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BUILDING RESILIENT AND AGILE GLOBAL SUPPLY CHAINS: A STUDY ON THE IMPACT OF THE COVID-19 PANDEMIC

VASTUPIDAVATE JA AGIILSETE GLOBAALSETE TARNEAHELATE ÜLESEHITAMINE: UURING COVID-19 PANDEEMIA MÕJUTUSTEST

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Tallinn 2023

AUTHOR'S DECLARATION

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THESIS TASK

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Thesis topic:

(in English) Building Resilient and Agile Global Supply Chains: A Study on the Impact of the Covid-19 Pandemic

(in Estonian) Vastupidavate ja Agiiliste Globaalsete Tarneahelate Ülesehitamine: Uuring COVID-19 Pandeemia Mõjutustest

Thesis main objectives:

1. To study impact of Covid-19 pandemic on global supply chains.
2. Investigate strategies and measures that were applied in order to cope with disruptions.
3. Create a set of guidelines for supply chain experts.

Thesis tasks and time schedule:

No	Task description	Deadline
1.	Literature research	1.12.2022
2.	Collect qualitative data through interviews	1.04.2023
3.	Data analysis and conclusions	20.05.2023

Language: English **Deadline for submission of thesis:** "22" May 2023 a

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PREFACE

I am pleased to present this thesis, which explores the effects of the Covid-19 pandemic on global supply chains and proposes strategies for building resilience and agility. This preface provides an overview of the thesis, acknowledges the individuals who supported and contributed to its completion, and offers a concise summary of its key findings.

The initiation of this thesis topic was driven by a collective effort to address the unprecedented challenges faced by supply chains worldwide during the Covid-19 pandemic. The topic was inspired by the recognition of the critical need to understand and enhance the resilience and agility of supply chains in the face of disruptive events. The interest in this topic by the author was the main driver for this research work that was done individually, without involvement of any organisation. The support and guidance provided by the faculty and staff of TalTech throughout the research process are greatly appreciated.

I extend my heartfelt gratitude to the individuals who generously contributed their time and expertise to assist in data collection, consultation, and insightful discussions. Their invaluable input and guidance have played a crucial role in shaping the direction and outcomes of this research.

Furthermore, I would like to express my gratitude to those who have provided unwavering support, encouragement, and inspiration throughout my academic journey. Their belief in my abilities and their encouragement along the way have been instrumental in the successful completion of this thesis.

In summary, this thesis explores the effects of the Covid-19 pandemic on global supply chains, investigates the strategies for building resilience and agility, and proposes practical recommendations for supply chain practitioners.

Keywords: Supply chain management, Covid-19 pandemic, Resilience, Agility, Master thesis.

List of abbreviations and symbols

JIT (background and motivation)

SC (global supply chain)

SCM (supply chain management)

SCD (supply chain disruption)

ERP (enterprise resource planning)

PESTEL (Political, Economic, Social, Technological, Envronmental, Legal)

IMF (International Monetary Fund)

CO_2 (carbon dioxide)

Covid-19 (CoronaVirus Disease – 19)

WHO (World Health Organization)

B2B (Business to Business)

B2C (Business to Cutomer)

IOT (Internet of Things)

AI (artificial intelligence)

1. INTRODUCTION

In 2020 the world has faced an unprecedented event in modern history the global pandemic of Covid-19. Decease which was first time spotted in Wuhan, China late 2019 very rapidly has spread around the globe, and already in early 2020 governments had to react by introducing restriction measures. Restrictions were aimed to reduce social interaction between the people in order to slow down the spread of Coronavirus disease as soon as the cure for the virus was not discovered yet. People had to avoid social interaction by any possible means, which caused very rapid and dramatic changes in every aspect of life. Besides, this means that business activities were significantly limited by lockdowns and travel restrictions. Supply chains have faced serious disruptions which resulted in the unavailability of commodities, production stops, and significant financial losses. Businesses had to react rapidly to the new reality and apply practices that would reduce damage to their operations. As soon as, such fortuity as a global pandemic has never happened in modern history architecture of business operations has never considered concomitant risks when they were developed. This led to the situation when supply chain experts had to discover completely new solutions in order to maintain supply chains operating.

Even though in 2022 most of the restrictions were recalled and businesses adopted their operations to the new conditions, the risk of new global crises is significant. The most effective way to prepare for a new challenge is to review, analyze and evaluate experience gained previously. The author of this work aims to review risk mitigation practices described in the literature and in interviews with supply chain experts. The final target of this research is to build a list of the most effective practices which can be applied by the industry in order to rebuild supply chains to be more flexible and reliable.

1.1 Background and motivation

The global pandemic caused by Covid-19 decease became the world's most vital problem just in a matter of few months. Restrictions and limitations introduced by governments in order to withstand the spread of the disease affected and limited people's most common activities. Social contacts and freedom of movement are essential parts of modern, urban society and key factors of any supply chain. Unprecedented restrictions immediately caused a negative impact on the operations of supply chains worldwide. According to the survey made by (Institute for Supply Management, 2020), 97% of supply chain professionals and their organizations have noticed a negative impact on their business. Undoubtedly, such a major disturbance in

operations has led to significant financial losses and a prominent economic crisis. The World Bank estimated that the influence of supply chain disruptions is so significant that it would have decreased global GDP between 5.4% and 9.7% (World Bank , 2020). At the same time businesses around the world were not prepared for the such impactful and global event as the pandemic of Covid-19. In fact, only 49% of respondents said that their organizations have prepared an action plan for their business continuity and 57% identified critical products and suppliers (Prasad, 2020). This means that even effective and successful organizations in the pre-covid era have faced serious challenges in adapting their processes to the new reality.

Moreover, fundamental approaches to the financially effective supply chain such as Just-In-Time (JIT) and lean have bared weaknesses in existing processes causing more disruptions and uncertainties unable to promptly rebuild operations according to the new needs. The constant chase for „waste" reduction and cost savings has put many organizations in a vulnerable situation when only a minor disruption in one part of the supply chain led to major disruptions in a whole supply chain due to the low variability of suppliers and safety stocks (McDermott, Antony, & Douglas, 2021). Moreover, Covid-19 was not the only problem businesses had to cope. Political instability, energy crises, and enormous inflation revealed serious threats to supply chain practitioners. Companies should find a way to modify their current supply chain practices, so they would bring more value and resilience to their organizations, and so they could successfully tackle challenges in the nearest future. In the end, supply chains are not only about the effective management of company resources and generating revenues. Supply chains play a crucial role in society by fulfilling the needs of products all around the globe. By considering the facts described before the author decided to research this subject in order to find the best practices available which would be a foundation for a resilient and agile supply chain.

1.2 Research Objectives

History of humanity had faced global pandemics in the past. Historians have a sufficient amount of sources to assume the disastrous impact of a plague on medieval-age society. Only a hundred years ago Spanish flu had spread globally which resulted in more than 500 million infected people (Piret & Boivin, 2021). However, historical facts proved that the consequences of a global decrease always were adverse, belief in modern medicine and the deficit of new potentially dangerous deceases persuaded businesses not to consider global pandemics in their risk mitigation plans. Moreover, before the Covid-19 topic of business process resilience in terms of the pandemic had received insufficient

attention from researchers. Overconfidence in global stability made business operations fragile to unexpected risks. Based on that author of this work has decided to investigate the impact of Covid-19 on disruptions of global supply chains and collect solutions that could be practically implemented in order to reconfigure supply chains to be more resilient in order to successfully cope with new potential challenges. In support of this research author raises research questions that are highlighted below:

1. Which supply chain disruptions happened to global supply chains due to Covid-19?

2. What were the consequences of supply chain disruptions to the stakeholders?

3. What risks should be considered in the development of a risk mitigation plan?

4. Which practices can be applied to the global supply chains in order to be prepared for the new risks?

In addition, I would want to apply PESTEL analysis to highlight the effect of COVID-19 on each macroeconomic aspect in the global supply chain in this study. The PESTEL framework is used to examine the macroenvironmental elements that have an effect on a business or organization. The acronym PESTEL stands for Political, Economic, Social, Technological, Environmental, and Legal factors. PESTEL framework provides a comprehensive approach for examining the impact of the COVID-19 pandemic on the global supply chain. Understanding the Political, Economic, Social, Technological, Legal, and Environmental factors that have influenced the supply chain during this time is crucial for improving its resilience and efficiency. Outcomes of analysis can be presented graphically as an a figure below.

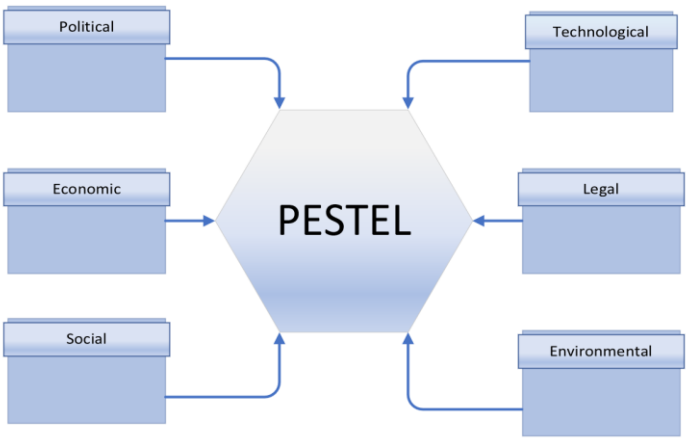

Figure 1. Visual representation of PESTEL analysis

1.3 Research methodology

The research methodology for this study involved gathering data from both primary and secondary sources. The secondary sources consisted of a thorough review of academic literature related to the impact of the Covid-19 pandemic on global supply chains. The PESTEL analysis was used to identify key drivers of change in the global business environment, and to assess their impact on supply chain operations.

In addition, semi-structured interviews were conducted with supply chain experts to gain deeper insights into the challenges and opportunities arising from the pandemic. These interviews were conducted using a set of pre-determined questions, while also allowing for the interviewee to expand on their answers (Silverman & Marvasti, 2008).

The data collected from both primary and secondary sources were analyzed using content analysis and thematic analysis. This allowed for the identification of recurring themes and patterns in the data, which were used to answer the research questions.

It is important to note that this study has certain limitations. The semi-structured interviews were conducted with a small sample size, which limits the generalizability of the findings. Additionally, the study was conducted during a specific period of time and may not reflect the long-term impact of the pandemic on global supply chains. Nonetheless, this study provides valuable insights into the impact of the pandemic on global supply chains and suggests several strategies for improving their resilience and agility.

2. Literature review

2.1 Global supply chain

A supply chain is a relatively old phenomenon. From Ancient times people had a demand for resources that were fulfilled by the basic supply chains. Through the development of civilization and technologies interaction between individuals, their needs, and supply routes became more and more complex. In fact, during the last few decades supply chains became so big and complex that the term global supply chain was introduced.

According to Kinra, Kotzab, Hsuan, & Larsen, (2015) in the modern world, not a single organization can stand alone as the needs of any organization cannot be fulfilled independently. Meeting the demands of global markets requires a partnership between different organizations in response to rapidly changing business environments and customer needs. In general, a supply chain is a process of resource distribution in order to achieve the strategic goals of an organization. As soon as, the goal of any business is to generate profit by providing a product or a service for a competitive price, they have to build partnership networks that bring additional value to their own processes. This strategic partnership allows companies to execute the benefits of different geographical areas regarding resources or production facilities without personal involvement in place (Drake, 2012). Then these partnership networks compete with networks built by other companies in the efficiency of operations in order to fulfill customers' demand for both services and products for a competitive price.

The variety and complexity of the supply chain networks are most frequently interconnected with the complexity of the final product. However, a typical global supply chain consists of suppliers, manufacturers, distributors, and retailers. According to Ivanov, (2019) they collaborate in order to transform raw materials into finished products and provide them to the customers. It can be said that their main objective is to manage supply in order to match demand. Moreover, this process can be described as the transformation of input into the output of higher value. Graphically it is presented in the figure below.

