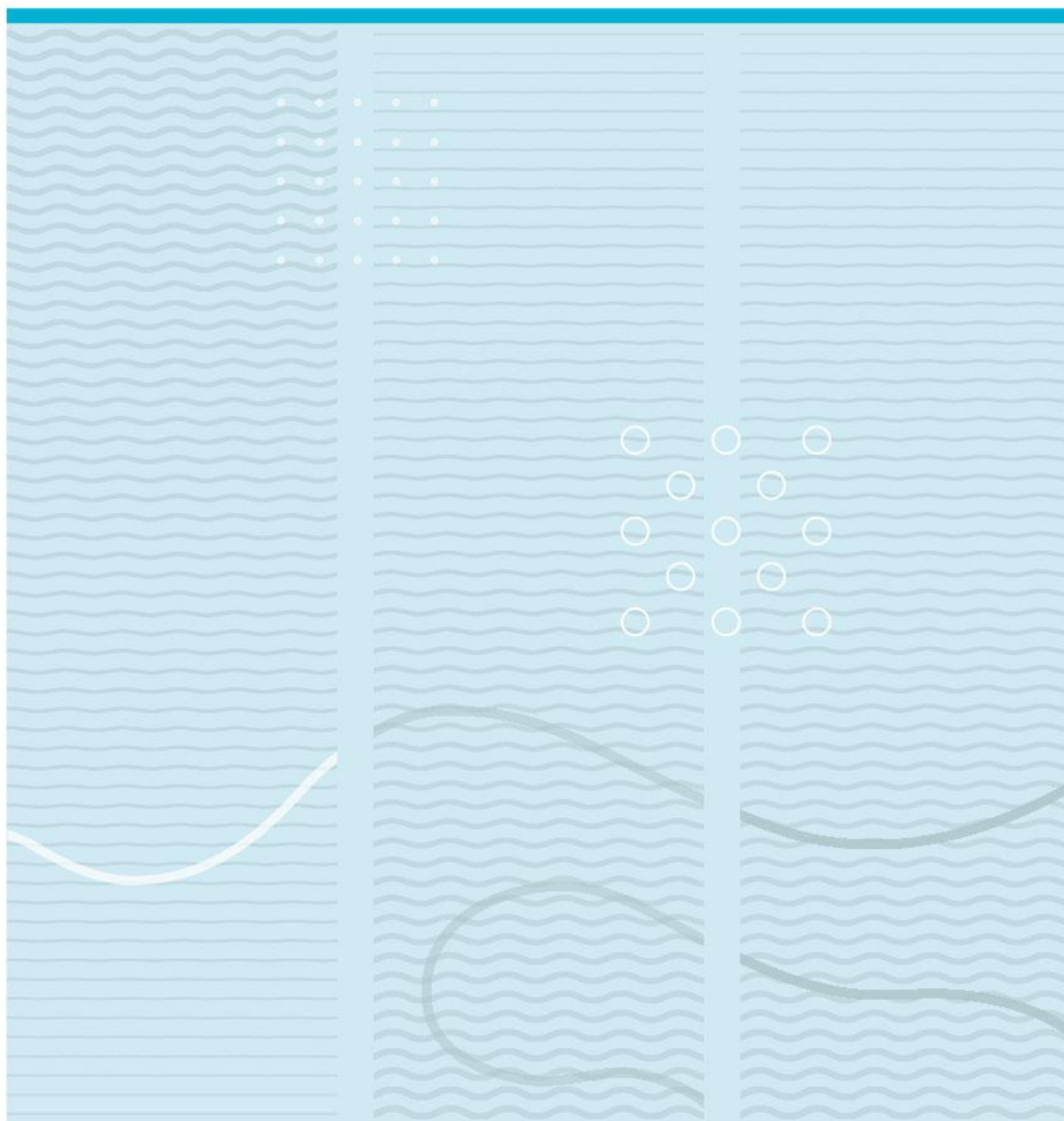


The Impact of COVID-19 on Global Supply Chains

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This thesis is worth 30 study points

Executive Summary

In a short period of time, the COVID-19 pandemic has had a dramatic impact on the whole world and changed the way we live our lives. Global supply chains, which are highly dependent on geopolitical factors, have seen major disruptions in their operations as a result of COVID-19. This has resulted in shortages and shifts in demands, leading to severe delays both from the suppliers and to the end customer.

The purpose of the master thesis is to discover how various firms have been impacted by COVID-19, as well as how they can become better prepared for future disruptions in their supply chain. The master thesis is based on the literature review from the preliminary thesis, which revealed a clear need for more robust and resilient supply chains. According to Taleb, today's global supply chains have become especially vulnerable to disruptions, as they have chased for higher efficiency and consequently paid less attention to risk management strategies (Taleb, 2012).

From the theoretical findings, we established four factors that we see as the most important for a firm's ability to handle disruptions. Those are complexity, communication, risk management and geopolitical factors. Additionally, we created eight propositions, that we confirmed or denied through our findings. For our study, we wanted to use a qualitative approach by gathering information through 10 in-dept interviews. This provided detailed information from multiple firms where we discovered the differences and similarities between them. In the empirical findings we identified that few of the firms were prepared for the pandemic. While all of them were affected in some way, the larger and more robust firms managed themselves better than the smaller ones. Although several of the firms had a decline in sales and were forced to lay-off some of their employees, most of the firms managed to get back on schedule relatively quickly with few delays to the end customer.

From the discussion, we established several measures that firms can incorporate to become better prepared for future disruptions. The most essential are analysis of the firm's stakeholders and becoming aware of the risk involved with each supplier, having a safety stock of critical components that potentially can lead to bottle necks in the production and lastly the shift to digitalized supply chains that will enhance the communication flow and transparency with the supply chain partners. This study contributes to increased knowledge and understanding of the four factors that are essential for a firm to handle disruptions, as well as measures the firms can take to be more robust and resilient for future disruptions in the supply chain. This is especially important to be aware of in an uncertain future where disruptions occur more frequently.

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Preface

The master thesis marks the end of our master study in Business Administration with a specialization in industrial economics, at the University of South-Eastern Norway. The master thesis is based on our preliminary project, which was completed in the fall of 2020.

The process of writing this thesis have been challenging and provided us with great insight to the possibilities and risks related to today's supply chains, and which measures that can be incorporated by firms to mitigate some of these risks.

We want to use this opportunity to thank our supervisor Dr. David S. A. Guttormsen for his help and guidance, by providing comprehensive feedback on mail and in video meetings. He has always been easy to reach out to and quick to answer if we had any questions.

Additionally, we want to thank the firms that participated in our study. Their contributions have been very valuable for our study, and we wish them all the best in the future.

Hokksund & Kongsvinger, May 30th, 2021

Fredrik Pedersen & Lise Cecilie Nylænder

1 Introduction

In just a short period, the COVID-19 pandemic has affected the whole world and had a dramatic impact on how we people's lives. National restrictions have resulted in numerous firms being forced to shut down most of their business activities where several firms have gone bankrupt (Kumar & Managi, 2020). Global supply chains, which are highly dependent on geopolitical factors, have seen major disruptions in their activities as a result of the virus. Global supply chains are defined as networks that expand across borders, where the purpose is to source goods and services (CIPS, 2020)

1.1 Purpose of the Thesis

The purpose of the master thesis is to study COVID-19's impact on global supply chains and suggest how to mitigate these effects. The core literature areas that have been reviewed are global supply chains, emerging technologies, risk management, and COVID-19. Previous research has shown a clear need for more robust and resilient supply chains. While striving for efficiency and paying minimal attention to risk management strategies, today's global supply chains have become especially vulnerable to disruptions (Taleb, 2012). Several authors propose risk mitigating strategies to combat some of the risks related to the COVID-19. Unfortunately, most of the recommendations lack any research-based evidence (Miroudot, 2020).

Furthermore, we want to study if there is a connection between global supply chains and emerging technologies and how risk management and advancements in technologies can strengthen the supply chains, making them more robust and resilient. Several authors agree on the importance of emerging technologies and how digitalization can contribute to more robust and resilient supply chains in the future (Belhadi et al., 2021; Tsolakis, Harrington, & Singh Srjai, 2020).

1.2 Research Question

COVID-19 is a global pandemic that has affected all industries and made the world economy even more unstable. Meanwhile, the technology is developing rapidly, creating new and improved solutions every day. Therefore, we see it as highly relevant to discover how today's firms have been impacted by the pandemic, and which measures firms can take to make their supply chains more resilient and robust in the future. Our research question is as follows:

How have multinational firms been affected by COVID-19, and how can they improve their robustness and resilience to handle disruptions in their global supply chains?

We have chosen to limit the scope of our thesis to global supply chains and firms that have their business operations both domestically and internationally. The time frame of the study is from January to June of 2021; hence, we have set a limit for the number of interview candidates. The optimal outcome is five candidates from firms with more than 1.000 employees, and five candidates from firms with less than 1.000 employees. By doing so, we can compare the size difference between different firms and see if this has had a significant effect on the impact from the pandemic, and the measures that they should incorporate. The study will provide knowledge on how firms can create robustness and resilience in their supply chains, which in turn gives them a competitive advantage.

1.3 Structure of the Thesis

The master thesis is structured into six chapters. Chapter two presents a theoretical framework that is based on previous research, relevant to our research question. In addition, essential definitions are defined to create a good understanding of the theoretical framework, and this is also where our propositions will be presented. The chapter is concluded with a theoretical model. Chapter three presents the methodological choices we have taken during the study, including research strategy, research design, method for data collection and method for data analysis. The quality of the research is discussed before the research process is visually summarized. Chapter four presents the empirical results from the qualitative interviews. Then, in Chapter five, the empirical findings are compared to our theoretical framework, before the conclusions of the discussion are presented in Chapter six. Furthermore, Chapter six concludes with limitations of our study, contributions to existing theory, recommendations to managers, as well as proposals for further research.

2 Theoretical Framework

Chapter two presents a theoretical framework which describes how global supply chains can become more robust and resilient in the future, in order to survive significant crises and disruptions such as COVID-19. The theoretical framework is based on the preliminary thesis from the fall semester of 2020 (Nylænder & Pedersen, 2020).

2.1 Theoretical Approach

When deciding our theoretical approach, we started by developing a temporary research question. The research question was then broken down into different parts, which formed the bases of our literature gathering. The first area of literature we researched was global supply chains. This was done to get an overview of the current trends and discover the challenges today's supply chains are facing. The next area we covered was COVID-19's effect on global supply chains. Here we looked at the impact the pandemic has had so far and examined whether some of this could be related to the challenges discovered in the previous part. To mitigate some of these challenges, we looked at the risk management literature and found some of the current trends and strategies. Lastly, we decided to investigate some emerging technologies such as Big Data and Internet of Things (IoT), to explore the benefits they can provide for global supply chains.

2.2 Global Supply Chains

In this part, we are describing the challenges of today's global supply chains. Foster et al defines supply chains as *"a network of facilities that produce raw materials, transforms them into intermediate subassemblies and final products to customers through a distribution system"* (Foster, 2017, p. 460). Vrium & Persson, on the other hand, defines supply chains as *"a set of resources and participants that is required to conduct a specific business process, as well as the relationship between these resources and participants"* (Virum & Persson, 2011, p. 60). CIPS, which is a professional body for the procurement and supply profession, defines global supply chains as *"networks that stretch across borders, where the objective is to source and supply goods and services"* (CIPS, 2020). In other words, global supply chains are networks of firms that collaborate across borders and involve the flow of information, processes, and resources across the globe (CIPS, 2020).

Supply chains have developed and grown larger in both length and complexity, as firms are expanding their business around the world in the search for better margins. In the past decades, globally traded goods have more than tripled their value to \$10 trillion USD a year. According to McKinsey Global Institute, successful implementations of lean manufacturing models have resulted in improvements in both lead times, inventory levels, and on-time-in-full deliveries (McKinsey Global Institute, 2020). Nevertheless, they also claim that some of these operating choices can lead to unwanted consequences if the involved risk is not taken into

consideration. The new manufacturing networks were created to improve efficiency and proximity to markets, while also reducing costs. This has had a negative effect on transparency and resilience. In today's world, disruptions occur on a regular basis. Some of these events can last for months or even years and can be very financially demanding (McKinsey Global Institute, 2020).

The International Labour Organization argues that today's global supply chains usually are too dependent on specific suppliers, that are only found in certain places of the world. Additionally, they often utilize production principles such as Just-In-Time, which is meant to reduce inventory by only producing goods based on the demand (International Labour Organization, 2020). While this leads to improved efficiency, it also makes firms more vulnerable to unforeseen events, like nature disasters or currency fluctuations.

Many authors in the global supply chain literature point to the lack of transparency, as one of the main problems with global supply chains. Free & Hecimovic argue that as supply chains grow in size and become more complex, the transparency within the chain is reduced. As a result, the visibility between the different tiers becomes limited, and it gets difficult for participants to identify manufacturing and capacity threat. This will harm the firm's resilience (Free & Hecimovic, 2020). Egels-Zandén et al, states that transparency can strengthen both cooperative action and top-down compliance (Egels-Zandén & Hansson, 2016). As described by McLean and Rebernak "*There is no better way to build trust among stakeholders than through transparency*" (MacLean & Rebernak, 2007, p. 4). The next subchapter compromises some of the literature regarding COVID-19's effect on global supply chains. Based on the literature above, we can present our first proposition:

Proposition 1: As the length of the supply chains grow and the complexity increases, they also become more vulnerable to disruptions.

2.3 COVID-19's Impact on Global Supply Chains

COVID-19 has had an enormous impact on the world's supply chains and has caused a considerable amount of damage to the job market, human health, and the global economy. Restrictions, both nationally and internationally, have resulted in stricter border restrictions and national lockdowns, causing a negative impact on international trade and global supply chains (Kumar & Managi, 2020). The virus has forced firms to look at some of the flaws in their supply chains, for instance, the lack of robustness. During the last decades, firms have been moving towards strategies such as lean, agile, and flexible production systems. Better coordination and collaboration methods, real-time monitoring systems, as well as enhanced visibility, have been heavily

focused on. Nevertheless, this has not been sufficient enough to mitigate the impact of crisis like COVID-19 (Oloruntoba, 2020).

Supply chains all over the world are facing major disruptions and are struggling to handle the new demands and needs (G. Zhu, Chou, & Tsai, 2020). The fast spread of the virus generates undefinable disruptions in the supply chain (Khan, 2020). Zhu et al. state that the four most significant effects COVID-19 has brought to the supply chains are supply shocks, demand shocks/higher variability in demand, the bullwhip effect, and lastly transportation requirements and costs (G. Zhu et al., 2020). One of the largest impacts has been on the firms' ability to acquire necessary supplies. The lockdown regulations have directly affected business activities and the movement of goods and resources. Parsons highlights how the production facilities in China were forced into a standstill due to the virus. This meant that many of the world's retailers and manufacturers were no longer able to acquire the materials that they needed, and in turn had to shut down their operations (Parsons, 2020).

Another vital effect is the increased variability in demand. In fear of running out of food and other necessary items, many individuals ended up panic buying and stockpiling these products. This caused a major shift in demand, which many firms were not prepared for. Larger firms were mostly able to manage the variability in demand, while the smaller ones that could not keep up with the new demand struggled. As a consequence, many of these were ultimately forced to shut down their business (Parsons, 2020; G. Zhu et al., 2020).

Future Magazine reported that 94% of the Fortune 1,000 firms have been affected by COVID-19, with both upstream and downstream supply chain partners being disrupted (Sherman, 2020). As a result, supply sources were disconnected and production facilities were shut down (Barter, 2020), creating a shortage at the retail/customer end and surpluses at the supplier/manufacturer end (Donaldson, 2020). The supply shortage and supplier/manufacturer surpluses correspond with the bullwhip effect. The Bullwhip effect occurs when swings in inventories are rising in response to changes in customer demands (G. Zhu et al., 2020). For instance, if the demand for canned food increases, grocery stores buy more canned food from their suppliers to have enough food for their customers. However, if the demand for canned food is short termed, the grocery stores and their suppliers will as a result have produced more canned food than the customer demand. Since the grocery store buys products based on its customer's shopping history, there is a risk of the forecast being too positive or too negative. The main issue of the bullwhip effect is according to Zhu et al. the lack of transparency in the supply chain (G. Zhu et al., 2020).

The increase in transportation costs, as well as the need for more transportation, has had a large impact on global supply chains (Selwyn, 2020). Many supply chains are reliant on personnel that travels across borders

to maintain their operations. This has become much more difficult due to the travel restrictions and quarantine laws. Raw materials and goods often travel by air. As commercial flights have been forced to postpone due to Corona, cargo that usually travels on these types of flights must find different ways of transportation. The result from all of this is that the cost of global air freight has gone up. The need for cargo flights has increased, while the firms struggle to keep up with the demand. The transportation network of today's global supply chains has made them vulnerable to disruptions like COVID-19 (Selwyn, 2020). While some borders have started to open up, new safety measures and regulations have resulted in a number of delays and increased costs for suppliers (G. Zhu et al., 2020).

As mentioned in 2.2, the lack of transparency is one of the largest challenges with today's global supply chains. Increased complexity and many participants hamper the visibility of information up and down the supply chain (Hartmann & Moeller, 2014). Each chain is usually broken down into multiple tiers (Wilhelm, Blome, Bhakoo, & Paulraj, 2016). The firms in the lower-level tiers, are often out of touch with the information that the main firms receive. This makes it very difficult to keep effective control over the activities in the chain, and also forming strong relationships between suppliers and distributors (Free & Hecimovic, 2020). In the context of COVID-19, this becomes problematic. Poor visibility of information makes it demanding for firms to forecast material shortages and other disruptions in the supply chains. This became evident when the pandemic forced large parts of the world into a lockdown and many supply chains came to a standstill. If the communication and information sharing within the chains were better, the impact would likely have been much smaller. Therefore, we developed the second proposition:

Proposition 2: There is a negative connection between global supply chains and COVID-19.

The effects of COVID-19 have brought the need to build more resilient and robust supply chains (Simchi-Levi, Wang, & Wei, 2018). Therefore, it is necessary to rethink and reimagine new methods of managing global supply chains (Free & Hecimovic, 2020). In the next subchapter, we will describe which measures the current literature suggests mitigating these shortcomings and discuss the most relevant trends and concepts for our research.

2.4 Concepts and Measures in Response to Disruptions

The effects of COVID-19 have had an enormous impact on global supply chains and brought several uncertainties and risks to businesses. Firms that rely on external factors have an urgent need to transform their supply chain, in order to handle future disruptions (G. Zhu et al., 2020). In this subchapter, we will discuss measures that the literature proposes to mitigate some of these supply chain risks.

2.4.1 Risk Management

Neiger et al define supply chain risk management as a process that *“is aimed at developing strategies for the identification, assessment, treatment, and monitoring of risks in supply chains”* (Ho, Zheng, Yildiz, & Talluri, 2015; Neiger, Rotaru, & Churilov, 2009; Xie, Anumba, Lee, Tummala, & Schoenherr, 2011). The objective of supply chain risk management is to control the exposure of disruptions, from both inside and outside of the supply chain. This reduces vulnerability and helps maintain business activities (Goh, Lim, & Meng, 2007; Jüttner, 2005; Wieland & Wallenburg, 2012).

Manuj and Mentzer denote that global supply chains offer more risk than domestic supply chains since they consist of various links in an extensive network of firms. These links are exposed to disruptions, bankruptcies, breakdowns, macroeconomic and political changes, which makes risk management challenging (Manuj & Mentzer, 2008). Other risks are currency fluctuations, transit time, variability, forecasts, quality, safety, business disruption, survival, inventory ownership, culture, dependency and opportunism, oil price fluctuation, and risk events affecting suppliers and customers (Birou & Fawcett, 1993; Cho & Kang, 2001; Chopra & Sodhi, 2004). Research shows that different risk events in global supply chains are connected in complex patterns with one risk leading to another, or influencing the outcome of other risks (Manuj & Mentzer, 2008). Although these connections are present in domestic supply chains, their unpredictability and impact increase in global supply chains (Manuj & Mentzer, 2008). The following subchapters presents which measures the risk management literature recommends to dealing with different types of risk. Based on the statements above we developed the following proposition:

Proposition 3: Risk management has a positive effect on global supply chains.

2.4.1.1 Resilience

Resilience in the supply chain risk management literature is defined as *“the system’s ability to return to its normal condition or move to a more desirable situation after the system has been disturbed”* (Christopher & Peck, 2004). In a supply chain context, the point of resilience is to reduce the time it takes for the normal production to proceed, after a disruption has occurred (Brandon-Jones, Squire, Autry, & Petersen, 2014). According to Miroudot, several authors mistake resilience for robustness (Miroudot, 2020). In contrast to resilience, robustness is the supply chain’s ability to maintain its function despite internal or external disruptions (Brandon-Jones et al., 2014). The common mistake is that the authors neglect to report how quickly global supply chains generally adjust, which is a sign of resilience (Miroudot, 2020).

As stated by Strange, it is a debate if businesses should build greater resilience by reshoring global supply chain activities that previously have been offshored, and on the other hand, internationalize activities that formerly have been undertaken by independent suppliers (Strange, 2020). Reshoring can be accomplished by multinational enterprises (MNEs) repatriating activities by foreign affiliates, or businesses substituting overseas suppliers with domestic suppliers (Strange, 2020). Reshoring results in shortened supply chains, which makes them less vulnerable to restrictions concerning the cross-border movement of people. Still, the supply chains are affected by domestic restrictions of travel. Potential benefits of reshoring are dismissal of opportunistic recontracting and enhanced supply, scheduling and coordination, and bargaining power between buyers and suppliers (Strange, Magnani, Strange, & Magnani, 2018). Reshoring may be an appropriate solution if it enhances businesses to be closer and more responsive to the customers' needs. However, it intensifies the exposure of businesses to supply disruptions in their domestic economies (Strange, 2020).

According to Yossi Sheffi, who is one of the main experts in organizational resilience, states that increasing redundancy is one way of building greater resilience (Sheffi, 2015). Redundancy means that if one of the suppliers is unable to provide the necessary resources, others can help and deliver what is needed. Redundancy is an effective tool for managing risk and can also be used for inventory and capacity planning (Kamalahmadi & Parast, 2016). However, having large amounts of extra inventory and production capacity is usually very expensive and is often not worth the reduction in risk that it brings (Miroudot, 2020). Miroudot argues that it might be necessary for firms that are regularly facing crisis like tornados or earthquakes. On the other hand, expecting firms to invest tons in extra production capacity to prepare for a pandemic that happens once every century, is unrealistic (Miroudot, 2020).

Transparency in the supply chain refers to visibility, data sharing and openness with the parties involved in the supply chain (G. Zhu et al., 2020). Before the pandemic struck, risk management that was adopted in the supply chains, was usually only used for the top-tier suppliers. This made it difficult to locate disruptions occurring in the lower-level tiers, which could quickly cause ripple effects throughout the whole supply chain. Communicating with these tiers is crucial, as they might detect problems that the organization is not aware of (Staff, 2020). In order to be prepared for some of these disruptions, Sheffi suggests that firms perform a comprehensive analysis of the whole supply chain, from top to bottom (Sheffi, 2020). This should not just be a list of all the suppliers, it should include geographical locations of relevant manufacturing plants and factories. This will help firms to get an indication of the risk involved in their different products, based on their location. Being aware of the whole supply chain network and how the participants interact with each other, is critical to effectively mitigate risks similar to COVID-19.

There is some risk involved when implementing transparency in the supply chain, for instance, cyber-attacks and leakages of sensitive information. According to Bartley and Doorey, there is a tradeoff between threat and collaboration with suppliers. They argue that, despite transparency contributing to increased collaboration between the actors along the supply chain, it can be persuaded as threatening since sensitive information is shared with multiple different firms (Bartley, 2007; Doorey, 2011). This can induce fear of bad publicity being leaked about an organization and undermine firm-supplier trust (Egels-Zandén & Hansson, 2016).

In the literature regarding supply chain transparency, Egels-Zandén et al. state that the term is inconsistently defined, and that authors tend to focus on one of the many dimensions of transparency. This paints a very black and white picture of transparency and suggests that firms are either transparent or nontransparent. They argue that firms can show multiple different transparency outcomes at the same time, and that is something the scholarly conversation must take into consideration. Additionally, few studies have examined firms that have attempted to be transparent in practice. Therefore, it is a need for more research and grounded studies of supply chain transparency (Egels-Zandén & Hansson, 2016). On the basis on the discussion above, the following proposition is presented:

Proposition 4: With the correct risk management strategies, global supply chains should be resilient enough to handle future extraordinary crises such as COVID-19.

2.4.1.2 Robustness

Robustness is an essential element in risk management. It helps firms to withstand disruptions from both the internal and external environment and can mitigate many of the risks related to crises like COVID-19. Numerous authors responding to COVID-19 suggested that manufacturing principles such as LEAN and Just-in-Time, has made today's firms more vulnerable to disruptions (International Labour Organization, 2020). A switch to "Just-in-Case" management will trade some of the efficiency for higher security in the supply of inputs. However, according to Miroudot, "Just-in-Case" management is just used in the literature to describe the situation before JIT. It is not a defined management strategy. The term is very vague, and may only suggest that JIT should be adjusted, to put more emphasis on risk management. Still, many firms might already be moving in this direction, as JIT and risk management strategies usually work well together. Firms that are striving to build lean and efficient manufacturing processes, are often investing in risk mitigation strategies (Miroudot, 2020).

In an article by Financial Times, the editorial board claims that firms should shift from Just in Time (JIT) to Just in Case (JIC) strategies (The Editorial Board, 2020). By focusing too much on efficiency, risk management

strategies such as robustness, resilience, and effectiveness have been neglected. COVID-19 has shown the need for preparing for future shocks, and the need for more robust, resilient supply chains. Nassim Nicholas Taleb recommends an antifragile approach, going beyond resilience and robustness (Taleb, 2012). This can be done in three steps, first, the businesses must rebuild their cash reserves with help from the government. Then, the businesses should transform their supply chains from JIT to JIC models. The pandemic has shown the need for suppliers and customers to collaborate, for instance, that the larger businesses help the smaller businesses in the supply chain to survive. The third step is to reinforce the network of people that underpin their success. The authors mention that the main concern is that businesses may have to lay off large amounts of their staff to survive. However, the third step is the most crucial element of a post-crisis strategy in order to be better prepared to handle future disruption (The Editorial Board, 2020). Pisch on the other hand, states that firms that pursue the JIT strategy have lower inventory costs, and therefore are better situated to increase inventories to reduce risks in a more competitive way (Pisch, 2020). Firms with low inventories usually have smaller losses than those with high inventories. Furthermore, Pisch claims that if Just in Case was the major strategy of businesses, rather than JIT, more of them could be bankrupt as a result of COVID-19 (Pisch, 2020).

As dominant countries like China shuts down their production factories in response to the COVID-19, several firms are forced to look for alternative sources for their materials. Being very reliant on one supplier has proven to be insufficient in the context of COVID-19, and investors and government bodies have urged decoupling from China. According to an article from Oxford Business Group, the current situation has increased the trend of US firms moving their supply chains closer to home, in countries like Mexico. They also try to diversify them to reduce potential risks, by moving to the Association of Southeast Asian Nations (ASEAN) states. On the other hand, some are suggesting that measures like these will take a long time and not be favorable or even achievable for specific firms (Miroudot, 2020). In a study involving 4.000 US firms, Jain, Girotra and Netessine identified that supply chains that relied on multiple different sources for their materials actually recovered slower from disruptions, than the ones that used only a single source (Jain, Girotra, & Netessine, 2016). They argue that using only a single source makes it easier to establish long term relationships with the supplier. Suppliers will then be more committed to mitigate risk and recover from disruptions (Miroudot, 2020).

Thuan & Hoeng and Mishra et al. state that many risk management strategies may have compounding effects. Still, the literature has paid little attention to how one can combine different strategies or how some strategies can be used for multiple types of risk (Mishra, Sharma, Kumar, & Dubey, 2016; Thun & Hoenig, 2011). Further research is therefore needed, that investigates the interactions between various risk management strategies and how they can complement each other (Nooraie & Parast, 2016). Moreover, Fan et al. remark that most of the research on supply chain risk management has focused on a focal firm perspective and consequently neglected to address the inter-organizational relationships (Fan & Stevenson, 2018). Past research

recommends building relationships and enhance collaboration, which will result in more effective supply chain risk management (Christopher, Mena, Khan, & Yurt, 2011; Hallikas & Lintukangas, 2016; Ojala & Hallikas, 2006; Ritchie & Brindley, 2007; Xie, Anumba, Lee, Kam, et al., 2011). Therefore, we developed the following propositions:

Proposition 5: With the correct risk management strategies, global supply chains should be robust enough to handle future extraordinary crises such as COVID-19.

Proposition 6: Just in Time and risk management can work well together.

2.4.2 Technology and Digital Supply Chains

Digital Supply Chains has taken advantage of technologies such as Internet of Things, Artificial Intelligence, Machine Learning, Robotics, and 5G (Tsolakis et al., 2020). The advancement of technology has led towards Industry 4.0, which is known as the “Fourth Industrial Revolution” (Hendler, 2019). As stated by Brettel et al, Industry 4.0 is expected to facilitate factories to autonomously organize and control themselves, in real-time and in a decentralized manner (Brettel, Friederichsen, Keller, & Rosenberg, 2014), enabling multiple intelligent factories and smart manufacturing (Liboni, Cezarino, Jabbour, Oliveira, & Stefanelli, 2019; Y. Lu, 2017). Ben-Daya et al describe the features of digitalized supply chains as crucial elements, that enable digital connectivity and communication with both the physical and digital parts of the supply chains. This allows for real-time storage, analysis, and sharing of data, and also helps to coordinate the activities and processes in the supply chain (Ben-Daya, Hassini, & Bahroun, 2019).

Garay et al, refer to several authors that found gaps in the present supply chain models that incorporate Industry 4.0 (Garay-Rondero, Martinez-Flores, Smith, Morales, & Aldrette-Malacara, 2019). Ben-Daya et al. found the following shortcomings while conducting a literature review on applications of digital technology in Supply chain models; few frameworks gave a comprehensive guide for the adoption of Internet of Things and Cyber-physical systems in the context of supply chains. They also found a shortage of models clarifying the challenges with supply chains in an emerging technological environment, and registered numerous obstacles against the implementation of Industry 4.0 elements in supply chain models, both from a management perspective and a technological perspective (Ben-Daya et al., 2019).

Barata et al. state that the supply chain literature is lacking an innovative and multi-dimensional model, that allows for a clear visualization of the interconnections and exchanges between all participants of the supply chain. They argue that the classic models fail to convey the quick changes and responses, in the whole

structure of the physical and digital supply chain. In addition, new approaches for value-creation are missing (Barata, Da Cunha, & Stal, 2018; Ganji, Coutroubis, & Shah, 2018). Therefore, Garay-Rondero et al. have developed a comprehensive model of new concepts and components that are the drivers of the rising and current digital supply chains, see Figure 1 (Garay-Rondero et al., 2019).

