated with SCM (Authors, 2022).

Trade-off made pre-crisis	**References**
Global sourcing VS. Local sourcing	(Golini & Kalchschmidt , 2011), (Bohnenkamp et. Al, 2020)
Single sourcing VS. Multiple sourcing	(Whitney et. al, 2014), (Yu et. al, 2009)
Low inventory levels VS. High inventory levels	(Holl et al, 2007), (McLachlin, 1997)
Resilient Supply Chain VS. Effective Supply Chain	(Van Hoek , 2020), (Brakman et. Al, 2020)
Trade-off made during crisis	**References**
Transportation costs VS. Production costs	(Falsafi et al, 2018), (Dörnhöfer et al, 2016)
Keeping a supplier VS. Switching to a new one	(Holweg et. al, 2011)
What's best for me VS. What's best for the company	(Dayton, 2009), (Dwiedienawati et.al, 2021)

3. Methodology

The chapter below aims to present the methodology chosen for the report's layout as well as a short description of the approach taken regarding the case study of Volvo Group AB. Furthermore, the data collection of the report will be examined and ultimately end in an analysis of its research quality and limitations.

3.1 Research approach

The report's research approach has its point of departure in an interpretivism paradigm as the findings have been derived from qualitative analysis methods and has thus been based on an interpretation of qualitative research data (Collis & Hussey, 2013). Moreover, the research is classified to be of an exploratory nature as it aims to examine a relatively new phenomenon which has few earlier studies in which to refer to. The phenomenon referred to is the worldwide crisis that occurred as a result of the Covid-19 pandemic with the reason being that it caused an unprecedented chain of events which has not been thoroughly researched in modern times. Hence, what will be studied in more detail is how a large corporation, in this case AB Volvo, has responded to the uncertainty and disruptions that the pandemic brought with it. In terms of choosing Volvo as a research subject, the main idea as to why they were chosen was that the company is a large organization reliant on a number of critical suppliers and where a culture of Just in Time practices has been implemented. Additionally, due to their size, Volvo has developed a complex supply chain that involves many different stakeholders and therefore is

likely to experience potential disruptions in the case of a global crisis. Thus, Volvo was deemed to be the most suitable subject to research as it was the most accessible and was also of the highest interest to both authors. Lastly, the empiric material gathered laid the basis of the theories and conclusions presented in the report which ultimately makes the research of the study inductive (Collis & Hussey, 2013).

3.2 Case Study

Case studies are beneficial in the sense that they can provide researchers with a holistic view of a certain phenomenon or a series of events (Noor, 2008). He further emphasizes that it is common to criticize them for lacking scientific rigor or generalizability. However, case studies can provide useful insights in capturing inherent and emerging properties within organizations, especially during times of change. In addition, Collis and Hussey (2013) suggests that although a case study methodology can offer many advantages, research can be very time-consuming and there may be difficulties in deciding its scope. Despite AB Volvo being a single research object, they do not exist in a vacuum and are in constant interaction with the rest of society. Therefore, complications may arise when attempting to understand certain events during the time of the research as one does not possess the same understanding of what has taken place prior to or after the study (Collis & Hussey, 2013). Hence, the time frame of the case study and the obstacles involved with distinguishing the scope of the research can impact the thesis greatly. As such, deriving what stems from where and if those effects are direct or an indirect cause of the phenomenon being researched creates additional challenges. It becomes especially complex when attempting to derive if those processes or effects are a natural course of events that are solely caused by the problem being researched in the case study or some outside factors that are not being examined.

3.3 Data collection

In regards to data collection, the data collected is of a qualitative nature and has been collected through semi-structured interviews with respondents representing various areas within the case company. Furthermore, the authors then used the data collected from the interviews in order to find relevant literature for the theoretical framework.

3.3.1 Interviews

The interviews were semi-structured in terms of having questions sent out to respondents beforehand in order for them to check for sensitivity and also be adequately prepared. Collis and Hussey (2013) indicate that this encourages the interviewee to talk about their main topics of interest while allowing the interviewers to develop other questions during the course of the interview. The interviews were conducted as previously described while also granting us the opportunity to be more flexible in how the order of the questions were asked. The reason being that by allowing the interviewee to freely discuss the main topics of interest, in a semi-structured fashion, they were able to provide a lot of relevant information when answering questions that did not directly cover those areas. Hence, as Collis and Hussey (2013) stresses, all pre-prepared questions were not asked since the interviewee already provided the necessary information for those questions. Additionally, by providing the interview questions beforehand it became clear to the respondents what information was wanted from them. In terms of setting up the interviews each respondent was contacted in the earliest stages of the report in order to ensure that there was time to either reschedule certain interviews or find replacements in case someone declined the request.

Moreover, as the research is of an interpretivist nature, findings are derived from the empiric material gathered which made the interviews a necessity in order to proceed with the remainder of the report. When it comes to the selection process of choosing which respondent who was to participate in the study, it was done with establishing a holistic view of the company in mind. The purpose and role of each respondent can be examined in Table 3 below. With reference to which type of interview was conducted it alternated between two main types, more specifically in person or online via Zoom or Teams. As suggested by Collis and Hussey (2013) the traditional approach of conducting an interview face-to-face offers the advantage of creating a more comprehensive picture of the data collected. It is also beneficial when asking more complex or sensitive questions as it creates a more intimate setting being there in person rather than not being in the room with the respondent. During the interviews that were done face-to-face there was a different dynamic where it became more natural to interject and develop follow up questions. Additionally, it became clear that during those interviews, the respondents felt more open and talkative in regards to their responses to the interview questions. However, there were also many upsides involved in conducting interviews digitally and one of the most notable

ones was in terms of scheduling and coordinating the interviews. This allowed for respondents to choose a time and setting that suited them best.

When designing the questions for the interviews it was of great importance to ensure that the respondents elaborated on their answers as much as possible in order to gain the most amount of information. Collis and Hussey (2013) mentions that a greater understanding can be achieved by asking questions that require the interviewees to elaborate on their initial statements and asking open ended questions. Hence, all questions written were designed in a way that facilitated longer and more reflective answers. After each interview, the respondents were asked if they could provide us with other persons of interest for the study. This was done in order to find respondents that could give insight into those areas where they did not possess adequate knowledge and also in order to expedite the search for more respondents. A general outline of the interview questions can be found in Appendix 1. However, one has to bear in mind that, since the respondents represented different departments within the company, Appendix 1 includes only the questions that were asked to all of the respondents. Each respondent was also provided with more detailed and customized questions about their specific department.

Table 3 Interview Guide (Source: Authors)

Respondent	**Role in the organization**	**Date and time of interview**	**Type of interview**	**Purpose in short**
Respondent A	Former VP Global Contracting at Volvo Logistics	2022-02-04 10:00-11:30	Zoom	Historical overview of strategies and crisis management within the organization
Respondent B	Transport Material Coordinator at Volvo Logistics	2022-02-10 13:00-14:00	Teams	Operational changes and/or effects in the transport process: both historical and present
Respondent C	Material Controller at Skövde plant	2022-03-03 13:00-14:00	Teams	Operational changes and/or effects on the Supply Chain from supplier to Skövde Plant
Respondent D	Director Logistics at Tuve plant	2022-03-04 14:15-15:15	Teams	Tuve Plant holistic perspective: Main changes and/or effects and strategies
Respondent E	Director	2022-02-22	Face-To-Face	Holistic view of transport

	Transport Material at Volvo Logistics	13:30-15:00		effects on the Swedish Plants
Respondent F	VP Logistics Purchasing at Volvo Logistics	2022-02-25 10:00-11:00	Face-To-Face	Holistic view of the changes and/or effects in the LSP purchasing processes
Respondent G	VP Logistics Volvo Group Trucks Organization	2022-02-16 13:00-14:00	Teams	Holistic view of the Logistics at Tuve plant as well as the KD Market

3.3.2 Literature Review

The theoretical framework of the thesis consists of sources gathered from Gothenburg University's own library search engine 'Supersök' as well as 'Google Scholar'. Due to these search engines providing results that are of a more academic nature, using them during the data collection phase was an obvious choice as it provided accessible and applicable sources that increased the legitimacy of the thesis. Hence, all literature used in the theoretical framework has been chosen as a means of tying the research question and case study's results together in order to make it more focused and to establish both context and validity. During the research, a plethora of keywords were used to map out relevant literature for the thesis and to increase the scope of the searches. When conducting the literature research, terms that were used include: *Just in Time, Supply Chain, Crisis Management, Disruptions, Supplier Management, Manufacturing, Purchasing, Trade-offs, Transaction costs.* Additionally, the words have been combined in various ways in order to increase the reach of the searches and find other relevant literature.

Furthermore, the theoretical framework is divided into five major parts which are Just In Time, Supply Chain Disruptions, Supplier Management, Crisis Management and Trade-offs. JIT and Supply Chain Disruptions were decided beforehand to be a great part of the report and after

conducting the interviews the authors decided to add the last three parts as well as all these themes became a great part of the interview discussions.

3.4 Research quality

Under an interpretivist paradigm emphasis is put on the research quality and depth of the data collected about a phenomenon (Collis & Hussey, 2013). The approach chosen to assess the research quality of the thesis has its point of departure in three main measurements, namely validity, reliability and sensitivity. Validity and reliability will be measured as they increase transparency and decrease opportunities for any researcher bias (Mohajan, 2017). Sensitivity will be discussed due to the nature of certain confidential and internal data related to the company. Lastly, there will be a concluding paragraph which discusses potential limitations related to the methodology.