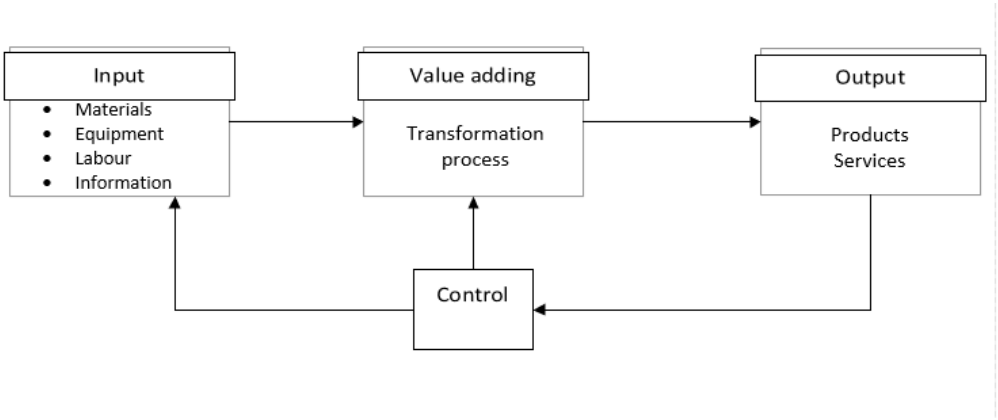

Figure 2. Block diagram represents transformation input into output

The figure illustrates that even though the transformation of input into output is the activity that adds value to the supply chain network, control is playing a vital role in the management of risks and uncertainties that might create disruptions to the core process of value-adding. Moreover, planning, control, and management of the network resources are the key activities that are required for the efficient transformation process.

Globalization of the markets, demand for customized products, and development of information-sharing technologies created competition globally between the networks which resulted in a higher standard of operations management efficiency. In order to cope with the new challenges companies adapted their organizational structure based on the functions they perform. A typical organization of enterprise working in the global supply chain would have departments responsible for a respective function in the supply chain. The naming of the department might vary from company to company, but their main goal would be to cover such areas as: marketing, research and development, warehousing, procurement, manufacturing, sales, and finance. Despite differences in the area of responsibility, all these functions have to be interconnected with a systematic approach to information sharing and managed simultaneously in order to make the supply chain effective.

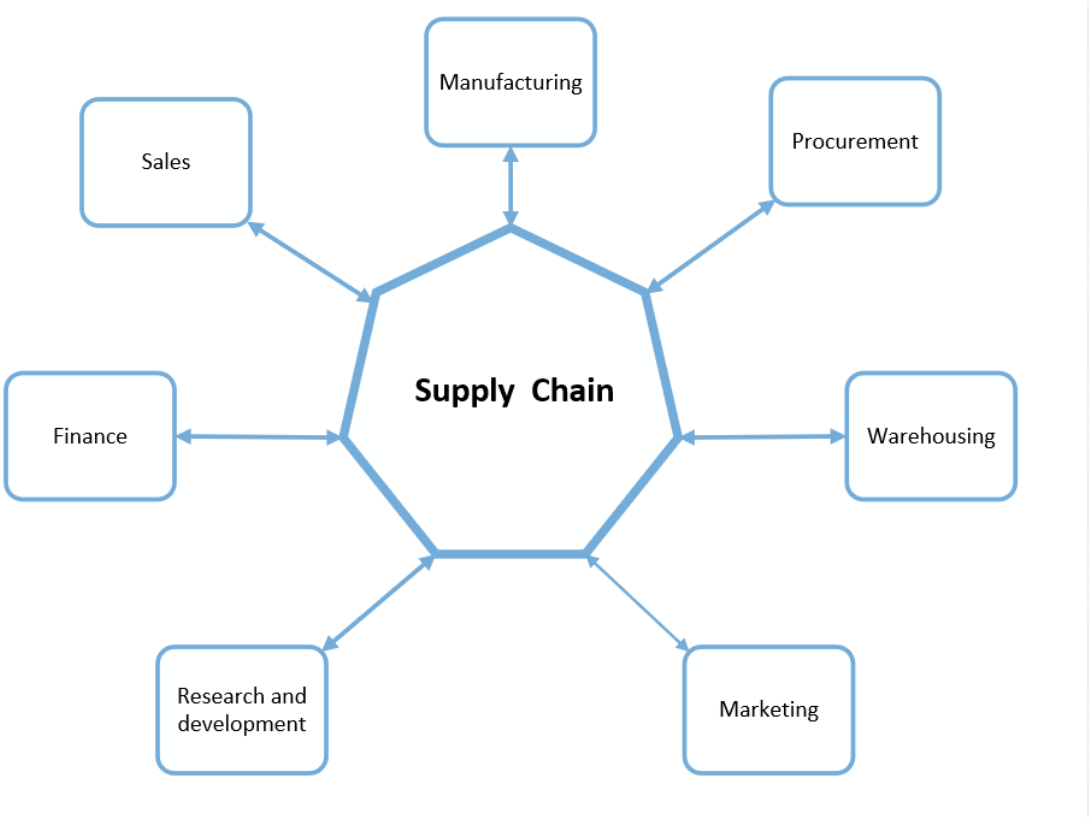

Figure 3. Parts of supply chain

Performance efficiency of supply chain can be measured by numerous metrics, but the three main pillars of Supply Chain are cost-quality-time. They are interconnected and right balancing of these parameters is the key factor of competitive supply chain. In other words, all operations in supply chain should be lowest cost, highest quality, and fast as possible.

According to Palagyi, (2004) understanding customers' needs is crucially important for a SC configuration and most of the customers prefer "better, cheaper, now" approach. Constant chase for continuous improvement brings innovation and development, but at the same time complexity to the supply chains. At the same time, Harland, Brenchley, & Walker, (2003) write that complexity of SC brings more risk. Risk in the supply chain creates a probability of failure to meet desired outcomes. Supply chain practitioners have a strong interest to mitigate risks fundamentally. Risk mitigation practices are a part of supply chain management (SCM) that is a wide and separate topic, but shortly it can be defined as the selection and implementation of a strategy that manages SC operations.

Complexity and differences in global supply chains cannot be fulfilled with one common strategy, therefore, the development and implementation of an efficient strategy is one

of the biggest challenges for supply chain managers. Even if the best practices of management are selected, they have no value without proper utilization (Christopher, Peck, & Towill, A taxonomy for selecting global supply chain strategies, 2006). Wrong decisions of supply chain managers lead to financial losses and possibly supply chain disruptions.

2.2 Supply chain disruptions

According to Bugert & Lasch, (2018) Supply chain disruption (SCD) is an unplanned event that causes undesired consequences to the planned material flow or business activities in the supply chain. Disruption can be triggered by a natural disaster or either an intentional or unintentional man-made event. Sheffi & Rice, (2005) write that supply chain disruption can be a high-probability and low-impact event that is considered in regular supply chain management planning or low probability high impact event that is most commonly out of the scope of regular operations planning. The consequences of high-impact events might be crucially destructive for either firms or individuals. For instance, the terrorist attack on 11 September 2001 resulted in an immediate stoppage of inbound and outbound flights all across the United States. Ford Motor Co. had to stop several production lines as they had experienced a shortage of supplies and it was reported that it caused a 13% reduction in production in the fourth quarter of 2001 compared to their initial production plan. Moreover, Hurricane Harvey in 2017 with estimated damage of 125 billion USD not only had a disastrous impact on the United States oil refining industry but at the same time caused a deficit of basic commodities for civilians.

At the same time, even major and unplanned supply chain disruptions should not be considered as the only outcome possible is a financial loss. In 2000 both Nokia and Ericsson suffered significantly from a fire at the Phillips microchip plant as it was their major source of supply. Nokia’s management reacted promptly changed the design of their chips architecture and using backup suppliers while Ericsson failed to handle this situation and stopped production lines. As a result, Ericsson suffered a 400 million USD loss in sales, while Nokia managed to overcome this crisis steadily and even profited by increasing their market share mostly because of Ericsson’s market share decrease. (Bugert & Lasch, 2018)

These examples demonstrate the possibility of a single disruption event creating an adverse impact on businesses and society and this is why SC practitioners and academics paid significant interest to investigating reasons why supply disruptions appear. Previously, it was defined that SCD happens rather because of uncontrollable

events such as natural disasters or human activity. This is the broad definition that requires clarification. Supply chain entities are firmly dependable. SCD happens when at least a single entity is not performing and providing the required output as it is expected. An unplanned event triggering supply chain disruption can be named a risk.

A modern, global supply chain consists of an enormous number of simultaneous and interdependent operations and all of them have a risk of failure. Risk mitigation practices have become an essential element for any supply chain management strategy. However, the source of risk is limitless it can be categorized. Shahbaz, Rasi, & Ahmad, (2019) proposed to categorize risks into seven types based on the source of the origin. These risks are supply-side risk, demand-side risk, process-side risk, collaboration-side risk, logistics-side risk, financial-side risk, and environmental side risk. The relationship between these categories is explained in the figure below.

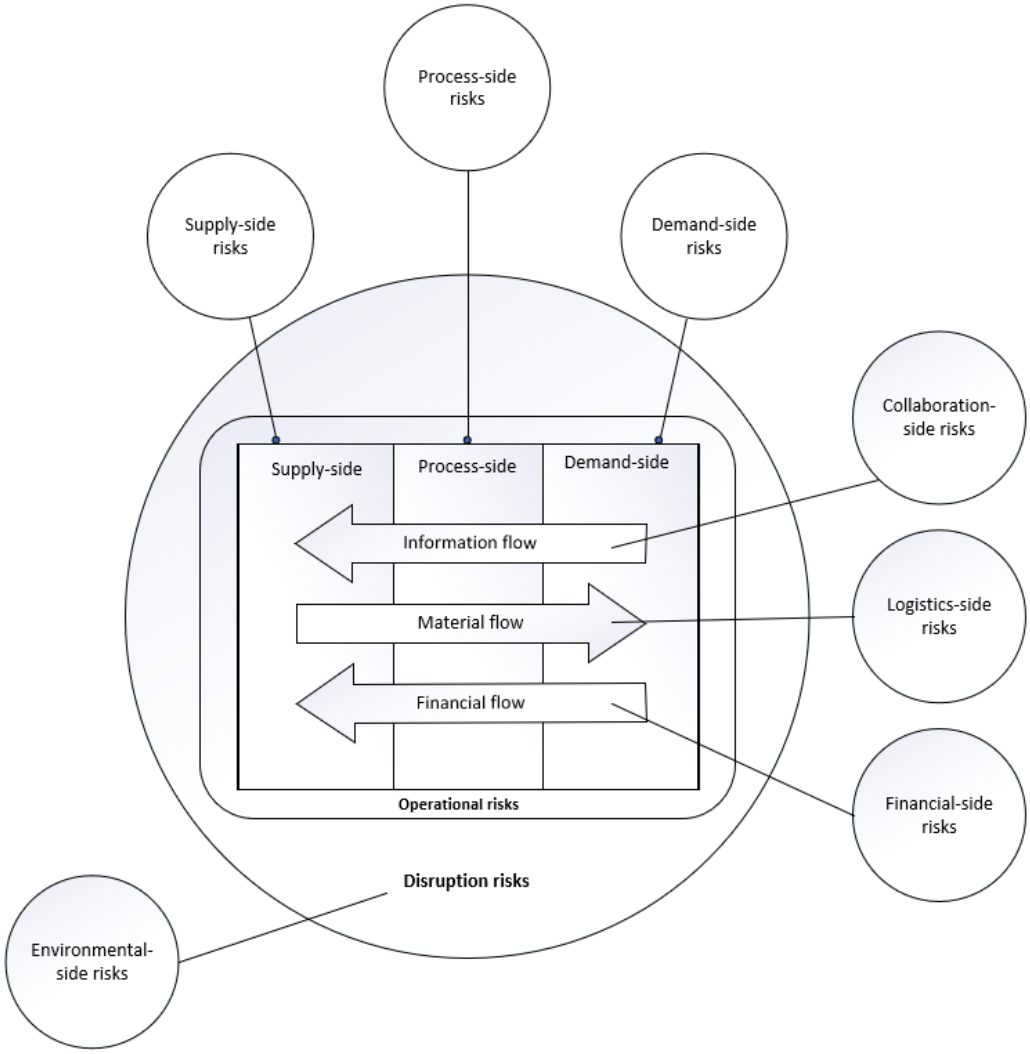

Figure 4. Relationship of supply chain risks

2.2.1 Supply-side risks

Supply-side risk is an event of uncertainty that has a possibility to negatively influence inbound of materials or sub-products for a firm in terms of quantity, quality or time. This means that upstream supplier output is failing to meet the scope. There might be numerous factors that result in poor supplier's performance. Upstream supplier might suffer from unavailability of the materials, general market conditions, logistics failures, and environmental factors that are out of the control from supplier's scope. Besides, failure of suppliers might be due to production capacity limitations, poor quality control, or equipment breakdowns. (Chen, Sohal, & Prajogo, 2012). The dependency on the effective inbound supply on a firm's performance is crucial. Companies are implementing lean, JIT, and other practices in their operations in order to gain financial benefits from cost reduction. This approach implies small buffer inventories and low variability of suppliers, so even a minor disruption of supply might lead to vital consequences on a whole supply chain (McDermott, Antony, & Douglas, 2021).