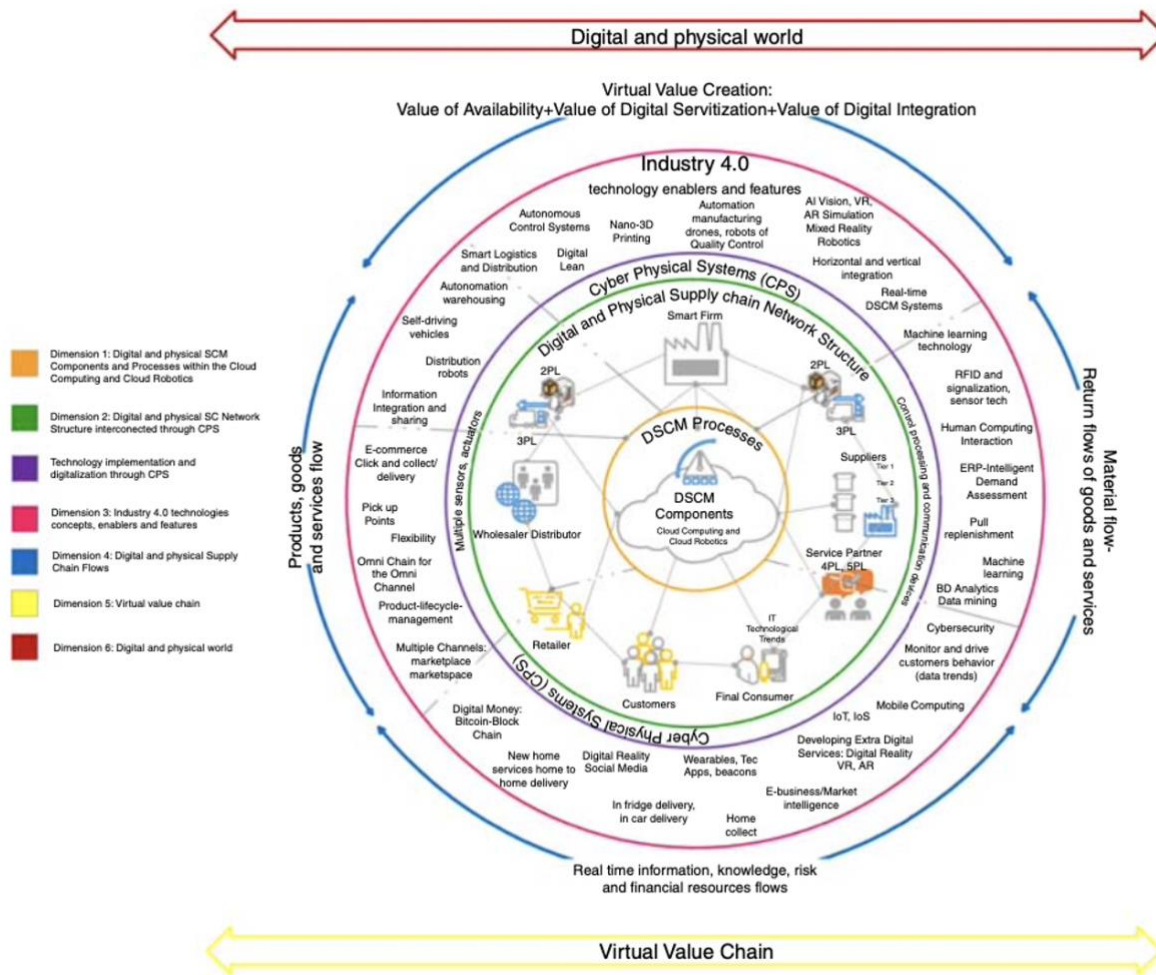


Figure 1 Digital Supply Chain Model in Industry 4.0 by (Garay-Rondero et al., 2019, p. 16)

Figure 1 consists of six dimensions, (1) digital and physical SCM components and processes within cloud computing and cloud robotics, (2) digital and physical supply chain network structure interconnected through cyber-physical systems (CPS), (3) Industry 4.0 technology, concepts, enablers and features, (4) Digital and physical supply chain flows, (5) virtual value chain, and (6) digital and physical world (Garay-Rondero et al., 2019). The digital supply chain model shows how the six dimensions continuously interact with each other, within the physical and virtual supply chain (Graham & Hardaker, 2000). It can be utilized as a guide for how Industry 4.0 technologies can be implemented in digital supply chains. This will mitigate some of the obstacles involving the adoption of these emerging concepts in the digital supply chain, both from a management perspective and a technological perspective (Garay-Rondero et al., 2019).

2.4.2.1 *Blockchain*

Blockchain is a technology that has been mostly used within finance. Still, it has seen some experimentation in other fields. Blockchain is formed as a network of computers, referred to as nodes, where each node represents a participant in the chain. Essentially it works as a bookkeeping method and links together the financial activity of the members. It allows them to safely keep track of transactions and transfers of ownerships between the participants of the blockchain (Pagano & Liotine, 2020).

One of the more promising applications of blockchain, outside of the finance field, is believed to be in supply chains. With technologies like Internet of Things (IoT), barcodes, radio-frequency identification (RFID) tags and GPS tags, products and goods can be tracked real-time, in every step of the supply chain. Consequently, there is an increased need for a secure way of confirming the identity of IoT applications. One of the main advantages with blockchain is that it can help with identity management. It can provide information about the ones that are performing a specific action as well as determine the location and time that action took place (Kshetri, 2018).

Traditionally, the movement of data in a supply chain follows the flow of goods. When utilizing blockchain, the sharing of data and information is performed in a decentralized fashion, allowing all members to access the same data. This removes the need for supply chain partners to serve as intermediaries, for the purpose of information sharing. Every new transaction carries the information from the prior transaction, including an identification key, and creates a unique key for itself. These keys, called cryptographic hashes, works as a digital fingerprint, and cannot be altered. When new transactions are added, they are collected in blocks and arranged in a tree-like structure, which is referred to as a “Merkle tree”, see Figure 2.

Before a transaction can be placed in a block, the ones handling the transaction must be validated by the other members of the network. Sometimes the transaction itself is also validated. The rules dictating the agreement process between the participants, can vary depending on how the blockchain is implemented (Pagano & Liotine, 2020).

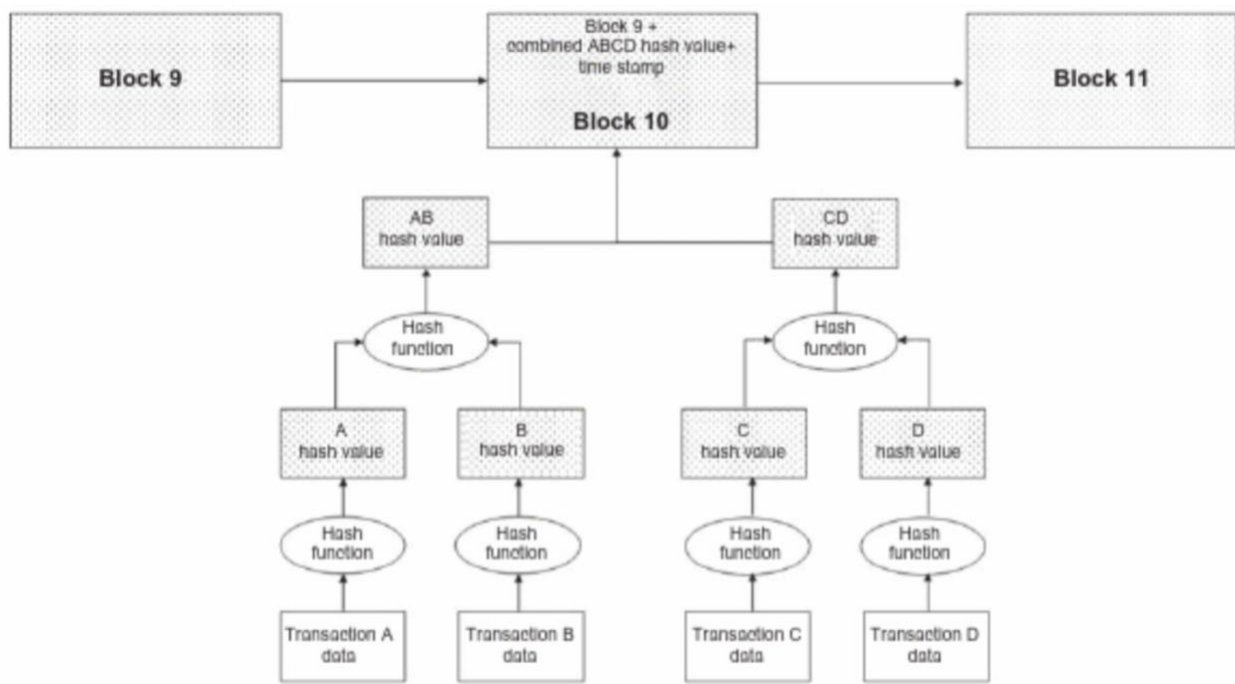


Figure 2 Merkle Tree (Pagano & Liotine, 2020)

The most obvious advantage blockchain offers is the increased traceability of products. It can track a products digital footprint all the way from the production process to when it is delivered to the customer. While allowing for real time tracking of goods, it also offers a high level of transparency in the data sharing process, which is crucial for ensuring the authenticity and legitimacy of products (Casey & Wong, 2017; Q. Lu & Xu, 2017; Mansfield-Devine, 2017). As such, one of the main benefits of utilizing blockchain is that it facilitates trust between the suppliers. All participants along the supply chain can track each other’s orders, deliveries, and progress, meaning that they must trust that the information won’t be misused by others. By getting rid of middleman auditors, suppliers can conduct checkups and balances on their own. This reduces costs and increases efficiency (Kshetri, 2018). It also encourages collaboration between multiple parties. For instance, when a problem is affecting multiple members along the supply chain, they are incentivized to find a solution together (Wang, Han, & Beynon-Davies, 2019). This is beneficial, as it strengthens the relationship between the different participants, and increases the likelihood of fixing the problem.

Another advantage with blockchain, is that it allows for an accurate way of estimating the quality of a product that is being transported. By going through the data output from the transportation process, one can estimate if the product was in one place for too long, or in the wrong place altogether. This is especially relevant with goods that are sensitive to temperature fluctuations etc. Blockchain can therefore help determine whether a product will be delivered in its desired state, which is one of the key goals of supply chain management (Flint, 2004).

Security in the data sharing process, is highly significant in a supply chain. Transactions usually contain very sensitive information that, if leaked out, could be damaging to the ones involved. Blockchain could mitigate some of the risks involved with traditional centralized databases, by encrypting the information on goods and sensitive data, and utilize business rules to govern the access by customs and other necessary bodies (Kshetri, 2017; van Engelenburg, Janssen, & Klievink, 2017). It enables data integrity and security and works as protection against cybercrime and fraud. One of the main weaknesses of a centralized system is that if it gets hacked or suffers some technical issues, this could possibly bring down the whole system. Blockchain uses a different way of managing data and is much more resilient in case of any cyberattacks (Wang, Han, & Beynon-Davies, 2019).

Smart contracts are by many seen as the most transformative usage of blockchain, in the supply chain. It is a form of computerized transaction protocol, that automatically generates the conditions of a contract. The goal is to fulfill common contractual conditions, while simultaneously reduce the delays and costs related to traditional contracts. A smart contract can become partly or fully automated and be monitored by the supply chain network. For instance, it can automatically send out a payment to the supplier, when the delivery has arrived to the buyer. This eliminates the issue of payments being withheld. Additionally, costs will be reduced, and efficiency improved, as the need for manual control is much lower. However, the integration of smart contracts represents a fundamental change in both the structure and governance of the supply chain, meaning that it might take a long time before this becomes the standard (Hull, 2017; Wang, Wu, Wang, & Shou, 2017).

Even though blockchain is seen as a valuable addition to supply chains, there are some challenges when it comes to the integration process. One aspect that might work against it, is the reliance on total transparency. This can throw some supply chain actors off, as there is risk of valuable information being leaked out. Some people also have negative assumptions about blockchain, due to Bitcoin's history of being used for criminal purposes. This can work as a barrier for its inclusion in supply chains (Hoy, 2017; Kshetri, 2017). In order for blockchain to be successfully implemented in the supply chain, all participants must take part. Global supply chains are part of complex environments, which require all involved parties to follow various different laws, regulations and institutions. This makes implementing blockchain quite challenging (Casey & Wong, 2017).

Another barrier is the actual cost of introducing blockchain to the supply chain. The implementation process or even just participating in a blockchain system can be very expensive, as it requires technical and specialized expertise (Patel, Bothra, & Patel, 2017; Wang et al., 2017). This might be especially challenging for small/medium-sized firms, as these usually possess fewer financial resources and technical competences. As mentioned before, blockchains rely on trust and openness in a decentralized system, which is very different from traditional ways of managing and structuring supply chains. This leads to reduced control for supply chain

participants, which may throw some of them off. Therefore, resistance due to existing business methods or cultural differences also represents a barrier for the implementation of blockchain (Patel et al., 2017; Wang et al., 2017).

2.4.2.2 *Big Data*

Big data is defined by Leveling, Edelbrock and Otto as “*a way of collecting, managing and analyzing large amounts of data*” (Leveling, Edelbrock, & Otto, 2014). Peter Drucker and W. Edwards Deming are known for the phrase “You can’t manage what you can’t measure” (Deming & Edwards, 1982; Drucker, 2012). Big data has the advantage that managers can measure, and therefore comprehend more about their business, and directly transform that knowledge into improved decision making and performance (McAfee, Brynjolfsson, Davenport, Patil, & Barton, 2012). McAfee et al remarks how big data has transformed the bookstore industry by using online retailers. The retailers have access to the customers purchase patterns, how they navigated through the website, what they have looked at, how they were influenced by promotions, reviews, and page layouts, as well as resemblances between individuals and groups. By developing algorithms to predict which books individual customers are likely to read in the future, the algorithms performed better every time the customer responded to or ignored a recommendation. This provided online booksellers an enormous advantage compared to traditional booksellers (McAfee et al., 2012). The use of big data has the potential to transform traditional businesses, by providing even greater opportunities for achieving a competitive advantage. This can be done by measuring and managing more precisely than before, make better predictions and smarter decisions as well as aim for more effective interventions (McAfee et al., 2012).

Big Data is traditionally divided into volume, velocity, and variety (Beyer & Laney, 2012; Katal, Wazid, & Goudar, 2013; Robak, Franczyk, & Robak, 2013). Volume involves the amount of data that is generated, velocity on the other hand reflects the speed of data creation, while variety means the different sources of big data and how it is structured (McAfee et al., 2012). In addition, some researchers have defined seven V’s of Big Data, those are value, volume, variability, visualization, veracity, variety and velocity (McAfee et al., 2012). In supply chain management, optimization of the supply chain visibility is a complex challenge because of the interaction between the involved people, processes, technologies and information flows (Heaney, 2013). The objective with the supply chain visibility is to display current activities and involvements in a supply chain (Katal et al., 2013; Leveling et al., 2014; Robak et al., 2013).

Even though the possibilities with big data are enormous, there are still some obstacles that should be taken into consideration. First and foremost, there are legal and ethical issues as privacy, regulation, risk, and transparency concerning the data collected and how the data is collected (Richey Jr, Morgan, Lindsey, Adams, & Autry, 2015). Next, it is vital that the data is meaningful in both the operational and strategic levels in order

to utilize the data (Kache & Seuring, 2017). Another concern related to transparency is the exposure of weakness in relation to competitors. In addition, national and regional differences because of data veracity is a cause for concern since communication within and across borders creates severe complications for managers (Richey Jr et al., 2015). Van Hoek et al addresses the importance of collaborative sharing of information between partners, which is fundamental to achieve visibility and transparency across the supply chain (Van Hoek, Ellinger, & Johnson, 2008).

2.4.2.3 *Machine Learning*

Machine learning is a form of artificial intelligence that learns from experience to improve its decision making and predictive accuracy over time. Algorithms, as defined by IBM are “*a sequence of statistical processing steps*” and are instructed to find features and patterns in large amounts of data to provide better decisions and predictions based on data. As the algorithm improves over time, the more accurate the decisions and predictions will become as it processes more data (IBM, 2020). Machine learning is divided into three areas, supervised learning, unsupervised learning and reinforcement learning (Adam & Smith, 2008). Supervised learning requires labeled data with desired outputs, while unsupervised learning does not. In circumstances where the learning is unsupervised, the environment provides input without desired targets. Reinforcement learning learns from feedback received through interactions with an external environment (Qiu, Wu, Ding, Xu, & Feng, 2016). Supervised learning is mostly used for classification, regression, and estimation, while unsupervised learning is used for clustering and prediction of data. Reinforcement learning on the other hand, is used for decision making, which is the most advanced form of machine learning, that is most relevant for supply chains (Qiu et al., 2016). Representation and deep learning are two advanced learning methods for machine learning. Representation learning is a method to learn meaningful and useful representations of the data that make it easier to extract useful information (Tu & Sun, 2012). Deep learning uses supervised and/or unsupervised strategies to learn hierarchical representations (Yu & Deng, 2010).

The usage of emerging technologies instead of traditional methods can be more accurate and efficient, while at the same time saving resources in money and time (Krauth, 2018). The McKinsey Global Institute states that machine learning is one of the main drivers of Big Data, since it has the ability to learn from substantial amounts of data, in addition to provide data driven insights, decisions and predictions (Manyika et al., 2011). According to L’Heureux et al, machine learning is complementary to Big Data, and can be used in accordance with the Big Data Vs (volume, velocity, variety and veracity), as described in 2.4.4 (L’heureux, Grolinger, Elyamany, & Capretz, 2017).

In a supply chain context, this knowledge can be applied to find the key drivers influencing inventory levels and demand forecasting with the greatest predictive accuracy (Columbus, 2018). Baryannis et al expresses

that machine learning models can be leveraged to accurately predict supply chain risks. Moreover, by choosing more interpretable models, it may require a compromise in performance. In the case of prediction related metrics, performance is slightly more affected. Furthermore, decision tree models can reveal correlations that influence supply chain risk management decision making (Baryannis, Dani, & Antoniou, 2019).

Some of the weaknesses of big data are similar to the weaknesses of machine learning. For instance, the fear of inaccuracy, where machine learning has a possibility of high error (L'heureux et al., 2017). However, most decisions that are made by the help of big data and machine learning, are executed by a manager (Robak et al., 2013).

Based on the theory from subchapter 2.4.2, we developed the following propositions:

Proposition 7: Digital supply chains can enhance supply chain risk management.

Proposition 8: There is a positive connection between global supply chains and emerging technologies.

2.5 Gaps in the literature

This section concludes the most significant gaps we have found in the literature. According to Miroudot, the major challenge with today's ongoing debate surrounding the COVID-19, is that it can result in international firms and policymakers using supply chain concepts that are not coherent with business reality. In turn, this can lead to the wrong decisions being made (Miroudot, 2020). An example of this is the concept that reshoring will improve the resilience of a supply chain, which is not backed up by any academic research (World Bank, 2019). In addition, Miroudot expresses that several authors tend to mistake resilience for robustness (Miroudot, 2020). Both robustness and resilience are important factors for withstanding crises similar to COVID-19. They are accomplished in different ways and should be handled separately.

Manuj and Mentzer mention that there are three major gaps in the literature on risk management in supply chains. The first gap is that there is no clear definition of the unique dimensions of risk and risk management in relation to global supply chains. Instead, there are numerous definitions and conceptualizations, which results in confusion between terms as vulnerability, uncertainty, and risk (Manuj & Mentzer, 2008). The second gap is that strategies in relation to risk warrants require more attention (Jüttner, 2005). Studies that provide a list of risk management strategies tend to neglect how managers select among them, e.g., the reasoning to global supply chain risk management strategies and their consequences (Jüttner, Peck, & Christopher, 2003;

Manuj & Mentzer, 2008). The third gap is that there is restricted research on the moderators in the risk management literature (Manuj & Mentzer, 2008).

Many of the authors writing about the impact of COVID-19 on global supply chains, is stating that manufacturing concepts like LEAN and Just-in-Time make supply chains more exposed to disruptions, and that firms should be moving towards Just-in-Case management. On the other hand, Miroudot points to the fact that Just-in-Case management is not a defined management strategy. He argues that the term is very vague and that it is only used as a reference to the situation before Just-in-Time was introduced (Miroudot, 2020).

Xu et al. state that there is a lack of studies looking at what Big Data can offer in terms of mitigating supply chain disruptions. Although Big data has been widely explored in many different fields, it has not received much attention in relation to supply chain disruptions. Technologies like these could potentially have a massive impact on disruption recovery methods and should therefore be researched further (Xu, Zhang, Feng, & Yang, 2020).

As mentioned earlier, supply chain transparency can contribute to better information sharing along the whole chain and mitigate some of the risks related to the COVID-19. However, according to Egels-Sandén et al, the term supply chain transparency is inconsistently defined in the literature, and most of the definitions consider only one of the numerous dimensions of transparency (Egels-Zandén, Hulthén, & Wulff, 2015). In subchapter 2.4.2 we presented some emerging technologies that can help facilitate transparency, by improving data and information sharing, and help firms keep track of the entire supply chain. Nevertheless, according to Barata et al., the supply chain literature lacks a multidimensional model, that clearly illustrates how all participants of the supply chains are connected. Furthermore, the classic models do not communicate the rapid changes and responses in the entire physical and digital supply chain (Barata et al., 2018; Ganji et al., 2018).

2.6 Theoretical Model

Based on the literature review, we established a model that shows the firm's ability to withstand disruptions, see figure 3. The framework consists of four factors: complexity, risk management, transparency, and geopolitical factors. The first factor involves the complexity of the supply chain, e.g., the size of the supply chain, type of production, and if the production is done locally or across borders. The second factor, risk management involves the firm's ability to control risk. The third factor, communication, was selected since several researchers have emphasized the importance of transparency in the supply chain and being able to communicate openly with the participants. The last one is geopolitical factors are, which is comprised of factors like travel restrictions, infection control rules, domestic and international regulations, as well as other factors that are uncontrollable for the firms.

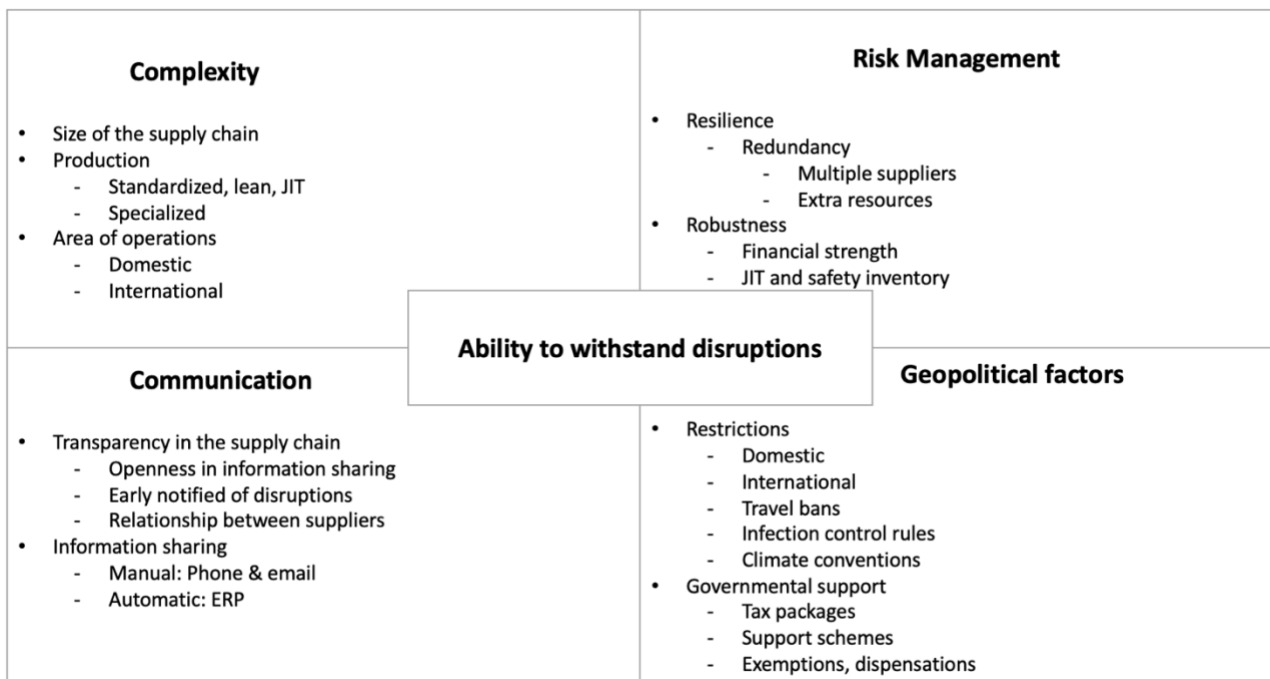


Figure 3 Firm's Ability to Withstand Disruptions

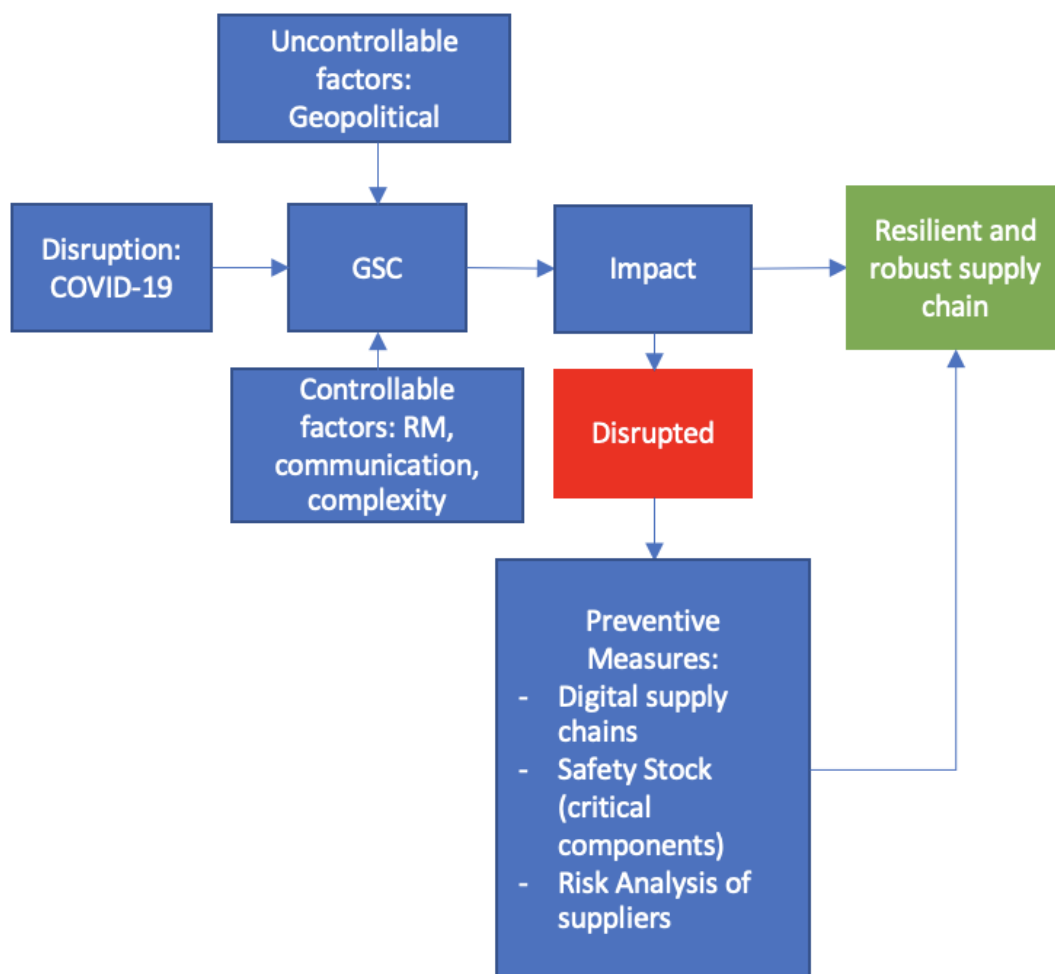


Figure 4 Theoretical Model

Figure 4 shows how global supply chains are affected by disruptions and how they can reduce the impact. It starts with a disruption going towards the supply chain. The level of impact is decided by the three controllable factors we established in Figure 3 (Risk management, communication, and complexity), and the uncontrollable factors, which are geopolitical. If the firms in the supply chain perform well in relation to these factors, the supply chain will be resilient and robust enough to handle the disruption, and the overall impact will be smaller. If the performance is poor, the impact will be larger, and disruptions will occur along the supply chain. In order to become more resilient and robust in the future, several preventative measures can be introduced. Among these are digital supply chains, safety stock of critical components and risk analysis of suppliers. Note that we have not included any reactive measures in this model. This is done by choice, as we feel like these kinds of measures are dependent on the situation and would make the model less applicable in other scenarios. In the next chapter, the methodology of the research process will be described, including research strategy, research design, data collection methods, and quality of the research.

3 Methods

The theoretical framework contributes to an increased understanding of the phenomenon that is studied and is necessary to develop a great research progress plan that is the most suitable to answer the research question (Kvale, Brinkmann, Anderssen, & Rygge, 2015). The planning of the study involves selecting a research plan that is relevant to the research question in addition to a plan that is feasible within the time frame (Jacobsen, 2015). Chapter three describes the procedure in our research process with a basis of the research question. First, we present a breakdown in the structure of the research question, that provides guidelines for the choice of research strategy, research design and methods for data collection. Then, the quality of the research is discussed by addressing significant topics within the research validity and reliability. The chapter concludes with a summary of the research process.

3.1 Structure of the Research Question

Our research question tries to answer how multinational firms have been affected by COVID-19, and how they can improve their robustness and resilience to handle future disruptions in their supply chain. The objective is to get a deeper understanding of the different variables that effect the performance of a supply chain, and how these variables are interconnected to each other. Therefore, our research question has an explanatory form (Jacobsen, 2015).

3.2 Selection of a Research Strategy

There are two main research strategies, qualitative and quantitative methods. These methods have significant differences in how the research is performed and how the research data is collected. The purpose of qualitative studies is to gain a deeper understanding of social phenomena, while the purpose of quantitative studies is to quantify results & generalize to larger population (Savin-Baden & Major, 2013). Qualitative studies usually use observations or in-depth interviews to collect detailed descriptions (Thagaard, 2013). Quantitative studies, on the other hand, has a wide scope to illuminate the extent of a phenomenon (Harboe & Eriksen, 2008). In contrast to qualitative research methods, quantitative research methods has the objective to study a large sample through questionnaires (Tjora, 2017). These quantitative studies are rigorously structured, by premade questions and predefined answers (Jacobsen, 2015). Qualitative research is embossed by flexibility and openness since the study allows room for changes during the research process. In addition, the qualitative research can be customized and tailored to changes if challenges should occur (Thagaard, 2013). The information from qualitative studies is registered and transcribed to text and then analyzed using informal techniques e.g., NVivo. The information from quantitative studies, on the other hand, are transferred and analyzed with quantitative values by using statistic techniques of analyzing (Ringdal, 2018). This can be done with statistical programs such as SPSS.