3.4.1 Validity

The validity of the research will be measured in order to assess if it measures what aims to be measured as well as if its results reflect the phenomena being studied (Collis & Hussey, 2013). Thomson (2011) suggests that qualitative research is based on subjective, interpretive and contextual data which can be difficult to measure from an interpretivist viewpoint. Qualitative research is based around the notion that validity is a matter of trustworthiness, utility and dependability (Mohajan, 2017). An integral part of the thesis has therefore been to ensure that the transparency of the research is considered along every step of the process. A concrete example of this is that every respondent participating in the study is offered an opportunity to read the report and verify their answers before the report is finalized. Hence, the research gains more legitimacy and becomes more accurate as a result of respondents being allowed to provide their input. In order to guarantee effective validity, multiple sources of evidence must be gathered and integrated over a period of time with specified areas being covered (Lakshmi & Mohideen, 2013). Thus, the decision to conduct a vast amount of qualitative interviews with respondents from different sectors of the organization was taken. The aim was to collect diversified responses that would enhance the holistic view of the research and further increase its validity as multiple dimensions of the organization would be analyzed.

Collis and Hussey (2013) emphasizes that it is of great importance that interview questions are related to the purpose of the study; otherwise respondents may find the questions irrelevant and

lose interest in answering them which lowers the validity of the results. Additionally, they indicate that a common mistake is to compose far too many interview questions which could potentially discourage and deter respondents from participating. This was essential during the construction of each interview form and allowed the authors to hone in on the most necessary questions while preserving potential follow up questions for the interview opportunity. Naturally, this is not the sole reason as to why all of the respondents contacted were open to participate in the study but it is certainly a contributing factor. Moreover, the authors also made an assessment of not pressuring the respondents to provide certain answers by asking leading questions or only offering specific answer choices as this could tamper with validity. Mohajan (2017) mentions that it is vital to not pressure respondents in that sense as well as comparing the data available in order to improve the study's validity. By asking more open-ended questions and allowing the respondent to talk more openly about the topics of their choosing while still ensuring that they remained within the frame of the research; a more relaxed and comfortable atmosphere was created. Furthermore, Mohajan (2017) stresses that a sub-component of validity is reliability which is something that first must be attained in order to achieve validity. It is common to design research studies with high reliability and low validity due to overlooking less rational criteria regarding aspects of the research (Collis & Hussey, 2013; Lakshmi & Mohideen, 2013). As mentioned, it was therefore beneficial to develop more open-ended questions and allow the respondent to steer the direction of the conversation to distinguish what they found important.

3.4.2 Reliability

In regards to the reliability of the research, it is often of little importance or may have different interpretations under an interpretivist paradigm (Collis & Hussey, 2013). Furthermore, they refer to it as the accuracy of repeated measurements and the consistency of those results. The reason as to why reliability is of less importance is because the research is of a qualitative nature which in turn influences the results depending on who the researcher is. Hence, the thesis will not measure reliability in the positivist sense but rather examine factors such as consistency, accuracy and trustworthiness. According to Lakshmi and Mohideen (2013), low consistency within a study is often the result of choosing an excessively broad research area. It was therefore important to ensure that both the research problem and research question were sufficiently delimited in order to reduce the scope and increase the consistency and accuracy of the study. An additional concern in terms of the study's reliability is that of observer subjectivity. Mohajan (2017) emphasizes that reliability issues are closely connected to

subjectivity which in turn compromises the level of reliability of the research. Further, he mentions that there is a greater risk of adopting a subjective approach to the study if there is only a single researcher observing and collecting the data. It is therefore greatly beneficial that there are at least two researchers conducting the study as this will reduce any subjectivity and in turn increase the trustworthiness of the thesis.

3.4.3 Sensitivity

Research sensitivity is an area that you as a researcher have to tread with caution in order to avoid potential risk factors related to anonymity and confidentiality. All participants of a study should be offered anonymity and confidentiality to encourage greater freedom of expression and more open responses (Collis & Hussey, 2013). Hence, consent was a crucial issue for the authors and is something that was discussed during each meeting with the participants of the study. All respondents were offered anonymity and it was decided to not use any names of those partaking in the interviews as the authors agreed that this would counteract potential problems related to them not expressing themselves to their fullest capability. In addition, it was decided not to record any of the interviews or create any transcripts of them but rather make notes of the core findings from each meeting. The reason behind this was that it was difficult to gather any company data as most of it is either internal or confidential. The sensitive nature of the interviews created obstacles when attempting to attain certain pieces of information that would be of use to the thesis. Thus, recording the interviews and creating transcripts was regarded to be less efficient in gathering vital data.

3.4.4 Limitations

Limitations are always present and are something that always have to be taken into consideration, regardless of what type of research you are conducting. No matter how well a study is conducted or constructed there are always matters and occurrences that may arise which are out of the researcher's control (Simon & Goes, 2013). A prevalent limitation within this study was a gap in external partners such as material and transport suppliers. An explanation for this was likely due to the sensitive nature that arises when one of the authors is employed by AB Volvo. Hence, partners associated with AB Volvo may be discouraged and therefore refrain from participating or sharing information as it potentially could affect their business relation.

As the research is centered around a case study there are a number of limitations associated with its findings. It is difficult to rule out alternative explanations and the generality of the findings may as a result be unclear. Since a case study involves the behavior and thoughts associated with one group of people within an organization, at least in this case, certain findings may not reflect those of similar business entities (Simon & Goes, 2013). However, as this study's main focus is concerned with AB Volvo, emphasis is not placed on findings from other businesses. One thing that is worth mentioning is that there naturally are limitations in participants' views of their experiences and the organization as a whole (Collis & Hussey, 2013). As mentioned, the authors have attempted to counteract this to the best of their ability by finding participants that represent different areas of operations and have different responsibilities.

An additional limitation is concerned with researcher bias which is a continuous risk throughout all stages of the thesis. All data collected is filtered through the eyes and past experiences of the two authors and that is something that is impossible to circumvent completely. Although, the authors have attempted to limit these risks to the best of their ability by using as many theoretical sources as possible in order to reduce errors and misinterpretations. Collis and Hussey (2013) indicates that relying on multiple sources of evidence in a triangulating fashion is a common method when conducting case studies. Hence, focus has been to promote objectivity by constantly reviewing what literature exists regarding each topic mentioned and then attempting to find multiple sources that strengthen them.

4. Empirical Findings

This chapter presents all the relevant information and insights received during the conducted interviews. It aims to provide a greater understanding of AB Volvo as a company and how the company has dealt with Covid-19 from a supply chain perspective. The chapter is then summed up by two tables created by the authors to visualize both the direct and indirect supply chain effects and actions taken by AB Volvo during the Covid-19 pandemic. All interviews were conducted during a period from February to April 2022.

4.1 AB Volvo

AB Volvo is a world leading company focusing on manufacturing trucks, buses and construction equipment. The organization consists of some group functions, business areas and truck divisions. Within the truck division you find Volvo Group Truck Operations where Volvo Production Logistics (PL) operates in order to provide all the different production plants with the needed production material in the right time (AB Volvo, 2022). Furthermore, within PL there is one department focusing on the import of production material to the Swedish plants. This department is in turn divided into two different teams, one focusing on the ordinary transport flow and one focusing on the express transports. The express team is responsible for all transport bookings placed due to the fact that it does not fit in the ordinary flow. This can be due to unknown pickup or delivery location, tight lead time or changes in demand that require additional transports from a supplier (Respondent B).

In addition, AB Volvo has around 100’000 employees worldwide and production plants in 18 different countries. 40% of the net sales are from the European market, which makes it the

largest market in terms of net sales. In Sweden the largest plants are located in Tuve (Gothenburg) and Skövde but there are however a number of other plants as well like Umeå, Arvika, Eskilstuna and Borås. The Tuve plant is a part of Volvo Trucks and build some of the trucks models (the cabs are delivered from the production plants in Umeå) while the Skövde plants are a part of the Powertrain Production (PTP) organization that mainly produces engines for the different truck models. (AB Volvo, 2022).

4.2 Just in Time

During the Covid-19 pandemic, Volvo's strategy with Just In Time has been challenged. This is, according to the majority of respondents, shown by lack of production material resulting in production stops and an increased amount of express bookings. In addition, Volvo has worked closely with minimizing inventory levels in line with Just In Time principles. This has had the effect of material shortages since there have been issues at suppliers related to lockdowns, Covid-19 outbreaks etc (Respondent B, C & G). These issues have, according to Respondent G who works as VP for Logistics within Volvo Group Trucks Operations, made it "impossible to receive the material on time" during this period. However, in order to manage to deliver the material on time, the increased amount of express-booking is mentioned as a common solution by several of the respondents, including Respondent B, E and F, and is motivated by the aim of saving the production from retrofitting or production stops. Express bookings means creating bookings outside of the ordinary transport network flow. This is done either because there is no existing transport network arranged from that one supplier or in order to skip one or two stops in the network by creating an order with shorter lead time going directly from the first-tier supplier to the production plant (Respondent B, Transport Material Coordinator within Volvo Logistics). This means that when Respondent G states that it is impossible to get the goods delivered on time, this is mainly by using the ordinary setup. With this in mind, when using express-booking as a backup solution, transportation has not been the main issue or reason for the production disturbances during the times of Covid-19 (Respondent B, D & G).

However, there has been an issue indirectly related to transportation. This issue is connected to the capacity issues at the different cross-docks that are part of AB Volvo's ordinary transport network (Respondent E & F). Capacity issues at the cross-docks have a direct impact on the production plants as it results in delayed deliveries due to increased loading and unloading

times as well as space limitation, which in turn results in external warehouses being used as a backup (Respondent F).

On the other hand, AB Volvo has been forced to start using external warehouses in order to cope with the last-minute changes in production planning (Respondent G). According to several respondents, the production material is usually planned and ordered on a three-week basis from the first-tier supplier but during Covid-19 the production plants have been forced to do last-minute changes, meaning that they might need to re-plan around three days before delivery. This means that if the goods are already shipped, there is a need to store the goods when they arrive as the production plant itself has a limited space for material (Respondent D & G). Another reason for the increased use of external warehouses is that there has been an increased need to support buying from suppliers in order to financially support them during these tough times (Respondent D & G).