In 1997 Aisin Seiki Co. had a fire that destroyed their plant which produced brake valves for Toyota. Toyota had a small buffer inventory that lasted 4 hours of production only. After they had to stop production in their 20 plants in Japan for 5 days. Approximately, their loss in production during the shutdown was 70 000 cars. Moreover, experts assumed that it would take much more time to recover and only the effective management of Toyota allowed them to launch production in 5 days (Reitman, 1997). This example intelligibly represents the consequences of supply-side risk. A small part that costs only 5$ led to the plants' shutdowns and multimillions of financial losses.

Moreover, the risk of supply disruption might be caused by factors that are out of business control. Governments reacted to the spread of Covid-19 by applying additional restriction measures on their borders that resulted in longer delivery schedules on every level of supply chains. Besides, the military conflict between Russia and Ukraine negatively influenced the availability of wheat globally and interrupted many logistic routes between Europe and China.

Even though risks that are related to supply cannot be fully controlled and often they might be unpredictable, it is crucially important for any firm to build a sourcing strategy that would take this risk seriously into account and build a diversified portfolio of suppliers (Yu, Zeng, & Zhao, 2008).

2.2.2 Demand-side risks

Oppositely to supply, demand-side risks are referred to downstream of the supply chain. This risk is the uncertainty of outbound flows that has a possibility to fail fulfilment of

consumer demand. A variety of risks related to demand is plentiful. Wrong forecasting, demand variation, and market fluctuations are the most typical ones faced by companies regularly (Shahbaz, Rasi, & Ahmad, 2019). Moreover, serious demand fluctuations might be caused by seasonality, the introduction of new products to the market, and natural disasters (Jüttner, 2005). The spread of Covid-19 disease early in 2020 surged demand for face masks, antiseptics, and medical gloves drastically.

Balance in matching forecasts and demand is one of the most important factors for a firm's financial sustainability. Producing more goods than is required by demand might lead to negative financial consequences for a firm. In this case, a company might need to sell its products with a discount or keep high inventory costs. On the other side, producing less than needed in order to fulfil market demand leads to missed opportunities regarding revenues (Jian , Fang, Jin, & Rajapov, 2015). According to (Jajja, Chatha, & Farooq, 2018) demand variability risk creates incorrect and unreliable information flow that makes integration of the supply chain ineffective, it negatively affects the firm's supply chain functions, and might result in under or over-stocking in a whole network. Moreover, demand variation might lead to bullwhip or ripple effect. Events that are different by a nature but respectively harmful to a supply chain (Dolgui, Ivanov, & Rozhkov, 2020).

2.2.3 Process-side risks

Process-side risks are usually referred to as firm internal processes meaning that possibility to fail to achieve the targets set by the company is caused by the disturbance of the processes internally. It can be caused by equipment breakdown, personnel mistakes, or flaws in the manufacturing process. The complexity of modern business creates significant space for factors that might be a trigger for the disturbance of internal processes. Low impact and thus unnoticed drawbacks such as outdated technologies, inefficient labor distribution, and uncertainties of responsibilities might sum up during the time and lead to serious negative impacts. The negative influence of these risks can result not only in significant financial losses but also reputational damage (Shahbaz, Rasi, & Ahmad, 2019).

Moreover, nowadays companies are heavily integrated with different software solutions for most of their operations. The development of computer technologies supported efficient information sharing, processing, and control. At the same time, new threats have been created. Failure of the enterprise resource planning (ERP) system might paralyze the firm's operations completely until the software is fixed. Besides, the cyber threat might come externally from hacker attacks. For instance, The Saudi Aramco power station had been shut down due to a cyberattack by the cyber espionage group

called Dragonfly (Yeboah-Ofori, et al., 2021). This means that operational risks might come externally either, thus it is crucially important to constantly control and review processes, investigate vulnerabilities and eliminate them.

2.2.4 Collaboration-side risks

The complexity of modern products and the chase for cost reduction have led to horizontally integrated, complex, and geographically diverse supply chain networks. Businesses have to outsource and build partnerships across the globe in order to stay competitive (Shih, 2020). Collaboration between companies is aimed to be beneficial to all stakeholders. However, complexity and an increasing number of variabilities lead to an increase in uncertainties either. Moreover, there is always a chance that a member of a partnership would not cooperate the way it is expected. New challenges arise when a partnership is built within different cultures and personal interests are prioritized rather than cooperation. A lack of trust between partners might result in insufficient information sharing and poor communication making the whole concept of cooperation insolvent (Shahbaz, Rasi, & Ahmad, 2019).

2.2.5 Logistics-side risks

Traditionally logistics-side risks are addressed to uncertainties related to the transportation, warehousing, and handling of the cargo. This means that rather a cargo was damaged during transportation or cannot be delivered to the receiving site (Cavinato, 2004). Consequences of transportation disruptions lead to undelivered or late-delivered goods that cause failures in schedule plans downstream supply networks.

According to (Pokrovskaya, Kirpicheva, Lipatov, & Mustafin, 2019) transportation risk cannot be fully eliminated but it should be reduced by an acceptable level of residual risk. Risk reduction measures can be divided into two types: physical protection of the goods and economic protection such as insurance. Both measures are equally important to be applied as soon as there are numerous threats related to the logistics-side risks. Cargo possibly can be damaged during packing, loading, transportation, unloading, and receiving of the goods. Besides, the uncertainty of delivery can be caused by road accidents, transit delays, and wrong documentation.

Transportation disruption between tier-one supplier and warehouse or distribution center is considered to be one of the greatest threats to the traditional supply chain performance. Thus, the development of effective measures for tackling potential threats should be the key priority for supply chain decision-makers (Zhen , Li, Cai, & Shi, 2016).

2.2.6 Financial-side risks

Financial risk in terms of business is a broad term that usually is explained as uncertainty in a deviation between expected financial outcome and actual. In SCM financial-side risks are related to diverse risks associated with transactions and financial flows. Under the term financial risk, various factors affecting the economic sustainability of the company are meant such as inflation, interest rates, default risk, market risk, price fluctuations, currency exchange rates, and changes in accounting and tax laws (Ghadge, Jena, Kamble, Misra, & Tiwari, 2021).

Lately, financial risks are a growing concern to businesses as soon as the global economy is suffering from the crisis. According to (IMF, 2022) Covid-19 pandemic and Russia's invasion of Ukraine negatively influenced the global economy. Global inflation raised to 8.8%, the economic growth forecast decreased from 6.0% to 3.2%, and interest rates are growing. European firms are experiencing the negative effect of the euro currency decrease when purchasing outside European Union.

Sustainability in finance is the key factor of success for any business. Without proper finance management, any company would be bankrupt. In supply chains companies have a strong interdependence, thus negative consequences of financial risks might affect not the single firm but the whole supply chain.

2.2.7 Environmental-side risks

Environmental-side risks are the external threats that may cause negative impact to the focal firm, supply chain or the whole market (Christopher & Peck, 2004). Some research papers indicate environmental risks exclusively as ecological issues. However, in this work this term would have broader meaning proposed by (Shahbaz, Rasi, & Ahmad, 2019) that includes such factors as political instability, social uncertainties, diseases or epidemics, and natural disasters. These events are very different by its nature but they can be united by the fact that they have low probability and high impact and also they are arising externally from the business scope.

Growing awareness about climate change has persuaded developed countries' governments to apply strict ecological standards regarding CO_2 and other sources of pollution. Adaptation to the new standards has been a major issue for many supply chains, but companies that already had sustainability measures implemented in their processes had received a significant advantage (Mukhtar, Romli, Abdullateef, & Al-bashiri, 2019).

Political decisions are another source of uncertainty that is hard to predict but could be crucially harmful to the business. The trade war between USA and China started in 2018 has influenced severely not only economic relations between the United States and China by raising export tariffs between these countries but at the same time made a significant impact on global markets as well (Schmieg, 2019). For instance, Huawei had a significant market share in the global smartphone market but after they were banned from using Google technologies their market share dropped drastically from 20% in 2020 Q2 to 4% in 2021 Q1 (Counterpoint, 2022).

The least predictable, controllable, and most harmful threats are related to natural disasters or diseases. These types of events not only create disruptions in business operations but also affect negatively human lives. For instance, the earthquake and following tsunami in 2011 made tremendous damage to Japan. The number of confirmed deaths has reached 19 747 lives, more than 100 000 buildings were destroyed and a nuclear plant in Fukushima was heavily damaged which resulted in the leakage of radioactive chemicals. Direct financial damage was estimated to be $199 billion dollars (Oskin, 2022). At the same time, humanity underestimated the risk of spreading global diseases until recent times. The belief in modern medicine and the lack of global pandemics in the last hundred years made people careless until Covid-19 spread around the globe.

2.3 Supply chain disruption risks summary.

As was stated earlier modern supply chains are complex networks interdependent between the nodes. The variety of operations and processes within the scope of the whole supply chain is enormous, thus numerous amounts of risks arise proportionally. A resilient supply chain should be able to handle any possible risk in order to stay operatable or at least to be able to react with flexibility in order to recover timely and reduce possible consequences of negative impact. Table 1 represents the summary of supply chain disruptions risk in their categorization based on the information reviewed above.

Risk category	Explanation	Risks
Supply-Side Risks	Upstream along the supply chain	unavailability of materials, market fluctuations, logistics failures, machines and equipment breakdowns, political restrictions
Demand-Side Risks	Downstream along the supply chain	wrong forecasting, demand variations, market

		fluctuations, unreliable information flow
Process-Side Risks	Inside the focal firm	Failures and inefficiency in manufacturing, material shortage, outdated technologies, labor strike, fires, explosions, industrial accidents, IT infrastructures failures due to viruses and other malware
Environmental-side Risks	Externally from the supply chain	diseases, epidemics, pandemics, fires, natural disasters, military conflicts, political restrictions, civil unrest
Logistics-side Risks	Transportation-related issues	damage of cargo during packing, loading, transportation, unloading, receiving, Road accidents, delays, labor disputes
Financial-side Risks	Financial flows issues	interest rate fluctuations, changes in currency exchange rate, changes in accounting and tax laws
Collaboration-side Risks	Cooperation and information sharing related issues	poor communication, unequal partnership, lack of trust, cultural differences

Table 1. Supply chain risks summary

2.4 Global Supply chain disruptions due to COVID-19

The pandemic caused by the coronavirus COVID-19 has significantly hampered supply chains on both the global and local scales. The virus, which was discovered for the first time in Wuhan, China, in late 2019, has had an effect on the economic as well as the social lives of virtually every nation. By the end of 2022 according to World Health Organization, (2022) more than 640 million cases of infection were confirmed which caused more than 6.5 million deaths around the world. The global pandemic caused by the COVID-19 virus has caused widespread disruption. According to the Gates Foundation's research (2020), the pandemic has regressed human growth by twenty years in all aspects, including health and the economy. This harm has an effect on global poverty as well as relationships, education, the environment, and a variety of other domains. The economy of most countries has seen considerable contraction, and the global SC has slowed considerably, as shown by the huge decline in shipping activity, for instance.