The selection between qualitative and quantitative research methods can be seen as a pragmatic decision where the research question determines the most suitable research strategy (Jacobsen, 2015). Our research question has an explanatory approach, to discover why and how it is happening. Consequently, qualitative research method is the most suitable research strategy. One research strategy can rarely replace the other, however, they have a complementary relationship where they together can supplement each other (Grønmo, 1996). The qualitative research contributes with detailed descriptions and better insight and understanding of a phenomenon (Marschan-Piekkari & Welch, 2004).

The qualitative research methods enable the design of more concrete and relevant questions for the quantitative survey. By doing so, the qualitative research method strengthens the quantitative method, and the two methods contribute collectively to highlight the phenomenon from different perspectives and give a better view of the reality. This requires clear and consistent guidelines for how the data from the qualitative method should work as a preparatory (Grønmo, 1996). The guidelines constitute a critical part of the research design which is presented in the next subchapter.

The research strategy normally uses an inductive, deductive, or abductive approach. A deductive approach means to go from the general to the particular. This involves starting out from a theory, creating hypotheses, testing the hypotheses, and then revising the theory (Locke, 2007; Nola & Sankey, 2007). Induction moves from the particular to the general. This involves making empirical observations about a topic of interest, and create theories and concepts based on these observations (Locke, 2007). Abduction is used when combining the two approaches. According to Thagaard, abduction as a research strategy, is to use both theory and empirical data as basis for developing a better understanding of a phenomenon (Thagaard, 2013). For our research strategy, we first used a deductive approach and based the research on existent theory. After establishing the categories that was going to be researched, we then used an inductive approach and added elements from our empirical findings to what we found in the literature. As we combined a deductive and inductive approach, we used an abductive research strategy.

3.3 Selection of a Research Design

The next step after the research strategy is to determine which research design that is the best suited for our research question. A research design includes guidelines for how the researcher(s) should perform the study (Johannessen, Christoffersen, & Tufte, 2010). The guidelines contains descriptions of the research's focus areas, participants, where the study is performed and how it is executed (Thagaard, 2013). There are various research designs for diverse purposes. For our study we consider case design as the most suitable research design to answer our explanatory research question.

Case studies can be used to provide description, test theory and/or generate theory (Eisenhardt, 1989). According to Welch et al, case studies is the most popular qualitative research strategy (Welch, Piekkari, Plakoyiannaki, & Paavilainen-Mäntymäki, 2011). Case studies are characterized by collecting much information from few units or cases through a detailed and comprehensive data collection (Johannessen et al., 2010). Case studies are designed to fit what's the most appropriate for the specific study. The objective is to go in depth by collecting detailed information, in addition to investigating several firms to create a theoretical replication in the data we collected and increase the transferability of the findings. By doing so, we can get deep insight from several firms, and discover similarities and differences within the organizations. By combining the complementary research methods, qualitative and quantitative, and comparing large firms with SMEs, the research project is quite complex within the time frame given by the university. Therefore, it is necessary to limit the study by the number of firms involved, to make sure that it can be performed with good results within the time frame.

In our study, each case was investigated and analyzed separately, and then compared to each other. In Chapter 3.4, each of the cases are presented, which describes the selection criteria of this study.

3.4 Method for Data Collection

As previously mentioned, the research strategy we have utilized is a combination of qualitative and quantitative research methods, where the qualitative should strengthen the quantitative. This combination requires different methods for data collections, which resulted in in-depth interviews as a qualitative approach and a questionnaire as a quantitative approach. In each case, we executed in-depth interviews, which contributed to a questionnaire that was sent to the candidates. Before the interviews were performed, it was necessary to determine which samples in the population that was the best suited to contribute with knowledge and experiences on the phenomenon we are studying.

Before the research process started, the study was submitted to Norsk senter for forskningsdata (NSD) (see Appendix 1). This means that the treatment of personal information in this study is in compliance with the privacy act. We have followed the guidelines of NSD in conjunction with the research proposal for each organization with request of their participation. This was accomplished by an informational letter (see Appendix 2) that describes the purpose of the study, what it means to participate, how personal information are stored and treated, that the participation is optional and that the participants at any time can withdraw themselves from the study. In addition, the informants signed a statement of consent to give information of which organization that participate. Moreover, we informed the participants that the information they gave were anonymized in the presentation of empirical findings, which means that the reader is not able to track directly what the different informants has said.

3.4.1 Sample

In order to collect the necessary information to answer the research question it is necessary to define the right sample for the interviews and questionnaire (Thagaard, 2013). Since the context for the questionnaire is risk management in relation to disruptions in global supply chains, the next step is to identify a case that is suitable for the study and that corresponds with the pre-defined criterions. According to Tjora, it is favorable if there are similarities between the cases, which will make them relevant for the phenomenon (Tjora, 2017). In order for an organization to qualify for participation it had to fulfill the following criteria's:

- A multinational firm
- The firm is part of a global supply chain
- Division / office in Norway

In addition to these criteria's, we decided that the selected cases should represent different industries to create width and variation. This was done by performing a strategic selection of which organizations that was seen as potential candidates to include in our study. Preferably the firms included had some type of production and used advanced technology, however, this was not a demand. We contacted each organization to determine if they satisfied all the criterions, since not all information was available from their websites. In some cases, we used our contacts to find out if they are potential candidates for our study, other candidates were contacted by email where we sent an informational letter and questions based on the criteria. We ended up with 10 candidates, which were then divided between firms with < 1.000 employees and firms with > 1.000 employees. The idea was to compare these two groups and explore if the size-difference had any effect on the way each organization handled the COVID-19 pandemic. We established contact with these firms early in January, and our study was accepted by NSD a couple of weeks later. However, we still had to wait a month for permission to perform the interviews in February and March. The following table provides an overview of the firms that participated in our study, which industry they operate in, and if they have more or less than 1.000 employees. After the table, each firm is introduced, with information of where they operate, the number of employees they have and which industry they compete in.

Firms	Industry market	Nr of employees
1. AirThings	Measure air quality	< 1.000
2. Allum Engineering	Offshore, maritime & industry	< 1.000
3. Aker BP	Oil and Gas	> 1.000
4. DB Schenker	Transport	> 1.000
5. Glitre Energi	Energy	< 1.000
6. KDA	Defence and Aerospace	> 1.000
7. Kongsberg Maritime	Subsea	> 1.000
8. Moen Marin	Subsea	< 1.000
9. TechnipFMC	Oil and Gas	> 1.000
10. Tronrud Engineering	Engineering	< 1.000

Table 1 Sample



3.4.1.1 AirThings

AirThings is an international technology firm that sells products to measure air quality for both the private and professional market. AirThings consist of more than 100 employees with 25 nationalities, and have 4 offices, with their head quarter in Oslo (AirThings, 2021).

3.4.1.2 Allum Engineering

Allum Engineering delivers engineering solutions and technology to process, marine and offshore industries. The core business area is engineering, and their products have been developed from the proficient and innovative engineering team. Allum Engineering has its headquarter in Sandefjord and consist of 13 employees (Allum Engineering, 2021).



3.4.1.3 Aker BP

Aker BP is a well-developed oil organization with exploration, development, and production activities on the Norwegian continental shelf. Measured in production, Aker BP is one of the largest independent oil firms in Europe. Aker BP consist of approximately 1 400 employees and has its headquarters in Lysaker, in addition to its offices in Stavanger, Trondheim, Harstad and Sandnes (Aker BP, 2021).



3.4.1.4 DB Schenker

DB Schenker is a global industry leader with close to 150 years of logistics experience through sea, air, and land. DB Schenker has more than 76 000 employees worldwide and over 21 000 locations (DB Schenker, 2021). In Norway, DB Schenker has its headquarter in Oslo with approximately 1 050 employees at 27 terminals/locations (DB Schenker, 2019).



3.4.1.5 Glitre Energi

Glitre Energi produces 100 % renewable energy and is owned by Buskerud County Council through Vardar AS and Drammen municipality. Their headquarter is in Drammen and they have approximately 220 employees (Glitre Energi, 2021).



3.4.1.6 Kongsberg Defence and Aerospace (KDA)

Kongsberg Defence & Aerospace (KDA) is a subsidiary of the Kongsberg Group. They are one of the world's leading suppliers of defense products and systems for tactical communications, surveillance, command and control, space, remote weapon stations and missiles. KDA offers repairs and overhauls of helicopters and aircrafts. Their products and solutions operate both under and on the sea, on the surface, in the air, and space. They are divided into seven divisions with a total of 3.100 employees. Their headquarters are located in Kongsberg (KDA, 2021).



KONGSBERG

3.4.1.7 Kongsberg Maritime

Kongsberg Maritime is a subsidiary of the Kongsberg Group, that delivers systems for the maritime industry. Their headquarter is in Kongsberg, Norway. Kongsberg Maritime have 117 offices in 34 countries with approximately 7 600 employees (Kongsberg Maritime, 2021)



KONGSBERG

3.4.1.8 Moen Marin

Moen Marin is one of the world's largest suppliers of work vessels to the aquaculture industry. Moen Marin leads the way in electrification and digitalization of the fisheries and aquaculture surface. Their headquarter is situated in Trondheim, and they have local departments across the Norwegian coast. Moen Marin is a small organization with 26 employees and consist of 27 departments in 11 different countries (Moen Marin, 2021).



Moen Marin
A PART OF SCALEAQ

3.4.1.9 *Tronrud Engineering*

Tonrud Engineering develops, produces, and delivers customized automotive solutions to its clients both nationally and globally.



Thonrud Engineering consist of 150 employees and has its headquarter close to Hønefoss at Eggermoen Technology Park. In addition, Tonrud Engineering has 50 employees in its subsidiary in Moss (Tonrud Engineering, 2021).



3.4.1.10 *TechnipFMC*

TechnipFMC is considered one of the global leaders in the energy industry, offering projects, products, technologies, and services. They are split into three different business areas, which is Surface, Subsea and Technip Energies. The first two are concentrated around delivering products for the oil and gas industry, while Technip Energies is more centered around renewable energy solutions. The organization has ruffly 37.000 employees globally and 2.500 located in Norway (Heiberg, 2020). Their headquarters are found in Houston, London, and Paris. In Norway, they have several offices, where the main offices are situated in Kongsberg and Lysaker (TechnipFMC, 2020).

3.4.1.11 *Prerequisites*

In order to collect knowledge and experience form each firm, it was essential to find units of analysis with great prerequisites to give detailed descriptions of the phenomenon (Tjora, 2017). This can be accomplished by various different sample strategies (Johannessen et al., 2010). We utilized a strategic sample which follows our qualitative research methods. Strategic sample indicates that participants that have some characteristics or qualifications are selected in compliance with the research question and the study's theoretical perspectives (Thagaard, 2013). The target group are people who have information and knowledge about the logistics activities of the firm, either a logistics coordinator, a supply chain quality manager, or similar roles. The selection process is a quota sample, since there is a predefined quota of participants that are contacted from each of the categories > than or < than 1.000 employees (Grønmo, 1996). Afterwards, we defined criterions for the sample of participants in the different categories.

The interview candidate must

- Have knowledge of firms' global supply chain
- Have knowledge of the organization's risk management strategies
- Be involved with the management group
- Must be familiar with the organization's logistic activities

By involving participants that fulfilled these criteria, we increased the probability of collecting trustworthy and relevant information about the phenomenon we are studying. Hence, the participants had great prerequisites to contribute to answer the research question, in addition to provide information to design a questionnaire with concrete and relevant questions. Qualitative studies often involve topics that are personal and/or sensitive, that can make it demanding to find candidates that are willing to participate (Thagaard, 2013). We do not consider our topic of discussion to be very personal for potential contestants. However, an important factor is that the candidates have a hectic workday, which can set limitations for their opportunity to participate. In addition, the contestant may not be willing/allowed to share confidential information. To ensure our sample it was vital to perform an accessibility selection based on available participants that have the time to participate in this study. A normal method is the snowball sampling, where we used "snowballs" for each method, e.g., we were given one contact person that gave us contact information to the right candidates that could answer our questions. Normally the contact person was an employee within H&R, where we asked for contact information of employees that fulfilled our criteria for the interview candidate. The information from the qualitative and quantitative survey constitutes our primary data which was collected by in-depth interviews and questionnaires.

3.4.2 In-depth Interview

In order to gather information from the participants to answer our research question, we determined that in-depth interviews are the most suitable method for data collection. According to McCracken, in-depth interviews are the most dominating method in qualitative research, as well as the most significant data source to case studies (McCracken, 1988; Savin-Baden & Major, 2013). In-depth interviews are an exchange of viewpoints from people that collectively are speaking about a topic (Kvale et al., 2015). The purpose is to gather deep and detailed information that describes the informants own experiences, thoughts and feelings related to a certain situation (Dalen, 2004). However, it is not a mutual form for interaction between the parties involved, since the interviewer defines the situation, presents the topics, and leads the interview with follow-up questions (Kvale et al., 2015). The most common interview methods take place face to face since this method contribute to a visual and auditory research. Hence, in addition to receiving detailed descriptions with words from the informant, the body language is observed (Kvale et al., 2015). In our study, we have performed the interviews digitally by meeting the participants in Teams. Due to COVID-19 and the national restrictions, it is safer for the participants and us as researchers to meet digitally. This allowed us to interview firms that geographically are far away, since travel time no longer is an issue. Additionally, we were able to arrange several interviews in a day, which was very time efficient.

Furthermore, we utilized a semi-structured approach based on an interview guide. The interview guide contains central topics and questions that covers the most vital areas of the research (Dalen, 2004). Thereby,

the interview guide works as a guidance throughout the interview (McCracken, 1988). Semi-structured interviews are flexible since the questions in the interview guide are open, which allows the interviewer to ask follow-up questions (Kvale et al., 2015). Hence, the interviewer can uncover topics and relationships that (s)he was not able to predict beforehand (Tjora, 2017). In the interview guide we developed (see Appendix 4), the questions were designed with different topics that are relevant to answer our problem statement. Before the interviews were executed, we tested the questions in the interview guide on acquaintances. By doing so, we ensured that the questions are open and understandable, to make sure that the informant can talk freely about what he or she believes is important. This resulted in considerable and detailed information, in addition to the fact that the informant in some cases answered questions we had not asked yet or drifted away from the topic.

Therefore, it was essential to utilize the interview guide as a guideline to keep control over which questions and topics that had been answered, in addition to leading the informant back to the topics if necessary. Moreover, follow up questions was used to get more detailed descriptions when the informants did not give in depth answers. Along the way in the interviews, the informants presented new information and new angles that was necessary to follow up on. In the interview process we received more knowledge and understanding about the phenomenon, which contributed to better formulated questions, and we became more comfortable in the role as interviewers. This experience is backed up by researchers. The interviewer usually gets wiser after each interview that is performed, since the informant gives new and unforeseen perspectives about the phenomenon that both widens and changes the researchers understanding (Kvale et al., 2015).

In the interview situation, it is essential that the researcher is a good listener and show the informant respect, as well as showing a genuine interest for the information the informant shares during the interview (Rubin & Rubin, 2011). This will in turn contribute to an informant that is willing to share its experiences, thoughts and feelings about a topic, which are necessary requirements for the interview to be used in a research context (Dalen, 2004). The relationship between the informant and the interviewer is vital for the final result, and trust should be established early in this relationship (Ringdal, 2018).

It can be demanding to decide the number interviews that is needed for the data to be significant. Numerous researchers states that the researcher should continue to interview until the stage where the researcher does not receive new information, e.g., the saturation point. This limit is quite unclear, still, it depends on the research question and what is possible practically (Johannessen et al., 2010). We selected to execute six interviews. This decision was taken in advance of the interview process in accordance with the research question and the time frame. We had to remove one of the firms from our sample, since they were a startup firm, and consequently could not provide the answers for the questions we asked. Later on, we decided to

expand the number of in dept interviews from six to ten, where we had an equal distribution of smaller and larger firms.

All the interviews started with an introduction of us, the purpose of the study and the interview. In advance of the interview, the informants had received and read through our letter of information. The statement of consent was signed before or during the interview. Moreover, we asked for permission to record the interview since this has many advantages. First, by recording we could keep full attention on the informant, and show interest through body language, smiling, eye contact and nodding. Secondly, if we had not recorded, too much time would have been spent at taking notes, and we could possibly have missed important information by the informants. This could passively have impacted the relationship between the researcher and informant negatively since the notetaking takes attention away from the informant. By using the recording, we could go back and study what they said and find information we would have otherwise missed. We did however have to take some notes, as this made it easier to keep track of what topics had already been discussed.

Each interview started with short concrete questions about the informant's background, experience, and role in the organization. The purpose of these questions is to get information about the informant and to ease he or she into the interview. Afterwards, we moved over to questions concerning the research topic. As researchers, we divided roles in the interview process, where one was the main interviewer, while the other paid attention to the interview guide and kept track of which questions that was answered. Hence, the second person was used to assist the main interviewer. Both interviewers were responsible to ask follow-up questions. The interviews lasted from 45 minutes to an hour, and all informants were pleasant and accommodating, and showed a genuine interest for the topic we are researching.

After the interviews were completed, we listened and transcribed the interviews for analysis purposes. It is recommended to transcribe the interviews immediately after the interviews are completed, since this gives the best chances of recalling what the informants said (Dalen, 2004). In addition, this contributed to us getting more familiar with the data material and receiving a better understanding of the information that was collected (Dalen, 2004). In some circumstances, it was necessary to send an e-mail after the interview with follow-up questions, to clarify that we interpreted the information correctly. The transcribed interviews were then imported to NVivo to categorize and analyze the findings.

Afterwards, the data material from the in-dept interview was utilized to design the questionnaire, which was then sent out to the informants. The informants were asked to send the questionnaire to others in their organization.

3.4.2.1 Demographic table

Below we have included a demographic table which gives an overview of the sample in our study. In order for protect the privacy of the participants, the names of the firms are anonymous in the table.

Firm	Informant	Gender	Large/small firm
1	1	M	Small
2	2	M	Small
3	3	M	Small
4	4	M	Small
5	5	M	Small
6	6	M	Large
7	7	M	Large
8	8	F	Large
9	9	F	Large
9	10	M	Large
10	11	M	Large

Table 2 Demographic table

3.4.3 Additional Reflections

In order to include new perspectives, the questionnaire was sent to the recipients by e-mail after the in-depth interviews (see Appendix 5). By combining questionnaires with the in-depth interviews, it included a greater sample from this unit of analysis. Questionnaires is a structured form for standardized questions of larger samples, which means that all respondents are asked the same questions in the same way (Ringdal, 2018). According to Grooves et al. questionnaires are a systematic method for collecting data, which gives statistic descriptions of the population (Groves et al., 2011).

The questionnaire is based on the theoretical framework. After the in-depth interviews in the different organizations were completed, we used the result to design good, customized, and relevant questions. This approach is supported by Johannesen et.al. which emphasizes the importance of reviewing relevant literature and research concerning the topic. In addition, it is recommended to get familiar with the phenomenon through qualitative research. Furthermore, Johannesen et al explains that questionnaires as a data collection method has its flaws, since there are few or no opportunities to adjust questions and answers after the questionnaire is filled in (Johannessen et al., 2010).

The questionnaire is semi structured, this means that the questionnaire consists of a combination of pre coded and open questions. Pre coded questions are questions with pre-defined answer options (Johannessen et al., 2010). According to Ringdal it is vital to structure the questionnaire to avoid confusion when the respondent is answering the questions (Johannessen et al., 2010). Part one of the questionnaire consist of general questions of the respondent, e.g., work title, e-mail address and name. These questions are neutral and easy to answer, which increases the respondents motivation to complete the whole questionnaire (Haraldsen, 1999). In this part we used questions with free text. The remaining parts of the questionnaire consist of multiple-choice questions, in order to map and compare how the different organizations are performing. For instance, in relation to the complexity of the supply chain, lean and just in time principles, risk management strategies and usage of technology.

Once the questionnaire was completed, we executed a pilot study, which meant that we sent the questionnaire to acquaintances to test the survey. The purpose is to receive feedback on structure, typos, how long time they used to complete the survey and if the survey is understandable. This resulted in some adjustments in accordance to understanding of word choices and typos. This is essential since the answers from the questionnaire should be presented in accordance with the data from the same organization. This contributed for the objective to maintain the holistic picture for each organization.

The questionnaires were sent as a link per e-mail to the contact persons in each of the organizations or directly to the candidates, which forwarded the emails to the right candidates. Once the questionnaires were answered by the respondents, the answers were automatically anonymized and sent to us. Because of the time frame we set a deadline of 14 days for the respondents to answer the survey.

Unfortunately, after multiple reminders to the organizations, we did not receive enough responses for the questionnaire to be valid. Only 17 candidates answered the questionnaire, while we originally had set a target of at least 30. Additionally, the findings did not provide any additional information to the in-depth interviews. Therefore, we will not be presenting the findings in Chapter 4. Despite this, the methodology chapter presents how we originally planned to use qualitative and quantitative research methods by data triangulation.

3.5 Method for Data Analysis

There are different methods to choose from in social science research for analyzing the collected data. Since our data material consist of both qualitative and quantitative data, it was analyzed by the usage of theme centered approach. A theme centered interaction approach involves dividing the data into categories, where each category represents central data in the survey. The objective is to compare the information from each

topic from all of the units of analysis (firms), to create a deeper understanding for each single topic through a holistic perspective (Thagaard, 2013).

As described in subchapter 3.4.2, the qualitative data was transcribed by listening to the recordings right after the interviews were completed. Afterwards, we organized and systemized the text from the documents with transcribed text. This process is supported by Johannesen et al., who states that these are important prerequisites for the understanding of the data material (Johannessen et al., 2010). We utilized the analysis tool NVivo to ensure that the data analysis was performed in a structured and clear way. This involves coding the data material and exclude irrelevant information. This means that we established categories, one for each of the factors as shown in Figure 3, in addition to sub-categories because of the large amounts of data the study provided. This was done in ten rounds, for each organization. We included our notes during the process to maintain the context of the excerpts from the informants in order to ensure that the analysis and the interpretation of the data are legitimate.

When we prepared the questionnaire, we used nettskjema.no, which is a tool for performing questionnaires by the University of Oslo. The benefits of nettskjema.no is the opportunity to invite people to respond to our questionnaire, have an overview of the answers, send reminders to those who has not responded, and export the results to Excel. The questionnaire allows us to select whether we want to see who answered the questionnaire, or to have anonymous answers. Regarding GDPR, the questionnaire analyzes and collects the personal information that is asked for, in addition to the opportunity to add, remove or edit the questionnaire after the survey is created. In our survey, we asked for name and e-mail, to be sure of who had replied and who had not. Since the survey includes personal data, we had to answer some follow up questions at Nettskjema, for instance the purpose of the survey, which is the master thesis. Furthermore, we are not collecting sensitive personal information, e.g., health conditions, alcohol or drug use, or attitudes to religious or political questions. The last question concerned if the personal information is to be delivered outside the organization. The answer is no, since the information in the master thesis will be anonymized, it should not be possible for the reader to find out who said what.

By the analysis of the data material, we displayed the information from all the units of analysis. In order to acquire a holistic understanding it is vital to study how the single units relates to each other (Thagaard, 2013). This is ensured by analyzing each unit of analysis individually, as well as presenting the statements and answers of the questionnaires regarding the same topic. The empirical findings, presented in Chapter 5, includes various statements that are used to support interpretations and conclusions from the data material. As mentioned in 3.4.3, the quantitative data material will not be presented in Chapter 4.

In order to preserve the participants anonymity, we have coded the informants and respondents in each organization, independent of the participants role and order of the interview. In this context, we have excluded repetitions and irrelevant information in accordance with the research question and context, in addition to all information that can relate to the data belonging to the participants or organizations.

The data analysis has its starting point in Figure 3 (presented in subchapter 2.6), which means that the data material in each case is analyzed in accordance with the 4 factors. After the review of the 4 factors, the results are summarized in a figure that shows how all the firms have performed in relation to these factors. Our interpretation of the empirical data material is embossed by our interpretation of the topic based on the data collected and the theoretical review. Lastly, the empirical findings are discussed against the theoretical framework, before the conclusions are presented in Chapter 6.

3.6 Quality of the Research

It is vital to ask questions of the credibility of our study. This involves evaluating the quality of the different elements the study consist of, respectively data collection, processing, analysis and interpretation (Repstad & Repstad, 1993). Reliability, validity, and transferability are fundamental terminologies to evaluate the quality of the study. These terminologies provides a basis of how the participants and other researchers can evaluate the procedures of the study (Marshall & Rossman, 2016). Reliability relates to the evaluation of the quality of the data and to the procedures behind the data collection, while validity involves the data materials validity in relation to what is measured and the interpretation of the findings. The transferability of the study relates to the analytical procedure and involves acquiring an expanded understanding of the topic of research (Leseth & Tellmann, 2018). It tells you to what extent the results of a qualitative study can be generalized. Nevertheless, it is critical to evaluate how the methodical choices and the researcher's position can influence the quality of the research. Another aspect is to evaluate how the researchers research method takes care of and accommodates the participants in the research, since humans are significant in qualitative studies.

3.6.1 Reliability

Reliability involves whether the implementation of the study is regarded as dependable (Thagaard, 2013). A study with a high degree of reliability gives the same result with repeated measures if the same preconditions are set (Ringdal, 2018). Hence, the reliability is related to the preciseness of the study's data, the method they are collected and how they are processed (Grønmo, 1996). Yin emphasizes the importance of the focus on reliability throughout the research process (Yin, 2018). In addition, the reliability will increase by making the research process transparent (Silverman, 2015). Throughout the master thesis we are providing detailed and structured descriptions of how we have performed the research process, as well as reasons for the

methodological choices, making sure that the readers can evaluate the implementation of the process step by step.

Before we began the planning of the study it was necessary to acquire prior knowledge of disruptions, global supply chains, emerging technologies, and COVID-19. As mentioned earlier, this was done in our preliminary thesis (Nylænder & Pedersen, 2020). Additionally, it was essential to create insight and knowledge of potential issues which we discovered during past research of this topic. It is beneficial to acquire comprehensive knowledge of the topic in order to ask precise and relevant questions which contributes to strengthen the reliability of the collected data (Tjora, 2017). This knowledge can on the other hand cause the researchers to create their own opinions that may distort the design of the research questions and interpretation of the data material, which in turn weakens the reliability on these areas. According to Repstad & Repstad, the most important factor is that the researcher is open to adjust these during the process, instead of going out to the field without understanding and knowledge about the research topic (Repstad & Repstad, 1993). To ensure that we completed the study with an objective approach we developed an interview guide with open questions which means that the informants are able to talk freely about what they felt was important and relevant. This contributed to new insights and deeper understanding of the topic we are researching.

The reliability of the study can be connected to how the data material is developed throughout the research process (Thagaard, 2013). Throughout the interview process we recorded the interviews which enabled us to transcribe the interviews right after the interviews were completed. This helped preserve the informant's voices to the reader by presenting the citations as the informants expressed them. This is supported by Seale, which states that this contributes to strengthen the reliability (Seale, 2007). It is important to notice that the interviews were conducted in Norwegian.

During the interviews we experienced in some cases that the interview candidate took over the interview, which Kvale mentions is a vulnerability with in-depth interviews (Kvale, 2006). Since we sent over the interview guide in good time before the interview took place, the interview candidates were well prepared to answer the question. In some instances, this resulted in the informants answering questions before we had the chance to ask them. While this made it harder to keep track of the interview, it was not a huge issue.

In the presentation of empirical findings in Chapter 4, we have utilized citations from the informants to ensure a good foundation for the analysis of the data material, and to make sure that the analysis is not largely embossed by our own perceptions. According to Ryen it is essential to utilize citations to strengthen the reliability in the analysis of the data material (Ryen, 2002). Furthermore, the author addresses that a limited excerpt from the data material, that is meant to illustrate the researcher's conclusions, rarely is sufficient for

the reader to judge whether this basis is good enough. The decision of which citations that were utilized is based on what is relevant for the topic, hence, irrelevant information was excluded. In addition, since we analyzed the participating organizations individually, it enabled us to reproduce much of what the informants expressed.

Regarding the reliability for the questionnaire, it was sent out to relevant workers in supply chain and logistics roles within the participating organizations. This implies that the ones that answered the questionnaires possesses the right knowledge, and therefore the data is considered as reliable. However, since we did not receive enough respondents to our questionnaire and it did not contribute to additional information, we made the decision to withdraw it from our study.

The fact that we are two people working on this study contributes to increased reliability (Thagaard, 2013). We have worked closely together and had numerous productive discussions. This enhances the accuracy of the results and makes the study more reliable. High reliability is a precondition for high validity (Ringdal, 2018).

One thing that might contribute to lower reliability, is if the employees want to portray their organization better than it actually is. Some of the people we have interviewed could have done this, in order to protect themselves or the organization (Fox, 2009). Most employees want their organization to look as good as possible, and they might be afraid of, or not even allowed to talk negative about it. This will make some of the data invalid and decrease the reliability of the study. However, we do not suspect that this has happened in our study.

3.6.2 Validity

Validity deals with which conclusions the researcher can draw from the collected data material (Leseth & Tellmann, 2018). A study is considered to have a high degree of validity when the study captures what it is meant to capture (Holme, 1996). Validity is divided into internal and external validity. Internal validity involves if the data material complies with the researcher's intentions with the study, as well as in what degree the conclusions reflect the reality that is studied. External validity, on the other hand, involves if the results can be transferred to represent a larger sample than what is studied. In this subchapter we are first performing a review of the study's internal validity, before we in the next subchapter discuss the external validity, also called transferability (Repstad & Repstad, 1993).

The validity of the analysis and the conclusions that we have arrived at are strengthened of our choice of methodology. Since we utilized a qualitative approach with a quantitative survey, it has entailed with several different sets of data material. According to Leseth and Tellmann, triangulation of data strengthens the

internal validity (Leseth & Tellmann, 2018). Our data generation contributes to more perspectives being included, and therefore highlights the phenomenon in a holistic way that ensures a realistic picture of the reality. The qualitative research contributed to our understanding, which meant that we were able to ask better questions in the questionnaire. According to Jacobsen, this strengthens the validity (Jacobsen, 2015). As earlier mentioned, we have withdrawn the questionnaire from our study. However, since the questionnaire did not provide additional information, we do not believe that the internal validity is weakened as a result. Furthermore, it was important with a sample that was suited to provide information that is relevant for the research question. This was ensured by including the ones that are involved in the logistics and supply chain departments that has great knowledge of the phenomenon.

In social sciences, intersubjectivity is a focus area which involves that the closest we come to the truth is that several people agree about something. The more people that agree about something, the higher the probability is that it is correct (Jacobsen, 2015). In this regard, the validity in our study is strengthened in how we analyze the empirical data from each organization individually. This is done because across the analysis the participants express several of the same factors.