To summarize, several respondents agree that Volvo has started to move away from the Just In Time principles and are moving more towards Just In Case principles (Respondent A, B & G). This is done by for example using higher inventory levels and external warehouses where and when it is possible. According to Respondent G, AB Volvo have also needed to re-evaluate the ideas behind Just In Time to allow themselves to have increased buffers on the most critical material needed in production. One thing that argues for the use of external warehouses and increased inventory levels are according to Respondent A, B & G that inventory and warehouse costs are quite cheap in Sweden, especially in relation to the increased transportation costs.

4.3 Supply Chain Disruptions

Historically, AB Volvo has been affected by various crises such as strikes, volcanic eruptions and issues related to specific suppliers. However, the effects of these crises have been limited to more of a regional or local level and have naturally affected AB Volvo's supply chain but not nearly in the unprecedented way that Covid-19 has (Respondent A, B & G). In regards to supply chain disruptions, the most prevalent and critical contributor to issues in AB Volvo's supply chain has been related to material shortages from suppliers. More specifically, shortages of semiconductors which are a fundamental component in their vehicles and in turn caused two of their factories to shut down entirely for a period of time (Respondent D, F & G). Disruptions became evident as early as in the beginning of 2020 due to factory lockdowns

which resulted in material shortages from suppliers paired with restrictions being imposed on them leading to limited production (Respondent E, F & G).

Additional obstacles on top of material shortages and production stops, which are directly interconnected with the previously mentioned disruptions, are lockdowns of various ports and canceled flights. Hence, respondent B, D and G emphasized that a consequence of this was that transport precision suffered while lead times and prices increased as a result. Apart from the direct effects on AB Volvo's supply chain, respondents mention various indirect effects as well that they suggest has caused disruptions. According to respondent A and G indirect effects related to the material shortages can potentially be a result of trade and political effects between China and the US as well as Russia. Especially since the majority of semiconductors are manufactured in China (Respondent G). Furthermore, respondent B mentioned that another indirect effect is the increased digitalization, which became a necessity when restrictions and lockdowns were imposed. It disrupted their processes and created some challenges at first before the employees became familiar with the implementation of new ways of operating as well as remote working. As mentioned, there have been a plethora of disruptions to Volvo's supply chain and these will be presented in more detail below.

4.3.1 Material supplier

It became especially difficult to navigate through disruptions related to the semiconductor shortages as material is ordered on a three week basis (Respondent E & G). The reason as to why this led to complications was mainly because many suppliers had already sent the goods when factories became inoperable. Thus, respondent E and G indicated that the storage of the goods became an issue since external stock was nonexistent before the pandemic made itself known. As a result, both AB Volvo themselves and the suppliers had to handle the storage of this material which became a great challenge in terms of balancing the flow of material while managing that these deliveries ran smoothly. On top of this, Respondent G mentions the challenges involved with trying to maintain business as usual and running the operations as planned when there are shortages of people due to the Covid-19 outbreak. In addition, it was not necessarily first tier suppliers that were experiencing these disruptions firsthand but instead AB Volvo's second tier suppliers that were unable to provide the materials needed or not being able to do so in time (Respondent B & G). Hence, financial issues became imminent for some of the suppliers and at certain times AB Volvo had to step in and support them financially in order to minimize potential disruptions throughout the supply chain (Respondent G). A

common scenario is to re-invoice suppliers if it can be proven that they are at fault when not being able to deliver materials. Due to some suppliers' financial hardships during the pandemic there were times where Volvo decided to refrain from doing so to avoid further financial complications (Respondent C & E).

4.3.2. Transport supplier

On the transport supplier side of AB Volvo's operations there has mainly been a lack of capacity in terms of available drivers and trailers (Respondent B). The capacity issue existed well before the pandemic but became increasingly more noticeable and severe when disruptions started to occur throughout the supply chain. Furthermore, respondent B and F emphasized that the capacity issue paired with canceled flights and ferries led to increased transport costs and longer transport durations which ultimately disrupted their standard way of operations greatly. An additional issue related to the capacity and material shortages has been that of displacements regarding containers. Due to containers and material not being in the correct place at the correct time an imbalance in the freight flow occurred as a result (Respondent F).

As if this was not enough, restrictions and lockdowns placed the general population in the comfort of their own homes which reduced their demand of buying services outside of it. Hence, e-commerce became increasingly more popular and led to a demand boom which strained the transport suppliers further as more pressure was put on the flow of goods (Respondent D & F). As many ports shut down or nearly did, sea freight became less viable and due to the majority of air freight using passenger flights as a transportation means, moving the goods long distances became difficult. However, respondent B, F and G suggest that there was an increase in express air freight to complement sea freight due to the low transport precision which at times was 0%. This was done in order to avoid production stops. Respondent F mentioned that transport operations have faced many challenges due to the increased demand for express transports. Specifically in regards to the volumes that cross-docks have been forced to adapt to and handle. A worrying development has therefore been if the cross-docks have the capacity to handle the new volumes. As respondent F emphasizes; they want good margins to work with otherwise it may create ripples throughout the entire supply chain.

4.3.3 Production plant

Volvo's production plants are no exception when it comes to experiencing disruptions in their operations, mainly due to component shortages from the suppliers earlier on in the supply chain. Respondent D pointed out that there have been capacity issues related to the inflow of material coming in which continued despite certain component shortages. Thus, this led to an overflow of material coming in due to production not being able to proceed as components were missing. Because of the JIT-oriented nature of their operations, inventory levels were kept at a minimum which created a demand for external warehouses in order to store the goods somewhere (Respondent B, F & G). Simultaneously, there were not nearly enough personnel to handle the new volumes and no proper system in place to handle the new inventories. Hence, the inflow of goods had low visibility and was difficult to manage for the understaffed production plants (Respondent D). Respondent E suggests that the planning process has been too shortsighted in terms of the overwhelming volumes that must be handled. Due to the lowered visibility and understaffing issues it was therefore too time consuming to find the material at times and new orders had to be placed to avoid further disruptions.

4.4 Supplier management

First of all, all of the respondents that are involved in relationships with either material or transport suppliers agree that Covid-19 has led to something positive in terms of increased relationships and collaborations between Volvo and their respective suppliers (Respondent D, E, F & G). This is, according to the respondents, because both AB Volvo and their suppliers have been put in a tough situation which has in a way forced them to focus more on collaboration rather than competition in order to achieve what is best for all parties. Respondent F, working as VP Logistics Purchasing at Volvo Logistics, does also mention that there has been an increased transparency between AB Volvo and their respective material and transport suppliers and that this transparency together with good communication has been the keys for the successful cooperation. Respondent D also confirms that there has been an increased and better relationship during Covid-19 in general, however he does also mention that some of the suppliers have acted in a way that has been disappointing.

Furthermore when it comes to supplier management, AB Volvo has a history of trying to help suppliers at place when it is needed. However, during Covid-19 the traveling restrictions prohibited these types of actions (Respondent G). Respondent A & G also mentions that AB Volvo sometimes owns the tools and machines used at material suppliers' if production

requires any specific tools or machines to be able to produce the goods according to the AB Volvo standards. Furthermore, as mentioned before and by several respondents, AB Volvo has decided to sometimes not invoice the supplier for the express transports in order to financially support them. This, even though both parties agree that the reason for the express transport is supplier-related.

Another aspect of supplier management during Covid-19 can be related to the shortage of AB Volvos' standard emballage, which is a word used especially for AB Volvos specific type of packaging and packaging instructions (Respondent C). This shortage has, according to Respondent C who works as a Material Controller at the Skövde plant, resulted in AB Volvo needing to send express-transports with the standard emballage to the suppliers in order to get the material packed in the required way. When the shortage of emballage reached its peak, AB Volvo did accept that some suppliers sent the material in a non-standard packaging to then re-pack it when it arrived at the production plant (Respondent C). During this situation, communication and collaboration was of high importance in order to make sure that the goods arrived at the correct working station in the plant, packed in the right way in order to fit for production (Respondent C).

When discussing supplier management during Covid-19, one also needs to examine the transport suppliers and include them in the discussion as well. Respondent F agrees that the relationship between the transport suppliers and AB Volvo has increased during this period as well and that there have been, in the majority of cases, a mutual understanding for each other. According to Respondent F there has been an increased demand on flexibility on the transport suppliers as the volume of each shipment has varied depending on the availability of material at the time of pickup. In addition, Respondent E mentions that the delivery precision for the transport suppliers included in the ordinary transport setup have in general decreased due to a number of factors being e.g. required Covid-passport, restrictions and lack of drivers.

Lastly, Covid-19 and its effects have also increased the understanding and interest from AB Volvo's side towards their most critical first-tier suppliers as well as their respective second-tier suppliers (Respondent C, D, E & G). One thing that needs to be taken into account when discussing the critical suppliers is that it does not only include the suppliers who produce a critical component. It does also include the suppliers producing the less-critical components or

material but where there are no alternative suppliers available on the market. Hence, these suppliers need to be prioritized as well (Respondent G). Furthermore, as a result of the increased understanding of the overall supply chain, Respondent G mentions that AB Volvo sometimes during Covid-19 has helped their first-tier suppliers by negotiating with their respective second-suppliers. He describes it as a way to gain leverage on the second-tier suppliers as AB Volvo might have a better bargaining power than their smaller suppliers when negotiating with their respective second-tier suppliers. This goes in line with what both Respondent G & F mentions about the importance of purchasing during Covid-19, in order to get their suppliers to choose to deliver to AB Volvo rather than their other customers as soon as they have material available. This has been even more important due to the semiconductor crises, leading to increased issues related to material shortages (Respondent G & F).