Numerous nations have seen the closing of retail and food chain outlets, as well as a significant decline in industrial activity.
Foxconn, Apple's assembler, is operating below capacity, as Apple's suppliers in Malaysia, South Korea, and Europe have been impacted by government lockdowns and a shortage of components and supplies from their sub-suppliers (Ivanov & Das, 2020).

With the global spread of COVID-19, supply chain disruptions have become a hot topic of conversation. Handfield, Graham, and Burns (2020) discovered that COVID-19 reactions caused an unprecedented bullwhip effect in the industrial sector. Ivanov and Dolgui (2020) explored two important viewpoints in SCD, namely the ripple effect and resilience, and established a methodology for minimizing and recovering from disruption-related risks.Their findings demonstrated that SCs must be stable, robust, and resilient to preserve their fundamental properties, guarantee execution, and be adaptable in the face of future disruptions.

With the emergence of COVID-19, it is imperative to place safety and human welfare above everything else. This has occurred at nearly every point of the supply chain. Upstream supply chain channels (such as farms and factories) have been required to adhere to safety rules, resulting in decreased output and slowed transit of commodities. In the intermediate and downstream channels of the supply chain, companies that carry and distribute commodities have set safety regulations, hence altering the speed and efficiency of SCs. By enforcing social distance, providing sanitisers, rescheduling restocking, and allowing contactless payments, retail outlets have moved their attention from shop image and customer delight to safety goals (Mollenkopf, Ozanne, & Stolze, 2021).

Moreover, COVID-19 pandemic may cause additional disruptions in some nations, such as rice value chains in West Africa, which increases reliance on imports as a result of global lockdowns (Soullier, Arouna, Mendez del Villar, & Demont, 2020).This was also addressed by Inegbedion (2021), who stated that COVID-19 lockdowns have greatly decreased the availability of farm laborers and the transit capability to convey agricultural products. Xu, Elomri, Kerbache, & El Omri (2020) noted that the quarantine limits or infection of both white-collar and blue-collar employees have led in a labor shortage and disruption of the global supply chain. Other researchers who examined COVID-19 in the perspective of SCs identified that lockdowns and social distancing initiatives have adversely affected the functions of national and international SCs during the pandemic, with preventative measures creating a great deal of social inequality, particularly in developing nations (Arndt, et al., 2020).

The COVID-19 crisis revealed severe Supply chain deficiencies, particularly in the pharmaceutical and medical supply industries, such as a lack of personal protective equipment for healthcare workers and ventilators in hospitals, prompting governments to prioritize domestic production of medical supplies. The COVID-19 epidemic has drastically altered the global demand and supply of goods and services. The vulnerability and fragility of global supply chains and service networks have been shown. Nonetheless, some businesses were able to adapt to the pandemic environment and increase their agility and productivity by interacting with end-consumers and keeping their liquidity, e.g., by embracing e-commerce and shifting from Business to Business (B2B) to Business to Consumer (B2C) (Fonseca & Azevedo, 2020).

During the period from March 2020 to March 2021, Cherrafi, Chiarini, Belhadi, El Baz, & Benabdellah (2022) estimated that economic losses in the car and aviation supply chains owing to COVID-19 likely surpassed 520 and 375 billion USD, respectively. This devastation to the economy was mostly the result of so-called "supply" and "demand" shocks.The supply-side shock was caused by the closure of non-essential industries and the inability of workers to do tasks at home (Sarkis, 2020) Individuals's early response to the epidemic, such as panic purchasing and decreased demand for items or services whose usage was likely to put people at risk of infection, such as transportation and tourism, resulted in demand side shock. Impact severe of the COVID-19 epidemic on the employment security of thousands of people worldwide (Cherrafi, Chiarini, Belhadi, El Baz, & Benabdellah, 2022) Indeed, the economic impact of the pandemic has driven (or offered an excuse for) businesses to cut their workforce and social contributions, as well as terminate continuing socially-related initiatives. In addition, interruptions in important supply chains, such as those in the agriculture, food, and pharmaceutical industries, endanger the food and health security of millions of people worldwide. (Hoek, 2020)

It was reported that COVID-19 has significantly disrupted the formerly smooth operations of SCs, hence reducing their capacity to satisfy demand. COVID-19 and other SCDs have introduced new obstacles that will influence the future design of SC flows (Beatriz, et al., 2020). Numerous organizations have reevaluated their SC structures as a result of COVID-19's protracted impact. The sproblems with global commodities movement owing to COVID-19 have inspired initiatives to restrict global flows and resort to local supplies. After COVID-19, regionalization of industrial SCs might become the norm. However, utilizing local resources is not always simple and may be impossible in a short amount of time. Due to cost, material resources, and technology, the majority of manufacturing enterprises import materials and components from other nations. Replacing imports with local supply sources needs serious development and

development of local enterprises that can possibly become long-term suppliers (Pujawan & Bah, 2022).

The observed consequences of the pandemic on the ecosystem are rather debatable. Several studies have emphasized the favorable short-term effects of a slowdown in industrial production, including the decrease of hazardous gas emissions and the repair of ecological systems. Other studies, however, have highlighted several medium- and long-term concerns, such as the crisis rebound effect, in which society's recovery actions would concentrate solely on economic and social sustainability, producing infectious and plastic waste accumulation issues (Cherrafi, Chiarini, Belhadi, El Baz, & Benabdellah, 2022).

The COVID-19 epidemic has compelled SC players to consider the optimal structures and operations for SC. As the worldwide transportation of products has been substantially disrupted, some individuals have proposed that SC players purchase supplies locally, hence shortening SC pathways. Clearly, the optimal approach would differ for each SC. Nonetheless, any design would now prioritize robustness and adaptability over the long term, such that any SC could endure both normal and disruptive situations. Supply chain architecture, processes, information, and financial systems should be lucrative during prosperous times, resilient during turbulent times, and hence long-term sustainable (Pujawan & Bah, 2022).

In order to summarize, the coronavirus COVID-19 pandemic has caused widespread disruption to supply chains on a global scale. It has had a negative impact on human growth in all aspects, including health and the economy, and has caused contraction in the economies of many countries. The pandemic has also led to a decrease in industrial activity and a slowdown in the global supply chain, with companies implementing safety regulations to prioritize human welfare. The COVID-19 crisis has highlighted deficiencies in the pharmaceutical and medical supply industries, leading to a focus on domestic production of these items. Researchers have studied the effects of COVID-19 on supply chain disruptions, including the bullwhip effect and the importance of stability, robustness, and resilience. The pandemic has also had a negative impact on agriculture and labor availability in supply chains.

2.5 PESTEL analysis of global supply chain during COVID-19

PESTEL analysis is a framework used to analyze and evaluate the impact of various political, economic, social, technological, environmental, and legal factors on a business or organization. It is commonly used in strategic planning and business analysis to

identify potential risks and opportunities, as well as to help organizations make informed decisions about the future.

The PESTEL acronym stands for Political, Economic, Social, Technological, Environmental, and Legal factors. The political factors consider the impact of government policies and regulations, as well as changes in political stability and global events. Economic factors include the overall economic climate, changes in consumer behavior, and fluctuations in interest rates and exchange rates. Social factors analyze the impact of population demographics, cultural norms, and changes in consumer preferences. Technological factors consider the impact of advancements in technology and the adoption of new technologies by consumers. Environmental factors analyze the impact of environmental regulations and sustainability initiatives, as well as changes in resource availability. Finally, legal factors consider the impact of legal regulations, such as changes in labor laws and patent laws (Johnson , Whittington , & Scholes , 2017).

PESTEL analysis is widely recognized as an effective tool for organizations to use in their strategic planning and decision-making processes. It is a comprehensive method for examining the impact of external factors on an organization and helps organizations to anticipate and respond to change (Issa, Chang, & Issa, 2010).

In this research work, the PESTEL framework will be utilized to analyze the effect of COVID-19 on the global supply chain's various components based on the data reviewed previously in this work.

The COVID-19 pandemic has had a significant influence on the worldwide supply chain. Political factors have played a crucial role in shaping the global supply chain during the COVID-19 pandemic. The widespread border closures and travel restrictions have made cross-border trade and transportation more difficult, leading to supply chain disruptions. Governments have also implemented policies to prioritize their own national supply chains, leading to changes in trade agreements and tariffs.

Economic factors have also had a significant impact on the global supply chain during the pandemic. The slowdown in global economic activity has resulted in reduced demand and supply chain disruptions. Additionally, the shift towards remote work and e-commerce has increased demand for certain goods while reducing demand for others.

Moreover, social factors have played a vital impact in shaping the global supply chain during the COVID-19 pandemic. The pandemic has changed consumer behavior and preferences, leading to changes in demand patterns. Furthermore, the pandemic has

raised awareness of supply chain resilience and the need for more local production capabilities.

Technological factors have played a crucial role in the global supply chain during the COVID-19 pandemic. The pandemic has accelerated the adoption of digital technologies such as automation, data analytics, and remote monitoring, which have improved supply chain efficiency and resilience. Additionally, the increasing use of e-commerce has changed the way goods are purchased and delivered.

Legal factors have also had a significant impact on the global supply chain during the COVID-19 pandemic. Governments have implemented various measures to control the spread of the virus, including mandatory quarantine measures and restrictions on gatherings, which have affected the operations of many businesses. Furthermore, the pandemic has led to changes in labor laws and regulations, as well as increased pressure for companies to prioritize worker safety.

The global supply chain has also been influenced by environmental factors during the COVID-19 pandemic. The pandemic has led to changes in production processes, with an increased focus on sustainability and reducing waste. Furthermore, the shift towards local production and reduced cross-border transportation has reduced greenhouse gas emissions.

In conclusion, the COVID-19 pandemic has had a profound impact on the global supply chain, affecting Political, Economic, Social, Technological, Legal, and Environmental factors. These changes have influenced the way goods are traded, transported, and delivered, leading to significant disruptions and shifts in the global supply chain. In order to offer a clearer insight, the figure below provides a visual depiction of PESTEL analysis.

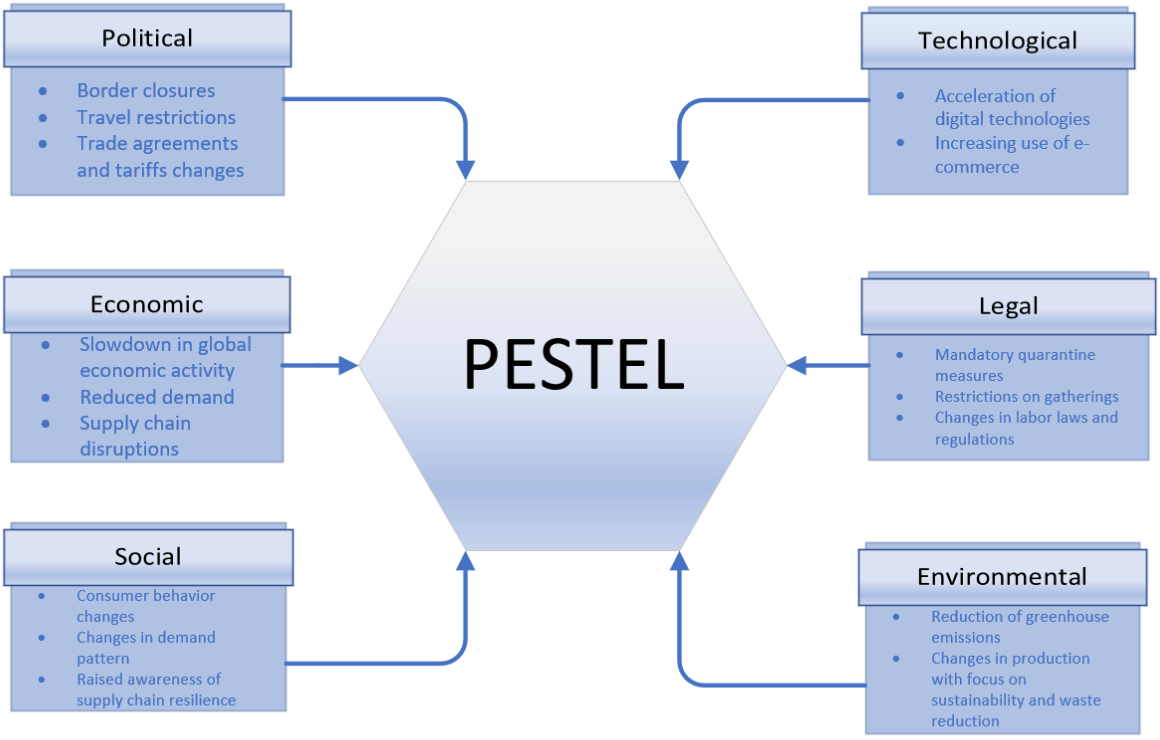

Figure 5. PESTEL of supply chain risks during COVID-19

3 Research design and methodology

This section of the study will delineate the chosen research methodology and the procedures employed in conducting the research. The first subsection will explicate the selected research design adopted in addressing the research inquiries of the present study. Subsequently, it will provide an overview of the data collection techniques employed (rationale behind the choice of data collection method, data collection process, and measures taken by the researcher to warrant the validity of the findings).