As with reliability in the research process, validity in the data material and the interpretations we have done can be strengthened by transparency, in this relation called theoretical transparency (Silverman, 2015). In this master thesis we have developed a theoretical framework by taking the research question into consideration, which formed the basis for how we collected and interpreted the empirical findings. Furthermore, the theory and analysis represent the foundation for the conclusions we have drawn. The results of the discussion of the empiric against the theory showed that several parts of our empirical findings can be confirmed by previous studies. According to Thagaard, validity is based on whether interpretations from various studies can confirm each other, which strengthens the findings validity (Thagaard, 2013).

In relation to data saturation, we have in subchapter 3.4.1 argued for why we sat the limit of 10 interviews. Tjora states that if data saturation cannot be argued for, it is other conditions that must decide how many that should be interviewed in a qualitative study (Tjora, 2017). The number of interviews is limited in relation to the nature of the problem, as well as the time frame of the master thesis.

As with the reliability of our study, the validity is strengthened since we are two students that have a close cooperation. This implies that the analysis, interpretations, and conclusions has been followed up by discussion from different points of view.

3.6.3 Transferability

Transferability involves whether the understanding we develop within the framework in our study can be relevant in other contexts (Thagaard, 2013). Since the methodology chapter includes frameworks and information concerning the sample process, context and methods for data collection and data analysis, this contributes to see who the results can be transferred to (Johnson, 1997). Furthermore, transferability involves if the depth of the interpretations provide good conditions to relate the content to own experiences, which we ensured by two individual and detailed analysis within each dimension (Thagaard, 2013). Transferability can be done by two methods, naturalistic generalization and replication logic (Johnson, 1997).

Naturalistic generalization involves whether similarities between humans and circumstances in a study matches the ones it is desirable to transfer to. The more similarities, the stronger is the transferability (Gomm, Hammersley, & Foster, 2000). The sample, both in combination with organizations and participants are based on predefined criterions that are designed with a basis in our theoretical framework. The participating organizations and the sample within these have therefore a number of similarities, which enables transferability to other organizations with the same similarities (Leseth & Tellmann, 2018). This entails that our findings can be transferred to other organizations that operates within a global supply chain.

Replication logic, on the other hand, involves that the more times findings agree with various types of humans, the more trust these findings has in relation to be transferred to other people beyond those that participated in the original study (Yin, 2018). This is interpretations and descriptions by the help of patterns in the data material that lays the foundation in this context (Johnson, 1997). Since we have executed the research within different organizations and analyzed these individually this increases the transferability through the replication logic (Ridder, 2017). Several findings were clearly represented independent of the organization and can confirm past research presented in our theoretical framework.

3.6.4 Potential Effects of the Quality

A study is rarely designated as flawless, since there are various factors that can impact the progress. According to Halvorsen the researcher must evaluate if the result could have been impacted by the methods used for sampling, data collection and analysis of the data material, as well as if these methods bring one or more sources of error (Halvorsen, 2008). In addition, it is essential to explain how the researchers position can impact the research (Tjora, 2017).

External characteristics as age and gender can impact how the participants perceives the researcher (Thagaard, 2013). The interviews we conducted was dominated by males. However, we do not have the impression that this was of importance for the informants since we were well received, and they showed a

high degree of interest for the topic. Moreover, the researchers understanding of the phenomenon that is studied and the collaboration with the informants can to a certain extent affect the data development. Before we started the interview process, we had developed a great understanding of global supply chains and risk management. Still, global supply chains and risk management involves a high degree of complexity, which means that we do not have a complete overview and understanding.

It is vital to reflect over the fact that it is not only the researchers and the choices of methodology that affects the data collection, the informants can influence each other. Since we have established contact with the different organizations and sent letters of information in advance, the informants had time to prepare in advance of the interview. Hence, the informants had the opportunity to discuss with colleagues or other informants, which could affect what they are willing to share during the interview. Therefore, we limited the information in the proposal letters to reduce the risk of this. Another potential risk is that the participants would withhold information to protect their firm's reputation. In addition, it is important to notice that the informants we interviewed represents a division of the organization, and is not necessarily representative for the whole organization, as other divisions could have experienced the effects of the pandemic differently.

The questionnaire was designed to be understandable and not require too much effort, which is essential to limit absence. Early on we decided to use both interviews and questionnaires as a part of our data collection, which would strengthen the study providing different perspectives. This is time consuming, and we established contact with relevant organizations at the beginning of January to utilize the time we had available until the deadline in June. As soon as our study was approved by NSD in mid-January, we agreed upon the time for the interview. Regarding the questionnaire, we had to send multiple reminders to some organizations in order to obtain more answers. Unfortunately, as mentioned earlier, we did not receive enough answers, and made the decision to withdraw the questionnaire from our study. Still, we do not believe that this have impacted the quality of the study in a large degree.

3.6.5 Research Ethics

Research ethics regards rules, guidelines, and principles for evaluating if actions are right or wrong. The relationship between humans are central in this context, where the question is related towards what we can and cannot do to each other (Johannessen et al., 2010). Ethical decisions are done throughout the research process and is vital with the data collection throughout interviews since this research method directly affects humans (Kvale et al., 2015). A formal approval from an ethical committee and an informal approval from those that are interviewed are required to conduct the data collection (Fangen, 2010).

As mentioned earlier, before we could start the interviews, we had to send the study to Norsk senter for forskningsdata (NSD) for approval. Our study was evaluated and approved according to their research ethics guidelines in relation to the General Data Protection Rights (GDPR). NSD used the document information regarding the master thesis, see Appendix 2 as a part of the evaluation, in addition to the statement of consent, interview guide and questionnaire, see Appendix 3, 4 and 5. The purpose of the document “Information regarding the master thesis” is to inform the contestants of the purpose of the study, as well as what it means to participate to the study. In addition, the participants are allowed to withdraw from the study at any time. By doing so we ensured that the participants had some control over their participation. It was vital that the letter of information did not contain more information than necessary, since too detailed information about the study could affect the participants behavior (Thagaard, 2013).

In the beginning of each interview, we asked the informants if they had signed the letter of consent, where they consented that they had read and understood the letter of information. The informants have the rights to control of which information that is shared and what the information is used for (Alver & Øyen, 1997). Consequently, it is important that the researcher ensures that the research is presented in the letter of information in a way that takes care of the informants rights (Fangen, 2010). The informant’s signature and NSDs approval of our study confirms that we have achieved this.

In the process of collecting data materials in an interview it is essential that the researchers own viewpoints and interpretations are kept outside of the interview, and should neither be argued or moralized (Dalen, 2004). We have shown interest of what the informants has said during the interview, for instance by body language and nodding, however, beyond this we have appeared neutral during the interview. In addition, we have respected the informants and shown gratitude for their willingness to participate in our study. This is supported by Thjora, which states that this is a great foundation for good ethical research in qualitative studies (Tjora, 2017). Moreover, the questions we asked the informants were not formulated in a way that could appear offensive or judgmental. It is vital for us to formulate questions in both the qualitative interview and the quantitative survey that are not negatively charged. Since the study concerns global supply chains and how these firms have handled the COVID-19 pandemic, we do not perceive this as a sensitive topic for those who participated.

Furthermore, the data material is treated in regard to the informant’s consent. Every participant consented either written or orally during the interview. The organization the informants represent is presented in Chapter 3, however the organizations have full anonymity in the analysis and discussion of the findings in Chapter 4 and 5.

When it comes to the storing of the data material it is critical to make ethical considerations. The researcher must treat information she or he has access to in a careful manner that ensures the participants confidentiality (Leseth & Tellmann, 2018). Throughout the interview process we have recorded the interviews, with consents from the informants, which we have transcribed and analyzed in NVivo. Both the recordings and the transcribed interviews has been stored in password protected computers that only the researchers have access to. Additionally, we are the only ones that has treated the research material, and when the master thesis is completed all of the files are deleted. Throughout the analysis we have taken care of the participants statements by presenting citations from the interviews. Since we utilized recordings and transcriptions, we have ensured that the statements are cited correctly. However, since we chose to interview in Norwegian, the citations are translated to English. Still, we believe that the citations correspond with what the informants expressed during the interview.

Another vital principle in research is to avoid plagiarism of other researchers work. Plagiarism is considered as a significant violation of the research ethic (Thagaard, 2013). In the development of our research process, we have used the preliminary project as a starting point for the theoretical framework and improved it from the feedback we received from our supervisor and the sensor. Furthermore, we have used the theory as a foundation to discuss the findings from the interviews and questionnaire. Additionally, we have utilized literature to support the methodological choices we have done throughout the research process. Hence, we have shown good research ethic by referring to the author and the year the literature was published. The references are listed alphabetically after the conclusion of the master thesis, which provides a more detailed description of all the sources we have utilized. This allows the reader to control the references, and to read more about the topic.

Throughout the research process we have followed the ethical guidelines in a good manner. We have shown a moral responsibility and taken care of the organizations and participants in a good way.

3.7 Research Process

Throughout the methodological chapter we have described in detail how the research process has been executed, as well as explaining the reasoning behind each decision. Besides, we have discussed the research process validity and reliability and how we maintained a good research ethic and considered potential effects in the research process. This has resulted in a comprehensive methodological chapter, which makes it appropriate to summarize the research process. Therefore, we have developed a visual model which depicts how the process was structured, see Figure 5 on the next page. We have utilized a qualitative research method in order to get in depth information from firms with global supply chains of their experiences from the pandemic. In addition, we have sent out questionnaires, which was meant to quantify the impact, and be used in visual models, but was later scrapped. As shown in the figure, we ended up with case design where we compared large and medium sized firms.

Afterwards, the data material was analyzed in order to validate and potentially uncover more information, since the different units of analysis illuminates several perspectives of the same phenomenon. The next step was to discuss and analyze the empirical findings in relation to the theoretical framework and compare large and medium sized firms. Finally, we presented the conclusions of the study.

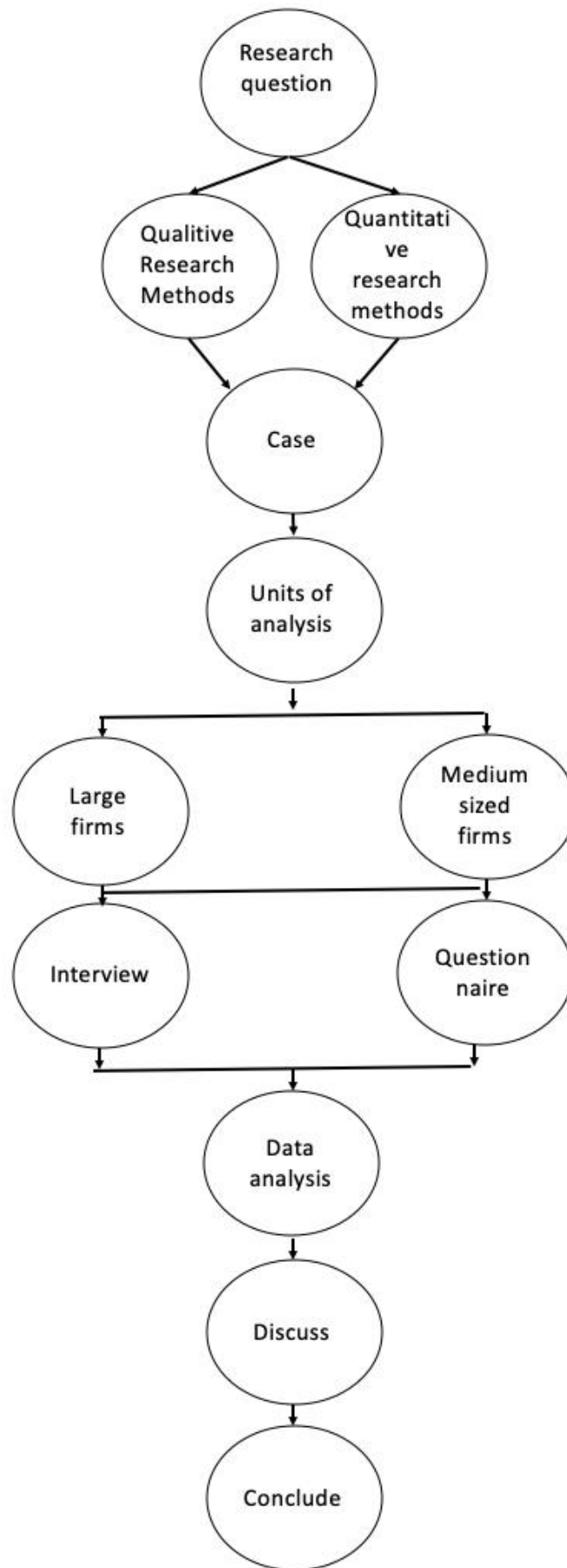


Figure 5 Research Process

4 Empirical findings

Chapter 4 presents the empirical findings from the in-dept interviews. The chapter is structured into two parts. First, we are presenting how the different firms has been affected by the COVID-19 pandemic, followed with a presentation of which factors that are necessary to handle a disruption. The firms are presented in relation to the coding in NVivo. The five first are the organizations with less than 1.000 employees, and the five remaining organizations have more than 1.000 employees. The interviews were conducted in February and March of 2021.

4.1 Factors to Handle a Disruption

In subchapter 2.6 we established a model that determines a firm’s ability to withstand disruptions in the supply chain. The four factors are complexity, risk management, communication, and geopolitical factors, and are presented in Figure 4. The first three factors are controllable, while the geopolitical factor is more challenging to control. According to the theory, the firms who score well on these factors should have a high ability to withstand disruptions.

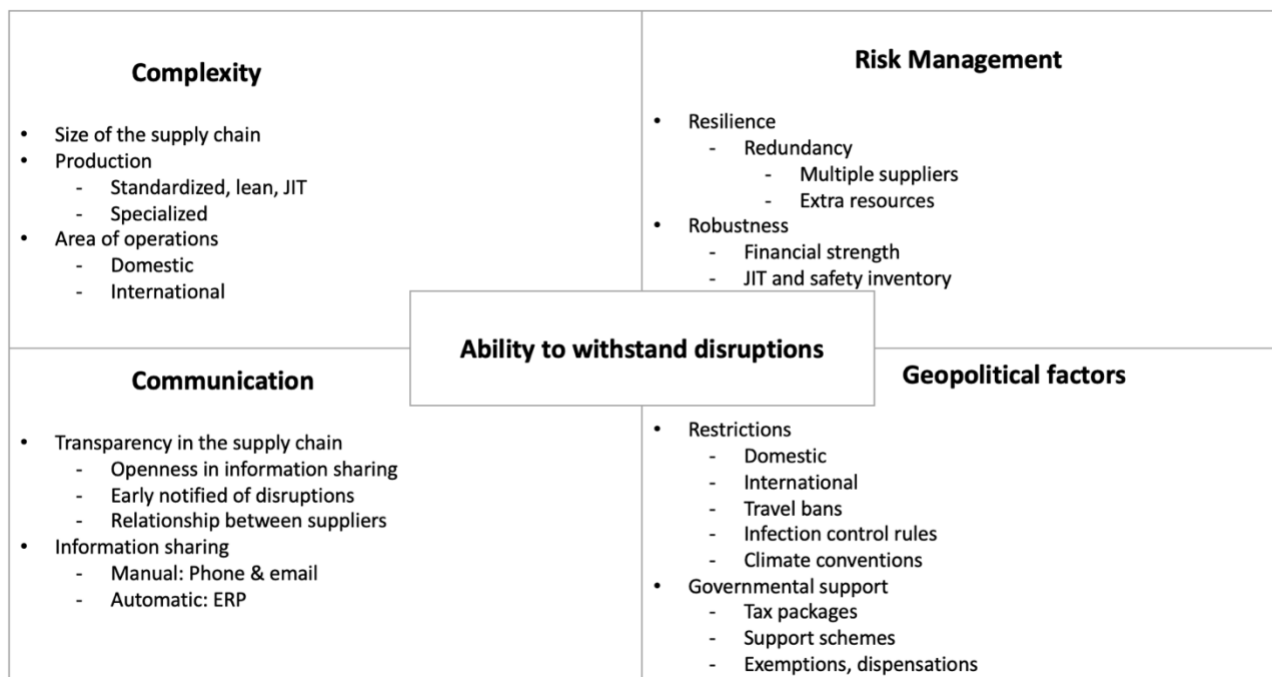


Figure 4 Firm’s Ability to Withstand Disruptions

4.1.1 Complexity

Firm 1 is a small global organization that develops their products in Norway. These are mass produced in their fabrications in the Middle East and stored in warehouse locations in US, Canada and Drammen; *“Our products are shipped to Drammen where we can ship directly to the customers. In addition, we have a warehouse in US*

and Canada which ship goods from Norway” (Informant from Firm 1). They state that they have control over most of the materials they use:

“We select most of the components, however, our partners determine standard products like resistors and capacitors. In addition, we have professional instruments that is produced in Norway, which is targeted to the professional market.” (Informant 1 from Firm 1)

They utilize LEAN and JIT to some degree; however, it is not as the same extent as the car industry; “*We plan the inventory for a couple of months, and order more when needed. We are dependent on the inventory to handle the production; however, we focus on keeping it as low as possible.*” (Informant from Firm 1)

Firm 2 is a small organization that delivers products and services to their customers. Their production consists of three parts; “*We establish contracts with a Norwegian fabrication firm which outsources the production to Romania*” (Informant from Firm 2). As they outsource their production, they do not utilize LEAN principles or Just in Time; “*We are first and foremost a project-oriented organization, and do not utilize JIT and series production.*” (Informant from Firm 2). The products are custom made and specific to each customer. Primarily, they use raw materials as steel to produce their products.

Firm 3 is a smaller global organization that develops, produces, and delivers products through their global departments. They have production in Asia and Southern Europe, as well as some production locally in Norway. “*The production facilities in Asia and Southern Europe purchases material based on the specifications from us*” (Informant from Firm 3). Some of the materials are bought locally where the production facilities are situated. Furthermore, the informant informs that the main components are shipped from Norway and installed on the facilities. The products are 90 – 100 % completed when they are delivered to Norway. They usually do not offer customized products for their customers.

“We only deliver customized solutions when there is a potential of it becoming a standard product in the long term or if it can introduce us to new markets. We have five main suppliers that we use for most of our products.” (Informant from Firm 3)

Even though they have a standardized production, they do not have a standard form for LEAN. “On a general basis our production is following the JIT principle. The bottle neck for the production capacity is delivery time, which is the case in 90 % of the circumstances” (Informant from Firm 3). Normally, they initiate the production on the standardized products before they have signed agreements with its customers. Their inventory normally consists of 3-4 products.

Firm 4 is a smaller organization that produces products. They use both domestic and international suppliers for their components.

“We have international suppliers for our main components; however, we also use a Norwegian supplier. Most of the components and hardware are shipped from abroad and is compiled in Norway.”
(Informant from Firm 4)

The parts are highly specialized and therefore they must wait if there should occur any form for delays. In terms of LEAN, they stated that they do not have a direct form of LEAN, however they use tools from Six Sigma in their daily activities, such as 5S.

“We have implemented 5S which involves cleanliness and order. It focuses on removing waste and making sure that everything is orderly placed. We have a large emphasis on labeling which makes it easy and recognizable for the installers.” (Informant from Firm 4)

Since their components are specialized, they have a low inventory.

Firm 5 is a smaller organization that produces machines for its customers around the world. The base of the products they deliver are standardized, while the rest is custom made based on criteria from their customers; *“When we deliver a product, 80 % of it is standardized and 20 % is customized to the customers’ requirements”* (Informant from Firm 5). The production takes place in Norway; however, certain components as electrical motors, surface treatments and varnishing they do not produce themselves. When asked about whether they have implemented LEAN, they said that they do not have LEAN in their main organization, however, their subsidiary has a LEAN production.

“We do not have LEAN in our main production; however, we have fixed routines and systems that handles these processes for us. We have developed process documents. Since some parts of the production are specialized, we sometimes have to deviate from this.” (Informant from Firm 5)

Firm 6 is a large global organization that is part of a complex supply chain.

“Our supply chain is quite large. It consists of more than 2 000 suppliers where 50 % of them are located in Norway. Consequently, we support many small and medium sized firms in Norway.”
(Informant from Firm 6)

Previously the market has noticed shortages of electrical components which usually happens in a cycle of 7 to 9 years. This has forced the organization to increase their safety inventory. *“In 2019, the market noticed a large scarcity of electrical components, which made us buy additional inventory. This has helped us during COVID-19”* (Informant from Firm 6). While they are working after the Just in Time principle, they also have a large focus on risk management.

“Critical and specialized components, even the ones that are cheap can potentially stop the whole production. Therefore, it is important to have a safety stock of these types of components.” (Informant from Firm 6)

In the beginning when Firm 6 implemented JIT, they experienced that it caused significant delays, since the employees took the JIT term literally. It is important to find a balance.

Firm 7 is a large global organization that offers services and products. The division we interviewed is responsible for receipts of goods and inventory in the warehouse, in addition to deliver products to its own production and other parts in the organization, both in Norway and globally.

“Our supply chain is relatively complex since we are a global organization. The warehouse is a part of the supply chain, where we have tender and purchase department that deals with the process before the goods are placed in the inventory.” (Informant from Firm 7)

They utilize the FIFO (First in, first out) principle to control if their goods are obsolete. Moreover, they have a focus on LEAN production and making their processes leaner.

“In our industry it is a high focus on traceability, e.g., if there should occur an issue with one of our products, we must quickly be able to identify each part and see if there has occurred an error during the process.” (Informant from Firm 7)

They have a large focus on quality assurance and that everything that they produce must be in accordance with requirements and specifications. This can be time consuming, and they are working on making this process leaner. The objective is that their processes should be as lean as possible, the whole way to the customer. Besides, they have implemented several measures to make the production leaner.

“We have multiple LEAN measures in our current production. Among other things, the employees who collect parts have fixed places where they deliver products to the production. There are also three large component lifts which collect parts based on equipment lists.” (Informant from Firm 7)

Firm 8 is a large global organization and is a part of a rather complex supply chain. We have interviewed a leader for operational purchase within logistics. Hence, the informant expresses that she does not speak for the whole organization, since other departments could have other experiences of the pandemic. The department we interviewed has a low degree of production and is more concentrated on the after-service market. Firm 8 was affected by the first lockdown in China, where they have several business activities. *“We have several business activities in China, where some of our suppliers are located and we do project delivery”* (Informant from Firm 8). The supply chain is rather complex and there are many links that must correspond. In relation to LEAN, they have implemented some measures, which is mostly related to mindset.

“We do not follow every LEAN principle. Still, everyone that works here has an eye for making things better for each day. We also have a large focus on reducing waste and removing things that are of no use.” (Informant from Firm 8)

Firm 8th's ERP-system has a JIT approach to a certain extent, still, the informant believes that the slack has saved them during the pandemic and given them room to adjust their projects.

Firm 9 is a large global organization with a high degree of complexity. They have LEAN in their production, with a focus on resource optimization. They experience a high degree of uncertainty of whether the material will be delivered to the right time, to the right place and to the right personnel that are executing the job. This issue is further explained under the subchapter 4.1.2 Risk Management and 4.1.3 Communication.

Firm 10 is a large global organization with business activities all over the world. They import most of their goods from China, and exports to USA and Canada for a broad spectrum of customers who work in various segments. They are not part of one specific supply chain and the parts involved are usually changed from each delivery.

4.1.2 Risk Management

Firm 1 had sufficient capital to deal with the situation and managed to increase their sales from last year. They found it necessary to increase their inventories and production, to make sure that they had enough products. *“We have had few delays to the end customer; however, our inventory has been at a minimum, and close to*

zero for certain products" (Informant from Firm 1). Therefore, they were forced to look for alternative solutions to acquire the materials and ended up with paying more for the different components.

Firm 2 is a small firm and does not have the financial robustness of some of the others we have interviewed. They have invested a considerable amount of money in collaborations with firms, making them very vulnerable to disruptions. *"We have invested money in the technology of the firm which makes us vulnerable"* (Informant from Firm 2). However, they do have strong owners which are able to secure the operation of the firm. The components they use can usually be obtained from multiple suppliers. Yet, in some instances, they use specialized components which very few suppliers offer. This can in turn lead to bottlenecks. One risk mitigation measure they are currently working on, is to be able to move their production to Norway in case the facilities they use abroad experience disruptions. *"Depending on where in the project we are, we have the option to produce in Norway"* (Informant from Firm 2). This is currently very dependent on the type of project they are dealing with, and if their main production facility would be halted. At this point in time, they would most likely have to deal with large delays.

Firm 3 was not prepared at all for the pandemic and did not know how to cope with the situation. *"We could have been more prepared for the pandemic. We had no action plan or risk management plan for how to act during these types of situations"* (Informant from Firm 3). Although they experienced a decline in sales and turnover, they managed to get a surplus and were never in a crisis economically. The components that are used in their production are mostly specialized, meaning that they have few options when it comes to suppliers. If they experience delays with these components, they usually must wait. In some cases, this have taken up to 4 months. The products they produce are large-scale and they typically start the production before they get an order. However, they do not have a large inventory stock.

Firm 4 acquires most of their parts from India and Italia, which has led to some challenges since the pandemic started. The parts they use are highly specialized, and they have few options when it comes to suppliers. Switching suppliers is normally very time consuming. *"The delivery time from when the order is placed, to when the parts are installed, are usually between 1-1,5 years. Therefore, we can't switch between suppliers that easily"* (Informant from Firm 4)

Due to the type of parts Firm 4 use, they do not have a large inventory stock to rely on. This makes them very vulnerable to disruptions. They have been able to handle the situation, as they are financially robust. Additionally, their main businesses are more or less unaffected by COVID-19, so they have managed themselves quite well.

Firm 5 is a smaller firm that is quite solid financially. *“While we did lose a couple of million NOK, we have strong and robust owners which has been beneficial during this time”* (Informant from Firm 5). They were not prepared for a disruption like COVID-19 to occur and did not know how to cope with the situation. Their production is specialized, however, the process of obtaining parts has not been a large issue during the pandemic. There have been a few delays, which they have combatted this by ordering earlier or using alternative solutions.

“If some parts are unobtainable, we can usually find alternative solutions. This is not always the case though, and some components are very critical for our production. On the other hand, our production is flexible, and we can often reorganize it and do other things in the meantime.” (Informant from Firm 5)

Firm 6 were robust enough as an organization to withstand the pandemic. They were never in a crisis moneywise, and they were quick to gather a response team and develop risk-analysis on where potential problems could occur. As mentioned in 4.1.1 Complexity, they found it necessary to increase their inventory of electrical components and this has helped them during the pandemic. While they do work after the Just-In-Time principle, risk orientation is also a large focus.

“Shortages to certain products can potentially stop the whole production, some degree of safety stock is therefore necessary in our production. We also have a deal with our suppliers, where they can hold back products in their own warehouse in case we are not ready to receive the product. This helps us split the risk between them and their suppliers.” (Informant from Firm 6)

Firm 7 is a large global enterprise that are financially robust. When the pandemic struck, they had just been through a large downsizing-process. At the same time, they were managing a production that was growing, and this made the situation challenging. The department we interviewed however, had been given extra resources to meet the new demands of the production, which helped them during the pandemic. Many of the components they use are specialized, which can be a demanding if one of them are unable to deliver the components.

“We have many specialized components, and it can be challenging if a product becomes unavailable. At the same time, what we produce at our department has a relatively large inventory, which enables us to reprioritize our tasks.” (Informant from Firm 7)

This is just a temporary solution though, as other materials will pile up if they don't receive what they need.

Firm 8 is a large and robust organization, with strong financial resources. They have managed themselves well, although 2020 is far from one of their best years. They are very focused on risk mitigation and being proactive.

“We were well prepared for the pandemic and monitored the situation months before the lockdown started. Already in January we held weekly meetings, where we discussed how the organization could be affected and established risk management measures.” (Informant from Firm 8)

Regarding materials and shortages, this is something Firm 8 have a plenty of experience with. Their purchasers understand the mechanisms that occur during shortages and know how to act in these types of situations.

Firm 8 is a project-organization which assembles the end product. The production is specialized and mostly unique for each project. Switching out articles that are delayed is very difficult. *“Our main source for electrical components is located in China and switching these out normally take half a year to a year. This is usually not something we do”* (Informant from Firm 8). One thing they did was to make sure that their purchasers added a larger safety margin. Purchase orders usually have a time horizon of about 2-3 months, which has increased. They have, in some instances, added more safety stock, but their inventory has not increased substantially. They do have a principle of producing close to their customer if possible. *“If our customer is located in China, we try to do most of the assembling there. The same goes for Korea.”* (Informant from Firm 8).

Firm 9 is a large and robust organization with strong financial resources. They have large inventory stocks, however, due to bad data systems it is difficult to see whether the material they need is in stock. Poor quality of master data is a problem across their industry and means that they often must change their plans last minute.

“Often, we are not aware if the material will arrive at the right time, in the right place and if the right personnel is available to do the job. If one of these things go wrong, we are forced to move our activities and do something else. This interrupts the whole ecosystem.” (Informant from Firm 9)

They are often reactive, rather than proactive. Yet, they have a sophisticated contingency plan where they practice on various scenarios. One of these things are pandemics, however, the pandemic they prepared for was of a much smaller scale. *“Practicing pandemics is not easy. We did have some procedures which was more in relation to stuff like the flue, etc.”* (Informant from Firm 9). Their base contingency, however, is strong.

Firm 10 is a large global enterprise with many different activities. This has been a great strength during the pandemic, as when there is less activity in one business area, there is increased activity in another. The informant addresses the importance of having multiple business areas. *“Being too reliant on one activity is very risky in our industry. We have a large product mix, which makes us better suited to handle global crisis like this.”* (Informant from Firm 10).

Originally, Firm 10 is a B2B organization. During the pandemic they have seen a considerable growth in B2C services. Being a diverse and robust organization, makes transitioning to different business areas much easier. They have been exposed to delays, however, due to them operating in many business areas, they have found a way to work around this. Financially they are very robust.

4.1.3 Communication

Firm 1 has good communication with its different stakeholders in the supply chain. They are working close with their component suppliers and gets frequent updates of order times. They have not integrated technologies such as blockchain in their supply chain to improve the transparency between the participants. *“In relation to verifying transactions or tracking of products, we do not see blockchain technology as relevant at this time. Maybe when the technology becomes more available.”* (Informant from Firm 1).

Firm 2 has close contact with their suppliers, and their collaborative partners have worked closely with the production facility in Romania. However, all their communication is done through manual processes, using email, phone, and Teams. They have not integrated any technology in their supply chain which enables seamless communication between their partners. They have noticed that it is more challenging to receive confirmation on deliveries. *“The largest consequence in the supply chain is that the communication is more time consuming, since our suppliers can’t confirm delivery times, which results in multiple reminders.”* (Informant from Firm 2).