4.4.1 Supplier sourcing strategies

When it comes to sourcing strategies, several respondents confirm that AB Volvo has chosen to work with single sourcing. The majority of the respondents does also bring up the challenge with this strategy during Covid-19, as the company becomes highly dependent on a few suppliers and their ability to produce and deliver the requested quantity of the material in the required time. Their suggestion to this challenge is that AB Volvo could choose to work more with dual sourcing in order to secure a backup supplier when one of them is not able to deliver. However, as discussed with Respondent E, there are some challenges related to dual or multiple sourcing as well. Some of them include being able to secure the exact same quality of the material from both suppliers as well as the increased costs of machines and tools if choosing to work with dual sourcing even for the material when this is needed, as described above (Respondent E).

Furthermore, when discussing the geographical aspect of sourcing, AB Volvo has the absolute majority of their suppliers located in Europe and since they work with single sourcing, this means that even the majority of suppliers for the worldwide plants are located there (Respondent E). In addition to this, a lot of them are located in Sweden (Respondent E). Respondent E brings up the benefits of this strategy for the production plants located in Europe but does also bring up the challenges with this related to e.g. the US market. This can also be related to what respondent A & G mentions about AB Volvo moving more towards regional sourcing. This means that the aim is to have suppliers producing components or material for

the US markets located in close proximity to the US production plants and the same with the plants located in Europe (Respondent A & G).

4.5 Crisis management

Volvo has been using crisis groups for several years according to respondent A and in light of the Covid-19 pandemic; crisis groups were implemented when it was time for operations to restart after the temporary lockdowns (Respondent F). The crisis management teams within the organization were relatively well prepared or at least as prepared as one can be due to the characteristics of the crisis (Respondent G). However, the unprecedented nature of Covid-19 introduced new risks and scenarios where its extent was something that was difficult to predict and thus prepare for (Respondent D, F, & G). For example, respondent D mentioned that crisis management is something that they have been working with at the production plants, but this only included scenario planning for one production plant shutting down and not all of them. In other words, the predefined processes that were already in place could only take one so far in terms of the crisis.

An additional effect that can be distinguished is that AB Volvo as a response to the crisis have been forced to work more closely internally as well as externally (Respondent G). Internally, the frequency in which meetings occur between different departments have increased greatly and a stronger connection and teamwork between these departments have been the result (Respondent B, D, F & G). By being united against a common enemy, the Covid-19 pandemic, and being focused on solving the problem without blaming anyone; a greater understanding for one's coworkers have been the result according to the respondents that were a part of this crisis management team. However, it is not solely coworkers relationships that have flourished but also external partners such as material and transport suppliers (Respondent F & G). Moreover, the contact between AB Volvo and their suppliers have increased in frequency and a greater understanding of one another but also the supply chain as a whole has developed throughout the crisis. Respondent F mentions the importance of ensuring that everyone feels included and part of the solution. He is aware that there are times when there can be an abundance of information which makes it difficult to navigate and hence mediate in a useful manner. Although, he indicated that high transparency was a vital part of steering through the crisis and not being afraid of bringing up negative news.

Conclusively, there has been a constant conflict of balancing between short-term and long-term objectives while safeguarding the interests and vision of the organization (Respondent F). Furthermore, he has together with Respondent E emphasized the importance of continuing to work towards transformation and having a long-term perspective while still managing the challenges that occur on a daily basis. Severe issues can manifest themselves further down the road if the crisis is allowed to consume everyone's energy and is constantly top of mind (Respondent F). For example, lagging behind in the electrical vehicle race, losing sight of sustainability goals or stopping the continuous work with digitalization. Respondent F suggests that it is critical to find a balance between the two approaches and assuring that employees working with long-term goals are being heard even if short-term goals are gaining a lot of focus. Ultimately, he stresses the importance of not allowing the crisis to completely consume and overwhelm you. In addition, working towards inspiring coworkers and making sure that they still enjoy their workplace despite facing a crisis. Hence, a lot of the crisis management has been concerned with the balance of keeping Volvo's daily operations going while simultaneously ensuring that they do not lose sight of the organization's future (Respondent F).

4.6 Trade-offs during Covid-19

During Covid-19 there have been a lot of trade-offs needed to be taken into account for AB Volvo before making any decisions. Some of these have been related to day-to-day work while others are more related to the long-term strategic goals. One of the main trade-offs is therefore the one mentioned above, namely the trade-off between focusing on these short-term crisis management decisions or the long-term strategic goals in order to be able to not only survive the crisis but also come out of this crisis stronger than before (Respondent E & F). This is according to Respondent F because there is always a risk that you will lose your competitive advantage in the long run if you choose to just focus on the crises and its short-term effects. As an example, Respondent F mentions the continued work with sustainability and digitalization as two important areas where AB Volvo wants to gain competitive advantage but also two areas that naturally might lose some focus during Covid-19. This is also confirmed by Respondent E who describes the challenge related to focusing too much on the daily issues, that you lost the long-term thinking for example developing work in each department.

Some other more strategic-related trade-offs that appeared during Covid-19 are for example related to keeping a supplier or changing to another (Respondent G), prioritizing between the production facilities when supplier have material ready that can be used in more than one production facility (Respondent D) and also the trade-off related to both internal and external communication (Respondent F). According to several respondents, AB Volvo has decided to keep their suppliers closeby during Covid-19, even though they have faced issues with material shortage. There is also a common view between the respondents that AB Volvo has chosen to support some suppliers financially in order to handle the trade-off between supporting them financially or not recieving the material at all, which might be the case if the supplier faces bankruptcy or decides to serve another one of their customers instead of AB Volvo. In addition, not supporting them might result in them not being able to afford the costs of express-transports, which might in turn result in production stops due to delayed deliveries.

Some of the more day-to-day related trade-offs are also related to transportation. Both Respondent B and C, who work more operationally towards the production plant, bring up a number of trade-offs. Both of them mention the trade-off between accepting a higher transportation cost by booking an express transport, or saving this money by transporting the material with the ordinary flow. According to Respondent C who acts like the booking requester for these types of bookings; there is a constant consideration regarding this where it is her job to weigh the transportation costs against the cost that a shortage of the material might cause to production. This goes in line with what Respondent B mentions about the trade-off between lead time and price, as the acceptable lead time often is related to the time when the material is needed in the production plant. Furthermore, as Respondent B works with the express-transports, he also mentions the trade-off between a cheaper but less-performing transport supplier and a more expensive one with a higher delivery precision. However, as the number of express transports have increased during Covid-19, one can conclude that AB Volvo have decided to accept an increased cost for express-transports in order to ensure production (Respondent B, C & E). Furthermore, there is an additional trade-off that confirms that Volvo have decided to prioritize production during this time. That is the one regarding offering the employees short-term layoffs or not (Respondent B). According to Respondent B, AB Volvo first offered the employees working with express-transports short-term layoffs in the beginning

of Covid-19 but realized already after a couple of weeks that the department is needed in order to secure the deliveries to the production plants.

Lastly, another more production-related trade-off during Covid-19 has been the one related to adjusting the production after the given governmental restrictions or shutting down the production plant. This, since it might be hard to keep distance when working in a production environment. In this question, according to Respondent D, AB Volvo clearly decided to adjust the production after the restriction by encouraging the employees to keep distance where possible, offering hand sanitizer, recommending employees to stop riding to work together etc. This has been proven to be a successful strategy as the Tuve Plant has not been forced to shut down their plant due to an outbreak of Covid-19. Instead, all stops have been related to material shortage (Respondent D).

In table 4 you will find a summary of the mentioned trade-offs and actions discussed by the respondents during the interviews in order to create a more clear picture of what actions have been taken in response to each trade-off.

Table 4: Summary of trade-offs and actions taken in response (Source: Authors)

Trade-offs during Covid-19	What actions have been taken?
A: Focusing on short-term crises management B: Focusing on long-term strategic goals	Try to find a balance by e.g., continue with digitalization projects but have although decided to have production as prio number one
A: Keeping a supplier B: Change to another one	Keep the supplier to the extent possible. Financially support and support in negotiations with 2-tier suppliers when needed
A: Focus on keeping transportation costs low B: Focus on keeping the lead-time short	Use express-transports when there is a need for production disturbances. Put production costs against transport costs and evaluate.
A: Sending employees on short-term layoffs B: Keeping the employees working	First Volvo tried to put all employees on short-term lay-offs but then decided to bring back the ones with jobs that are critical for the production.
A: Adjust production to respect the Covid-19 governmental restrictions B: Shut down the production plants	Volvo have adjusted the production to ensure that they can keep the plant going and at the same time respect all given restrictions

4.7 Summarizing table of effects and actions

In order to visualize the findings from the interviews, Table 5 was created. The aim of the table is to show how the three effects being Governmental restrictions, Transport network disturbances and Lack of critical components have affected the different parts of AB Volvos supply chain during the Covid-19 pandemic.

Table 5: Summary of major effects affecting sectors of the supply chain (Source: Authors)

	Material Supplier	Transport Supplier	Production Plant	Internal Processes
Governmental restrictions	Lockdowns, high amount of sick leave, Covid-19 outbreaks	Boarder checkpoints, Covid tests, lack of drivers	Increased sick-leave, adjust production to secure distance between workers	Offer remote work where possible, e.g., by increased digitalization. No business travel at all
Transport network disturbances	Decreased flexibility. If possible, offer replacement goods when goods are stuck in transit.	Need for increased flexibility and cooperation to secure that goods are delivered	Delayed transports. If no safety stock available, production disturbances	Increased use of express-transports to avoid risks at cross-docks etc. Cooperation between departments
Lack of critical components	Production material not ready to be sent in time	Increased number of partly or full empty runs	Production stops. Adjust production plans and schedules more often, based on goods availability	Increased collaboration with supplier to secure that the material are sent directly. Increased express-transports

5. Analysis

In the following chapter, theory and empirical findings will be combined in order to establish the foundation of the report's analysis. The analysis chapter is divided into three main sections based on the research questions for the thesis and then further into the areas that have been covered previously in the theoretical framework and empirical findings. It will follow a similar structure in order to remain consistent and to create a clear picture of how the analysis ties into

preceding chapters as well as to the research questions. In addition, the three main sections of the analysis aim to provide a coherent relation to the purpose of the study.