3.1 Case Description and Research Setting

This section will conduct an analysis of the distinctive characteristics of supply chain disruptions caused by the COVID-19 pandemic in comparison to other forms of disruptions. This analysis will serve as a background study on the topic and will provide a justification for the selected research methods utilized in the execution of this research.

3.1.1 Difference between typical SCD's and SCD's due to COVID-19

Supply chain disruptions are a common occurrence for businesses, and understanding their impact on business operations is crucial for companies to mitigate the risk of such disruptions. The COVID-19 pandemic has introduced a new level of supply chain disruption, with global lockdowns, travel restrictions, and increased demand for certain products leading to unprecedented challenges for businesses.

Typical supply chain disruptions, such as natural disasters or transportation issues, can be addressed through established risk management protocols. However, COVID-19-related disruptions have highlighted the limitations of these protocols and the need for more comprehensive risk management strategies (Gupta, Rathore, & Biswas, 2022).This is because COVID-19 disruptions affect multiple aspects of the supply chain, including sourcing, manufacturing, transportation, and logistics (Mahajan & Shekhar, 2021).

Furthermore, typical disruptions are usually localized and short-lived, while COVID-19 has had a global impact and is likely to have long-lasting effects on supply chain management (Xu, Elomri, Kerbache, & Omri, 2020). For example, the pandemic has led to a shift in consumer behavior, with more people shopping online and expecting faster delivery times (Ning, Li, Xu, & Yang, 2022). This has put pressure on businesses to adapt their supply chain strategies to meet changing customer demands.

To address these challenges, companies need to adopt more agile and flexible supply chain strategies (Sarkis, Cohen, Dewick, & Schröder, 2020). This includes establishing alternative sourcing and manufacturing options, increasing inventory levels, and investing in digital technologies to improve supply chain visibility and resilience Additionally, collaboration between supply chain partners is crucial to enable a coordinated response to disruptions (Ivanov & Dolgui, 2020).

In conclusion, the COVID-19 pandemic has presented unprecedented challenges for supply chain management. While typical supply chain disruptions can be addressed through established risk management protocols, COVID-19 disruptions have highlighted the need for more comprehensive risk management strategies. Companies need to adopt more agile and flexible supply chain strategies, including investing in digital technologies and collaborating with supply chain partners to ensure resilience and adaptability. In order to graphically finalize findings of this chapter following Table was created.

Characteristic	Typical supply chain disruptions	COVID-19 supply chain disruptions
Trigger	Localized events or natural disasters such as earthquakes, tsunamis, or hurricanes.	Global pandemic leading to widespread shutdowns and quarantines.
Duration	Short-term disruptions lasting from weeks to months.	Long-term disruptions spanning several months to a year or more.
Scale	Limited to specific geographic areas or industries.	Affects global supply chains across all industries.
Severity	May cause minor disruptions or lead to significant supply chain bottlenecks.	Causes significant and widespread supply chain disruptions affecting both demand and supply.
Supply chain visibility	Supply chain disruptions are often predictable and can be monitored using real-time tracking and analytics.	Disruptions were largely unpredictable and caught many companies off guard.

Impact on consumer behavior	Consumers are typically not directly affected and can continue to purchase products from unaffected regions.	Consumers may panic-buy or hoard essential products leading to stockouts and supply chain disruptions.
Role of technology	Technology can help companies respond to disruptions through real-time tracking, automation, and predictive analytics.	COVID-19 has highlighted the need for digitalization and the use of emerging technologies such as blockchain and AI to improve supply chain resilience.
Mitigation strategies	Strategies include risk management, inventory optimization, and diversification of suppliers and transportation modes.	Companies have had to implement new strategies such as reshoring, nearshoring, and increased collaboration with suppliers and customers to mitigate the impact of COVID-19.

Table 2. Comparison of typical and COVID-19 diruption characteristics

3.2 Data collection method

When conducting research, choosing the appropriate data collection method is crucial to obtaining valid and reliable results. Two common data collection methods used in research are quantitative and qualitative. Quantitative data collection methods, such as surveys and experiments, involve collecting numerical data that can be analyzed statistically (Creswell , 2013). Qualitative data collection methods, such as interviews and focus groups, involve collecting non-numerical data that can be analyzed thematically (Creswell , 2013).

For this research, the semi-structured interview method was chosen as the data collection method. Semi-structured interviews offer the benefits of both quantitative and qualitative data collection methods, as they allow for open-ended responses while still following a structured approach (Kvale & Brinkmann, 2009). This method provides the researcher with a predetermined set of questions to ask, while also allowing for flexibility to explore topics in greater depth (Kvale & Brinkmann, 2009).

The semi-structured interview method was chosen as it allowed for the collection of rich and detailed data on the experiences of supply chain experts during the COVID-19 pandemic. This method enabled the researcher to gain insights into the challenges faced by supply chain experts during this period and the strategies employed to overcome them.

To ensure the validity and reliability of the results obtained through the semi-structured interview method, several steps were taken. First, the interview questions were developed based on a thorough review of the literature on supply chain disruptions during the COVID-19 pandemic. Second, the interviewees were selected based on their expertise in the field of supply chain management and their experiences during the pandemic. Finally, the data collected through the interviews were analyzed thematically, ensuring that the themes identified were grounded in the data and reflective of the experiences of the participants (Braun & Clarke, 2006).

Overall, the semi-structured interview method was chosen as the most appropriate data collection method for this research. It allowed for the collection of rich and detailed data on the experiences of supply chain experts during the COVID-19 pandemic, while also ensuring the validity and reliability of the results obtained.

3.2.1 Semi structured interview

The aim of this research is to investigate the resilience of the global supply chain industry in the face of disruptions, with a specific focus on the COVID-19 pandemic. The goal is to provide proactive strategies that supply chain managers can implement to minimize future risks and disruptions. In order to gain insights into how supply chain experts deal with these issues, individual semi-structured in-depth interviews and questionnaires are being used as the primary methods of data collection.

This approach allows the experts to freely express their subjective views on how they implement supply chain risk management strategies and the resulting outcomes. The interviews are conducted in a conversational manner, with no specific order of questions being used, but an interview guide is employed to ensure that all relevant topics are covered. This is necessary because such information cannot be obtained through mere observation but requires input from experts in the field.

3.2.2 Respondents selection

In order to collect data, the researcher required sources of information, which were obtained through interviews with selected respondents. The researcher utilized a

purposive sampling technique, which is a qualitative research approach that targets individuals who possess rich and relevant information related to the research topic (Patton, 2002). The chosen respondents were selected based on the researcher's judgement, with preference given to those who are knowledgeable and experienced in the research topic.

To ensure credibility of the respondents, the researcher employed two techniques in the purposive sampling design: expert sampling and criterion sampling. Expert sampling involved selecting respondents who have expertise and experience in the topic (Patton, 2002), while criterion sampling involved using pre-established criteria to select respondents who held high-level positions in supply chain management for at least five years.

Following the sampling process, the researcher was able to select a total of five respondents for the study.

3.2.3 Interview process

Due to the geographical distance between the respondents and the interviewer, online interviews were conducted. All respondents were professionals with a vested interest in the topic, and as such, their responses were pragmatic and conversational, with each interview taking approximately 40 minutes. All interviews were given under condition that interviewer’s name and company is not revealed, so in order to provide more clarity about background of these professionals Table 3 was created.

	Interviewee A	Interviewee B	Interviewee C	Interviewee D	Interviewee E
Industry	Electrical equipment	Automation technology	Pulp and Paper	Electrical equipment	Transportation and logistics
Location	Nordic region	Nordic region	Nordic region	Baltics	Nordic region
Enterprise size	Large	Large	Large	Medium	Medium
Professional experience	More than 30 years	More than 15 years	5 years	2 years	More than 15 years

Table 3. Interviewees background

During the interviews, all topics in the interview guide were covered. In situations where the interviewer was dissatisfied with the response due to its shallowness or failure to address the exact area of interest, follow-up questions were asked to obtain

more specific or in-depth information. The interviews were conducted in English and were recorded with the consent of the interviewees to ensure that no critical information was overlooked and that the interviewees remained focused on the task at hand.

An interview guide was utilized to ensure that all important questions within the research question were addressed. To avoid short and shallow answers, why-questions were eliminated, while descriptive questions were used instead.

3.3 Research results

In this section, the results of the interviews will be discussed. Every interview would be discussed separetely with an emphasis on responding to research questions. At the end, of every section table would be created connecting interview results with research objectives.

3.3.1 Interview A

The purpose of this study was to understand the impact of COVID-19 on global supply chains and to identify the best practices for mitigating the risks associated with supply chain disruptions. The interview conducted with the supply chain expert shed light on several important issues related to the research questions.

The interviewee identified various types of supply chain disruptions that occurred due to the COVID-19 pandemic. These disruptions included transportation delays, labor shortages, and inventory shortages. The consequences of these disruptions were also discussed, such as increased costs, longer lead times, and reduced customer satisfaction. The expert highlighted the importance of being proactive in identifying and addressing these disruptions to minimize their impact on the supply chain.

Regarding risk mitigation, the interviewee emphasized the need to consider various risks such as financial, operational, and reputational risks, and to develop a risk management plan accordingly. They suggested that a risk management plan should be based on a thorough understanding of the supply chain network, including suppliers and customers, and should be regularly reviewed and updated.

Finally, the interviewee recommended several best practices for preparing the global supply chains for future disruptions. These practices included diversifying the supplier base, building stronger relationships with suppliers, adopting new technologies such as

digital platforms and automation, and improving communication and collaboration across the supply chain network.

Overall, the interview provided valuable insights into the challenges and opportunities associated with supply chain disruptions caused by the COVID-19 pandemic. The findings of this study can inform the development of effective risk management strategies for global supply chains, thereby enhancing their resilience in the face of future disruptions.

Research Question	Key Findings
1. Which supply chain disruptions happened to global supply chains due to Covid-19?	• Shutdown of factories and transportation networks • Shortage of raw materials and products • Changes in consumer demand and behavior • Reduced workforce availability and productivity • Border closures and trade restrictions • Financial and economic impacts
2. What were the consequences of supply chain disruptions to the stakeholders?	• Reduced revenue and profits • Decreased customer satisfaction and loyalty • Increased costs and delays • Damaged reputation and brand image • Supply chain disruption cascading effects • Increased reliance on single sourcing
3. What risks should be considered in the development of a risk mitigation plan	• Supply chain complexity and interdependence

	• Uncertainty and volatility • Lack of visibility and transparency • Lack of collaboration and coordination • Overreliance on technology • Political and regulatory risks
4. Which practices can be applied to the global supply chains in order to be prepared for the new risks?	• Diversification of suppliers and geographic locations • Strengthening relationships with suppliers and customers • Improving supply chain visibility and transparency • Enhancing collaboration and communication among supply chain partners • Developing contingency plans and risk mitigation strategies • Increasing investments in technology and digitalization

Table 4. Summary of interview 1 results

3.3.2 Interview B

The aim of this interview was to explore the impact of the COVID-19 pandemic on global supply chains and identify potential strategies to mitigate the effects of future disruptions. Semi-structured interview was conducted with a supply chain expert, and the data was analyzed using thematic analysis. The findings revealed a number of key insights into the disruptions caused by the pandemic, the consequences of those disruptions, and potential strategies to mitigate future risks.