Firm 3 has good communication with their eight suppliers; *“We have good communication with our suppliers and are early notified if there are delays in the production.”* (Informant from Firm 3). The main challenge is that their suppliers’ suppliers have experienced delays too, which makes it challenging to confirm the delivery time. For more information of delays, we refer to Chapter 4.2.1 Delays. They do not use technology to improve the transparency in their supply chain, as they feel the technology is not mature enough at this point time.

Firm 4 has a close dialogue with their suppliers. They are quickly notified if there should occur any delays, this is further explained in 4.2.1 Delays. They use machine learning to process the data in the cloud. Moreover, they use project hotels and teams as a platform for sharing information with their supply chain partners. Their

ERP system is internal for the organization. The ideal solution is that the customers and suppliers can interact directly with it. As of now, sharing of documents and information with their partners is done manually; *“We put documents in another platform and transfer it manually to the ERP system, which is ineffective.”* (Informant from Firm 4).

Firm 5 has good communication in their supply chain. However, most of the communication is done manually through phone calls and emails. They use technology like IoT, Machine Learning, Big Data and Artificial Intelligence in their production. They have not implemented the technology in their supply chain to increase the transparency between the participants.

Firm 6 have very good communication with their suppliers, and expresses that they have been good at reprioritizing and keeping their focus on the most crucial tasks. Another thing they pointed out is the importance of trust during the pandemic, both between employees and suppliers. For more detailed information, see subchapter 4.2.2 Home office. Before the pandemic they began two large improvement programs for digitalization, where one of them is targeting their internal Enterprise Resource Planning (ERP) system. To get the optimal effect of Machine Learning and AI, they must have good quality in the fundamental data. The informant believes that the changes they do today will contribute to increased quality in their data, which will enable them to use technologies like this in the future. They are using 5G and Internet of things, however there are some restrictions concerning 5G which implies that it is not fully utilized. Cloud services are not used in a large degree, since their customers have high requirements for safety and risk management.

Firm 7 has good communication with their suppliers and stakeholders. The informant expresses the importance of taking the whole supply chain into account:

“What we need to improve on is to think holistic through the supply chain. It is often easy to only focus on your own tasks instead of looking at how this will affect the next step in the process.” (Informant from Firm 7)

They do not use emerging technologies to enhance the information flow in their supply chain, and most of the communication is done through phone and email. Still, they are continuously working with data technical improvements. In their production they use material managements systems, and SAP as their ERP system. This is used for everything from inventory, production, internally in the organization, administration, time management etc. They have a continuous focus on improving their systems. Still, many of them are old and outdated.

Firm 8 has good communication with their stakeholders in their supply chain and are quickly notified if there should occur obstacles. However, the informant states that there are room for improvement; *“We must improve of the flow of information between our departments”*. They have a collaboration with an external party where they structure the purchasing process, deals, strategic partners, and producers. The ERP system is very old fashioned where nothing is automatized and is therefore very dependent on the employees to communicate by phone and email to their customers and suppliers. There are good possibilities for extracting data in the ERP system. However, they are very careful with who are given access to their systems. A combination of little willingness to use money to improve the system and the fear of losing control of the data are the main reasons of why the ERP-system has not seen many changes. Still, they are working with technology and digitalization, for instance to communicate better with their transportation partners.

“We believe that there will be implemented more technology in the supply chain in the future. Currently, GDPR, risk of hacking and leakage of sensitive information is why we are waiting until the technology becomes more mature.” (Informant from Firm 8)

Firm 9 has good communication with the stakeholders in their supply chain. However, the ERP system is old and outdated, which requires manual work. *“The systems do not communicate, which means that the people need to communicate through phones, email and do manual tasks.”* Some of the operative coordination in the organization is done manually, with great quality, however, it requires many employees. They need more employees to perform the same work as earlier. In the future they are aiming for completely automated processes and tools that automatically provide information about how much volume that needs to be shipped the next months. This is an industry problem that everyone involved experiences. The Norwegian planning tool that distributes the logistic does not meet the global level. *“In South America and Africa, they still use pen, paper and Excel-sheets, we have a combination”* (Informant from Firm 9).

The informant speaks about the logistics iceberg, where everything looks good on the surface. Under the surface, there are much reactive work that is done through phone and email. It is not necessarily bad planning; the plans are not shared in an aggregated structure. The plans are very unstable, and they change the plans shortly before they are executed. They are not good at updating their activity set and their system is very vulnerable. Their sister organization works with releasing the data from a data lake, where they can contextualize and give meaning to the users. They have a very large inventory; however, it is not easy to see in the data system if the equipment is in storage. *“If we can’t find patterns in the systems, it is easier to buy new materials than to see if the materials are in storage”* (Informant from Firm 9).

They must relate to many different source systems that do not communicate where the data has poor quality. Poor master data is an industry problem, e.g., that they do not have master data for what they are looking for. Most of the logistic processes are manual where they work on understanding the plans of which products that are shipped to the specific locations. This is saved in Primavera in their master plan, which is a project planning tool. Moreover, they are working on improving their prognosis. Their systems are characterized by little user-friendly data extraction, where it is challenging to get historical numbers, since this is a manual job. The objective in the future is to perform simulations where they can estimate how much material they will need.

Much of the digital investment in technology involves improving the flow from end to end of processes and data, ensuring that they can get real time overview of everything they are shipping to their customers. They are not there yet. Currently they are working on getting all the source data in one data platform, where they can share and get more predictability on what they are shipping. It is not easy for their suppliers to know how they are responding on what they want them to do, and as a result they get a bad horizon. This is something they want to change in the future. *“Normally, our data base does not know more than 30 % of what they are shipping four days before”* (Informant from Firm 9). Consequently, they are extremely reactive. They have a good operative muscle in their organization which makes them very robust and better at responding to disruptions like COVID-19. They have an ambiguous improvement agenda, where they are introducing new technology. Therefore, they are dependent on their suppliers to follow the same journey. This is extremely challenging since most of their suppliers are in a survival mode. For more information see 4.2.3 Financial Impact.

After the interview with Firm 9 we received additional information of their systems. The informant stated that their planning and supply chain is stuck in manual processes. A variety of systems are involved, without common data structure and common identifiers. A high degree of manually duplication of same data into the planning system, ERP system and transport system results in late and fragmented information, inconsistent definitions, data never showing reality and always being out of date and sequence. Two of many consequences are:

1. The lack of demand management and low planning horizon. Personnel needed to compensate for missing information, late detection of errors leads to firefighting and low utilization of resources: 40% utilization, 31% waiting time.
2. Financial tracking of services is poor due to lack of resource granularity in service order.

“Covid 19 has significantly increased the market uncertainty and the need for an increased planning horizon, transparency, and scenario planning both for the firm and the supplier. There is a huge

opportunity to redesign the supply chain and the way we work through connecting plan and SC/log in the same digital ecosystem to enable demand management.” (Informant from Firm 9)

Firm 10 has good communication with the different parts in the supply chain. They have a large network where all participants communicate within the same systems. The main issue is the linkage from the customers to their supply chain. Customer contact is mainly done by phone and e-mail.

“In the future I believe that e-mail will be replaced by a better and more effective tool, as it is ineffective and unproductive to spend most of the workday on reading and answering e-mails.”
(Informant from Firm 10)

They have a good track and trace solution, where the customers themselves have access to portals and can track the products. This is very user *friendly*. Moreover, they are highly technological and are utilizing things like artificial intelligence for their customer service.

4.1.4 Geopolitical factors

The geopolitical factors are different to the others, in the sense that they are more or less uncontrollable by the firms. These are rules and regulations imposed by world leaders and the government of each individual nation and is something that every organization must deal with. It includes factors like travel restrictions, infection control rules, tax packages and support schemes, climate conventions and other regulations that control how firms can conduct their business. They apply either to specific parts of a country, whole nations, continents or even the whole world. Each organization must make themselves familiar with the rules that are relevant to them, and make sure that their operations comply. Firms can get exemptions and dispensations for this, which is essentially something they cannot control.

4.1.5 Summary

The figure below summarizes the controllable factors (complexity, risk management and communication) that impacts an organization’s ability to handle a disruption. These have then been further divided into different categories such as redundancy, robustness, transparency, automatic processes, etc. If the firm fits any of these categories, this is symbolized with an “x”.

Factor	Firm									
	Small to medium sized					Large				
	1	2	3	4	5	6	7	8	9	10
Size of the firm										
< 1.000 emoloyees	x	x	x	x	x					
> 1.000 employees						x	x	x	x	x
1 Complexity	1	2	3	4	5	6	7	8	9	10
Size of the supply chain										
< 100 suppliers	-	x	x	-	-	-	-	-	-	-
100 - 1.000 suppliers	x	-	-	x	x	-	-	-	-	-
> 1.000 suppliers	-	-	-	-	-	x	x	x	x	x
Production										
Standardized	-	-	x	-	80 %	-	-	-	-	-
LEAN	x (some degree)	-	-	x (some degree)	-	-	x	x (some degree)	x (some degr	-
JIT	x (some degree)	-	x	x (some degree)	-	-	x (some degree)	x (some degree)	-	-
Specialized	-	x	-	x	20 %	x	x	x	x	-
Operates in										
Norway	x	-	x	x	x	x	x	x	x	x
Global	x	x	x	x	-	x	x	x	x	x
2 Risk Management	1	2	3	4	5	6	7	8	9	10
Crisis group						x	x	x	x	x
Resilience										
Redundancy										
Multiple suppliers	-	x	-	-	x	x	-	x	-	x
Extra resources	x	-	-	-	x	x	x	x	x	-
Robustness										
Finance	Robust	Struggled	Struggled	Robust	Robust	Very robust	Very robust	Very robust	Very robust	Very robust
Strong owners	-	x	-	-	x	-	-	-	-	-
JIC Safety inventory	-	-	-	-	x	x	x	x	-	-
3 Communication	1	2	3	4	5	6	7	8	9	10
Transparency										
Early notified of disruptions	x		x	x	x	x	x	x		x
Openness in information sharing	x	x	-	x (some degree)	-	-	-	-	-	x
Restricted information sharing	-	-	-	-	-	x	x	x	x	-
Poor data quality	-	-	-	-	-	-	-	x	x	-
Manual information sharing										
Phone	x	x	x	x	x	x	x	x	x	x
E-mail	x	x	x	x	x	x	x	x	x	x
Automatic processes										
Integrated in the SC	-	-	-	-	-	x (some degree)	-	-	-	x
Relationship in the SC										
Good relationship	x	x	x	x	x	x	x	x	x	x
Poor relationship	-	-	-	-	-	-	-	-	-	-

Figure 6 Summary of the Firm's Ability to Withstand Disruptions

Firm 10 is the organization that performed the best, followed by Firm 8, while Firm 3 and 2 struggled. Firm 10 has multiple suppliers, is very robust, are early notified of disruptions and have openness in their information sharing, as well as automatic processes integrated in their supply chain and a good relationship with their partners. They have a high degree of robustness and resilience. Firm 3 on the other hand, struggled financially and was not prepared for the pandemic. They have a low degree of both resilience and robustness. In general, we can see that the larger firms perform better in regards to financial strength and overall robustness.

4.2 COVID-19's Impact on the Firms

4.2.1 Delays

Firm 1 experienced both postponed projects and other delays. The largest delays were seen in the inventory, where the delivery to the end customer went pretty much as normal. There were some instances where they had to hold back some of their deliveries, as the customer did not need the product anymore, due to the COVID-19. Even though they have managed to transport their goods all over the world, this process has become slower and more expensive. Acquiring materials has become more difficult and delivery times has increased; *“Our inventories were almost at zero for certain products. Still, we have usually managed to deliver products on time, and we are growing larger and larger as an organization”* (Informant from Firm 1).

Firm 2 has experienced difficulties with receiving their materials within the scheduled time. Especially with materials that stem from German steelworks, which have seen shortages. Firm 2 have experienced delays and postponements in their projects.

“Some projects have been canceled since it has been too demanding to complete them. In addition, it has been problematic with confirming delivery times, since we have had a third-party inspector that could not guarantee when he or she would be finished with its tasks, which generated postponements and ripple effects.” (Informant from Firm 2)

Firm 2 has not been directly affected by the postponements. When postponements occurred, the main customers projects have been postponed too. During the pandemic the firm experienced chaos in their projects in Romania, since there was uncertainty of what was allowed. This halted the progress of the projects. Furthermore, the informant mentioned that they had experienced delays in the Philippines due to travel restrictions.

“We had delays from a product that were to be sent to the Philippines, where the customer arrived four months too late, due to uncertainty if the customer could travel there. Still, except from the project to the Philippines, all of the projects have been delivered within the deadline.” (Informant from Firm 2)

Firm 3 has also been affected by delays. They have 6-8 main suppliers which they have good communication with and is quickly notified if there are postponements. The main issue has been postponements from their suppliers' suppliers; *“The main problem has been that our suppliers have had delays from their suppliers, which makes it difficult to guarantee the delivery times”* (Informant from Firm 3). Additionally, some of the

production facilities they use abroad, have had reduced capacity during the pandemic. The year 2020 has been characterized by inertia and uncertainty in the market.

It is challenging to change the production, as it depends on the project and production lines. If a delay occurs in one of their production facilities, the whole production will be delayed. The production and suppliers are highly specialized. They have few options to choose from when it comes to suppliers, meaning that they usually must wait for the products to be delivered:

“Of the 30 projects we had last year, we had to wait for 3-4 months on special components. Most of the projects has proceeded as usual, and approximately 3-4 projects had more than a month of delays on components, which is about 12 % of the projects.” (Informant from Firm 3).

Even though the communication throughout the supply chain is good, Firm 3 has noticed that the suppliers are often not aware of the size of the delays; *“In some circumstances, a four-week delay ended up lasting several months, due to unforeseen events in the production”* (Informant from Firm 3).

Firm 4 experienced a four-month delay from a supplier from India, which resulted in a loss of 4-5 million NOK. However, their services are more or less unaffected by the pandemic and they have managed themselves very well.

For firm 5, everything came to a halt when the pandemic struck, as no one knew how to cope with the situation. They were forced to lay off half of their employees, which resulted in several projects being delayed. However, the delays did not affect the end customer; *“Although the layoffs in April caused some delays, we were able to catch up with most of the projects, after the workers came back in May”* (Informant from Firm 5). They have had some delays from their own suppliers, due to shortage of materials, especially steel. Nevertheless, this did not affect the production in a large degree, since they had ordered the necessary parts earlier than usual. They have good communication with their suppliers and are quickly notified if any delays should occur. Usually, they can find alternative solutions if the materials are delayed, which is not always achievable.

Firm 6 noticed large delays in airfreight and have been forced to look for alternative ways of transport.

“Over 70% of the airfreight marked stopped overnight, due to the travel restrictions. The same goes for sea freight, where it has been difficult to obtain containers. If there is a one-day delay in a boat

harbor in Long Beach, it will take approximately one week to fix, due to the traffic of boats”. (Informant from Firm 6)

Additionally, they needed to increase the number of drivers they used, which eventually led to a lack of drivers as well. One problem led to another, and on top of that, the prices increased drastically. Additionally, they have been forced to put some of their projects on hold, as they have used much energy and resources to deal with the problems of the pandemic. However, they have found ways of working around this, and there have been few delays out to the customer.

Firm 7 managed to maintain the production as usual and has not experienced severe delays.

Firm 8 was affected by the first lockdown in China in March 2020. They have much activity going on there, both from their suppliers, and from their own project delivery. Some parts of the organization use suppliers located in Italy, and these noticed it quite well when the virus was at its peak there. The informant stated that the main problem was transportation times:

“In general, the issue with COVID has not been to obtain goods, it has been the transportation times. Still, we have had few delays, as we have managed to work around these issues” (Informant from Firm 8)

Firm 9 has not experienced delays in a large degree and the pandemic has not affected their ability to supply their facilities. However, because some of the products did not arrive in time, they had to reprioritize their activities.

Firm 10 has experienced issues with delivering their products to their customers within the scheduled time. Therefore, they had to find other transport solutions to make sure that their customers got their products in time.

4.2.2 Home Office

During the pandemic, Firm 1 utilized home office and used Google Meet as their digital platform to hold meetings with colleagues and other stakeholders. This has been exhausting for many; however, it is a great solution, which they over time has gotten better at using digital tools. The main challenge is the creative process, where people get together physically and share ideas, which is more difficult over Google Meet; *“The creativity is hindered when we are not allowed to gather employees at the office and have discussions”* (Informant from Firm 1). After the pandemic, the new normal will allow for more flexibility, where employees

can choose whether to work from home or at the office. The interview candidate prefers to have its employees at the office and believes this is the best solution and is aware that some employees prefer to work from home.

Most of the customers of Firm 2 has utilized home office. Therefore, they have experienced difficulties with crafting new projects with new customers in the starting phase of the pandemic. They estimate that their customers, and their costumers' customers had the same issues. On the other hand, they experienced that they could deliver the same quality working from home, as they are working in the office. Firm 2 mentioned that the creativity has been hindered when working from home:

“In a Teams meeting it is more formal, with a different dynamic compared to a physical meeting. The way one facilitates a meeting can affect how people prepare for it. This was easier before, when all the meeting participants could be in the same room.” (Informant from Firm 2).

Firm 3 are still partly working from home. They are used to the fact that the employees are working from different places in Norway and globally before the pandemic began. The usage of home office has negatively affected the social aspect; *“The coffee talks in the hallway is no longer possible”* (Informant from Firm 3). They bought accessories for the work place, like video, camera and sound equipment to enhance the video conferencing quality.

Firm 4 have had most of their work force in home office, with the project department as an exeption. All of the physical meetings in the office are replaced with Teams. This is something they have had a positive experience with and they will continue this practice after the pandemic:

“The interaction in the department has gotten better. The different project are spread across Eastern Norway, and it is rare that everyone is gathered in the same meeting. This is much easier to do digitally”. (Informant from Firm 4)

Firm 5 were used to meeting most of their customers physically. Due to the pandemic, 98% of this were moved to Teams; *“While there initially were some skepticism related to home office, eventually as it were introduced, people got positive experiences with it”* (Informant from Firm 5). As of March 2021 they use a flexible solution, where most of their employees work from home 2-3 times a week, and do the rest at work. People have shown to almost be more effective working from home and overall they have had a positive experience using home office.

Firm 6 quickly established a crisis group for several levels in their organization, inclusive supply chain and transport. They had a quick and good transition from working in the office to working from home; *“Over the night 50 % of the work force worked from home. At the most, as much as 70 % of the work force worked from home”* (Informant from Firm 6). Furthermore, they had excellent IT-resources to handle the transition. All of the employees that worked from home received a desk and data equipment to make sure that their working day would be as similar to working at the office. Due to the travel restrictions, there has been a significant drop in travelling activity. After the pandemic, they will continue with a flexibility where the employees in a larger degree can work from home. In addition, they made sure to train both the employees and leaders since they wish to take care of their physical and mental health in the new work environment; *“It is vital to maintain the employees physical and mental health. This is especially challenging for the employees that has been newly employed during the pandemic”* (Informant from Firm 6).

In the beginning of the pandemic, Firm 6 had to close their offices and production facilities and several hundred employees had to work from home while they cleaned the facilities and got control of the situation. After a while, only those who had to work physical at a production facility was allowed back to work, which made it easier to control the infection:

“Some departments, such as production, manufacturing and cleaning personell had to be present at work in order to do their tasks. Home office was introdused as a measure to protect those who had to be physically present at work”. (Informant from Firm 6)

Furthermore, Firm 6 has noticed that trust, both between employees and suppliers has proven to be quite important for the way they handled the pandemic; *“It probably has to do with the Scandinavian leadership model, with a high degree of thrust and flat structure”* (Informant from Firm 6). This has contributed to measures like home office can be followed up in a good way. In addition, it has been easier to collaborate with suppliers. They have made matrixes internally in the division over their work tasks and responsibility, to make sure that each employee knows who to ask for help if they need help.

Firm 7 has followed the guidelines from the Norwegian Institute of Public Health (FHI), as well as the guidelines from their headquarter in the US. In Norway, most of the work staff work from home, typically those who have administrative roles or work in finance. Still, there are staff that must be psysically present at work, for instance the production and inventory department. Even though most of the work staff were working from home, they were able to maintain and/or increase their production.

As of March 2021, Firm 8 has most of their employees in home office. One thing they did not take into account, was that employees working from home, should have similar working conditions as their main office. They therefore had to reach out to all their employees and get an overview of their home office situation:

“We were informed about their home office solutions, what they had and needed of equipment, if they needed a better chair etc. After the months went by, we became aware that the Working Environmental Act applies when the employees are working from home as well. We initiated measures and talked to the employees, where they got better screens, keyboards, docking etc. Most of the employees that are working from home has a complete office setup at home. As a result of the pandemic, flexibility will be a permanent solution where the employees in a larger degree can choose if they want to work at the office or from home”. (Informant from Firm 8)

Another consequence of the pandemic is the increased competence of digital tools and Teams. The creativity can be hindered by digital meetings, since discussions and creative meetings have a better flow in face to face meetings. It is beneficial that the ones involved in projects or meetings know each other from past projects, where they have a better dynamic, can joke with each other etc. Another factor with home office is that one has to take consideration to the other members in the household, either housemates or family members. It is limited how many good locations one have in a house or an apartment. In addition it can be demanding with internet capacity. In the beginning of the pandemic there were capacity issues with VPN where the IT department had to solve issues and prepare for everyone that would work from home. The IT-department were prepared for some to work from home, and there has been a significant improvement which has been a factor for them to succeed in the way they work. They are more facilitated to work from home.

Firm 8 mentions that the Norwegian leadership model with trust to their employees is an important factor to handle the pandemic. Previously, they did not accept home office for our employees. As a leader the informant allowed its employees to work from home if they have dental appointment, parent teacher conversations etc. which makes it inconvenient to be at the office for a couple of hours. This type of flexibility has given an accept for that home office is a good solution that has come to stay. From the informants perspective, there is no doubt that those who live alone and dependent of their home situation has a strong will to come back to work. They believe that there will be a combination of people who work from home and those who work at the office, with a high degree of flexibility.

Firm 9 was early on with initiating preventative measures;

“March 6th 2020, a week before the national shutdown of Norway, we required all employees that are able to work from home to do so. We believe that this is the new normal, with a higher degree of flexibility and trust of the employees. There are never more than 40 % of the employees that are physically present at the office in Stavanger. This has as a changed the way we interact, where large meeting rooms can be altered to smaller rooms to have teams meetings”. (Informant from Firm 9)

Furthermore, Firm 9 is very appreciative of their Norwegian IT department which made it easier to communicate. Digital tools as Teams was initiated before the pandemic. They experienced a decrease in activity as a result of efficiency with home office. Still, this has not affected their ability to perform their tasks. Home office is seen as unsocial and many perceive it as monotonous and are looking forward to work physically at the office.

Firm 10 states that the most significant effect of the pandemic is home office. They are using Teams as a digital platform to meet other colleagues. They are rigid to come back to work with physical meetings at the office. In the future they will be more flexible where the employees in a larger degree can choose if they want to work from home or work in the office.

“We have established rules and guidelines with opportunities for the employees to work from home. A year ago, this was not accepted. Not because there is a risk that they are not doing their work in an effective manner, generally it is not accepted in the organization. It was joked about “hiding” office, where home office was an excuse to do other tasks, for instance skiing in the mountains. This has to do with trust and the Norwegian vs global leadership style. The most significant effect of home office is the savings in time and resources by having digital meetings.” (Informant from Firm 10).

4.2.3 Financial impact

Firm 1 has had enough capital to deal with the COVID-19 situation and ended up selling more in 2020 than they did last year. Firm 1 did not have any form of layoffs or downsizing.

Firm 2 had a terrible year financially, with a quite severe loss in turnover. In September 2020, they received the government guaranteed loan which helped them financially. Several of the employees are owners of the organization and have contributed with capital with emissions to secure the equity. They had to lay off all their employees in periods of little to no activity. Things were especially quiet right before summertime and they ended up laying off their whole employee-base, including 50% of the management; *“In the beginning of the*

pandemic, some of our customers had completely or partly stopped their purchases, which impacted us financially” (Informant from Firm 2).

Moreover, they developed a product before the pandemic where they were in the process of patenting and commercializing the technology in collaboration with a larger organization. The large organization that operates in the oil and gas industry, noticed a severe decline of the outbreak of COVID-19. Therefore, they were afraid of the changes in the stock price and stopped all investments and projects that could result in more spending. Their stock exchange rate was significantly affected, and they were forced to downsize, and restructure their organization; *“The fact that this process stopped, impacted us significantly. We are currently working on restarting it with different candidates” (Informant from Firm 2).*

The currency fluctuations that resulted from the pandemic had a dramatic impact on Firm 3. Usually, they buy in Euros or Chinese Yen, where the ongoing situation made things more challenging. The calculations they made for their production in 2020 was based on a Euro-price of about 10 NOK. In March 2020, the euro price was 13 NOK. Despite the decline in turnover and sales, they were financially robust enough to cope with the situation. They managed to get a surplus, even without any layoffs. Normally their organization have an expected turnover of about 500 million NOK, where it decreased in 2020 to between 320 and 330 million NOK. This is quite significant, still they dealt with it quite well. Firm 3 did not have any form of layoffs or downsizing; however, they were unable to hire as many as they had originally planned and had to postpone their hiring process until August 2020.

Firm 4 has experienced several delays, which have affected them economically. One in particular, is estimated to cost them between 4 to 5 million NOK. They still feel like they have been robust enough, as their main businesses are more or less unaffected by COVID-19. All things considered, they have managed themselves quite well. Firm 4 had to lay off some of their employees, for instance the service engineers. We refer to firm 4 on 4.2.4 Travel restrictions for more information.

Firm 5 lost a couple of million NOK due to the virus. Still, the organization is economically robust.

“Our owners have contributed with a fair amount of extra money. We had 2-3 difficult years with liquidity problems and deficits prior to COVID-19, however, we managed to get a surplus of 3,3 million NOK in 2020. This year we are expecting a major surplus, as we are seeing plenty of opportunities for entering new markets and offering new products”. (Informant from Firm 5)

Firm 5 had full stop in their production due to risk of infection and were forced to lay off half of their employees in April 2020 which resulted in delays. They were however quick to find solutions and in the beginning of May 2020, 95% of their employees were back to work. In the middle of May, their full workforce was back to work and there have been no layoffs since.

Firm 6 feel like they have been robust enough to handle the situation. They were never really in a crisis moneywise and they were quick to assemble a response team, which created risk-analyses on where potential problems could arise.

The informant from Firm 7 feels that things have been challenging even without the Corona-situation; “We are focused on cost savings and to always have a robust and flexible organization, that allows for different things” (Informant from Firm 7). Firm 7 went through a down-sizing process last summer, which affected their production. However, in their department, they had an increase in their activity levels, resulting in extra staff and resources being moved over to them.

Firm 8 is financially robust, however, the informant stated that they had to take some measures to protect their economy in the department.

“Financially, things have gone much better than expected. We have made several adjustments along the way to cut our expenses. 2020 will not go in the history books as our best year.” (Informant from Firm 8)

Firm 8 did not have full insight in terms downsizing or lay-offs, due to GDPR and privacy rules, and confirmed that they have had capacity issues. As a result, they had to rearrange some of their production and bring back employees that were temporarily laid off.

Firm 9 is a very robust firm however, as mentioned, they were forced to let some of their consultants go when their operations stood still. They were never close to bankruptcy, still they took preventive measures to protect their own cash. By doing so, the organization had something to lean on, during a time of uncertainty and lack of control. As a risk measurement, they frequently analyze the probability of their 30 largest suppliers will go bankrupt; “We have noticed that several of our suppliers are in survival mode and have a shortage of resources, both in time and money to work on developing their firms” (Informant from Firm 9). Firm 9 sees a stagnation if they do not facilitate their business model in a way that their suppliers can profit together with them.

Firm 9 operates in a volatile market and is embossed by the oil price. In March 2020, they noticed a major shift in oil and gas prices, which resulted in uncertainty in the market:

“For a longer period, the prices were far too low from what they normally would have been. Around June/July 2020, the prices started to raise again and as of March 2020 the oil price is back to where it was before the pandemic.” (Informant from Firm 9)

The Norwegian Tax Package did also help Firm 9 financially. Firm 9 did not have to let go of many of their own employees, on the other side they let go of some of their consultants. They did not have an exact number of how many. They predicted the situation in March 2020 to be even worse than it turned out to be. On the positive side, the future is starting to look a little brighter now. Given the circumstances surrounding the situation, they don't think they should have done anything any different.

Firm 10 managed themselves quite well, as they have multiple business areas.

“In our industry, those who are only active in one service-area, are very vulnerable in situations like these. We have a diverse product mix, which makes us better suited and less affected in crises like the COVID-19”. (Informant from Firm 10)

As a result of the national and global restrictions, and the travel bans, the costs of transportation have increased rapidly. It is extremely expensive to buy sea freight, which previously have been an inexpensive transport method. In addition, they had to restructure their business, and lay off some of their employees in accordance with the activity level.

“Some of our departments had less available capacity, while others saw a reduction in activity. This forced us to both downsize and lay off some of the workforce. A process like this is very demanding and it was heavy personally for those involved. Still, this is something we feel was solved well, and it helped us adjust our short-term expenses.” (Informant from Firm 10)

4.2.4 Travel Restrictions

Firm 1's operations has not been affected by the travel restrictions.

Firm 2 has its production in Romania. Usually, they travel together with their collaborative partners to check that the production is in accordance with the quality they demand. During the pandemic they are prevented

from doing so. Their Norwegian organization that they collaborate with has some Romanian employees that enables them to continue with it, which is a continuation.

“In many ways it has been a strength for us that our Norwegian partner has Romanian employees, and is a competitive advantage compared to many other firms that do not have the opportunity to travel to the production facilities and follow up.” (Informant from Firm 2)

In formal meetings with the clients, Firm 2 have rented a third part verifier, e.g., inspectors in Romania that are granted to travel in Romania. These third part verifiers are KIVA, DNV-GL etc. where one can rent them as neutral parties that can verify that the parts is in accordance with the quality and writes a report.

Firm 3 introduced video inspections in the production which allowed them to control and verify the quality. By doing so, local inspectors at the production facilities can communicate over video with experts in Norway. Other firms have done their inspections online, where they had to lower the quality requirements.

“We have noticed both. One project was in a critical phase of the project, where the quality of the product was significantly lower than expected when it was shipped to Norway. In other projects we have experienced the opposite effect since the local inspectors have had a stronger ownership and responsibility to their projects.” (Informant from Firm 3)

Before they could hide and be less visible among the Norwegian inspectors. The quality has increased because of the new work methods and they have seen several positive effects regarding quality. In addition, video inspections have saved them for travelling expenses since we are not able to travel during the pandemic. They will continue with the video inspections after the pandemic since it has many positive effects. In some circumstances there will be more travelling, for instance signing contract and discussions with collaborators. They have noticed that this is more difficult on Teams compared to being physically present. When their boats are customized to fit the customers' requirements they must travel with our customers to the shipyards. With the standardized boats they can continue as they do today. Very much of the video inspections and the follow up will be done from Norway which allows for saved travel inspections and saved time. If the quality is maintained by the new work methods, it is no point of travelling to the production facilities in Eastern Europe.