5.1 Effects of the Covid-19 Pandemic

The below section will discuss and further analyze the main effects that the pandemic have had on AB Volvos supply chain. These effects are divided into five main effects being; supplier-related issues, risk for Covid-19 outbreak in production, disturbances within the transport network, mismatch between material shortages and material overflow and lastly, internal organizational effects.

5.1.1 Supplier-related issues

In regards to the area of supplier-related issues as an effect of Covid-19, there are a number of similarities that can be distinguished between the theoretical framework and empirical findings of the research. Respondents D, F and H emphasize that the dominant and most critical supply chain disruption has been related to material shortages from suppliers. This material shortage has in fact had different reasons and sub-effects which is both due to lockdowns, lack of components and high percentage of sick leaves which has resulted in a lower production pace. One more specific effect related to supplier issues is the issue connected to material shortage from their second-tier suppliers, which Durach (2020) suggests affects all downstream parts of the supply chain. Furthermore, Bagul & Mukherjee (2019) discusses the importance of taking into account even the second-tier supplier when working with supply chain management. Hence, one can say that during the time of Covid-19, there is an increased risk for larger companies, like AB Volvo, as they have a more complex supply chain with even more both first and second tier suppliers.

Another effect that has been a challenge both for the purchasing department as well as the logistics department according to the interviewees is the mismatch between AB Volvos' need and both the product supplier and transport suppliers capacity. This is also a risk with JIT according to Memari et al (2018) who describes these issues as an important aspect to take into consideration for the purchasing department in order to achieve a more flexible supply chain.

This mismatch has in turn resulted in effects on the supply chain being increased costs to cope with the need for flexibility and delayed deliveries when this mismatch could not be solved, which was mentioned by most of AB Volvo's respondents. It can also be perceived to be a result of the strategy with JIT principles that is based on low or no inventory levels for the product suppliers. Therefore, when analyzing these effects and its reasons one can say that a higher inventory level would have helped AB Volvo in this case to minimize this mismatch as the company would not have been that dependent on the current capacity of the product supplier. This is also confirmed by Nikokaar & Yanadori (2022) who mentions today's over-optimized supply chains as a reason for the larger extent of disruptions that the pandemic has brought with it. On the other hand, since Covid-19 has been ongoing for almost two years, AB Volvo would most probably have experienced this mismatch anyhow. However, it might not have been to the extent that it has now become.

Furthermore, in connection to the mismatch between supply and demand, one needs to analyze the strategy with single-sourcing as a potential reason for this effect as well. As mentioned by nearly all respondents, single sourcing has been a part of Volvo's strategy for a long time. This means that they do not have any backup supplier if or when their contracted suppliers fail to deliver as expected. Several respondents mentioned that they would prefer dual sourcing during this situation with Covid-19. Dual sourcing is perceived to mitigate the risks of supplier-related disruptions due to the company often having a backup supplier when the prior supplier is facing trouble (Yu et. al, 2009). In other words, one can say that this backup supplier has the role of minimizing the risk of mismatch between supply and demand as the aim is to compensate for the prior supplier's lack of supply.

However, as Respondent A & H described during the interviews, Volvo does own or supply special machines or tools to some of their suppliers in order for them to be able to produce according to the required AB Volvo standards. This means that if Volvo would choose to go for dual or multiple sourcing strategy, they would also need to consider scenarios where a multiple setup of machines and tools would be needed. In addition, AB Volvo would also need to ensure that both suppliers produce according to the exact same standards and with the same quality, which most probably will be a huge challenge for the material that requires special handling. If you use dual sourcing and one supplier outplays the other in terms of quality or standards, then you will in the end deliver different quality on your own end products, which

is not preferable. These thoughts were also discussed with Respondent E who confirmed that this might be a challenge if Volvo chooses to change to a more dual-sourcing strategy.

Another part of the sourcing strategy that could be seen as a way of making the supply chain more resilient is the discussion about global or local sourcing, where local sourcing is perceived to be the preferred one in terms of flexibility and resilience (Han et. al, 2008). As AB Volvo has the majority of their suppliers located in Sweden and Europe, Respondent E confirmed that the Swedish plant has had less issues related to transportation and supply than the plants in the US during the pandemic. Respondent G also confirmed this by saying that AB Volvo are moving more towards regional sourcing as a way of minimizing the risk for disturbances. Furthermore, local or regional sourcing is described to be preferable also in terms of government regulations, cultural clashes etc (Bohnenkamp et. al, 2020). This can be connected to what Respondent A mentioned regarding the trade policy effects that the pandemic might have had on AB Volvo. As an example, during the pandemic Sweden has been one of the countries that have not used lockdowns or other tough regulations as countries like China and Russia have done. To conclude, one can therefore say that due to this use of a partly regional sourcing for the Swedish plants in particular, the effects of mismatch between supply and demand have been relieved. This is thanks to the shorter lead times from supplier to the plant once the goods have been produced and ready at the supplier, as well as the mitigated regulations that have been in Europe compared to other parts of the world.

5.1.2 Risk for Covid-19 outbreak in production

One effect that is directly related to the Covid-19 pandemic is the actual risk for an outbreak within the production environment. This risk was also brought up by Respondent D who is the director of logistics at the Tuve plant. In addition, it was also brought up by Belhadi et. al (2020) as an effect which can affect production plants, especially those operating within the automotive industry. This can be perceived as the effect that is placed in the end of the supply chain described in this report, with the second-tier supplier being the first and the production plant being the last. However, this does not mean that it is less important than the other ones, since the effect has the potential to cause extensive disturbances for the production plants like Tuve.

5.1.3 Disturbances within the transport network

One of the most obvious effects related to the transport networks during Covid-19 was the issues at the different cross-docks that Volvo uses for their ordinary transport network setup. This goes in line with what Falsafi et al (2018) writes about when he describes crossdock related issues as a part of the transportation risks associated with JIT principles. In addition, it also confirms what Schwerdfeger et. al (2018) mentioned about cross-docks being a common part within the transports networks for companies operating within the automotive industry. This risk became reality for AB Volvo as this was brought up as one of the main effects on the supply chain during the interviews, mainly by Respondent F. The issues were, according to Respondent F, related to lack of space and staff which resulted in increased time for loading and unloading at the cross-dock. This in turn resulted in delayed pickups and deliveries for the goods that move through the cross-docks and hence delayed deliveries to the production plants.

According to Respondent F, Volvo is highly dependent on a smooth cross-dock process in their ordinary transport network as a huge part of the production material passes at least one cross-dock on its way from supplier to the production plant. This dependence on cross-docks is also visualized in Figure 1 where Dörnhöfer et al (2016) shows the process of consolidation and deconsolidation taking place at these cross-docks. With this in mind, one can understand the negative effects that come with the capacity issues at the cross-docks as this creates a disturbance for a lot more than just one shipment. This, since a delayed consolidation in the first step does both result in a delayed consolidation for all of the goods that are on the specific trailer, which often include goods to more than one production plant. It does result in a delay as well, in the form of either consolidation or deconsolidation at the next cross-dock when there are more than one cross-dock involved in the specific network.

In addition, there have also been disturbances connected to different types of transport modes. As Respondent B mentioned, the feeling was that when Covid-19 first appeared, the airfreight business disappeared and nothing worked like before. Then, Respondent F brought up sea freight as a business that has been greatly affected as well, mainly in terms of port lockdowns and container shortage. However, the road freight has, according to both Respondent E & F, managed Covid-19 relatively well. This can be related to what Lindsey & Mahmassani (2017) mentioned about the supply chain risk that comes with capacity issues from a contracted transport supplier, which can be perceived to be the case in both air and sea freight. When

applying this on the sea-freight issues, Respondent F stated that this situation also resulted in a lot of goods getting stuck in transit as the goods sometimes already were shipped to the ports but then the ferry was canceled or there was a lack of staff.

Goods stuck in transit is also something that is mentioned by Alberetzeth et al (2019) as a potential transport-related disruption, which in turn confirms that the Covid-19 disruptions discussed above goes in line with what the theory says about transportation disruptions. The same occurs to what Pellegrino et. al (2018) said about the lack of forecast during uncertainty leading to an increased risk of capacity issues. This lack of forecast as an effect of Covid-19 and the uncertainties that comes with it was also brought up by Respondent F as one of the biggest transport-related challenges during the time of Covid-19. One can therefore conclude that one effect of Covid-19 is transport suppliers capacity issues, that is mainly caused by a lack of forecasts being provided to both product and transport suppliers. This lack of forecasts are in turn a result of all the different uncertainties that come with Covid-19.

However, one can not say that the capacity issues for air and sea are completely due to the lack of forecasts. The issues with air transport is also, according to Respondent B, because of the fact that a lot of air freight forwarders use passenger aircrafts as a way to transport goods. Hence, when the travel restrictions appeared, a lot of flights were canceled meaning that there was no way to transport the goods either. In addition, Respondent E & F both discussed the increased use of e-commerce during Covid-19 as a potential reason for the capacity issues for sea-freight. This is because when the stores closed down or when consumers were recommended to stay at home, a lot of them started to order things online. Since some of the largest low value online-retailers like Wish, Alibaba and Amazon are located on the other side of the ocean, the increased use of sea-freight resulted in other companies suffering.