The supply chain expert noted that the pandemic led to several major disruptions in global supply chains, including factory closures, transportation restrictions, and increased demand for certain products. These disruptions had significant consequences for various stakeholders, including suppliers, manufacturers, retailers, and customers. For instance, many suppliers faced a shortage of raw materials, which

in turn led to production delays and increased costs for manufacturers. Retailers, on the other hand, experienced stock shortages and delays in the delivery of goods to customers.

To address these challenges, the supply chain expert recommended several strategies to mitigate future risks. Firstly, companies should adopt a more diversified sourcing strategy to reduce reliance on a single source of supply. Secondly, companies should invest in technology and automation to increase supply chain visibility and reduce lead times. Thirdly, companies should implement risk management plans that are flexible and adaptable to changing circumstances.

The study also revealed that the pandemic highlighted the importance of collaboration and communication between supply chain stakeholders. The expert noted that successful collaboration requires the establishment of strong relationships between stakeholders, as well as the sharing of information and resources. Finally, the expert emphasized the need for supply chain managers to be proactive and adaptive in their approach to risk management.

In conclusion, this study provides important insights into the impact of the COVID-19 pandemic on global supply chains and identifies potential strategies to mitigate future risks. The findings emphasize the importance of collaboration, diversification, and technology in building more resilient supply chains. Future research could build on these insights by exploring the effectiveness of specific risk mitigation strategies in practice.

Research Questions	Key Findings
Which supply chain disruptions happened to global supply chains due to Covid-19?	• International transportation disruptions, including container shortages and reduced air freight capacity • Domestic transportation disruptions, including driver shortages and restrictions on movement • Manufacturing shutdowns and labor shortages • Increased demand for certain products and decreased demand for others • Disruptions in raw materials and components supply

What were the consequences of supply chain disruptions to the stakeholders?	• Increased costs due to higher transportation costs, labor costs, and raw materials costs • Delayed shipments and reduced product availability • Decreased revenue and profits for companies • Increased demand for certain job roles, such as supply chain managers and logistics professionals.
What risks should be considered in the development of a risk mitigation plan?	• Transportation risks, including disruptions and delays in international and domestic transportation • Labor risks, including labor shortages and shutdowns at manufacturing facilitie • Demand risks, including shifts in demand for certain products and decreased demand for others • Raw materials and component risks, including shortages and disruptions in supply
Which practices can be applied to the global supply chains in order to be prepared for the new risks?	• Diversification of suppliers and transportation routes • Development of contingency plans for labor and transportation disruptions • Real-time monitoring of supply chain activities • Adoption of digital technologies to improve supply chain visibility and flexibility

Table 5. Summary of interview 2 results

3.3.3 Interview C

The interviewee identified several key issues related to supply chain disruptions caused by COVID-19. One of the main issues was the lack of transparency in the supply chain, which led to difficulties in tracking shipments and understanding the impact of disruptions. The interviewee noted that this lack of transparency was particularly challenging for global supply chains, where there are multiple actors involved in the production and distribution of goods.

Another issue that the interviewee highlighted was the lack of preparedness for the scale and scope of the disruption caused by COVID-19. The interviewee noted that many companies had not adequately planned for the potential impact of a global pandemic, and as a result, were caught off guard when disruptions occurred. This lack of preparedness led to significant delays and disruptions in the supply chain, which had a ripple effect on downstream operations and customers.

The interviewee also noted that there were significant risks associated with supply chain disruptions, including financial risks, reputational risks, and operational risks. The financial risks included the cost of delays and disruptions, as well as the potential loss of revenue from cancelled orders. The reputational risks were associated with how companies responded to the disruptions and whether they were seen as reliable and trustworthy partners. The operational risks were related to the ability of companies to continue to operate and maintain their supply chains in the face of disruption.

In response to these challenges, the interviewee suggested that companies need to focus on building more resilient and agile supply chains. This includes investing in technology and data analytics to improve transparency and visibility throughout the supply chain, as well as diversifying supply chain sources to reduce dependence on a single region or supplier. Additionally, companies need to develop more robust risk management strategies that can quickly adapt to changing circumstances and ensure continuity of operations in the face of disruption.

Overall, the interviewee's insights highlight the need for companies to rethink their supply chain strategies in the face of unexpected disruptions. By investing in technology, diversifying sources, and developing robust risk management strategies, companies can better prepare for future disruptions and ensure the continuity of their operations.

Research Questions	Key Findings
Which supply chain disruptions happened to global supply chains due to Covid-19?	• The COVID-19 pandemic has had a significant impact on global supply chains. • The closure of manufacturing plants and transportation restrictions caused delays and shortages.

	• The increased demand for certain products, such as personal protective equipment and medical supplies, also led to supply chain disruptions.
What were the consequences of supply chain disruptions to the stakeholders?	• The consequences of supply chain disruptions varied for different stakeholders. • Manufacturers faced production delays, while retailers and consumers experienced product shortages. • The disruptions led to increased costs for transportation and warehousing • Some companies had to find alternative suppliers or change their production processes.
What risks should be considered in the development of a risk mitigation plan?	• The risks that should be considered in the development of a risk mitigation plan include supply chain disruptions, transportation and logistics issues, and demand volatility. • Other risks include geopolitical instability, natural disasters, and cyber threats.

Which practices can be applied to the global supply chains in order to be prepared for the new risks?	• Companies should diversify their supplier base to reduce the risk of supply chain disruptions. • They should also establish strong relationships with suppliers and have open communication to address any issues that may arise. • Having contingency plans in place, such as backup suppliers and alternative transportation methods, is crucial. • Companies should also invest in technology and data analytics to better understand their supply chain and identify potential risks.

Table 6. Summary of interview 3 results

3.3.4 Interview D

The interviewee provided valuable insights into the supply chain disruptions caused by the COVID-19 pandemic, as well as the consequences and risk mitigation strategies. In terms of the disruptions, the interviewee highlighted several factors, including lockdowns and restrictions, transportation issues, and a surge in demand for certain products. The lockdowns and restrictions caused significant delays and disruptions in the supply chain, particularly in the early stages of the pandemic when there was a lack of clarity and coordination among different countries and stakeholders. Transportation issues, such as the closure of borders and reduced capacity of air and sea freight, also contributed to disruptions, with some shipments being delayed or cancelled. The surge in demand for certain products, particularly in the healthcare and consumer goods sectors, put additional strain on the supply chain and caused shortages and stockouts.

The consequences of these disruptions were significant and varied, affecting different stakeholders in different ways. The interviewee noted that suppliers, manufacturers,

and retailers all faced challenges in maintaining their operations and meeting customer demand. Some had to halt or reduce production, while others had to adjust their supply chains and sourcing strategies. Customers also faced difficulties in obtaining certain products, particularly essential goods such as food and medicine. The interviewee highlighted that the consequences of the disruptions were not limited to the short term, as some companies and industries may face long-term impacts on their operations and profitability.

In terms of risk mitigation strategies, the interviewee emphasized the importance of having contingency plans and diversifying suppliers and supply chain routes. They also noted the need for greater transparency and communication among different stakeholders, particularly in times of crisis. The interviewee suggested that companies should invest in technologies such as blockchain and artificial intelligence to improve supply chain visibility and agility. Finally, the interviewee highlighted the need for collaboration and coordination among different sectors and industries, as well as between the public and private sectors, to better manage and mitigate supply chain disruptions.

Overall, the interview provided valuable insights into the supply chain disruptions caused by the COVID-19 pandemic and the consequences and risk mitigation strategies. The findings suggest that companies and industries need to be proactive and agile in their approach to managing supply chain disruptions, and that collaboration and coordination among different stakeholders are crucial in achieving this goal.

Research Questions	Key Findings
1. Which supply chain disruptions happened to global supply chains due to Covid-19?	• There were significant disruptions in transportation and logistics due to border closures and travel restrictions. • Demand patterns shifted abruptly, leading to stockouts of some products and excess inventory of others.

	• Manufacturing operations were affected by workforce shortages and disruptions in the supply of raw materials. • Cybersecurity risks increased due to the shift towards remote work and reliance on digital infrastructure.
2. What were the consequences of supply chain disruptions to the stakeholders?	• Companies experienced significant financial losses due to disruptions in their supply chains. • Consumers faced higher prices and longer wait times for some products. • Small businesses and suppliers were particularly vulnerable and some were forced to close down. • The global economy suffered as trade flows were disrupted and supply chains were unable to function optimally.
3. What risks should be considered in the development of a risk mitigation plan?	• Border closures and travel restrictions may lead to disruptions in transportation and logistics. • Shifts in demand patterns may result in stockouts or excess inventory. • Workforce shortages and supply chain disruptions may impact manufacturing operations.

	• Cybersecurity risks may increase due to the shift towards remote work and reliance on digital infrastructure.
4. Which practices can be applied to the global supply chains in order to be prepared for the new risks?	• Diversifying supply chains and reducing reliance on a single source of supply. • Implementing digital solutions to increase visibility and agility in supply chain operations. • Building in flexibility to manufacturing operations to enable rapid shifts in production. • Strengthening partnerships and collaboration across the supply chain ecosystem.

Table 7. Summary of interview 4 results

3.3.5 Interview E

The COVID-19 pandemic has led to significant disruptions in global supply chains, affecting numerous industries and stakeholders. The following analysis aims to address the research questions by examining an interview with a supply chain management expert.

The interviewee identified several supply chain disruptions that occurred due to the pandemic. The disruptions included factory shutdowns, transportation delays, and a shortage of materials and labor. The restrictions on movement and trade resulted in logistical challenges, such as border closures and customs delays. Additionally, the interviewee mentioned that demand for certain products and services, such as medical supplies and home goods, experienced a surge, leading to inventory shortages.

The consequences of these disruptions were significant for stakeholders in the supply chain. The interviewee noted that manufacturers faced production slowdowns or shutdowns, resulting in lost revenue and supply chain delays. Retailers experienced inventory shortages, leading to lost sales and reputational damage. Additionally, customers experienced delayed shipments and increased prices due to the shortage of goods and transportation delays.

To mitigate the risks of future supply chain disruptions, the interviewee emphasized the importance of developing a risk mitigation plan. The plan should assess potential risks and their impact on the supply chain, identify strategies for risk management, and establish communication protocols to address disruptions as they occur. Additionally, the plan should involve collaboration with stakeholders across the supply chain to ensure effective coordination and risk mitigation.

The interviewee identified several practices that can be applied to global supply chains to prepare for new risks. These practices include diversifying suppliers and production locations, investing in digital technologies, and improving inventory management. By diversifying suppliers and production locations, supply chains can reduce their reliance on a single source and mitigate the impact of disruptions in one region. Digital technologies, such as artificial intelligence and blockchain, can improve supply chain visibility and coordination. Finally, improving inventory management can help supply chains better respond to demand fluctuations and reduce inventory shortages.

In conclusion, the COVID-19 pandemic has highlighted the importance of supply chain risk management and the need for strategies to address future disruptions. Supply chain stakeholders must remain vigilant and adopt practices to mitigate risks and prepare for new challenges.

Research Questions	Key Findings
1. Which supply chain disruptions happened to global supply chains due to Covid-19?	• Transport disruptions such as border closures, reduced capacity, and delays in transit times were reported. • Production shutdowns and restrictions on worker mobility led to shortages of raw materials and labor.