Firm 4 has experienced issues with labor immigration from Finland and Sweden, who have special competence of assembling the equipment; “*We were worried about how the labor immigration would be affected. In certain instances, we have gotten exceptions and dispensation from the travel restrictions*” (Informant from Firm 4).

However, they must still follow all the requirements in relation to quarantine and infection control, which requires additional planning.

Firm 5 experienced delays because of quarantine regulations, where their employees had been on working on projects abroad.

Firm 6 noticed challenges with testing the quality of their products that are produced outside of Norway:

“We had to ease of the requirements for documentation since this cannot be completed as pre COVID-19. The requirements are strict and regulates what tests and control that must be done. Because of the pandemic and travel restrictions, we had to apply for release to some of these requirements”.
(Informant from Firm 6)

As a result of travel restrictions, Firm 7 had to change the way they performed testing and control of equipment with their customers.

“Normally, the customer participates physically when testing different equipment and so on. Due to the pandemic, we arranged these tests via videocalls, so that the customer did not have to be there physically.” (Informant from Firm 7)

Firm 8 had some issues regarding their service engineers. These are important for the after-market, and must travel to the customers to execute upgrades, service, and support. In the beginning of the pandemic these tasks stopped completely because of the travel restrictions.

“In Korea they had to be on a Corona hotel for ten days, where they were living in poor conditions. One of the service engineers had a furnished apartment, with a TV, where the toilet was the only place he could sit. There was no bed, and he had to sleep on cardboard plates. This is unacceptable, and we do not want our employees or customers to work under such conditions. Therefore, we put these tasks on hold until the summer of 2020.” (Informant from Firm 8)

Firm 9 experienced limitations on travelling, both regional in Norway, and globally. The travel patterns will change, and they see that the interaction is just as good on Teams as with physical meetings. The meeting activities can be reduced by 50 % compared to the times before COVID-19 where they travelled across the offices in Norway.

“If there is a meeting and it requires to travel by plane, it is normally more complicated meetings which involves more concentration in the room. For instance, complex issues or strategy gatherings with blackboards, stickers etc. Ordinary meetings and quarterly meetings can be held digitally and still being effective. In most circumstances, these meetings required travelling before the pandemic struck. This is similar for the ones who work internationally, it is challenging to travel there with the travel restrictions, and home office is therefore the best solution for our organization.” (Informant from Firm 9)

Because of the travel restrictions, Firm 10 had to restructure their business in the beginning of the pandemic. Additionally, the air freight had a significantly limited the ability to transport goods through air, since there were few planes that were allowed to fly.

“All commercial planes were limited since few travelled in the second quarter of 2020, and there is still a limited travel offer for travelers. This makes it challenging to ship products for our customers, since the products are usually shipped on commercial and cargo planes.” (Informant from Firm 10)

4.2.5 Other notable impacts

Firm 2 noticed that it is more challenging to get in contact with customers. The physical meeting areas are still important, especially to see them in their eyes and form a new relationship.

“Some people are more afraid to get in touch, however, those who are afraid to pick up the phone and call is usually not the ones who greets a stranger in a conference. People are different, salespersons typically enjoy meeting new people, it is more challenging for engineers.” (Informant from Firm 2)

The positive aspect is that many clients are bored at their home office, which makes it easier for them to answer the phone or answer emails. They have established some new customer contacts; however, the number is significantly lower than if they had gone to a conference or seminar where you can meet many new contacts. As a result of the pandemic, they have gotten access to online conferences and seminars, and many of them are free or discounted. In addition, their organization has saved travelling cost, since there is no need for a hotel, lunch and travelling. Instead of travelling to Oslo for a two-hour seminar they can sit in their office, which is both time and cost saving.

Early on, Firm 10 saw that the customer’s willingness to buy products quickly changed, which impacted large parts of their organization. Shopping malls were closed because of the national restrictions and consumers

bought different products than they previously did. Some people hoarded products which resulted in displacements in the flow of goods. This affected them in a short term, and they had to restructure our business. In addition, they were impacted of the air freight, since there was a shortage of planes, see the subchapter about travel restrictions. Additionally, Firm 10 noticed that people prefer to get their products shipped to their home, rather than to shop at shopping malls. It is an enormous growth at online stores as kolonial.no. Porter buddy, Post Nord and Bring has enormous volumes and there are frequently new home delivery services that shows up. In addition, there is new innovations and solution as delivery boxes.

Firm 10 sees that this market is taking more of the shopping mall customers which will be a vital change.

“In Oslo, the shopping malls has been closed for several months which affects our business, and customers which are not allowed to keep their stores open, in addition to their flow of goods. We have seen this in other segments, when the demand of a product decreases, the demand of other products increases. When the government closed the Wine Monopoly in the Oslo area, the demand of alcohol increased. There is also an increased demand of medicine. People are more afraid to get sick and buys more medicines, face masks, gloves etc.” (Informant from Firm 10)

4.2.6 Summary

The figure below summarizes COVID-19's impact on the firms, in relation to delays, home office, financial impact, travel restrictions and other notable impacts.

Impact	Firm									
	Small to medium sized					Large				
	1	2	3	4	5	6	7	8	9	10
1 Delays										
from their suppliers	x	x	x	x	x	x	-	-	-	x
to their customers	-	x	x	x	-	-	-	-	-	x
2 Home office										
Digital meetings	x	x	x	x	x	x	x	x	x	x
Hindered creativity	x	x	-	-	-	-	-	x	-	-
Flexibility work from home/office	x	x	-	x	x	x	x	x	x	x
Negative impact on customer relationship	-	x	-	-	-	-	-	-	-	-
Reduced social interaction	x	x	x	-	-	x	-	x	x	x
3 Financial impact										
Decline in sale	-	x	x	-	x	-	-	-	x	-
Governmented loan	-	x	-	-	-	-	-	-	-	-
Changes in industry prices	-	x	-	-	-	-	x	-	x	-
Currency fluctuations	-	-	x	-	-	-	-	-	x	x
Layoffs	-	x	-	x	x	-	x	x	x	x
Downsizing	-	-	-	-	-	-	x	-	x	x
4 Travel restrictions										
Domestic travel bans	-	-	-	-	-	x	-	-	x	x
International travel bans	-	x	x	x	x	x	x	x	x	x
Third party verifiers	-	x	x	-	-	-	-	-	-	-
Video inspection	-	-	x	-	-	x	x	-	-	-
Quarantine	-	-	-	x	x	-	-	x	x	-
5 Other notable impacts										
Less customer contact	-	x	-	-	-	-	-	-	-	-
Changes in purchase patterns	-	-	-	-	-	-	-	-	-	x

Figure 7 Summary of COVID-19's impact on the firms

The figure shows that there is not a very visible difference between the small to medium sized firms and the larger firms concerning the impact of COVID-19. However, there are some differences that stand out. The small to medium sized firms have experienced more delays than the larger firms, both from their suppliers and to their customers. The smaller firms have also seen a larger decline in sales compared to the larger firms. On the other side, the larger firms have had more lay-offs and downsized their employees in a larger degree.

5 Discussion

Chapter 5 is a discussion and analysis of the findings presented in Chapter 4. In this chapter, we are comparing the findings with the literature we reviewed in Chapter 2, and analyzing if the data support, modify, challenge, or reject any of our existing theories, research findings, concepts, and frameworks.

First, we are comparing the impact the firms have had from COVID-19 in relation to the four factors we established in Chapter 2 to see if this is coherent with our theoretical findings. Then, we explore if our data gathering, and theoretical findings can confirm or deny the propositions we established in Chapter 2. The propositions are confirmed or denied in the order from Chapter 4, and not the order they were presented in Chapter 2. We chose to present them this way to naturally place them under their respective categories. Lastly, the chapter concludes with measures a firm can take to be better prepared for future disruptions regarding robustness and resilience.

Below are the eight propositions we established in Chapter 2:

1. As the length of the supply chains grow and the complexity increases, they also become more vulnerable to disruptions.
2. There is a negative connection between global supply chains and COVID-19.
3. Risk management has a positive effect on global supply chains.
4. With the correct risk management strategies, global supply chains should be resilient enough to handle future extraordinary crises such as COVID-19.
5. With the correct risk management strategies, global supply chains should be robust enough to handle future extraordinary crises such as COVID-19.
6. Just in Time and risk management can work well together.
7. There is a positive connection between global supply chains and emerging technologies.
8. Digital supply chains can enhance supply chain risk management.

5.1 COVID-19's Impact on the Firms

The COVID-19 pandemic has had an enormous impact on the world's supply chains and has harmed the job market, human health, and the global economy (Gu, Yang, & Huo, 2021). The virus has forced firms to discover some of the weaknesses in their supply chains, for instance, the lack of robustness. The theory claims that firms have been moving towards strategies such as lean, agile, and more flexible production systems during the last decades (Ivanov & Dolgui, 2020). Better coordination and collaboration methods, real-time monitoring systems, as well as enhanced visibility, have been heavily focused on. Nevertheless, theoretics states that this has not been sufficient enough to reduce the impact of COVID-19 (Oloruntoba, 2020). From the empirical findings we see that the firms have been affected in different ways, depending on the size of the organization, type of production, where they operate, and their level of transparency. All of this affects the firm's robustness and resilience, which is vital for the ability to handle disruptions.

The theory claims that supply chains all over the world are facing major disruptions and are struggling to handle the new needs and demands and in response to the COVID-19 pandemic (G. Zhu et al., 2020). The fast spread of the virus leads to significant disruptions in the supply chain (Khan, 2020). Zhu et al. state that the four most important effects COVID-19 has brought to the supply chains are supply shocks, demand shocks/higher variability in demand, the bullwhip effect, and lastly transportation requirements/costs (G. Zhu et al., 2020). The empirical findings are coherent with the theory, where the firms have experienced difficulties with supply and demand shocks which has resulted in bullwhip effects and increased transportation costs.

Both the theory and the empirical findings confirms that the firm's ability to acquire necessary supplies has been one of the major impacts of the pandemic. Furthermore, the lockdown regulation have directly affected the business activities and the movement of goods and resources (Parsons, 2020). Raw materials and goods often travel by air. As commercial flights have been forced to postpone due to COVID-19, cargo that usually travels on these types of flights must find different ways of transportation. The result from all of this is that the cost of global air freight has gone up. The need for cargo flights has increased and the firms cannot keep up with the demand (Selwyn, 2020). Selwyn states that the transportation network of today's global supply chains has made them especially vulnerable to disruptions like COVID-19 (Selwyn, 2020). While some borders have started to open up, new safety measures and regulations have caused delays and increased costs for the suppliers and customers (G. Zhu et al., 2020). Several of the informants revealed that the cost of transportation of the goods have increased because of the pandemic, where they had to find other methods to transport the products, which in turn makes the end-product more expensive for the customer.

When the production facilities in China were forced into a standstill due to the virus, many of the world's retailers and manufacturers were no longer able to acquire the materials that they needed, and consequently had to close their operations (Parsons, 2020). Some of the informants we interviewed stated that their production was put on hold in the beginning of March 2020, and they experienced uncertainty of what was going on since everything happened so quickly.

Another effect of the pandemic is the increased variability in demand. In the empirical findings, one of the informants noticed that the purchase pattern has changed drastically during the pandemic, where several people ended up panic buying and stockpiling products in the fear of running out of food and other necessary items. This is confirmed in the theoretical findings, that mentions major shifts in demand, which many firms were not prepared for. As a consequence, many of these were forced to shut down their business (Parsons, 2020; G. Zhu et al., 2020). While all of the firms we interviewed survived the pandemic, some of the firms struggled more than others.

The theory denotes that 94 % of 1.000 firms have been affected by COVID-19, where both upstream and downstream supply chain partners have been disrupted (Sherman, 2020). As a result, supply shortages were disconnected and production facilities were shut down (Barter, 2020), creating a shortage at the retail/customer end and surpluses at the supplier/manufacturer end (Donaldson, 2020). The supply shortage and supplier/manufacturer surpluses correspond with the bullwhip effect (G. Zhu et al., 2020). From the empirical findings the informants confirmed that they had either experienced delays from their customers or delays to their customers. The firms that had suppliers that operates in China and Italy was significantly affected by the first wave of the COVID-19 pandemic. Furthermore, the informants stated that they experienced delays from their suppliers' suppliers, which is coherent with the theory. The supply shortage and supplier/manufacturer surpluses correspond with the bullwhip effect, where Zhu et al mentions that the principal issue of the bullwhip effect is the lack of transparency in the supply chain (G. Zhu et al., 2020). The theory is coherent with the empirical findings, where the informants experienced bullwhip effects when their supplier's supplier had delays, which as a result delayed the product to the customer. This again is a result of poor transparency, where the flow of information must follow each link in the supply chain to get to its indented place. All of our informants used manual processes to share information with their supply chain partners, and this is likely why most of the firms experienced some form of delays.

Another impact mentioned in the literature, is that the firms have not been able to send their employees abroad to perform work, due to travel restrictions. Many supply chains are dependent on this to operate properly, however this has become much more complicated during the pandemic (Selwyn, 2020). This is coherent with what many of our informants have experienced. Several of the firms we interviewed are

dependent on traveling across borders to perform services and quality control on equipment. Some of the firms hire labor from different countries and transport them over to their facilities.

Proposition 2: There is a negative connection between global supply chains and COVID-19.

From the discussion above, we can conclude that the second proposition corresponds with the theoretical and empirical findings. There is a negative connection between global supply chains and COVID-19, as the firms and supply chains have been impacted negatively of the COVID-19 pandemic.

5.2 Factors to Handle a Disruption

In Chapter 4 we presented four factors that we believe are vital to handle a disruption. Those are complexity, risk management, communication, and geopolitical factors. In this subchapter we are comparing the empirical findings from Chapter 4 with the four factors, to confirm or deny their importance in relation to withstanding disruptions.

5.2.1 Complexity

As stated by McKinsey Global Institute in the report Risk, Resilience, and Rebalancing in Global Value Chains, supply chains have developed and grown larger in both length and complexity as firms are expanding their firms in the search for better margins (McKinsey Global Institute, 2020). Therefore, we found it appropriate to compare the small to medium sized firms with the larger firms to discover if this is coherent with the theory.

The figure below is an extract from Figure 6 and shows the complexity for the ten firms. As shown in Figure 8, the larger firms have a higher degree of complexity and specialized production, with a significantly larger supply chain compared to the smaller firms. One of the things we wanted to look at was if increased complexity made the firms more vulnerable to disruptions.

1	Complexity	1	2	3	4	5	6	7	8	9	10
	Size of the supply chain										
	< 100 suppliers	-	x	x	-	-	-	-	-	-	-
	100 - 1.000 suppliers	x	-	-	x	x	-	-	-	-	-
	> 1.000 suppliers	-	-	-	-	-	x	x	x	x	x
	Production										
	Standardized	-	-	x	-	80 %	-	-	-	-	-
	LEAN	x (some degree)	-	-	x (some degree)	-	-	x	x (some degree)	x (some degr	-
	JIT	x (some degree)	-	x	x (some degree)	-	-	x (some degree)	x (some degree)	-	-
	Specialized	-	x	-	x	20 %	x	x	x	x	-
	Operates in										
	Norway	x	-	x	x	x	x	x	x	x	x
	Global	x	x	x	x	-	x	x	x	x	x

Figure 8 Factor 1 Communication

Proposition 1: As the length of the supply chains grow and the complexity increases, they also become more vulnerable to disruptions.

Based on our data gathering, this can not be confirmed nor denied. From Figure 8 we see that the smaller firms have been more affected by disruptions and have had delays both from their suppliers and to their customers. While the larger firms have experienced significant disruptions, they have managed to handle this much better since they are more robust and have more options than the smaller firms. Still, we agree with the researchers, that the larger firms are more exposed to disruptions. However, their robustness make up for their vulnerability. To conclude, the first proposition can not be confirmed based on our sample.

The theory states that principles as JIT and LEAN have made the firms more exposed to disruptions. By focusing too much on efficiency, strategies in relation to risk management, like resilience and robustness, have not been prioritized. This has become even more apparent during the pandemic (The Editorial Board, 2020). Most of the firms we interviewed had not implemented LEAN manufacturing in their production, while some had LEAN to a certain extent. It is therefore difficult to confirm or deny these claims. Those who had implemented LEAN principles however, stated that this had not impacted them negatively during the pandemic. One of the informants mentioned that since they only had LEAN manufacturing to a certain extent, they had enough slack to handle delays from their supplier. This might suggest that a balance between efficiency and risk is the better solution. Hence, the theory and the empirical findings are coherent, where the theory states that some of these operating choices can lead to unwanted consequences if the involved risk is not taken into consideration (McKinsey Global Institute, 2020).

5.2.2 Risk Management

In today’s world, disruptions occur on a regular basis. Some of these events can last for months or even years and can be very financially demanding (McKinsey Global Institute, 2020). Figure 9 is an extract from Figure 6, which compares the ten firms in relation to risk management.

2	Risk Management	1	2	3	4	5	6	7	8	9	10
	Crisis group						x	x	x	x	x
	Resilience										
	Redundancy										
	Multiple suppliers	-	x	-	-	x	x	-	x	-	x
	Extra resources	x	-	-	-	x	x	x	x	x	-
	Robustness										
	Finance	Robust	Struggled	Struggled	Robust	Robust	Very robust	Very robust	Very robust	Very robust	Very robust
	Strong owners	-	x	-	-	x	-	-	-	-	-
	JIC Safety inventory	-	-	-	-	x	x	x	x	-	-

Figure 9 Factor 2 Risk Management

The International Labor Organization claims that today’s global value chains usually are too dependent on specific suppliers, that are only found in certain places in the world (International Labour Organization, 2020).

This allocation can partly be confirmed, as some of the informants states that they are dependent on their suppliers where they are in need of specialized components that are critical for the production. This can lead to bottle necks as they often have few suppliers to choose from.

The theory claims that today's firms often utilize production principles as LEAN and JIT, which is meant to keep their inventory levels at a minimum and remove anything that is unnecessary (International Labour Organization, 2020). While this leads to improved efficiency, it makes the firms more vulnerable to unforeseen events, like nature disasters or currency fluctuations (Birou & Fawcett, 1993; Cho & Kang, 2001; Chopra & Sodhi, 2004; International Labour Organization, 2020). From the empirical findings, some of the firms utilizes LEAN and JIT to some degree, which have allowed them to put some slack in their projects. Some of the firms have been affected by currency fluctuations and had to add a part in their contract where they took currency fluctuation into consideration.

According to El Baz & Ruel, there is a positive connection between the size of the firm and their supply chain risk management practices (El Baz & Ruel, 2021). From their study they found out that the larger firms had a higher ability to identify risks in the supply chain and mitigate them. Since larger firms are able to use resources, capabilities and processes, compared to small to medium sized firms (SMEs) which have been affected by shortages in resources when they want to implement strategic initiatives (Chowdhury, Agarwal, & Quaddus, 2019; Ramaswami, Srivastava, & Bhargava, 2009). This is coherent with our findings, where the larger firms have more resources compared to the SMEs, and therefore have performed better in regards to robustness and resilience.

Proposition 3: Risk management has a positive effect on global supply chains.

From the discussion above, we can conclude that risk management has a positive effect on global supply chains, by mitigating the impact of future disruptions.

5.2.3 Communication

Figure 10 below is an extract from Figure 6 of the communication for the ten firms.

3	Communication	1	2	3	4	5	6	7	8	9	10
	Transparency										
	Early notified of disruptions	x		x	x	x	x	x	x		x
	Openness in information sharing	x	x	-	x (some degree)	-	-	-	-	-	x
	Restricted information sharing	-	-	-	-	-	x	x	x	x	-
	Poor data quality	-	-	-	-	-	-	-	x	x	-
	Manual information sharing										
	Phone	x	x	x	x	x	x	x	x	x	x
	E-mail	x	x	x	x	x	x	x	x	x	x
	Automatic processes										
	Integrated in the SC	-	-	-	-	-	x (some degree)	-	-	-	x
	Relationship in the SC										
	Good relationship	x	x	x	x	x	x	x	x	x	x
	Poor relationship	-	-	-	-	-	-	-	-	-	-

Figure 10 Factor 3 Communication

From the literature review we identified that the lack of transparency is one of the main problems with global supply chains (Free & Hecimovic, 2020). As mentioned in the literature review, transparency refers to visibility in addition to data sharing and openness with the parties involved in the supply chain (Zhu et al., 2020). Free & Hecimovic argue that as the supply chains grow and become more complex, the transparency within the chain is reduced. As a result, the visibility between the participants becomes limited, and it becomes demanding for the participants to identify manufacturing and capacity threat, which will harm the firms resilience (Free & Hecimovic, 2020). This is confirmed by the empirical findings. Egels-Zandén et al states that transparency can strengthen both cooperative action and top-down compliance (Egels-Zandén & Hansson, 2016).

As described by McLean and Rebernak *“There is no better way to build trust among stakeholders than through transparency”* (MacLean & Rebernak, 2007, p. 4). Several informants mentioned the importance of trust, especially during the pandemic where both the employees and customers are working from home. The informants from the larger firms mentioned that it has been more challenging to maintain the trust between the employees, since it has been challenging to control that they are doing what they are supposed to. In the smaller firms it is easier to keep track of the employees, since the firms are smaller, and everyone knows everyone. Hence it is more visible in a small firm if some are not doing their tasks. In addition, the informants have addressed the importance of the leadership style, where the Norwegian leadership model with a flat structure has a higher degree of trust compared to an American or German leadership model with a hierarchic structure (Porter & Lawler, 1965).

The empirical findings revealed that most of the firms are still communicating through phone and email when there are inquiries to customers or suppliers. In addition, several informants stated that the ERP systems are old and is embossed by poor data quality. This applies for the larger firms that have a complex production, with many suppliers to keep track of. Most of the informants claimed that they are early notified of disruptions,

where some of them can reprioritize their tasks to finish their projects in time. From the summary in Figure 7 we saw that several firms were affected by delays from their suppliers, and a few firms had delays to their customers. We believe that there is a positive correlation between transparency and delays.

From Figure 10 we can see that the larger firms have more restricted information sharing while the smaller firms have a more open information sharing. A logical reasoning is the type of organization, where the larger firms have multiple linkages in a supply chain and where they want to limit the number of people who have access to the information. In a smaller organization it is easier to control who has access to the information compared to a larger organization.

5.2.4 Geopolitical Factors

From the empirical findings we saw that the firms were embossed by the national and global regulations. For instance, travel restrictions, infection control rules, quarantine, and requirement of home office for those who can work from home. Several firms were dependent on financial aid from the government, for instance the Norwegian tax package. This was especially important for the smaller firms that were more significantly affected of the pandemic. This is consistent with what the literature described (International Labour Organization, 2020; Selwyn, 2020).

5.3 Measures

This subchapter presents risk management measures that can be applied to the firms to be better prepared for a future disruption in the supply chain. The measures are divided into three categories: resilience, robustness and technology and digital supply chains.

5.3.1 Resilience

Resilience refers to a firms or supply chains ability to return to its normal situation or move to a more desirable state after it has been disturbed (Christopher & Peck, 2004). From the empirical findings, we found that some firms have struggled more than others, while other firms have taken advantage of the pandemic and sold more products than originally planned.

The theory proposes that reshoring is a measure to increase the resilience of a firm, as it moves the business activities closer to its home and makes it more responsive to the customer's needs (Strange, 2020). None of the firms we have interviewed had reshored their supply chain. However, one of the informants mentioned that they have the option to move their production back to Norway, if there should occur any obstacles where their production currently is situated. As of March 2021, they have not had to realize this measure. Some of the informants we interviewed stated that, if possible, they complete their product or project where the

customer is situated, either it is in Norway, Asia, or America. However, this only if the customer is close to one their existing facilities.

It is important to note that the process of reshoring business activities is a complex and takes time to finish. Therefore, reshoring is not seen as a short-term solution, and rather a measure that can be accomplished over a longer period of time. While reshoring is a good way of building resilience, the method does not come without risk. According to Strange, it intensifies the exposure of business to supply chain disruptions in their domestic economies (Strange, 2020). It leaves the firm with few options if any problems were to occur in their area of operation and might not be the best option in countries that are often exposed to disruptions.

Sheffi proposes that increased redundancy is a method to build greater resilience (Sheffi, 2015). According to Kamalahmadi & Parast, a firm is redundant if other suppliers can help to deliver what is needed if one of the suppliers is unable to acquire the necessary resources. Redundancy is an effective tool for managing risk, as well as inventory and capacity planning (Kamalahmadi & Parast, 2016). From the empirical findings we saw that some firms had implemented risk management measures to be prepared for shortages of components, while others had not. As mentioned in Chapter 4, those who excelled had previously noticed shortages of specific components that are critical for their production, and had therefore increased the stock on these components. This has been very valuable for them during COVID. However, having large amounts of additional inventory and production capacity is usually very expensive and is often not worth the reduction in risk (Miroudot, 2020).

Furthermore, Miroudot claims that it is unrealistic to expect firms to invest in tons of extra production capacity to prepare for a disruption or pandemic that could happen once every century (Miroudot, 2020). Redundancy is first and foremost targeted towards those firms that have a specialized production with critical components from few suppliers, and not those who have standardized production where they can acquire their components from multiple suppliers. Miroudot argues that redundancy is a measure targeting firms that are particularly vulnerable for facing crisis like tornados or earthquakes (Miroudot, 2020). The McKinsey Global Institute claims that disruptions happen more frequently which results in a more uncertain future (McKinsey Global Institute, 2020). We do not recommend firms with standardized productions and easy to access materials to invest tons of money in extra inventory. Instead, we see redundancy as a measure for the firms with more specialized production, that are often exposed to disruptions and nature disasters.

As mentioned in Chapter 2.1, the lack of transparency is one of the major challenges with today's global supply chains. Transparency in the supply chain refers to visibility in addition to data sharing and openness with the parties involved in the supply chain (Zhu et al., 2020). Staff et al states that risk management was usually used

for the top tier suppliers before the pandemic struck (Staff, 2020). Consequently, it was difficult to locate disruptions that occurred in the lower-level tiers, which quickly could cause ripple effects throughout the whole supply chain. Therefore, it is crucial to communicate with these tiers, as they might detect complications that the firm is not aware of. This is supported by several researchers, as supply chain collaboration enables the supply chain participants to help each other and mitigate the impact of the disruption (Barrane, Ndubisi, Kamble, Karuranga, & Poulin, 2020; Villena & Gioia, 2018; Q. Zhu, Krikke, & Caniëls, 2017). The statements above are confirmed by the informants. Several of the informants mentioned that the lack of transparency in the supply chain meant that they had to send multiple reminders to know if the products would be delivered within the time frame. Additionally, another informant mentioned the importance of supporting its suppliers, so they can work together to reach their goals.

Poor visibility of information makes it very challenging to forecast material shortages and other disruptions in the supply chains, which is confirmed by several of the informants. This became evident when the pandemic forced large parts of the world into a lockdown and many supply chains came to a standstill (Free & Hecimovic, 2020). Several of the informants mentioned that the information flow primarily consist of phone calls and emails when they are communicating with their customers and suppliers. This form of communication is slow and means that the information must travel through each link of the supply chain before it can arrive at its intended place. According to Free and Hecimovic, the impact of the pandemic would have been much smaller if the communication and information sharing within the chains were better, (Free & Hecimovic, 2020). We recommend a more open form of data sharing, where the participants can access information from the whole supply chain, and not be dependent on intermediaries. There are some challenges related to this, which we will discuss further in subchapter 5.3.3 Technology and digital supply chain.

As a preparation for possible disruptions, Sheffi recommends to perform a comprehensive analysis of the whole supply chain, from top to bottom (Sheffi, 2020). This will provide an indication of the risk involved with their different products based on their location. This is supported by several researchers, as it is a proven method to tackle uncertainty and risks related to supply chains (Ivanov & Dolgui, 2020; Ivanov, Pavlov, Dolgui, Pavlov, & Sokolov, 2016; Kamble & Gunasekaran, 2020; Tukamuhabwa, Stevenson, & Busby, 2017). Some of the informants in the larger organization stated that they had executed a similar analysis. Sheffi recommends performing this analysis of the whole supply chain, which some of the informants had done for their 30 most crucial suppliers. According to Ivanov and Sokolov, firms who analyze their supply chain to identify sources of risk, are better prepared to withstand the effects of disruptions and have a faster recovery (Ivanov & Sokolov, 2013). Some of the firms used approximately 2.000 suppliers and mentioned that the process analyzing all of them is time-consuming and probably not necessary. These types of lists must be continuously revised, as the conditions of their suppliers can change over time. While several of the larger firms from our data gathering

had performed such analysis, none of the smaller ones had done this, and were therefore much less prepared for the pandemic. This might be due to the larger firms having more resources and own risk management departments, while the smaller firms' employees have risk management work on top their main tasks. Therefore, a measure for the smaller firms could be to perform a less comprehensive analysis of their most crucial suppliers.

From the empirical findings several informants revealed that their planning and supply chain is stuck in manual processes. Numerous systems of systems are involved, without mutual data structure and mutual identifiers. A high degree of manual duplication of same data into planning systems, ERP systems and transport systems result in late and fragmented information, inconsistent definitions, data never showing reality and it being of date and sequence. Two of many consequences are:

1. Lack of demand management and low planning horizon. Personnel needed to compensate for missing information, late detection of errors leads to firefighting and low utilization of resources.
2. Financial tracking of services is poor due to lack of resource granularity in service order.

Some of the informants have experienced high uncertainty of whether their material will be delivered to the right time, to the right place and to the right personnel that are executing the job. Furthermore, one of the informants stated that COVID-19 significantly increases market uncertainty and the need for increased planning horizon, transparency, and scenario planning both for the firm and the supplier. The theory points to digitalized supply chains as something that could mitigate some of these problems. Digital supply chains enable digital connectivity and communication with both the physical and digital parts of the supply chain. This allows for real-time storage, analysis, and sharing of data, as well as coordinating the activities and processes in the supply chain (Ben-Daya et al., 2019). Consequently, the firms can have more accurate and up to date information which gives them a better foundation to take decisions (Hofmann, Sternberg, Chen, Pflaum, & Prockl, 2019; Ivanov, Dolgui, & Sokolov, 2019; Kamble & Gunasekaran, 2020; Ralston & Blackhurst, 2020) . Furthermore, the current issues regarding transparency in the supply chain will be improved, as the participant at any time has knowledge of any obstacles. In subchapter 5.3.3 Technology and digital supply chains this will be further explained.

The theory points out some risk involved when implementing transparency in the supply chain, for instance cyber-attacks and leakages of sensitive information. According to Bartley and Doorey, there is a balance between threat and collaboration with suppliers. Despite transparency providing increased collaboration between the actors along the supply chain, it can be seen as threatening since sensitive information is shared with numerous firms (Bartley, 2007; Doorey, 2011). This can induce fear of poor publicity being leaked about

an organization and undermine firm-supplier trust (Egels-Zandén & Hansson, 2016). This is confirmed by the empirical findings, where several of the firms said that they were reluctant with sharing information with their customers and suppliers in fear of sensitive information goes astray.