Furthermore, there are some minor effects of the Covid-19 that have been a part of the experienced disturbances within the transport network according to the respondents. Some of these are lack of drivers, border controls, face masks and requirement on vaccine passports. However, these effects have not been the ones with the greatest impact on AB Volvo's supply chain and therefore they will not be discussed in further detail in this report.

5.1.4 Mismatch between material shortage and material overflow

Another effect related to JIT is the mismatch between having material shortages on one hand but on the other hand struggling with material abundance (Respondent D & E). This can be related to JIT as this mismatch can be perceived to be a result of the aim of minimizing buffers in combination with working with a complex standard transport network involving cross-docks etc. When having this structure during a time like Covid-19, the effect is that some suppliers will struggle with getting the goods ready in time for the standard transport pickup time while others will already have sent their goods. This was confirmed by several respondents during the interviews as well. Furthermore, this results in AB Volvo having material shortages of some of the production material while they will have a lot of goods moving towards their production plants that can not be used in production when it arrives since the shortage of the other material might have the impact of production stops or at least disturbances. Since the aim of JIT is to minimize buffers and eliminate waste such as waiting times etc, one can say that this kind of effect might have the reverse result than planned for. This is because the result of this effect is mainly that Volvo gets higher buffers on some materials that can not be used in production instead of having higher buffers on the most critical parts for production capacity. The authors therefore believe that if Volvo would have had higher buffers on the most critical parts, they would have been able to use the other materials that arrive at the plant directly without having to store it first.

According to Respondent D, there has even been the case at the Tuve plant that they have had so much goods in the backyard of the plant that they have had trouble finding it. Hence, another effect is that the plant sometimes has to order new material in order to manage production while in reality, the first order material is most probably right outside the plant. As Mc Lachlin (1997) wrote, one of the main goal with JIT is to minimize the warehouse-related costs and therefore one can say that one of the reasons for this described mismatch between material shortage and material abundance is that Volvo focuses on JIT principles and try to eliminate waste in every part of the supply chain. This can also be related to what Swanson & Lankford (1998) described as the principles with JIT manufacturing. This was to get the goods delivered right when needed and avoid non-value added activities. On the other hand, during times of Covid-19 when delayed transports are a part of the everyday life for AB Volvo, following these principles might as well get the reverse effect of increased need for external warehouses and other wastes like lost goods, which was mentioned by Respondent D.

Another aspect that might contribute to this mismatch is the aspect of geographic proximity in regard to AB Volvo's first-tier suppliers. Since AB Volvo has suppliers operating worldwide, there is a difference in lead time from the different suppliers that needs to be taken into consideration when planning for production. The potential challenge here, according to the authors, is that some of the material suppliers located in e.g. the US, China or Japan might produce material that is equally critical for production as the material being delivered from a supplier located in Gothenburg. The result of this is that when these suppliers are facing disturbances in their production, the supplier located in Gothenburg will benefit from the increased flexibility in terms of lead time. This geographic proximity is, according to Holl et al (2007) a benefit when working with JIT as it enables this increased flexibility in contrast to the decreased flexibility from the suppliers located far away from the plant. This might also be one of the reasons for the, according to Respondent E, increased challenges for the plants located in the US and Brazil in contrast to the Swedish plant. Since AB Volvo works with single sourcing and has a large majority of suppliers located in Europe, this means that the general lead time from suppliers to the plants in US and Brazil is far more time consuming.

5.1.5 Internal organizational effects

The pandemic has not only resulted in effects that impact the direct flow of material from the supplier to the production plant, but has also had more indirect effects that have had an impact on the internal processes and standards that regularly are set up in order to manage these flows of materials. An indirect effect which Covid-19 has contributed to is that AB Volvo has been forced to focus more on their internal operations and procedures in order to meet the pandemic's challenges and adequately respond (Respondent G). In line with this, Dwiedienawati et.al (2021) emphasizes that despite facing a crisis; an organization can still encounter opportunities that can benefit their current operations in various ways. As respondent B mentioned, an indirect effect of the pandemic was the increased need for digitalization. AB Volvo had to evaluate and reassess the situation in terms of how internal processes and operations are being conducted. Pearson and Clair (1998) highlights that this is nothing out of the ordinary and that collective adaptation and replacement of old practices becomes an eventuality after facing a crisis. Thus, AB Volvo were able to adapt and maintain their internal processes even while being unable to physically attend the collective workspace to the same extent as before. In turn, one of the things that define successive crisis management efforts are

whenever core activities and operations are sustained in terms of organizational stakeholders (Pearson & Clair, 1998).

A broader effect is the increased collaboration within the organization that developed as a response to the crisis. Dayton (2009) highlights that a key determinant in effective crisis management is how well a group communicates and develops internal processes that are necessary in order to combat the crisis. Respondent B, D, F and H mentioned that the frequency in which meetings occur between departments have increased which in turn has created a stronger connection and understanding between them. A possible explanation to the success of AB Volvo's crisis management could very well be due to their ability of distributing responsibilities and making collective decisions where all departments have a chance to contribute. Pearson and Clair (1998) indicate that group efforts are much more likely to succeed whenever these parameters can be achieved and is something that respondent F stresses, namely the importance of ensuring that everyone feels included and part of the solution.

5.2 Mitigative Actions taken in Response to the Pandemic

Covid-19 is unique as its global disruptions affect all parts of the supply chain and different actions need to be taken based on where in the supply chain you are and what type of effects you are trying to mitigate. Hence, this following section will discuss the different actions taken by AB Volvo in order to mitigate the previously mentioned effects that the pandemic have had on their supply chain. The section is divided into five main actions being; Supplier management, increased use of express transports, adjusting production to minimize risk for Covid-19 outbreak, increased use of external warehouses as well as crisis management.

5.2.1 Increased focus on supplier management

One of the most obvious actions that have been taken from AB Volvo's side in order to reduce the negative impact on their supply chain during Covid-19 is, according to close to all respondents, to work more actively with supplier management. This occurs to both the material suppliers as well as the transport suppliers. All of the respondents agree that the supplier relationship and collaboration have increased as a result of Covid-19. As described in the empirical findings, there have been different effects from Covid-19 on the supply chain of AB Volvo and increased supplier management is an action that has had a positive impact in mitigating these effects.

One example of an action is the work that has been done by the purchasing department in order to make sure that AB Volvo is the preferred customer whenever the supplier has material that is ready to be shipped (Respondent F). This has, according to Respondent F, been done by working with more transparency and by using a more open communication strategy. This is a recommended strategy to use during crises according to the literature as well. As (Schiele et. al, 2012) mentioned, there is always a risk when you are dependent on your supplier that that supplier chooses to serve your competitors instead of you. This becomes even more important to avoid during times of crises, when the case might be that you are even more dependent on your supplier, especially when you work with single sourcing like AB Volvo and have no access to any backup supplier.

Also, the increased level of effective communication towards one's suppliers is an action that is mentioned as crucial for buying companies during times of crisis (Hittle & Leonard, 2011). As mentioned before, during Covid-19 AB Volvo have suffered from unreliable or even non-existing forecasts towards their suppliers, which have in turn affected the suppliers in terms of decreased possibilities for production and resource planning. Therefore, in order to be able to help each other and work together to survive the crisis, the partnership between AB Volvo and their suppliers have had a great impact on the final result. This is also confirmed by Yang et. al (2021), who mentioned the unplanned demand changes during times of crises as a contributing factor to increase the use of supplier management.

Another action that has been taken in the area of supplier management is that AB Volvo have decided to support some of their suppliers financially by, among other things, support buying some material even though they knew that they would not be able to use the material until a later stage. This can be perceived to be a sign of what Schiele et. Al (2012) mentioned about today's business environment where the buyer, in this case AB Volvo, and supplier are both part of a relationship based on a mutual dependence on each other. If it was the case that AB Volvo was not dependent on their specific supplier, they most probably would not have helped them in the way they have done during the crisis. Therefore, this can be seen as an action taken in order to mitigate the effects of the supplier-related issues involving the financial issues they have suffered from the lockdowns, component shortage etc. In addition, this can also be perceived to be an action taken in order to gain trust from the supplier as well as an action in

order to make sure that they remain as the preferred customer, which has been discussed earlier. This action is also supported by Van Hoek (2020) who according to Table 1 recommended companies to only seek payment and financial support from selected suppliers during times of crises, as a way of establishing a good and mutual relationship with them.

Furthermore, by helping suppliers in different ways during a crisis, AB Volvo is showing that they are familiar with the importance of keeping the suppliers close to the company in order to survive a crisis like Covid-19. This can also be connected to what Kannan & Tan (2002) discuss about the need for companies operating in today's business environment to view external suppliers as an extended part of the company rather than an external seller or producer. Hence, since the most obvious effect of Covid-19 on AB Volvo's supply chain is the material shortage, AB Volvo does also understand that without their suppliers it is not possible to produce anything at all at the different plants. Therefore, as Respondent C, D, E & G all mentioned, AB Volvo has understood the importance of viewing the whole supply chain as one and then taking actions based on what is best for them in the long run. Hence, supporting suppliers financially is one action that aims for an increased long-term relationship between AB Volvo and their suppliers.

5.2.2 Increased use of express transports

The departments within AB Volvo that have gained an increased focus and additional resources in order to cope with the crisis have been the express transport department. As the main focus has been to sustain production and ensure that it runs smoothly, the increased need for express transports have become a factor to take into consideration. Hence, both the material control department that are responsible for placing these bookings as well as the express department that ensure that the booking gets a dedicated transport supplier have been of high importance. Close to all respondents confirmed that one action that has been taken from AB Volvo's side during this crisis is to increase the number of express bookings. This, even though express transports come with a higher price for the actual transport.