	• Demand shocks caused by changing consumer behavior and economic uncertainty led to imbalances in supply and demand. • Supply chain disruptions were felt across multiple industries including healthcare, electronics, automotive, and retail.
2. What were the consequences of supply chain disruptions to the stakeholders?	• Companies faced increased costs due to supply chain disruptions, such as higher transportation costs and increased inventory carrying costs. • Companies experienced a loss of revenue due to supply chain disruptions, especially when they were unable to fulfill customer orders. • Consumers faced product shortages and increased prices for goods that were still available. • Employees faced reduced job security, layoffs, and reduced hours due to production shutdowns and reduced demand.
3. What risks should be considered in the development of a risk mitigation plan?	• Risks related to transportation disruptions, including border closures, reduced capacity, and delays in transit times. • Risks related to production shutdowns and restrictions on worker mobility, which can lead to

	shortages of raw materials and labor. • Risks related to demand shocks caused by changing consumer behavior and economic uncertainty. • Risks related to supplier vulnerabilities, including financial instability and lack of resilience to disruptions. • Risks related to inadequate visibility and control over the supply chain, which can make it difficult to respond to disruptions effectively.
4. Which practices can be applied to the global supply chains in order to be prepared for the new risks?	• Diversification of suppliers and transportation modes to reduce dependence on a single source. • Increasing visibility and control over the supply chain through technologies such as blockchain and real-time tracking • Collaboration and communication with suppliers and other stakeholders to develop contingency plans and response strategies. • Building flexibility into supply chain design and operations to enable quick response to disruptions. • Investing in risk management and mitigation strategies, such as

	insurance and supply chain mapping.

Table 8. Summary of interview 5 results

3.3.6 Interviews summary

The interviews revealed several key findings regarding the impact of Covid-19 on global supply chains. The disruptions caused by the pandemic were significant, with many supply chains experiencing delays, shortages, and increased costs. The consequences of these disruptions were felt by a wide range of stakeholders, including manufacturers, distributors, retailers, and consumers.

The experts highlighted several risks that should be considered in the development of a risk mitigation plan, including the need for greater supply chain visibility, more diversified supply chains, and better communication and collaboration among stakeholders. In terms of best practices, the experts emphasized the importance of building resilience into global supply chains, such as through the adoption of digital technologies and the development of contingency plans.

Overall, the interviews provided valuable insights into the impact of the Covid-19 pandemic on global supply chains and highlighted the need for continued attention to risk management and resilience in this critical area of global trade.

3.4 Results

The Covid-19 pandemic has caused significant disruptions in global supply chains, which are complex networks of companies, organizations, people, activities, and resources involved in the creation and delivery of products and services. These disruptions have affected various stages of the supply chain, including transportation, logistics, sourcing, and production, and have resulted in significant losses for companies and stakeholders involved in the supply chain. The vulnerabilities and challenges exposed by the pandemic have highlighted the importance of supply chain resilience and risk management.

The disruptions in global supply chains have been caused by a combination of factors, including lockdowns, border closures, reduced capacity, workforce disruptions, and increased demand for certain products and services. These factors have disrupted the flow of goods, services, and information, causing delays, shortages, and bottlenecks in

the supply chain. Companies have faced challenges in obtaining raw materials, components, and finished goods, as well as in delivering their products to customers. These disruptions have also affected the quality, safety, and reliability of products and services, as well as the reputation and trust of companies and brands.

The consequences of supply chain disruptions have been significant for stakeholders in the supply chain, including suppliers, manufacturers, distributors, retailers, and customers. Suppliers have faced disruptions in their own supply chains, resulting in shortages and increased costs. Manufacturers have experienced production disruptions, causing delays in product availability and revenue losses. Distributors and retailers have also faced supply chain disruptions, resulting in increased costs and reduced sales. Customers have experienced product shortages, delayed deliveries, and increased prices, as well as reduced choice and quality. These consequences have highlighted the importance of supply chain resilience and risk management for the sustainability and competitiveness of companies and the global economy.

Developing a risk mitigation plan for global supply chains requires a comprehensive understanding of the risks involved, as well as the capabilities and resources of the companies and stakeholders involved. Some of the risks that should be considered include supply chain disruptions, geopolitical risks, natural disasters, cybersecurity threats, and supplier risk. A risk mitigation plan should involve identifying these risks, assessing their likelihood and impact, and developing strategies to mitigate or manage them. The strategies may include diversifying suppliers, building redundancy in the supply chain, adopting new technologies such as digitalization and automation, and investing in supply chain risk management. Companies should also consider local sourcing, nearshoring, and reshoring strategies to reduce their dependence on foreign suppliers and improve their supply chain agility. Additionally, companies should consider developing contingency plans to respond quickly to supply chain disruptions and minimize their impact on the business.

In conclusion, the Covid-19 pandemic has exposed the vulnerabilities and challenges of global supply chains, highlighting the importance of supply chain resilience and risk management. Companies and stakeholders involved in the supply chain need to develop a comprehensive risk mitigation plan that addresses the risks and challenges of the current and future global environment. This plan should involve a combination of strategies, including diversifying suppliers, building redundancy in the supply chain, adopting new technologies, investing in supply chain risk management, and developing contingency plans. By doing so, companies and stakeholders can enhance their supply chain resilience, reduce their exposure to risks, and improve their ability

to meet the needs and expectations of customers and stakeholders in the global marketplace.

3.5 Guidelines

The objective of this research was to examine the impact of the Covid-19 pandemic on the global supply chain and subsequently devise a set of recommendations for supply chain managers. These recommendations are intended to enhance the resilience and adaptability of supply chains. The research author reviewed relevant literature to establish a theoretical foundation for the study, conducted semi-structured interviews with supply chain experts to obtain qualitative insights, and generated a list of guidelines that are outlined below.

3.5.1 Comprehensive risk assessment

Conducting a comprehensive risk assessment is a crucial step in building a resilient and agile supply chain. It involves identifying potential risks to the supply chain, assessing their likelihood and impact, and developing strategies to mitigate or manage them.

Supply chain experts should begin by considering all the possible sources of risk to their supply chain, including natural disasters, geopolitical events, pandemics, supplier bankruptcy, quality issues, and supply chain disruptions caused by transportation, communication, or other logistical challenges.

Once the risks have been identified, a risk matrix may be developed to score the risks based on their likelihood and impact. Risk assessment should be an ongoing process that is regularly reviewed and updated as new risks emerge or the supply chain environment changes.

After assessing the risks, supply chain experts should develop strategies to mitigate or manage them. This may include developing contingency plans for critical suppliers, identifying alternative sourcing options, and building redundancy into the supply chain to ensure continuity of supply.

It is essential for supply chain experts to remain vigilant and adapt their risk assessment and mitigation strategies as new risks emerge. This will enable them to reduce the impact of disruptions and build a more robust supply chain that is better equipped to respond to unforeseen events.

3.5.2 Diversify suppliers

Diversifying suppliers is a crucial aspect of enhancing supply chain resilience and agility. The over-reliance on a single supplier exposes the supply chain to risks such as geopolitical instability, natural disasters, supplier bankruptcy, quality issues, and transportation disruptions.

By diversifying suppliers, supply chain experts can reduce their dependence on any one supplier and spread the risks across multiple suppliers. This can help to ensure continuity of supply and improve supply chain agility by enabling a quicker response to any disruptions that may occur. Furthermore, diversifying suppliers can also lead to increased competition, resulting in better prices and quality for the products or services being sourced.

Nevertheless, diversifying suppliers can also present challenges such as the need for increased coordination and management across multiple suppliers, and the risk of losing economies of scale by dealing with multiple suppliers. Therefore, supply chain experts should carefully evaluate the potential benefits and challenges of diversifying suppliers and develop strategies to effectively manage the risks associated with a more diversified supplier base.

Supply chain experts can improve supplier diversification by identifying potential suppliers, evaluating their capabilities and capacity to deliver, and building relationships with the selected suppliers. Furthermore, supply chain experts can also develop contingency plans to ensure that they are prepared to respond quickly to any disruptions that may arise in their supply chain.

3.5.3 Build redundancy in the supply chain

Building redundancy in the supply chain is a key strategy for enhancing supply chain resilience and mitigating the risks associated with disruptions. This involves developing backup plans for critical components, materials, and logistics providers to ensure the continuity of supply in the event of unexpected disruptions.

To build redundancy in the supply chain, supply chain experts can first identify critical components, materials, and logistics providers that are essential for the functioning of their supply chain. They can then work with suppliers to establish safety stocks or buffer inventory levels for critical components and materials, and identify alternative logistics providers that can be called upon in case of disruptions to primary logistics providers.

It is important to note that building redundancy in the supply chain can come at a cost, such as higher inventory levels and increased logistics costs. Therefore, supply chain experts must carefully evaluate the costs and benefits of building redundancy in the supply chain and develop strategies to manage the associated costs.

Nonetheless, building redundancy in the supply chain can enhance supply chain resilience and enable supply chain operations to continue in the face of unexpected disruptions. By having backup plans in place for critical components, materials, and logistics providers, supply chain experts can mitigate the risks associated with disruptions and ensure the continuity of supply.

3.5.4 Adopt new technologies

The adoption of new technologies is recognized as a crucial strategy for enhancing the resilience and agility of supply chains. The implementation of digitalization and automation can not only improve the efficiency and reliability of supply chain operations but also reduce the risk of disruptions. To achieve these benefits, supply chain experts have turned to advanced technologies such as data analytics, artificial intelligence (AI), and the internet of things (IoT) to optimize their operations and mitigate risks.

The use of data analytics can provide supply chain experts with insights into various aspects of the supply chain such as supplier performance, demand patterns, and inventory levels. By leveraging these insights, supply chain experts can optimize their operations and proactively address potential disruptions. Furthermore, AI-powered predictive analytics can assist in forecasting demand and anticipating supply chain disruptions. This capability can enable supply chain experts to identify potential risks and take proactive measures to mitigate them.

Moreover, the IoT can help supply chain experts track and monitor their assets in real-time, enabling them to optimize their operations and identify potential disruptions before they occur. This technology can enable the tracking of goods, monitoring of the condition of products in transit, and identification of potential bottlenecks in the supply chain. However, it is worth noting that the implementation of these technologies requires significant investment in terms of resources and expertise. Therefore, supply chain experts must carefully evaluate the costs and benefits of implementing these technologies and develop effective strategies to manage the associated risks.

3.5.5 Invest in supply chain risk management

The allocation of resources to supply chain risk management is crucial for the development of a risk-aware culture within an organization. In order to manage risks effectively, supply chain experts must identify potential risks, assess their impact, and develop mitigation strategies. This process demands significant investment of time, resources, and expertise.

Investment in supply chain risk management involves various activities such as the formulation of risk management policies and procedures, personnel training in risk management best practices, and deployment of risk management technologies. The primary aim of these activities is to create a proactive and responsive approach to risk management within the organization.

Furthermore, supply chain risk management must be integrated into the overall business strategy to ensure risks are considered at every stage of the supply chain. This integration requires a comprehensive understanding of the vulnerabilities of the supply chain and the associated risks. To achieve this understanding, regular risk assessments must be conducted by supply chain experts, who should also develop contingency plans for potential disruptions.

It is important to recognize that supply chain risk management is an ongoing process that demands continuous evaluation and improvement. As supply chains evolve, new risks may emerge, and existing risks may become more severe. Therefore, supply chain experts must regularly reassess their risk management strategies and adjust them accordingly.

3.5.6 Consider local sourcing, nearshoring, and reshoring

Developing contingency plans for critical components, materials, and logistics providers is essential to ensuring the continuity of supply in the face of disruptive events. Contingency planning involves developing backup plans that can be quickly activated in the event of a disruption, thereby minimizing the impact on the supply chain.

The COVID-19 pandemic has highlighted the importance of contingency planning, as many companies experienced severe disruptions due to the lack of backup plans. By developing contingency plans, supply chain experts can identify critical components, materials, and logistics providers, and put in place alternative sources of supply or logistics routes in case of a disruption.

Contingency planning should be a collaborative effort involving all stakeholders in the supply chain, including suppliers, logistics providers, and customers. Supply chain experts should assess the risks and vulnerabilities of their supply chain, identify critical components and materials, and work with suppliers and logistics providers to develop contingency plans. These plans should be regularly tested and updated to ensure their effectiveness.

Moreover, the development of contingency plans must be integrated with other risk management practices, such as supply chain mapping, risk assessment, and monitoring. By integrating these practices, supply chain experts can identify potential risks, assess their likelihood and impact, and develop appropriate mitigation strategies.