Proposition 4: With the correct risk management strategies, global supply chains should be resilient enough to handle future extraordinary crises such as COVID-19.

From the discussion above, we agree with the fourth proposition, that global supply chains should be resilient enough to handle future extraordinary crises such as COVID-19, assuming that the right risk management strategies are implemented.

5.3.2 Robustness

Robustness is an essential element in risk management as it supports firms to withstand disruptions from both the internal and external environment and can mitigate several of the risks related to crises like COVID-19. As mentioned in Chapter 2, robustness is the supply chain's ability to maintain its function despite internal or external disruptions (Brandon-Jones et al., 2014). From the empirical findings we saw that the smaller firms, especially firm 2 and 3, struggled financially during the pandemic. Additionally, Firm 2 and 5 received financial support from their owners. On the other hand, several of the larger firms had to lay off their employees to protect their cash. In Figure 6 we saw that the larger firms were more robust compared to the smaller firms which suffered more during the pandemic.

Numerous authors responding to COVID-19 suggested that manufacturing principles such as LEAN and Just-in-Time, has made today's firms more exposed to disruptions (Ivanov & Dolgui, 2020). Moreover, the theory proposes that a switch to Just-in-Case management will trade some of the efficiency for higher security in the supply of inputs (Miroudot, 2020). For instance, from the empirical findings we can see that the larger firms were more prepared for the pandemic by having safety stock of critical components, which helped them during the pandemic. On the other side, Mirodot states that JIT and risk management strategies are complementary. Firms that are striving to build lean and efficient manufacturing processes often invest in risk mitigation strategies (Miroudot, 2020). This is partly confirmed by the empirical findings, where we saw that a firm could have a focus on risk mitigation regardless of whether it had LEAN in their production.

As earlier mentioned, few of the firms we interviewed uses LEAN and Just in time in their production. They either use LEAN and JIT to a certain extent, in another department in the firm or not at all. In some circumstances this is because the firms deliver services and have outsourced the production to other parts of the world. We noticed that even though they used other terms for LEAN manufacturing, they still had a focus

on continuous improvement and reducing waste in their production. Moreover, several firms had a strong focus on risk management even though they had a low degree of lean in their production.

In an article by Financial Times, the editorial board claims that firms should move from Just in Time (JIT) to Just in Case (JIC) strategies (The Editorial Board, 2020). The theory states that by concentrating too much on efficiency, risk management strategies as robustness, resilience, and effectiveness have been overlooked. COVID-19 has shown the need for preparing for future disruptions, and the need for more robust and resilient supply chains. Taleb advises an antifragile approach, beyond resilience and robustness (Taleb, 2012). The antifragile approach can be done in three steps:

1. Rebuild cash reserves by help from the government.
2. Transform their supply chains from JIT to JIC.
3. Reinforce the network of people that support their success.

First, Taleb states that the firms must rebuild their cash reserves with help from the government. As mentioned in the empirical findings, some of the firms received governmental aid, for instance the Norwegian tax package. The theory denotes that the main concern is that the firms had to lay off large amounts of the staff to survive (Taleb, 2012). This can be confirmed by the empirical findings. Some of the firms had to lay off their employees for a couple of weeks, while other firms had to lay off their employees for months. The next step is according to Taleb to transform their supply chains from JIT to JIC models. By doing so, the firms have a larger stock of components that are critical to their production. As earlier mentioned, several of the informants mentioned that their safety stock helped them to survive during the pandemic, especially when their suppliers were unable to provide the components due to shortages. The third step is to reinforce the network of people that support their success and is the most crucial element of a post-crisis strategy in order to be better prepared to handle future disruption (Taleb, 2012). The pandemic has shown the need for suppliers and customers to collaborate, for instance, that the larger firms help the smaller firms in the supply chain to survive. Firm 9 from the empirical findings is a great example of a large firm that helps the smaller firms in the supply chain. They are very focused on facilitating things for their suppliers, so that they can create value together and develop further. During the pandemic the supplier collaboration has proven to be important to assure that both the larger and smaller contestants in the supply chain can survive through disruptions.

Proposition 6: Just in Time and risk management can work well together.

The researchers disagree if JIT or JIC is the best solution for mitigating risk. Pisch states that firms that pursue the JIT strategy have lower inventory costs, and are therefore better situated to increase their inventories to reduce risks in a more competitive way (Pisch, 2020). Firms with low inventories usually have smaller losses than those with high inventories. Furthermore, Pisch claims that if just in case was the major strategy of businesses, rather than JIT, more of them may be bankrupt as a result of COVID-19 (Pisch, 2020). The empirical findings shows that a combination of Just in Time and Just in Case is the best solution, where the firms have small inventories and keep a safety stock of critical components that are crucial for the production. To conclude, proposition six is partly confirmed.

As dominant countries like China shuts down their production factories in response to the COVID-19, several firms were forced to look for alternative sources for their materials. Being very reliant on one supplier has proven to be insufficient in the context of COVID-19, and investors and government bodies have urged decoupling from China (Miroudot, 2020). From the empirical finding the informants have said that this is easier said than done, as it takes long time to switch suppliers, especially when it comes to specialized components. One the informants stated that it can take up to 1,5 years to switch out some of their suppliers. The informants statements are supported by Miroudot, who states that these measures will take a long time and not be favorable or even achievable for specific firms (Miroudot, 2020).

In a study involving 4.000 US firms, Jain, Girotra and Netessine identified that supply chains that relied on multiple different sources for their materials actually recovered slower from disruptions, than the ones that used only a single source (Jain et al., 2016). In addition, how fast a supply chain recover depends on the type of production. For standardized production, it is normally easier to find alternative solutions during disruptions compared to more specialized production with fewer suppliers.

Moreover, the theory claims that single sourcing makes it easier to establish long term relationships with the supplier (Jain et al., 2016). From our data gathering, several of the smaller firms that had few suppliers mentioned that they had strong long-term relationships with their suppliers. Past research recommends building strong relationships and enhance collaboration, which will result in more effective supply chain risk management (Christopher et al., 2011; Hallikas & Lintukangas, 2016; Ojala & Hallikas, 2006; Ritchie & Brindley, 2007; Xie, Anumba, Lee, Kam, et al., 2011). This leads to good supplier relationship, communication, and trust, where the supplier early notifies the firm if there should occur any obstacles, which again reduces the impact of the disruption. Suppliers will then be more dedicated to reduce risk and recover from disruptions (Miroudot, 2020).

Proposition 5: With the correct risk management strategies, global supply chains should be robust enough to handle future extraordinary crises such as COVID-19.

From the discussion above, we agree with the fifth proposition, that global supply chains should be resilient enough to handle future extraordinary crises such as COVID-19, assuming that the right risk management strategies are implemented.

5.3.3 Technology & Digital Supply Chains

Digital supply chains incorporates technologies as Internet of Things, Artificial Intelligence, Machine Learning, Robotics and 5G (Belhadi et al., 2021; Tsolakis et al., 2020). According to the literature, digital supply chains provide new features that enables digital connectivity and communication with the physical and digital parts of the supply chains. This allows for real-time storage, analysis, and sharing of data, and makes the process of coordinating activities and processes in the supply chain more efficient (Ben-Daya et al., 2019). As earlier mentioned, most of the firms we interviewed use old and outdated systems to keep track of their processes. Additionally, the information sharing with their supply chain partners is slow and mostly done through manual processes. Digital supply chains could help solve some of these issues, which is supported by numerous researchers looking into digital supply chains as a supply chain risk mitigation strategy (Belhadi et al., 2021; Hofmann et al., 2019; Kamble & Gunasekaran, 2020; Ralston & Blackhurst, 2020).

While there are many potential benefits of digital supply chains, there are very few firms that have incorporate these types of technologies in their supply chains. This is coherent with the results from our data gathering (Belhadi et al., 2021). Several of the informants stated that they used technologies like Machine Learning, 5G and Internet of Things, which this was in relation to their products and internal processes, not their supply chain. There were mixed reasons for this. The perhaps largest reason was the fear of sensitive information being leaked out and potentially harming the company.

The cost of implementation is mentioned as a barrier for digital supply chains. It requires investment in different technologies and knowledge on how to use it (Gu et al., 2021). Several of the firms we interviewed mentioned that this has been a challenge, especially during the pandemic. As mentioned by one of the informants, they are dependent on their suppliers to follow the same journey, which has been challenging since they do not have the time or resources to work on the development.

Another aspect is the availability of the technology. Several of the informants mentioned that they would look more into integrating technologies like Artificial Intelligence, 5G and Blockchain in their supply chain when the technology is more accessible. This is consistent with what we have found in the literature as well. One

technology which is thought to have a large impact on the way supply chains are managed is Blockchain. As mentioned in subchapter 2.4.2.1, Blockchain has several useful features like being able to safely track transactions and transfers of ownership, as well as decentralized sharing of data (Pagano & Liotine, 2020) and identity management (Kshetri, 2018).

While blockchain has been used in finance for many years, it is only recently that people have started experimenting with it in supply chains. Therefore, there is still a considerable amount of uncertainty surrounding its implementation. This is mostly due to its reliance on total transparency and the risk of information falling leakages (Kshetri, 2017). Other barriers for its inclusion are the cost. Implementing it, or just being a part of a blockchain system, is very expensive, and smaller or medium-sized firms might therefore not be able to take part (Patel et al., 2017; Wang et al., 2017). This leads to the major challenge with blockchain, which is that all participants must take part for it to work. This requires them to follow different rules and regulations and makes things complicated (Casey & Wong, 2017).

Most of the firms are aware that their current solutions in their supply chain are unproductive and that changes need to be made. Several of the informants mentioned that they had started working on programs and other initiatives to make their information sharing more automated. Among those are Firm 9, who have made analyses on the potential benefits: *“The analysis shows that there is great potential in reducing cost, increase productivity and reduce HSE risk through increased and automated data sharing between plan domain & SC/Log domain”* (Informant from Firm 9). As more and more firms become aware of these benefits, more initiatives will take place.

While many of the technologies mentioned above are well established and used, there are still few examples of them being utilized in a supply chain context. Many authors point to a gap in existing supply chain models, regarding the application of digital technology. According to Ben-Daya et al., few frameworks gave a comprehensive guide for the adoption of Internet of Things and Cyber-physical systems in the context of supply chains (Ben-Daya et al., 2019). Moreover, Barata et al. claim that the current models fail to convey the interconnections and exchanges between all participants of the supply chain and consequently does not show the quick changes and responses in the whole structure of the physical and digital supply chain (Barata et al., 2018).

From both our data gathering and the literature, it is clear that today’s supply chain models are outdated, and new models must be created. These models help firms to understand how they can integrate these technologies and make the transition to a more digitalized supply chain. The model developed by Garay-

Rondero (see subchapter 2.4.2, Figure 1) is a suggestion for how this could be done (Garay-Rondero et al., 2019). Still, this requires more research and initiatives.

Proposition 7: There is a positive connection between global supply chains and emerging technologies.

While none of our informants was currently a part of a digitalized supply chain, most of them were aware of the benefits and had already started working on programs targeted towards this. The literature also widely agrees on the potential these technologies can have for supply chains (Garay-Rondero et al., 2019), so it is safe to say that there is a positive connection between global supply chains and emerging technologies. Hence, the proposition is confirmed.

Proposition 8: Digital supply chains can enhance supply chain risk management.

Based on the information we received from our interviews, we can not confirm that digital supply chains can enhance supply chain risk management. However, some of the informants said that they are waiting until the technology is more mature while other informants stated that some are they are in the process of digitalizing their supply chain. Additionally, some one of the informants stated that digitalized supply chain will provide them with better predictions of delivery times. The potential benefits are clear according to the theory, as it enables real time sharing, storage, and analyses of data, and helps organizing the activities and processes in the supply chain (Ben-Daya et al., 2019; Hofmann et al., 2019; Ivanov et al., 2016; Kamble & Gunasekaran, 2020; Ralston & Blackhurst, 2020). We therefore strongly believe that digital supply chains can enhance supply chain risk management. Thus, the proposition is confirmed.

6 Conclusion

Chapter 6 concludes the master thesis where we address the limitations of our study, proposed contributions to existing literature, proposed future research for other researchers to consider and possibly conduct in the future, and lastly recommendations to managers.

In Chapter 1 we introduced the research question where the purpose of the master thesis is to discover how multinational firms have been affected by COVID-19 and how they can improve their resilience and robustness to handle future disruptions in their supply chains. In Chapter 2 we presented eight propositions based on the literature review that we confirmed or denied in Chapter 5, by comparing the propositions with the empirical findings from Chapter 4. We interviewed five large firms with more than 1.000 employees and five small to medium sized firms with less than 1.000 employees, where the objective was to discover if the size of the firm affects a firm's ability to handle a disruption in relation to its resilience and robustness. In subchapter 6.4 we have therefore divided the recommendations for small to medium sized firms and the large firms.

6.1 Limitations of Our Study

The first limitation is the time frame of the thesis. The master thesis has a limited time frame of five months from January to 15th of May. In April the deadline for the thesis was postponed by the Program Coordinator from May 15th to June 1st. Because of the deadline, we limited the study by having ten interviews in total in addition to the questionnaire. As mentioned in Chapter 3, we did not receive enough answers for the questionnaire to be valid. Additionally, the answers we received from the questionnaire did not provide any additional information to the in-dept interviews. Therefore, we made the decision to withdraw the questionnaire from our study.

In retrospect, we should have interviewed more firms that has LEAN production. The firms we interviewed had lean in some degree, or in another department. However, we should have had a larger sample size of LEAN production firms than we collected. In order to have a better basis we should have studied several linkages in the supply chain instead of several supply chains in various industries. For instance, the firm, the firm's customers, its supplier, and its supplier's supplier. By doing so we would have had a better understanding of each participant's understanding of the present situation and which factors that needs to be improved.

When we asked the firms about the communication between their suppliers and customers, all of the informants mentioned that they had good communication. However, the definition of good communication can be subjective. In hindsight, we should have clarified the term to the informants, to make sure that

everyone had a common and clear understanding. In addition, it is very unlikely that an informant will speak negatively of their firm, as they are the ones who represent them. This is further explained in Chapter 3 Methodology.

As mentioned earlier, our thesis has focused on preventative measures, not reactive. We want our study to be applicable in other scenarios as well and have therefore emphasized measures that will be useful against many types of disruptions.

6.2 Contributions to Existing Literature

In subchapter 2.6 we presented Figure 4 that shows a firm’s ability to withstand disruptions, which consist of the four factors complexity, risk management, communication, and geopolitical factors.

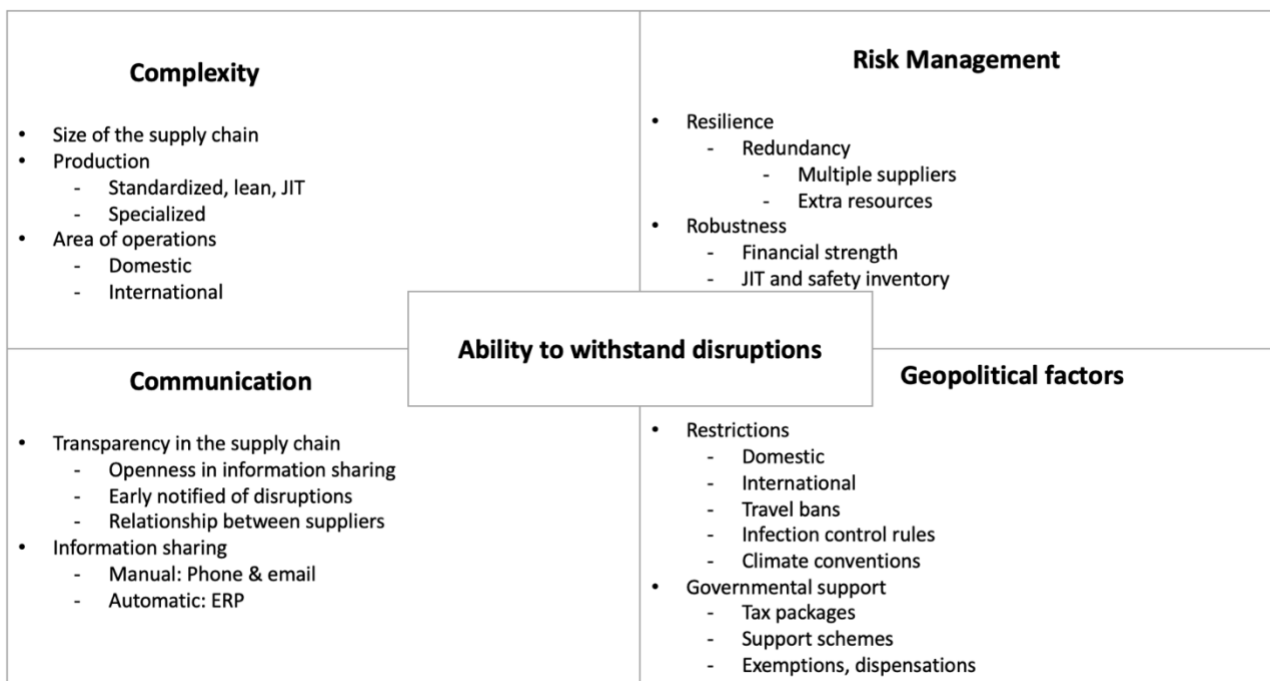


Figure 4 Firm’s Ability to Withstand Disruptions

The empirical findings contributed with knowledge of the information sharing in regards to communication. Still, most firms have a large degree of manual information sharing, e.g., phone calls and email when they are in contact with their suppliers or customers. Otherwise, the remaining subfactors have been partly or completely confirmed by the empirical findings, depending on the firm’s business activities and firm size.

Both our empirical findings and the literature agree that many of the technologies that are considered to have a large impact on supply chains in the future, are not mature enough in their current state. Several of our

informants had concerns regarding information privacy and that there is generally a considerable amount of uncertainty surrounding their implementation in supply chains. There are few examples of firms that successfully have integrating this into their supply chain and the current supply chain models does not sufficiently explain how this could be done.

From the information we received from the interviews, it was clear that the larger firms managed themselves better during the pandemic, compared to the smaller ones. While both seemed to be affected in similar ways in terms of travel restrictions, material shortages and delays, the larger firms were much more robust and better prepared for a situation like this. The smaller firms had to rely on funding from the government and struggled to get enough resources. The larger firms had a much stronger cash and could often put in extra resources if needed.

One measure that is mentioned in the literature, is being able to switch out suppliers if one is unable to deliver the critical components you need. On the other hand, several of our informants stated that this is much easier said than done. This is naturally linked to the type of material that is needed, where one informant mentioned that it could take up to 1,5 years to switch out some of their suppliers. Moving to different suppliers is therefore usually not a short-term solution.

While most of the firms we interviewed have good relationship with their closest suppliers and customers, they do not have control over the suppliers that are further away from them in the supply chain. This means that if a disruption were to occur far away from them, the information would have to travel between each link in the chain before they can receive it. By the time it arrives, it is often too late, and the firm will be affected by the disruption. This is coherent with the literature, which states that poor transparency and information sharing is one of the largest problems with today's supply chains (Van Hoek et al., 2008). Firm 7 States the importance of thinking holistically: *"What we need to improve on is to think holistic through the supply chain. It is often easy to only focus on your own tasks instead of looking at how this will affect the next step in the process."* (Informant 7 from Firm 7).

The whole supply chain and the interrelationships between each participant is crucial, as it provides an overview of how a participant's actions will affect the other participants, and how they will affect the organization. Even though none of our informants had prepared specifically for a pandemic, most of them managed themselves quite well. Most of them struggled in the beginning and had to stop many of their activities, still, they quickly got up to speed and caught up to their projects. Overall, there have been few delays to the customer and fewer setbacks than expected.

Home office have been effective and is a measure that all of the firms will continue with when the pandemic is over, with a flexibility where the employees can choose if they want to work at the office or from home. The same applies for video inspections, where the firms have saved resources in time and cost and delivering the same quality as they did when they were performing physical quality inspections.

6.3 Future Research

Our first recommendation is for researchers to study supply chains as a unit, instead of individual firms. For instance, the research should include suppliers from all the tiers in the supply chain and to show the interrelationships between. This is supported Fan & Stevenson, who states that most of the research on supply chain risk management has focused on a focal firm perspective and consequently has neglected to address the inter-organizational relationships (Fan & Stevenson, 2018).

Further research is also needed to investigate the benefits of digitalized supply chains and how emerging technologies like Big Data, Machine Learning and Blockchain can be integrated into the supply chain. Today's models are outdated and does not do a good job in explaining the integration process. The digital supply chain model by Garay-Rondero (see subchapter 2.4.2) is a great starting point.

Both the theory and the informants agree that the technology is not mature at this time (Garay-Rondero et al., 2019). Additionally, several of the informants mentioned that the data in their ERP systems are embossed by poor data quality. This indicates that before the supply chain gets digitalized, the data quality needs an improvement. Therefore, we recommend researchers to study how the firms that suffer with poor data quality can digitalize their supply chains.

Even though the literature describes many different risk mitigation strategies, some researchers argue that there is little explanation for how these can be combined or how some strategies can be used for multiple types of risk (Mishra et al., 2016; Thun & Hoenig, 2011). Therefore, more research is needed, which looks at how different risk management strategies can work together and complement each other (Nooraie & Parast, 2016).

According to Egels-Zandén, the term transparency is inconsistently defined, which leads to many authors focusing on just one of its many dimensions. This can suggest that firms are either transparent or non-transparent (Egels-Zandén & Hansson, 2016), while in reality, it is significantly more complicated than that. According to them, firms can have different forms of transparency at the same time, which is something that must be taken into consideration by scholars. They also argue that there are few studies on firms, that have

tried to be transparent in practice. Consequently, more studies and research which covers real supply chain transparency initiatives, is needed in the future (Egels-Zandén & Hansson, 2016).

6.4 Recommendations to Managers

This section proposes some recommendations to managers, which are divided into three categories. First, we present general recommendations that applies for all firms, then specific recommendations for the small to medium sized firms and lastly recommendations for the larger firms.

6.4.1 In general:

The general recommendations apply as stated above both for the small to medium sized firms and the larger firms. Our first recommendation is to slowly make the transition into more digitized supply chains, which will enhance the transparency in the supply chain. As mentioned, this will take time, as the technology needs to mature. Digitalized supply chains have many advantages, for instance real time tracking of goods, as well of data sharing with the remaining participants in the supply chain (Casey & Wong, 2017; Q. Lu & Xu, 2017; Mansfield-Devine, 2017). It is important to notice that the digital supply chain has flaws, and that there is a risk of hacking and leakage of sensitive information. Several informants mentioned the importance of having a holistic view, by thinking of the larger picture instead of just thinking of the next step in the process. We believe that the digital supply chains will make this process easier.

The second recommendation is to have a risk mitigation plan where they have a list the most important suppliers and customers, and analyze the risks related to them (Sheffi, 2020). As stated by Ivanov and Sokolov, the firms who conduct a risk analysis of potential threats, are likely to withstand disruptions better and have a faster recovery (Ivanov & Sokolov, 2013) When the technology is more mature, we believe that the analysis that currently is done manually has the possibility to be completed digitally by having real time information of each participant current situation, as well as forecasting a pessimistic, neutral, and opportunistic scenarios.

Additionally, we recommend the firms who have components that are critical to their production to have a safety stock. The second recommendation makes it easier to know which components they should have a safety stock for. Especially if there are few suppliers that can provide these critical components, and if the suppliers are located in areas that are exposed to nature disasters, such as tornados and earthquakes. By doing so, the firms will be less vulnerable in a situation where there is a shortage of these components, and will increase the firms redundancy, enabling them to continue their production as normal (Miroudot, 2020). In addition, some components, as electrical components, tend to experience shortages in specific cycles of 7 to 9 years, which is important to take into consideration when deciding inventory sizes.

The pandemic has shown the importance of being flexible and being able to use different work methods. For instance, home office and video inspections have enabled firms to maintain their operations during these difficult times. Flexibility and willingness to change is a strength, especially considering that the future is uncertain and disruptions occur more frequently (McKinsey Global Institute, 2020). Allowing for more slack on projects increases flexibility and makes it easier to rearrange the activities to combat disruptions.

6.4.2 Small to Medium Sized Firms

We did not find clear differences in the types of measures that small/medium sized firms and larger firms should make. The difference is mostly found in the scale of how things are implemented.

Given that the small to medium sized firms do not have their own risk management department, we recommend the smaller firms to conduct a more superficial and manageable analysis of their suppliers and customers of the risk involved. Additionally, we recommend the smaller to medium sized firms that are in the same industry to collaborate and establish a risk report.

Supplier relationship is especially important for smaller to medium sized firms, given that they have few options when it comes to attaining products. Therefore, they are dependent on having a close relationship to their supply chain partners, so that they can help each other when disruptions occur. This is supported by several scholars, as supplier collaboration enables the participants in the supply chain to meet shared objectives of recovery and help each other to mitigate the impact of the disruption (Barrane et al., 2020; Ivanov & Dolgui, 2020; Villena & Gioia, 2018; Q. Zhu et al., 2017).

6.4.3 Large Firms

Given that the large firms have their own risk management department, we recommend the larger firms to conduct a more comprehensive analysis of the participants in the supply chain and the risk involved, including a scenario analysis of pessimistic, neutral, and opportunistic outcome. Additionally, we recommend that the larger firms that are in the same industry to collaborate and establish a risk report. This measure was done by one of the informants which proved to be a competitive advantage compared to those who had not.

References

- Adam, B., & Smith, I. F. (2008). Reinforcement learning for structural control. *Journal of Computing in Civil Engineering*, 22(2), 133-139.
- AirThings. (2021). Who We Are. Retrieved from <https://www.airthings.com/about-us>
- Aker BP. (2021). About Us. Retrieved from <https://akerbp.com/en/>
- Allum Engineering. (2021). Who We Are. Retrieved from <http://www.allum.no/ag/allum-engineering-as/>
- Alver, B. G., & Øyen, Ø. (1997). *Forskningsetikk i forskerhverdag: vurderinger og praksis*: Tano Aschehoug.
- Barata, J., Da Cunha, P. R., & Stal, J. (2018). Mobile supply chain management in the Industry 4.0 era. *Journal of Enterprise Information Management*.
- Barrane, F. Z., Ndubisi, N. O., Kamble, S., Karuranga, G. E., & Poulin, D. (2020). Building trust in multi-stakeholder collaborations for new product development in the digital transformation era. *Benchmarking: An International Journal*.
- Barter, J. K. L. (2020). *COVID-19 Managing supply chain risk and disruption*. Retrieved from <https://www2.deloitte.com/global/en/pages/risk/articles/covid-19-managing-supply-chain-risk-and-disruption.html>
- Bartley, T. (2007). Institutional emergence in an era of globalization: The rise of transnational private regulation of labor and environmental conditions. *American journal of sociology*, 113(2), 297-351.
- Baryannis, G., Dani, S., & Antoniou, G. (2019). Predicting supply chain risks using machine learning: The trade-off between performance and interpretability. *Future Generation Computer Systems*, 101, 993-1004.
- Belhadi, A., Kamble, S., Jabbour, C. J. C., Gunasekaran, A., Ndubisi, N. O., & Venkatesh, M. (2021). Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries. *Technological Forecasting and Social Change*, 163, 120447.
- Ben-Daya, M., Hassini, E., & Bahroun, Z. (2019). Internet of things and supply chain management: a literature review. *International Journal of Production Research*, 57(15-16), 4719-4742.
- Beyer, M., & Laney, D. (2012). *'The importance of 'big data': A definition,*"Gartner Inc., Stamford, CT. Retrieved from
- Birou, L. M., & Fawcett, S. E. (1993). International purchasing: Benefits, requirements, and challenges. *International Journal of Purchasing and Materials Management*, 29(1), 27-37.
- Brandon-Jones, E., Squire, B., Autry, C. W., & Petersen, K. J. (2014). A contingent resource-based perspective of supply chain resilience and robustness. *Journal of Supply Chain Management*, 50(3), 55-73.
- Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M. (2014). How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective. *International journal of mechanical, industrial science and engineering*, 8(1), 37-44.
- Casey, M. J., & Wong, P. (2017). Global supply chains are about to get better, thanks to blockchain. *Harvard Business Review*, 13, 1-6.
- Cho, J., & Kang, J. (2001). Benefits and challenges of global sourcing: perceptions of US apparel retail firms. *International Marketing Review*.
- Chopra, S., & Sodhi, M. (2004). Supply-chain breakdown. *MIT Sloan Management Review*, 46(1), 53-61.

- Chowdhury, M. M. H., Agarwal, R., & Quaddus, M. (2019). Dynamic capabilities for meeting stakeholders' sustainability requirements in supply chain. *Journal of Cleaner Production*, 215, 34-45.
- Christopher, M., Mena, C., Khan, O., & Yurt, O. (2011). Approaches to managing global sourcing risk. *Supply Chain Management: An International Journal*.
- Christopher, M., & Peck, H. (2004). Building the resilient supply chain.
- CIPS. (2020). Global Supply Chains. Retrieved from <https://www.cips.org/knowledge/procurement-topics-and-skills/supply-chain-management/global-supply-chains/>
- Columbus, L. (2018, June 11th). 10 Ways Machine Learning Is Revolutionizing Supply Chain Management. *Forbes*. Retrieved from <https://www.forbes.com/sites/louiscolombus/2018/06/11/10-ways-machine-learning-is-revolutionizing-supply-chain-management/?sh=14c7ff23e370>
- Dalen, M. (2004). *Intervju som forskningsmetode: en kvalitativ tilnærming*: Universitetsforl.
- DB Schenker. (2019). Nøkkeltall. Retrieved from <https://www.dbschenker.com/no-no/om-db-schenker/om-db-schenker-i-norge/nøkkeltall>
- DB Schenker. (2021). About us. Retrieved from <https://www.dbschenker.com/global/about>
- Deming, W. E., & Edwards, D. W. (1982). *Quality, productivity, and competitive position* (Vol. 183): Massachusetts Institute of Technology, Center for advanced engineering study ...
- Donaldson, T. (2020). China Sourcing, Shipments Face 'Severe Disruptions' Amid Coronavirus Epidemic. *Sourcing Journal*. Retrieved from <https://sourcingjournal.com/topics/sourcing/china-sourcing-logistics-disruptions-coronavirus-dhl-193413>
- Doorey, D. J. (2011). The transparent supply chain: From resistance to implementation at Nike and Levi-Strauss. *Journal of Business Ethics*, 103(4), 587-603.
- Drucker, P. (2012). *Managing in the next society*: Routledge.
- Egels-Zandén, N., & Hansson, N. (2016). Supply chain transparency as a consumer or corporate tool: The case of Nudie Jeans Co. *Journal of Consumer Policy*, 39(4), 377-395.
- Egels-Zandén, N., Hulthén, K., & Wulff, G. (2015). Trade-offs in supply chain transparency: the case of Nudie Jeans Co. *Journal of Cleaner Production*, 107, 95-104.
- Eisenhardt, K. M. (1989). Building theories from case study research. (Special Forum on Theory Building). *Academy of Management Review*, 14(4), 532. doi:10.2307/258557
- El Baz, J., & Ruel, S. (2021). Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience and robustness? Evidence from an empirical survey in a COVID-19 outbreak era. *International Journal of Production Economics*, 233, 107972.
- Fan, Y., & Stevenson, M. (2018). A review of supply chain risk management: definition, theory, and research agenda. *International Journal of Physical Distribution & Logistics Management*.
- Fangen, K. (2010). *Deltagende observasjon*: Fagbokforlaget.
- Foster, S. T. (2017). *Managing quality : integrating the supply chain* (6th ed., global ed. ed.). Harlow: Pearson Education Limited.
- Fox, N. (2009). *Using Interviews in a Research Project*. Retrieved from Nottingham
- Free, C., & Hecimovic, A. (2020). Global supply chains after COVID-19: the end of the road for neoliberal globalisation? *Accounting, auditing, & accountability, ahead-of-print*(ahead-of-print). doi:10.1108/AAAJ-06-2020-4634
- Ganji, E. N., Coutroubis, A., & Shah, S. (2018). *DCM 4.0: integration of Industry 4.0 and demand chain in global manufacturing*. Paper presented at the 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC).