On the other hand, the use of express transports as an action to mitigate the effect of transport related disturbances are also recommended by Falsafi et al (2018). These disturbances, according to Falsafi et al. (2018), for example, include capacity issues for a contracted transport supplier or issues related to the handling at the different cross-docks that are a part of the normal transport network. Since these are two effects that have been described earlier as issues that

have affected AB Volvos supply chain during Covid-19, one can say that the increased use of express transports can be perceived to be a natural action in order to try to keep the delivery precision on a level that have the minimal effect on the production plants. In other words, the increased use of express transports has also been an action in order to mitigate the negative impact of the capacity issues at the cross-docks. This is because express transports usually do not pass through the cross-docks (Respondent B) and by that move the goods directly from the first-tier supplier to the production plant. Hence, by using express transports AB Volvo have also found a way to try to decrease the need for capacity at the cross-docks and thereby focus the cross-docks on the goods that have the possibility to go through the normal transport network.

Another action that has a close connection to the use of express transports is the use of spot bids. This is an action that is recommended by both Pellegrino et. al (2018) and Lindsey & Mahmassani (2017) as an action that helps the buying company to find capacity when a contracted transport supplier is facing capacity issues, which has been the case for AB Volvo during the Covid-19 pandemic. As with the case of express transports, spot bid solutions do also come with a higher transportation cost (Pellegrino et. al, 2018; Lindsey & Mahmassani, 2017). However, since the aim for AB Volvo during Covid-19 has been to secure production, one can conclude that they have chosen to accept the increased costs by using both express transports and spot bid transports as an action to fulfill the goal. In addition, Respondent B, F & H all mentioned that airfreight related spotibid, express transports have been an action to mitigate the negative impact caused by the huge decrease in sea freight during the pandemic as well as the capacity issues for the contracted airfreight forwarders.

The increased use of express transports can also be perceived to be an action that focuses on minimizing the negative impact of supplier-related issues. This is because, as Respondent B said, express transports shorten the lead times by avoiding at least one but often more than one stop within the network. Therefore, when the material supplier is facing material shortage issues and therefore cannot respect the original pickup dates for the standard transport network, AB Volvo has chosen to send the goods as an express transport instead. By doing so, they ensure that the delayed readiness of the material has as low impact as possible on production. This is done by using the shortcut in terms of express transports, to ensure that the material is

still delivered in time or with minimal delay compared to the longer lead times in the standard transport network. This action is also recommended by Falsafi et al. (2018).

Lastly, the increased use of express transports can be seen as a way for AB Volvo to minimize the negative effects of the JIT strategy involving lower inventory levels and JIT deliveries to the plants. This is because express transports, in the eyes of the authors, seems to also have been an action to mitigate the effects that comes with low inventory levels during times of disruptions like Covid-19. In addition, as Holl et al (2007) mentioned, a great part of JIT transportation is to secure flexibility. Therefore, one can say that using express transports as a backup solution for the regular transport network is a way of securing flexibility within the transportation part of JIT. This reasoning regarding the use of express transports as a way to hide the issues related to the JIT principles, is also connected to what Respondent D mentioned about AB Volvo sometimes, during Covid-19, using express transports as a way of ensuring that the material arrived at the production plant in time. Even though the same material from the ordinary transport network might have been delivered to the plant already, it cannot be found at the goods reception due to the area being overloaded with goods. The overload of goods at the area outside the plant, the goods reception, can be perceived to be a result of the imbalance between material shortage and material abundance. However, this does not go in line with the main principles of JIT which are to eliminate waste. To order additional material with express transports because the material cannot be found outside the plant cannot be perceived as a way of working to eliminate waste. However, the result of not doing so and the risk of not finding the goods at all makes it a necessity. Ultimately, because it otherwise will cause disturbances in the production (Respondent D).

5.2.3 Adjust production to minimize the risk of Covid-19 outbreak

In order to adequately mitigate the risks associated with Covid-19 and to prevent outbreaks within the production plant environments, protocols and safety guidelines had to be established (Respondent D). The need to prioritize employee safety in terms of avoiding Covid-19 was essential in maintaining production as outbreaks on a production level would be catastrophic as it could result in production stops. To minimize potential risks that could lead to stops in the production, it was vital to follow governmental guidelines and restrictions. As far as mitigating actions goes, adjusting their production plant environments by encouraging employees to keep a distance both at work and on their way to work and offering hand sanitizer proved to be successful (Repondent D). The reason why it was successful is that no labor issues ever

stemmed from a Covid-19 outbreak in the production environment. As discussed by Bai et. al (2016), it is of great importance to always consider disruptions that emerge from the production plant environment itself as these could cause ripples throughout the entire supply chain. In this case it was external factors that played a role in halting AB Volvo's production as the internal adjustments of handling Covid-19 related risks proved to be fruitful.

5.2.4 Increased use of external warehouses

An increased demand for storing materials developed as a result of having an abundance of certain materials and a shortage of other more critical components which led to disturbances in AB Volvo's supply chain (Respondent D & E). Thus, AB Volvo had to quickly adapt and modify their JIT-oriented supply chain to allow buffers for the materials that could not immediately be used. In short, the organization was forced to start using external warehouses to store the incoming shipments of goods due to limited capacity within the production plants but also due to the increased number of last-minute changes in the production planning that resulted in an increased use for external warehouses as well, as described by Respondent D & H. However, it is not as simple as receiving more materials and therefore needing additional storage. It has been established that a major reason for disruptions in AB Volvo's supply chain has been due to issues at suppliers.

The consequences of having a supplier shut down their business would be far more catastrophic than financially supporting them. Hence, at times when it was deemed necessary, AB Volvo came to the conclusion that they would purchase additional materials from them in order to keep them afloat.

Thus, the new demand for extra storage spaces and in turn an increased use of external warehouses. This action can therefore be seen as an action that supports the move from Just In Time to Just In Case, as described by Brakman et. al (2020) as an emerging strategy which seeks to increase the resilience of supply chains by increasing the buffers of material with the aim of creating a more agile supply chain. This is also in a way confirmed by Respondent D since he said that there are ongoing discussions regarding the permanent use of external warehouses, which make this action a potential long-lasting solution to cope with the risk of future disturbances caused by material shortages. This also seems to be a potential solution not only for the Tuve plant but also for the rest of the plants experiencing this issue since Respondent B mentioned that there has been an increased use of external warehouses as well

as an increased use of express transports with an external warehouse as delivery point during Covid-19. The action can also be perceived as an action that aims to increase the flexibility of the production planning. This is because the external warehouses are often located in close proximity to the production plant which decreases the lead time from the warehouse to the production plant compared to the lead time from the first-tier supplier (that is sometimes located outside of Europe) to the production plants. Therefore, this action is perceived to be an action that encourages the move towards a more resilient supply chain as a result of the Covid-19 pandemic (Nikobaar & Yanadoori, 2021; Ivanov, 2021; Ozdemir et. al, 2020 & Hobbs, 2020)

5.2.5 Crisis management

When faced with the Covid-19 pandemic, AB Volvo moved swiftly when enforcing crisis management actions in order to ensure operability throughout the organization (Respondent F). As mentioned by Parsons (1996) and Coombs & Laufer (2017) it is of great importance to remain flexible when constructing crisis management plans, except when there are standard operating procedures in place for specific scenarios. Respondent D indicated that scenario planning for a single plant shutting down was something that they had already prepared for. However, the uncertainty that a global pandemic brought with it was unprecedented and as respondent D, F and G touched upon, predefined processes can only take one so far. It is therefore critical to stress the need for organizational flexibility and quick adaptation. The organization could for example not be as flexible as they would like due to the urgency of certain decisions which Dayton (2009) discussed in relation to mitigating negative effects.

Respondent G emphasized that AB Volvo were as prepared as an organization can be and as Dwiedienawati (2021) points out; it is difficult for leaders to act alone in times of uncertainty and the crisis management team hence plays a vital role. It becomes especially challenging when a team is trying to navigate through abundances of information and respondent F therefore suggested that a success factor for AB Volvo was high transparency. By being transparent and not withholding negative information it became easier to keep employees engaged and feeling included in the decision making. Parsons (1996) emphasizes that open lines of communication and providing transparency throughout all levels of the organization is a key factor in steering successfully out of a crisis. As nearly all respondents have mentioned, the company has been effective in getting everyone on the same page and working together towards the greater interest of the company rather than individual departments. By organizing

daily and weekly meetings and being united against a common enemy, a greater connection to the company itself and an increased understanding of one's coworkers has been the result. In turn, AB Volvo has proven to be a flexible organization in terms of reorganizing and prioritizing between the plants and their needs while keeping their employees engaged.

5.3 The Future of Volvo's Supply Chain

The chapter below will delve further into how the Covid-19 pandemic may continue to affect the organization in the years to come. In addition, when or if the time comes when the pandemic is finally in the past, one may ask themselves if AB Volvo's operations will ever go back to the way they were or if new guidelines have been established.

5.3.1 An organizational perspective

In regards to AB Volvo and the future configuration of their supply chain, the Covid-19 pandemic has unquestionably had its effects on the organization. Although, this does not necessarily imply that the future ahead of them is riddled with hurdles; even if the general perception of the pandemic is of a negative nature. Instead, one can argue that a lot of the challenges and negative impacts of the pandemic are in the organization's past, at least with the information available during the writing of this report. In the case of AB Volvo, a lot of useful knowledge has been gathered and it is not unreasonable to believe that the company would be better prepared in the event of an upcoming crisis. As mentioned previously, the sheer size and magnitude of the crisis was something that AB Volvo had not foreseen or planned for. If scenario planning within the company historically included crises of a smaller scale; it is safe to say that they now include crises of a larger variety as they now know for certain that it is a possibility and can therefore plan accordingly. Crisis management efforts are deemed effective whenever lessons are learned and the knowledge gathered can be used in future crises (Pearson & Clair, 1998). Thus, a lot of what has been learned during the Covid-19 pandemic should be applicable in future similar crises. However, this mostly applies to the scale of the crisis and not the characteristics of a pandemic specifically as crises of another type may be more unpredictable due to not having any precedent to rely on.

It is also worth noting that due to the unprecedented nature of the Covid-19 pandemic, this called for overarching group efforts both internally and externally as emphasized by respondent F. Hence, by gaining a greater understanding for one's coworkers, not only in other

departments of the organization but also outside of the organization one can be better prepared in the future and in turn act quicker in the event of a crisis. Ultimately, the entire supply chain has gained increased visibility as a result of the crisis. Mostly because AB Volvo has been forced to closely analyze and make necessary adjustments to many of its components throughout the pandemic in order to succeed. It is therefore essential that when going forward, AB Volvo remains flexible in terms of balancing their short-term decision making which naturally gains an increasing amount of attention during a crisis. Although, even if a lot of time and resources are devoted towards managing daily operations, it is vital to not lose sight of long-term goals. Hence, continuing to simultaneously work towards these and the vision of the company in order to maintain and ensure that the organization still has a place in the business landscape further down the road.

5.3.2 Warehouse and sourcing strategies

From a supply chain perspective, due to the action taken regarding the increased use of external warehouses, one may suggest that AB Volvo re-evaluates their current inventory usage and way of handling incoming materials. Firstly because ordering materials on a three week basis leaves their supply chain vulnerable to last-minute changes which became clear during the crisis. Secondly, these last-minute changes have proven that maintaining a flexible and agile supply chain can be quite demanding and in the face of a crisis; external warehouses that can manage higher inventory levels can be the difference between maintaining production and a production stop. Lastly, as mentioned by several respondents, inventory and warehouse costs are quite cheap in Sweden, especially in relation to the increasing transportation costs. Thus, when confronted with the option of relying solely on JIT-oriented practices or maintaining some sort of buffer that can alleviate the pressure; it is arguably wise if AB Volvo can find a way to bridge the gap between them.

Another aspect that the authors believe will receive more attention when planning for the future of the supply chain, based on the response from the majority of the respondents, is the strategy with single sourcing strategy. The perception from the interviewees was that some of the respondents were highly doubting if the strategy with single sourcing is the one that should be used in the future. Since it has been discussed in this paper that AB Volvo seems to move away from JIT to start working towards having a more resilient supply chain, switching to dual or multiple sourcing might be perceived to be a preferable decision. Single-sourcing is the

preferred strategy for companies working with JIT due to the possibility to work more with long-term suppliers and relationships while dual or multiple sourcing is the preferred one while working towards a resilient supply chain Yu et. al, (2009). This, since dual or multiple sourcing enables the company to have a backup solution when one of the suppliers fails to deliver.

On the other hand, during a global crisis like Covid-19 the author believes that there is a great challenge with working with dual or multiple sourcing as well. This is because, as Bagul & Mukherjee (2019) mentions, it is of high importance to take even your 2-tier suppliers into consideration. This needs to achieve greater attention as there is a risk of two first-tier suppliers using the same second-tier supplier. Therefore, During Covid-19, which is perceived to be a global crisis that has affected 97% of the supply chains all over the world according to ISM (2020), the risk of second-tier suppliers being the ones facing issues increases. This was also confirmed by Respondent D and as the second-tier suppliers have been an issue, there is no evidence that dual sourcing would have helped during Covid-19, if the two suppliers would have used the same second-tier supplier. In cases like this, the authors therefore believe that it might even be a benefit to work with single sourcing in order to work closely with long-term suppliers that you have a good relationship with. This, since this most probably will increase the chance of being the preferred customer, which is something that has been confirmed to be of highest importance earlier in the report.

In addition, as discussed with Respondent E, there will also be a challenge related to AB Volvo's possibility to secure the quality and standards of the material if working with dual or multiple sourcing. To connect this reasoning to the literature, one can say that single sourcing and long-term relationships with suppliers are preferable while dual or multiple sourcing might be preferable during short-term crises as you have the possibility to secure capacity even though your main supplier is experiencing capacity issues (Whitney et. al, 2014).

5.3.3 Overall supply chain strategy and digitization

From a more general and holistic point of view, it seems based on the actions taken that AB Volvo is already moving in the direction towards a more resilient supply chain. One example of this is that some of their actions are actually listed as the resilience efforts by Van Hoek (2020). This includes higher buffers, taking care of critical suppliers (both financially and long-term relationships) as well as accelerated digitization initiatives which are all actions that were

discussed during the interviews as a way of mitigating the negative impact of Covid-19 on the supply chain. Based on this, one can say that there are signs that indicate that AB Volvo will work for a more resilient supply chain in the future. This is also supported by the actions listed in Table 4 where AB Volvo have taken decisions based on different trade-offs related to the Covid-19 issues. Nevertheless, one needs to take into consideration that moving from a supply chain based on JIT principles to a more resilient supply chain comes with some challenges as well. One of these challenges is partly brought up by Respondent C who mentioned the challenge of trying to increase the buffers when the supplier does not have the capacity to produce at the pace needed in order to increase the buffers. Therefore, the move towards a more resilient supply chain will not be a quick fix for AB Volvo but more of a continuous work that will be dependent on a cross-functional collaboration between both the internal departments as well as the external material and transport suppliers.

Furthermore, it seems like an increased understanding for the whole supply chain in combination with increased digitization will lead to a more visible supply chain, which in turn has the potential to create an even more resilient supply chain according to Van Hoek (2020). This, as AB Volvo will gain a greater overview of their supply chain and therefore, most probably, will be able to take the needed mitigating decisions at an earlier stage of the process. Hence, the increased focus on digitization has also proven to be a key factor for the handling of express transports according to both Respondent B & D already during Covid-19. Therefore, since AB Volvo have already understood the benefit of having a more digitized supply chain and working processes, the authors strongly believe that this focus will remain in order to gain even more advantages out of it in the future.

6. Conclusions and future recommendations

In conclusion, AB Volvo were faced with several challenges when the Covid-19 pandemic initially made its entrance and its effects still echo throughout their supply chain even two years later. Among the most prevalent effects were component shortages from suppliers, disturbances in the transport network and overall capacity issues both internally and externally due to certain material overflow. In turn this required mitigating actions from AB Volvo's side and some of these actions included actively working closer with their suppliers and supporting them whenever it was deemed necessary. Additionally, the crisis called for increased collaborative efforts internally to ensure that everyone was on the same page and had as much essential information as possible when making decisions. Despite the disruptions caused by the Covid-19 pandemic, the organization remained flexible in containing it and adjusting their supply chain to the new conditions, whether it was through express transports or using external warehouses. In a more practical sense, AB Volvo were forced to diverge from their JIT-oriented supply chain and way of conducting their operations. This meant that the organization had to begin managing higher inventory levels and ultimately expand on their current idea of how the supply chain configuration works in order to remain more resilient.

Based on the findings of the study, the authors propose the following going forward:

- Continually examining the vulnerability and resilience of their supply chain and possibly moving away from a JIT mindset to instead working with buffers and higher inventory levels in the case of a crisis
- Re-evaluate their sourcing strategies to work more closely with suppliers in geographical areas closer to the production plants and review their single sourcing strategy in favor of exploring multiple supplier sourcing strategies for the most critical suppliers if a crisis occurs
- Continue to work closely with their suppliers as it has proven to be a success factor when managing the effects of the crisis as well as fostering cross-functionality within the organization in order to respond and act more quickly

In terms of future research, it would be of great interest to explore the perspectives of the suppliers themselves in terms of how the Covid-19 pandemic affected them. As stated in the paper, it was difficult to find willing suppliers that wanted to participate in the study which partly could be explained by one of the authors working at AB Volvo. Thus, diving further into their insights and how they experienced the crisis could prove beneficial in establishing a more complete picture of the crisis.

Moreover, something that came to light during the writing of this report and which the authors found especially interesting was the constant balance act between achieving short-term strategic goals and still working towards the organization's long-term strategic goals. Hence, further research could explore the dynamic between short- and long-term goals within an organization especially in the midst of a crisis as this has proven to be something that is difficult to manage in the face of adversity. Lastly, the authors would in future research like to see a more critical view of JIT-practices as these do not necessarily do what they are intended to do. More specifically when disruptions occur; JIT can have the opposite effect of what it aims to achieve, which is eliminating waste. As seen in AB Volvo the end result became more express transports and higher inventory levels which required external warehouses. It would therefore be interesting to see more research that does not automatically establish JIT as the go-to way of handling one's operations but rather sees to the more complex and uncertain business landscape that firms operate in today.

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Appendix

Appendix 1: General outline of the interview questions

Questions

1. From the perspective of your department, what effects of the Covid-19 would you say have been the most significant ones? Please elaborate.
2. Have these effects affected your pre-defined processes and ways of working? If yes, in what way?
3. Have your department taken any actions in order to better handle these effects? If yes, please elaborate on what type of actions have been taken and why.
4. What measures have been necessary to take in order to minimize the negative effects of the Covid-19 pandemic on your production?
5. From a broader perspective, do you think AB Volvo will re-evaluate where their suppliers are located geographically or do you think that it will go back to the way it was? Will the strategy remain the same for the most critical suppliers?
6. How would you best describe AB Volvo's strategy with Just In Time? Do you think that this strategy has been affected by the Covid-19 pandemic? Please elaborate.
7. How would you say that your relationship with the different stakeholders (material and transport suppliers) have been affected by the Covid-19 pandemic?
8. From an internal perspective: Has the pandemic affected the collaboration between the different departments within the company? If yes, in what way?

9. In terms of crisis management and mitigating actions, was that something that AB Volvo actively worked with before the pandemic and in that case, was it of use for the organization?
10. Do you know anyone else who you think could contribute to the report and would be interested in participating in an interview?