- Garay-Rondero, C. L., Martinez-Flores, J. L., Smith, N. R., Morales, S. O. C., & Aldrette-Malacara, A. (2019). Digital supply chain model in Industry 4.0. *Journal of Manufacturing Technology Management*.
- Glitre Energi. (2021). Om Glitre Energi. Retrieved from <https://www.glitreenergi.no/konsern/om-glitre-energi/>
- Goh, M., Lim, J. Y., & Meng, F. (2007). A stochastic model for risk management in global supply chain networks. *European Journal of Operational Research*, 182(1), 164-173.
- Gomm, R., Hammersley, M., & Foster, P. (2000). Case study and generalization. *Case study method*, 98-115.
- Graham, G., & Hardaker, G. (2000). Supply-chain management across the Internet. *International Journal of Physical Distribution & Logistics Management*.
- Groves, R. M., Fowler Jr, F. J., Couper, M. P., Lepkowski, J. M., Singer, E., & Tourangeau, R. (2011). *Survey methodology* (Vol. 561): John Wiley & Sons.
- Grønmo, S. (1996). *Forholdet mellom kvalitative og kvantitative tilnæringer i samfunnsforskningen*. Oslo: Universitetsforl.
- Gu, M., Yang, L., & Huo, B. (2021). The impact of information technology usage on supply chain resilience and performance: An ambidexterous view. *International Journal of Production Economics*, 232, 107956.
- Hallikas, J., & Lintukangas, K. (2016). Purchasing and supply: An investigation of risk management performance. *International Journal of Production Economics*, 171, 487-494.
- Halvorsen, K. (2008). Å forske på samfunnet. *En innføring i samfunnsvitenskapelig metode*, 5.
- Haraldsen, G. (1999). *Spørreskjemametodikk etter kokebokmetoden*: Ad Notam Gyldendal.
- Harboe, T., & Eriksen, L. (2008). *Indføring i samfunnsvidenskabelig metode*: KLO.
- Hartmann, J., & Moeller, S. (2014). Chain liability in multitier supply chains? Responsibility attributions for unsustainable supplier behavior. *Journal of operations management*, 32(5), 281-294.
- Heaney, B. (2013). Supply chain visibility: A critical strategy to optimize cost and service. *Aberdeen Group*, 20.
- Heiberg, K. A. L. (2020, 04. mai 2020). TechnipFMC sier opp opptil 700 ansatte. *Laagendalposten*.
- Hendler, S. (2019). Digital-physical product development: a qualitative analysis. *European Journal of Innovation Management*.
- Ho, W., Zheng, T., Yildiz, H., & Talluri, S. (2015). Supply chain risk management: a literature review. *International Journal of Production Research*, 53(16), 5031-5069.
- Hofmann, E., Sternberg, H., Chen, H., Pflaum, A., & Prockl, G. (2019). Supply chain management and Industry 4.0: conducting research in the digital age. *International Journal of Physical Distribution & Logistics Management*.
- Holme, I. M. (1996). *Metodevalg og metodebruk*: Tano.
- Hoy, M. B. (2017). An introduction to the blockchain and its implications for libraries and medicine. *Medical reference services quarterly*, 36(3), 273-279.
- Hull, R. (2017). *Blockchain: distributed event-based processing in a data-centric world*. Paper presented at the Proceedings of the 11th ACM International Conference on Distributed and Event-based Systems.
- IBM. (2020, 15 July 2020). What is machine learning? Retrieved from <https://www.ibm.com/cloud/learn/machine-learning>
- International Labour Organization. (2020). *The effects of COVID -19 on trade and global supply chains*. Retrieved from https://www.ilo.org/wcmsp5/groups/public/---dgreports/---inst/documents/publication/wcms_746917.pdf

- Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International Journal of Production Research*, 58(10), 2904-2915.
- Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. *International Journal of Production Research*, 57(3), 829-846.
- Ivanov, D., Pavlov, A., Dolgui, A., Pavlov, D., & Sokolov, B. (2016). Disruption-driven supply chain (re)-planning and performance impact assessment with consideration of pro-active and recovery policies. *Transportation Research Part E: Logistics and Transportation Review*, 90, 7-24.
- Ivanov, D., & Sokolov, B. (2013). Control and system-theoretic identification of the supply chain dynamics domain for planning, analysis and adaptation of performance under uncertainty. *European Journal of Operational Research*, 224(2), 313-323.
- Jacobsen, D. I. (2015). *Hvordan gjennomføre undersøkelser? : innføring i samfunnsvitenskapelig metode* (3. utg. ed.). Oslo: Cappelen Damm akademisk.
- Jain, N., Girotra, K., & Netessine, S. (2016). Recovering from supply interruptions: The role of sourcing strategy.
- Johannessen, A., Christoffersen, L., & Tuft, P. A. (2010). *Introduksjon til samfunnsvitenskapelig metode* (4. utg. ed.). Oslo: Abstrakt.
- Johnson, R. B. (1997). Examining the validity structure of qualitative research. *Education*, 118(2), 282.
- Jüttner, U. (2005). Supply chain risk management. *The international journal of logistics management*.
- Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: outlining an agenda for future research. *International Journal of Logistics: Research and Applications*, 6(4), 197-210.
- Kache, F., & Seuring, S. (2017). Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management. *International Journal of Operations & Production Management*.
- Kamalahmadi, M., & Parast, M. M. (2016). A review of the literature on the principles of enterprise and supply chain resilience: Major findings and directions for future research. *International Journal of Production Economics*, 171, 116-133.
- Kamble, S. S., & Gunasekaran, A. (2020). Big data-driven supply chain performance measurement system: a review and framework for implementation. *International Journal of Production Research*, 58(1), 65-86.
- Katal, A., Wazid, M., & Goudar, R. H. (2013). *Big data: issues, challenges, tools and good practices*. Paper presented at the 2013 Sixth international conference on contemporary computing (IC3).
- KDA. (2021). KDA. Retrieved from <https://www.kongsberg.com/no/kda/products/>
- Khan, S. A. R. K. C. J. C. J. A. B. S. F. (2020). Resilience in Global Supply Chains (GSCs): COVID 19 Outbreak. *Operations Management Research*. Retrieved from <https://www.springer.com/journal/12063/updates/17978468>
- Kongsberg Maritime. (2021). Who We Are. Retrieved from <https://www.kongsberg.com/no/maritime/about-us/who-we-are-kongsberg-maritime/>
- Krauth, O. (2018, February 9th). Businesses are using the ledger technology behind Bitcoin to track their supply more efficiently. Retrieved from <https://www.techrepublic.com/article/5-companies-using-blockchain-to-drive-their-supply-chain/>
- Kshetri, N. (2017). Will blockchain emerge as a tool to break the poverty chain in the Global South? *Third World Quarterly*, 38(8), 1710-1732.
- Kshetri, N. (2018). 1 Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, 39, 80-89.

- Kumar, S., & Managi, S. (2020). Does stringency of lockdown affect air quality? Evidence from Indian cities. *Economics of Disasters and Climate Change*, 4(3), 481-502.
- Kvale, S. (2006). Dominance through interviews and dialogues. *Qualitative inquiry*, 12(3), 480-500.
- Kvale, S., Brinkmann, S., Anderssen, T. M., & Rygge, J. (2015). *Det kvalitative forskningsintervju* (3. utg. ed.). Oslo: Gyldendal akademisk.
- L'heureux, A., Grolinger, K., Elyamany, H. F., & Capretz, M. A. (2017). Machine learning with big data: Challenges and approaches. *Ieee Access*, 5, 7776-7797.
- Leseth, A., & Tellmann, S. (2018). Hvordan lese kvalitativ forskning?(2. Utg.). Oslo: Cappelen Damm akademisk.
- Leveling, J., Edelbrock, M., & Otto, B. (2014). *Big data analytics for supply chain management*. Paper presented at the 2014 IEEE International Conference on Industrial Engineering and Engineering Management.
- Liboni, L. B., Cezarino, L. O., Jabbour, C. J. C., Oliveira, B. G., & Stefanelli, N. O. (2019). Smart industry and the pathways to HRM 4.0: implications for SCM. *Supply Chain Management: An International Journal*.
- Locke, E. A. (2007). The case for inductive theory building. *Journal of Management*, 33(6), 867-890.
- Lu, Q., & Xu, X. (2017). Adaptable blockchain-based systems: A case study for product traceability. *IEEE Software*, 34(6), 21-27.
- Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of industrial information integration*, 6, 1-10.
- MacLean, R., & Rebernak, K. (2007). Closing the credibility gap: The challenges of corporate responsibility reporting. *Environmental Quality Management*, 16(4), 1-6.
- Mansfield-Devine, S. (2017). Beyond Bitcoin: using blockchain technology to provide assurance in the commercial world. *Computer Fraud & Security*, 2017(5), 14-18.
- Manuj, I., & Mentzer, J. T. (2008). Global supply chain risk management strategies. *International Journal of Physical Distribution & Logistics Management*, 38(3), 192-223. doi:10.1108/09600030810866986
- Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Hung Byers, A. (2011). *Big data: The next frontier for innovation, competition, and productivity*: McKinsey Global Institute.
- Marschan-Piekkari, R., & Welch, C. (2004). *Handbook of qualitative research methods for international business*: Edward Elgar Cheltenham.
- Marshall, C., & Rossman, G. B. (2016). Designing qualitative research . Loss Angeles. In: CA: SAGE.
- McAfee, A., Brynjolfsson, E., Davenport, T. H., Patil, D., & Barton, D. (2012). Big data: the management revolution. *Harvard Business Review*, 90(10), 60-68.
- McCracken, G. (1988). *The long interview* (Vol. 13): Sage.
- McKinsey Global Institute. (2020). *Risk, resilience, and rebalancing in global value chains*. Retrieved from <https://www.mckinsey.com/business-functions/operations/our-insights/risk-resilience-and-rebalancing-in-global-value-chains>
- Miroudot, S. (2020). Reshaping the policy debate on the implications of COVID-19 for global supply chains. *Journal of International Business Policy*, 1-13.
- Mishra, D., Sharma, R., Kumar, S., & Dubey, R. (2016). Bridging and buffering: Strategies for mitigating supply risk and improving supply chain performance. *International Journal of Production Economics*, 180, 183-197.
- Moen Marin. (2021). Om oss. Retrieved from <https://www.moenmarin.no/kontakt/>
- Neiger, D., Rotaru, K., & Churilov, L. (2009). Supply chain risk identification with value-focused process engineering. *Journal of operations management*, 27(2), 154-168.

- Nola, R., & Sankey, H. (2007). *Theories of scientific method*. Stocksfield. *Acumen Publishers*.
- Padidam, M., Sawyer, S., Fauquet, CM (1999) Possible emergence of new geminiviruses by frequent recombination. *Virology*, 265, 218-225.
- Nooraie, S. V., & Parast, M. M. (2016). Mitigating supply chain disruptions through the assessment of trade-offs among risks, costs and investments in capabilities. *International Journal of Production Economics*, 171, 8-21.
- Nylænder, L. C., & Pedersen, F. (2020). The Impact of COVID-19 on Global Supply Chains. In: University of South-East Norway.
- Ojala, M., & Hallikas, J. (2006). Investment decision-making in supplier networks: Management of risk. *International Journal of Production Economics*, 104(1), 201-213.
- Oloruntoba, S. R. K. A. A. S. A. W. R. (2020). The "New Normal": Rethinking Supply Chains during and after COVID-19 Global Business Environment. *International Journal of Physical Distribution & Logistics Management*. Retrieved from <https://www.emeraldgrouppublishing.com/journal/ijpdlm/new-normal-rethinking-supply-chains-during-and-after-covid-19-global-business>
- Pagano, A. M., & Liotine, M. (2020). *Technology in supply chain management and logistics : current practice and future applications*(1st edition. ed.).
- Parsons, T. (2020). How Coronavirus Will Affect the Global Supply Chain. Retrieved from <https://hub.jhu.edu/2020/03/06/covid-19-coronavirus-impacts-global-supply-chain/>
- Patel, D., Bothra, J., & Patel, V. (2017). *Blockchain exhumed*. Paper presented at the 2017 ISEA Asia Security and Privacy (ISEASP).
- Pisch, F. (2020). Managing Global Production: Theory and Evidence from Just-in-Time Supply Chains. *SEPS Discussion Papers*(2020-08).
- Porter, L. W., & Lawler, E. E. (1965). Properties of organization structure in relation to job attitudes and job behavior. *Psychological bulletin*, 64(1), 23.
- Qiu, J., Wu, Q., Ding, G., Xu, Y., & Feng, S. (2016). A survey of machine learning for big data processing. *EURASIP Journal on Advances in Signal Processing*, 2016(1), 1-16.
- Ralston, P., & Blackhurst, J. (2020). Industry 4.0 and resilience in the supply chain: a driver of capability enhancement or capability loss? *International Journal of Production Research*, 58(16), 5006-5019.
- Ramaswami, S. N., Srivastava, R. K., & Bhargava, M. (2009). Market-based capabilities and financial performance of firms: insights into marketing's contribution to firm value. *Journal of the Academy of Marketing Science*, 37(2), 97-116.
- Repstad, P., & Repstad, P. (1993). Mellom nærhet og distanse: kvalitative metoder i samfunnsfag.
- Richey Jr, R. G., Morgan, T. R., Lindsey, K. K., Adams, F. G., & Autry, C. W. (2015). *Global managerial perspectives of big data strategy in supply chain management*(1st edition. ed.).
- Ridder, H.-G. (2017). The theory contribution of case study research designs. *Business Research*, 10(2), 281-305.
- Ringdal, K. (2018). *Enhet og mangfold : samfunnsvitenskapelig forskning og kvantitativ metode* (4. utg. ed.). Bergen: Fagbokforl.
- Ritchie, B., & Brindley, C. (2007). An emergent framework for supply chain risk management and performance measurement. *Journal of the Operational Research Society*, 58(11), 1398-1411.
- Robak, S., Franczyk, B., & Robak, M. (2013). *Applying big data and linked data concepts in supply chains management*. Paper presented at the 2013 Federated Conference on Computer Science and Information Systems.
- Rubin, H. J., & Rubin, I. S. (2011). *Qualitative interviewing: The art of hearing data*: sage.
- Ryen, A. (2002). *Det kvalitative intervjuet: fra vitenskapsteori til feltarbeid*: Fagbokforlaget.

- Savin-Baden, M., & Major, C. H. (2013). *Qualitative research : the essential guide to theory and practice*. London: Routledge.
- Seale, C. (2007). Quality in Qualitative Research. IC Seale, G Gobo, JF Gubrium & D Silverman (red). *Qualitative research practice*, 379-389.
- Selwyn, S. H. M. (2020, 05.05.2020). How to protect global supply chains under threat from the COVID-19 pandemic. Retrieved from <https://www.weforum.org/agenda/2020/05/global-supply-chains-are-under-imminent-threat-from-the-covid-19-pandemic/>
- Sheffi, Y. (2015). *The power of resilience: How the best companies manage the unexpected*: mit Press.
- Sheffi, Y. (2020). Are You Prepared to Manage a Whack-A-Mole Recovery? Retrieved from <https://medium.com/mitsupplychain/are-you-prepared-to-manage-a-whack-a-mole-recovery-6b79127ad63a>
- Sherman, E. (2020). 94% of the Fortune 1000 are seeing coronavirus supply chain disruptions: Report. Retrieved from <https://fortune.com/2020/02/21/fortune-1000-coronavirus-china-supply-chain-impact/>
- Silverman, D. (2015). *Interpreting qualitative data*: Sage.
- Simchi-Levi, D., Wang, H., & Wei, Y. (2018). Increasing supply chain robustness through process flexibility and inventory. *Production and Operations Management*, 27(8), 1476-1491.
- Staff, M. L. (2020). Impact of the Coronavirus on Global Supply Chain. *Mateial Handling & Logistics*. Retrieved from <https://www.mhlnews.com/global-supply-chain/article/21122993/impact-of-the-coronavirus-on-global-supply-chain>
- Strange, R. (2020). The 2020 Covid-19 pandemic and global value chains. *Journal of Industrial and Business Economics*, 1.
- Strange, R., Magnani, G., Strange, R., & Magnani, G. (2018). Outsourcing, offshoring and the global factory. In *The Routledge companion to the geography of international business* (pp. 60-77): Routledge.
- Taleb, N. N. (2012, 23.11.2012). Whatever the wearther. *Financial Times*. Retrieved from <https://www.ft.com/content/a49f8514-3329-11e2-8e44-00144feabdc0>
- TechnipFMC. (2020). TechnipFMC About us. Retrieved from <https://www.technipfmc.com/en/about-us>
- Thagaard, T. (2013). *Systematikk og innlevelse : en innføring i kvalitativ metode* (4. utg. ed.). Bergen: Fagbokforl.
- The Editorial Board. (2020, April 22 2020). Companies should shift from 'just in time' to 'just in case'. Retrieved from <https://www.ft.com/content/606d1460-83c6-11ea-b555-37a289098206#comments-anchor>
- Thun, J.-H., & Hoenig, D. (2011). An empirical analysis of supply chain risk management in the German automotive industry. *International Journal of Production Economics*, 131(1), 242-249.
- Tjora, A. (2017). Kvalitative forskningsmetoder i praksis. 3 red. Oslo: Gyldendal Norsk Forlag.
- Tonrud Engineering. (2021). Om oss. Retrieved from <https://www.tronrud.no/no/om-oss/>
- Tsolakis, N., Harrington, T., & Singh Srai, J. (2020). Digital Supply Network Design: A Circular Economy 4.0 Decision-making System for Real-world Challenges. *Production Planning & Control*.
- Tu, W., & Sun, S. (2012). *Cross-domain representation-learning framework with combination of class-separate and domain-merge objectives*. Paper presented at the Proceedings of the 1st International Workshop on Cross Domain Knowledge Discovery in Web and Social Network Mining.
- Tukamuhabwa, B., Stevenson, M., & Busby, J. (2017). Supply chain resilience in a developing country context: a case study on the interconnectedness of threats, strategies and outcomes. *Supply Chain Management: An International Journal*.

- van Engelenburg, S. H., Janssen, M. F. W. H. A., & Klievink, A. J. (2017). Design of a software architecture supporting business-to-government information sharing to improve public safety and security: Combining business rules, Events and blockchain technology. *Journal of Intelligent information systems*, 52.
- Van Hoek, R., Ellinger, A. E., & Johnson, M. (2008). Great divides: internal alignment between logistics and peer functions. *The international journal of logistics management*.
- Villena, V. H., & Gioia, D. A. (2018). On the riskiness of lower-tier suppliers: Managing sustainability in supply networks. *Journal of operations management*, 64, 65-87.
- Virum, H., & Persson, G. (2011). *Logistikk og ledelse av forsyningskjeder* (2. utg. ed.). Oslo: Gyldendal akademisk.
- Wang, J., Wu, P., Wang, X., & Shou, W. (2017). The outlook of blockchain technology for construction engineering management. *Frontiers of engineering management*, 67-75.
- Welch, C., Piekkari, R., Plakoyiannaki, E., & Paavilainen-Mäntymäki, E. (2011). Theorising from case studies: Towards a pluralist future for international business research. *Journal of International Business Studies*, 42(5), 740-762.
- Wieland, A., & Wallenburg, C. M. (2012). Dealing with supply chain risks. *International Journal of Physical Distribution & Logistics Management*.
- Wilhelm, M. M., Blome, C., Bhakoo, V., & Paulraj, A. (2016). Sustainability in multi-tier supply chains: Understanding the double agency role of the first-tier supplier. *Journal of operations management*, 41, 42-60.
- World Bank. (2019). *World Development Report 2020 – Global value chains: Trading for development*. Retrieved from Washington, DC: World Bank.:
- Xie, C., Anumba, C. J., Lee, T. R., Kam, B. H., Chen, L., & Wilding, R. (2011). Managing production outsourcing risks in China's apparel industry: a case study of two apparel retailers. *Supply Chain Management: An International Journal*.
- Xie, C., Anumba, C. J., Lee, T. R., Tummala, R., & Schoenherr, T. (2011). Assessing and managing risks using the supply chain risk management process (SCRMP). *Supply Chain Management: An International Journal*.
- Xu, S., Zhang, X., Feng, L., & Yang, W. (2020). Disruption risks in supply chain management: a literature review based on bibliometric analysis. *International Journal of Production Research*, 58(11), 3508-3526.
- Yin, R. K. (2018). *Case study research and applications : design and methods* (Sixth Edition. ed.). Los Angeles: SAGE.
- Yu, D., & Deng, L. (2010). Deep learning and its applications to signal and information processing [exploratory dsp]. *IEEE Signal Processing Magazine*, 28(1), 145-154.
- Zhu, G., Chou, M. C., & Tsai, C. W. (2020). Lessons Learned from the COVID-19 Pandemic Exposing the Shortcomings of Current Supply Chain Operations: A Long-Term Prescriptive Offering. *Sustainability*, 12(14), 5858.
- Zhu, Q., Krikke, H., & Caniels, M. C. (2017). Integrated supply chain risk management: a systematic review. *The international journal of logistics management*.

Appendix 1 – NSD’s Evaluation

Prosjekttittel

Masteravhandling - Påvirkningen av COVID-19 på globale forsyningskjeder

Referansenummer

979051

Registrert

13.01.2021 av Lise Cecilie Nylænder - 146172@student.usn.no

Behandlingsansvarlig institusjon

Universitetet i Sørøst-Norge / Handelshøyskolen / Institutt for industriell økonomi, strategi og statsvitenskap

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

David A. Guttormsen, David.Guttormsen@usn.no, tlf: 46410118

Type prosjekt

Studentprosjekt, masterstudium

Kontaktinformasjon, student

Lise Cecilie Nylænder, liseceulyaender@icloud.com, tlf: 95793953

Prosjektperiode

04.01.2021 - 15.06.2021

Status

20.01.2021 - Vurdert

Vurdering (1)

20.01.2021 – Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 20.01.21, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER

Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke typer endringer det er nødvendig å melde:

<https://www.nsd.no/personverntjenester/fyll-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema>

Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET

Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 15.06.21.

LOVLIG GRUNNLAG

Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER

NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke behandles til nye, uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER

Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER

NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Microsoft Office 365 og Nettskjema er databehandlere i prosjektet. NSD legger til grunn at behandlingen oppfyller kravene til bruk av databehandler, jf. art 28 og 29.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET

NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Appendix 2 – Information regarding the master thesis

Do you want to participate in the research project:

The impact of COVID-19 on Global Supply Chains?

This is a question for you to participate in the research project where the purpose is to investigate how global supply chains can become robust enough to survive crises as COVID-19 in the future. This letter provides information about the purpose of the project and what participating in the project means for you.

Purpose

We are two master students at the University of South-Eastern Norway who writes our master thesis the spring of 2021 within industrial economics. The purpose of the master thesis is to study COVID- 19's impact on global supply chains and suggest how they can become better suited to handle similar crises in the future. The research is highly relevant since many firms has suffered to survive during the COVID-19 pandemic. The sample will consist of several multinational firms that produce products. In order to get a holistic picture, we want to execute an in-dept interview in combination with a questionnaire.

What does it mean for you to participate?

You will be invited to be interviewed about the topic of discussion. We want information about the firm's risk management strategies and production principles. In addition to the interview objects role in the firm and e-mail. Moreover, we would like to know how the firm has been affected by COVID- 19 and which measures the firm has taken to mitigate the consequences. There will be one interview per firm, with the possibility for follow-up questions after the interview sent by e-mail. The interviews are scheduled to last for 45 minutes to an hour.

The interviews will be recorded and used in the master thesis. Afterwards there will be sent a questionnaire to receive information of the firm's risk management strategies and production principles. The survey consists of 10 questions.

It is voluntary to participate

It is voluntary to participate in the project. If you decide to participate, you can at any time withdraw without consent from the project. All information about you will be deleted. It does not have any negative consequences if you decide to not participate, or later on decide to withdraw from the research project.

Your privacy – how we store and use your personal information

All personal information and information about the firm will be treated confidentially and in coherence with GDPR. The data will be stored on a password protected computer and will only be treated by the supervisor and the two involved students. The data and results that is presented in the master thesis will not be able to be tracked back to any organization or individual. The thesis is delivered within 15.05.2021. After thesis is completed, all collected data will be deleted.

As long as you can be identified in the data material, you have the right to insight to what personal information that is registered about you, delete personal information, and delivered a copy of your personal information. In addition, you can complain to the Data Protection Official (Personvernombudet) or the Norwegian Data Protection Authority (Datatilsynet) about the treatment of your personal information registered in our work with the master thesis. We treat your personal information based on your consent.

Who is responsible for the research project?

University of South-Eastern Norway

If you have questions for the study, please contact:

Fredrik Pedersen, fredrik.pedersen300696@outlook.com

Lise C. Nylænder, liseconylaender@icloud.com

The supervisor for the project: David Guttormsen, David.Guttormsen@usn.no

On the request from the University of South-East Norway has NSD – Norsk senter for forskningsdata AS evaluated that the treatment of personal information is in compliance with General Data Protection Regulation (GDPR).

If you have any questions related to NDS's evaluation of the project, please contact:

NSD – Norsk senter for forskningsdata AS on e-mail (personverntjenester@nsd.no) or phone: 55 58 21 17.

Best regards,

David S. A. Guttormsen Fredrik Pedersen Lise C. Nylænder

David Guttormsen

Fredrik Pedersen

Lise Cecilie Nylænder

(Supervisor)

(Student)

(Student)

Appendix 3 – Statement of Consent

Statement of Consent

I have received and understood the information about the project “The impact of COVID-19 on Global Supply Chains” and have had the opportunity to ask questions. I give consent to:

1. To participate in an interview that is recorded, and that the information will be presented anonymously in the master thesis.
2. To receive and answer follow-up questions per e-mail if necessary, after the interview. There will not be sent any follow-up questions after the master thesis is delivered.
3. *My personal information is treated until the master thesis is completed, 15.05.2021*

(Signed by the participant, date)

Appendix 4 – Interview guide

Context:

The ongoing COVID-19 pandemic has caused much of stress on firms and many are facing an uncertain future. Crucial business activities have been reduced dramatically or shut down completely, resulting in major revenue-losses and layoffs. Supply chains all over the world are experiencing large disruptions due to the effects of the virus. Manufacturers are unable to acquire the necessary materials and resources from their suppliers, thereby making it difficult to deliver products to their customers. In addition, new working conditions, often with a reduced work force and strict guidelines, has made it challenging to remain efficient.

Most firms were not prepared for this pandemic, and many flaws with current manufacturing principles have become apparent. This had forced many to rethink their strategy, in order to be better prepared for similar situations in the future.

The questions below seek to answer how the COVID-19 has affected your organization and the supply chain(s) it is a part of, and also what sort of measures you have taken to deal with the situation.

The master thesis is planned to be a qualitative study with in-depth interviews of multinational enterprises (MNEs). The objective is to answer the research question “How can global supply chains become better suited to handle crisis like COVID-19 and what is the role of technology?”.

Questions

General questions about the pandemic

1. What has been the largest impact of the COVID-19 pandemic in your firm?
2. How do you feel your organization has handled the pandemic so far?
3. What would your firm have done differently today?
4. Which new work methods have been introduced, as a result of the pandemic?
 - a. What obvious new ways of working have your firm identified as positive?
 - b. What obvious new ways of working have your firm identified as negative?
 - c. Will your firm continue with some of the new work methods after the pandemic is over?
5. Was your firm robust and resilient enough to handle the COVID-19 pandemic?
 - a. Which risk management measures was taken?

Supply Chains

6. Can you give us a basic overview of your supply chain?
 - a. How complex is it?
 - b. Is it vulnerable to disruptions?
7. How has the firm's global activities been affected?
 - c. How has your firm's ability to deliver products and services been affected by the pandemic?
8. Has your firm been able to acquire the necessary materials and resources to maintain production?
9. How has the communication between your firm and other supply chain members been during the pandemic?
 - d. Which factors could have been improved?
10. Does your firm utilize Lean production principles, like Just in time?

Emerging Technologies

11. Have your firm incorporated technologies like Big Data, 5G, Internet of Things, Artificial Intelligence and Machine Learning in your supply chain?
 - a. If so, has this helped to reduce risks related to the COVID-19?
 - b. If not, is this something you will consider in the future?

Other

12. Any other conditions of interest that you have identified due to the impact of the virus?

Appendix 5 – Questionnaire

Robustness of the supply chain

Which company do you work for? *

What is your role in the company? *

1. Is your firm part of a global supply chain?

- Yes
- No

2. Are you utilizing one or more Lean-based principles, e.g. Just-in-time?

- Yes
- No

3. Do your company have large safety-stocks in case of unforeseen events, or do you keep them at a minimum?

- Large safety stocks
- Keep them at a minimum

4. How is the information flow between the participants of your supply chain?

- Excellent
- Good
- Average
- Poor
- Very poor

5. When a disruption is occurring somewhere the supply chain, the company is alerted quickly about the situation.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

6. Have you incorporated any tools to enhance the flow of information in your supply chain?

Multiple answers are allowed.

- 5G
- Big Data
- Machine Learning
- Artificial Intelligence
- Internet of Things
- Digital Twin
- Blockchain
- Other
- No

7. In case any of your suppliers are unable to deliver necessary materials to you, you can quickly obtain these materials from somewhere else.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

8. I have calculated the risk involved with each of our suppliers, in case they are hindered from delivering the necessary products.

- Strongly agree

- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

9. How much does your company emphasize risk management?

- In a large degree
- To some degree
- In a small degree
- No at all

10. Are your workers involved in the risk management process?

- In a large degree
- To some degree
- In a small degree
- No at all