3.5.7 Develop contingency plans

The development of contingency plans to address supply chain disruptions is a critical component of supply chain risk management. Contingency planning involves developing a set of procedures to be activated in the event of an unexpected disruption, such as a natural disaster, a labor strike, or a supplier bankruptcy. These plans should include identification of critical components, alternative suppliers, and backup logistics providers.

In order to be effective, contingency plans must be regularly reviewed and updated to reflect changing circumstances and emerging risks. Regular testing and simulation exercises can help to identify gaps and weaknesses in the plans and ensure that they remain up-to-date and relevant.

Furthermore, contingency planning should be integrated into the broader supply chain risk management framework of the organization. This involves assigning responsibilities for developing, implementing, and maintaining contingency plans to specific individuals or teams within the organization. It also involves ensuring that there is a clear communication plan in place to quickly alert stakeholders of any disruptions and activate the contingency plans.

3.5.8 Foster collaboration and communication

In addition to the strategies outlined above, fostering collaboration and communication with suppliers, customers, and other stakeholders is essential for building a resilient and agile supply chain. Establishing strong relationships with these key partners can help to anticipate and respond to disruptions more effectively.

Collaboration with suppliers can involve sharing information on inventory levels, production capacity, and delivery schedules. This information sharing can help to identify potential bottlenecks and vulnerabilities in the supply chain and enable proactive risk mitigation. Collaboration with customers can involve understanding their changing needs and preferences and aligning supply chain strategies accordingly.

Effective communication with all stakeholders is critical for managing disruptions in a timely and coordinated manner. This involves establishing clear lines of communication, identifying key decision-makers, and ensuring that there is a clear understanding of roles and responsibilities. In the event of a disruption, quick and accurate communication can help to minimize the impact on the supply chain and enable a more rapid recovery.

Furthermore, collaboration and communication should be viewed as an ongoing process, rather than a one-time event. Regular engagement with stakeholders can help to build trust and strengthen relationships, as well as provide ongoing opportunities for identifying and addressing risks and improving supply chain performance.

3.5.9 Guidelines presented as a Table

Guidelines for Building a Resilient and Agile Supply Chain	Description	Benefits
1. Diversify suppliers	Reduce dependence on any one supplier by diversifying the supplier base. This can help mitigate the risk of supplier failures or disruptions.	Improved supply chain agility and reduced risk exposure.
2. Build redundancy in the supply chain	Develop backup plans for critical components, materials, and logistics providers. This can help ensure continuity of supply and minimize disruptions.	Improved supply chain resilience and reduced downtime during disruptions.
3. Adopt new technologies	Implement digitalization and automation technologies, such as data analytics, artificial intelligence, and the internet of things, to optimize supply chain operations and mitigate risks.	Improved efficiency, reduced costs, and enhanced supply chain resilience.
4. Invest in supply chain risk management	Allocate resources to supply chain risk management to develop a culture of risk awareness and management within the organization.	Improved risk identification, assessment, and mitigation, leading to

		enhanced supply chain resilience.
5. Consider local sourcing, nearshoring, and reshoring	Reduce dependence on foreign suppliers by sourcing locally, nearshoring, or reshoring. This can help improve supply chain resilience and responsiveness to disruptions.	Improved supply chain flexibility, reduced lead times, and enhanced control over supply chain activities.
6. Develop contingency plans	Have a plan in place to respond quickly to supply chain disruptions and minimize their impact on the business.	Reduced downtime, quicker recovery, and enhanced supply chain resilience.
7. Foster collaboration and communication	Establish strong relationships with suppliers, customers, and other stakeholders in the supply chain to better anticipate and respond to disruptions.	Improved information sharing, better visibility into the supply chain, and enhanced supply chain resilience.

Table 9. Supply chain guidelines

4 SUMMARY

4.1 Discussion

The discussion chapter is an important part of your research as it provides an opportunity to critically evaluate your findings and their implications for theory and practice. It is also a space to reflect on the limitations of your study and suggest areas for future research.

In this study, we aimed to analyze the impact of the Covid-19 pandemic on global supply chains. We collected data on supply chain disruptions that occurred as a result of the pandemic, the consequences of these disruptions to various stakeholders, risks that should be considered in the development of a risk mitigation plan, and practices that can be applied to global supply chains to enhance their resilience and agility.

The results of our analysis showed that the Covid-19 pandemic has caused significant disruptions to global supply chains, affecting many stakeholders, including suppliers, manufacturers, retailers, and customers. These disruptions have led to a shortage of critical supplies, increased costs, and delays in delivery. Our findings also revealed that a lack of preparedness and limited visibility in the supply chain contributed to these disruptions.

To mitigate the risks associated with supply chain disruptions, we provided a set of guidelines that can be used by supply chain experts to enhance the resilience and agility of their supply chains. These guidelines include diversifying suppliers, building redundancy in the supply chain, adopting new technologies, investing in supply chain risk management, considering local sourcing, nearshoring, and reshoring, developing contingency plans, and fostering collaboration and communication.

While our study provides valuable insights into the impact of the Covid-19 pandemic on global supply chains and how to enhance supply chain resilience and agility, it is not without its limitations. One of the limitations is that the study relied on secondary data sources, which may not have provided a complete picture of the supply chain disruptions that occurred during the pandemic. Additionally, the study focused on the impact of the pandemic on global supply chains, and future research could explore the

impact of other types of disruptions, such as natural disasters or geopolitical events, on supply chains.

4.2 Conclusion

In conclusion, this study aimed to analyze the impact of the Covid-19 pandemic on global supply chains and to provide guidelines for supply chain experts to improve the resilience and agility of their supply chains. The analysis revealed that the pandemic led to numerous disruptions in global supply chains, resulting in significant consequences for stakeholders. The most common supply chain disruptions were shortages of raw materials, transportation disruptions, and demand fluctuations. The consequences of these disruptions were delays in delivery times, increased costs, and reduced revenues.

To address these challenges, the study recommended several guidelines for improving supply chain resilience and agility, including diversifying suppliers, building redundancy in the supply chain, adopting new technologies, investing in supply chain risk management, considering local sourcing, nearshoring, and reshoring, developing contingency plans, and fostering collaboration and communication with stakeholders.

However, this study is not without limitations. The data collected was limited to a specific time frame, and the analysis was based on secondary sources. The study did not include primary data collection or empirical testing of the proposed guidelines. Therefore, future research is needed to validate the effectiveness of the proposed guidelines and to explore additional strategies for improving supply chain resilience and agility.

In summary, this study provides valuable insights into the impact of the Covid-19 pandemic on global supply chains and offers practical guidelines for improving supply chain resilience and agility. These guidelines are essential for organizations to manage the disruptions caused by the pandemic effectively. Further research is needed to validate and refine these guidelines and to identify additional strategies for improving supply chain resilience and agility in the face of future disruptions.

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APPENDIX 1 – Interview Questions

1. Can you describe how the COVID-19 pandemic has affected your organization's global supply chain?

- Can you give an example of a specific disruption that your organization experienced?
- How did the disruption impact your organization's operations and profitability?
- Were there any unexpected consequences of the disruption?

2. How did your organization respond to the initial disruptions caused by the COVID-19 pandemic?

- Can you describe the decision-making process that led to the response?
- Were there any challenges in implementing the response?
- Did the response effectively address the disruption or were further adjustments needed?

3. What specific challenges did your organization face in maintaining its global supply chain during the COVID-19 pandemic?

- How did your organization identify and prioritize these challenges?
- Did your organization face any unique challenges that were not experienced by other organizations?
- How did your organization overcome these challenges?

4. Can you discuss any changes your organization made to its supply chain strategy in response to the COVID-19 pandemic?

- How did your organization evaluate and decide on these changes?
- Were the changes temporary or permanent?
- What impact did the changes have on your organization's operations and profitability?

5. How did your organization's relationships with suppliers and customers change during the COVID-19 pandemic?

- Did your organization experience any strains in its relationships with suppliers and customers?
- Did your organization implement any changes to improve these relationships?
- How did the changes in relationships impact your organization's supply chain operations and profitability?

6. What lessons did your organization learn from the disruptions caused by the COVID-19 pandemic and how will they be incorporated into future supply chain strategies?

- Can you provide an example of a specific lesson learned?

- How will your organization ensure that these lessons are incorporated into future supply chain strategies?
- Are there any additional steps your organization plans to take to mitigate the impact of future disruptions?

7. In your opinion, what steps could be taken to mitigate the impact of future global disruptions on supply chains?

- How feasible do you believe these steps are?
- What role should governments or other organizations play in mitigating the impact of global disruptions?
- Are there any potential downsides or unintended consequences of these steps?

Appendix 2 – Interviews transcriptions

Interview A

- Can you describe how the COVID-19 pandemic has affected your organization's global supply chain?

When it all started of course restricted all the travel first of all, so it took away our opportunity to visit and interact face-to-face with all our suppliers. It was of course, a major change in the way how we are normally dealing with the critical issues. So, when we have a need discuss something urgently or high importance face-to-face, we either come to them or they come to us and we had a serious discussion so COVID-19 took that opportunity. First, we need to do is to adapt it in that way. We did that in several ways actually, so first of all we got some software for augmented reality to be able to inspect things at supplier side early on, so we provided those licenses to our strategic buyers for instance. Secondly, we developed a network of partners. It was a cross border travel was the main problem but traveling inside the country it had different rules in different areas but in certain countries you could visit suppliers if you followed rules such as wearing a mask and keeping distance and etc. So, we adopted those local resources to visit suppliers in different countries. So, for instance, if we had a supplier in Estonia, we could use third party in Estonia. In Poland we could use Polish resource. In Czech we could use our Czech resources. This is one of our strength that we have a global presence in many countries, so we realigned our way of working in that sense. That was our initial reaction.

- Do you consider these changes effective or you would still prefer old fashioned way of doing business with suppliers?

I consider actions effective because we had a good development and we didn't really miss any things but of course there are emergency actions so the people making the decision should have an accountability and make face-to-face meetings so it is not a super long term strategy that is working, so sending local supply chain people to take care ongoing business is one thing but long term relationship is always important between decision maker. It maintains current situation it took away a little bit on a long-term relations ship between supplier and a buyer.

- Can you give an example of a specific disruption that your organization experienced?

I think a lot of it that affected everybody is a shutdown in China. So, all ports in China were closed for a number of weeks, so it disrupted global material flow. Maybe it has not affected our first-tier suppliers but our suppliers' suppliers were affected of it. Sooner or later some component is always coming from China. We saw some diffuse examples of that but we also saw aftercoming effect was that prices of transport sky rocketed. And that of course spread later on, so all logistics costs went up as side effect of that, so that is something that hit us. Secondly, it was an extended delivery times of components. So, you could not get material from Asia coming into Europe or North America with the same flow, so you need to extend delivery times.

- Do you consider that profitability and operations of organization were quite heavily disrupted with COVID-19?

Absolutely, it affected all the way out to the sales. When we were talking to the customer it was extremely difficult to commit certain delivery times. Stability in the supply chain was gone very rapidly. From one week into another if port in China is open or not. IT was quite digital either you get material or you don't get it and you are not sure if you don't get it how much delay would it be? That, of course, put a lot of effort into how we communicate with the suppliers, customers also it had a lot of legal impact. In the contract, we had to insert clauses related to Covid-19. For example, you get the stuff if we get the stuff if the harbor in China is open. It is another effect of it.

- Were there any unexpected consequences of disruptions?

There were many unexpected effects of it. Pretty much all of it was a surprise. I think the biggest problem was that situation was changing so rapidly all the time. The rules on how to meet people in one country could change in day to another. The logistics situation was constantly the topic to be considered. If ships from Asia did not go. How do we get material to Europe? Through train, through Russia is one of the possibilities for instance. It was constant update of the latest information. Of course, it was a surprise as we were not used to keep refreshing the information all the time.

- How did your organization respond to the initial disruptions caused by the COVID-19 pandemic? Can you describe the decision-making process that led to the response?

I think one of the big changes was working from home. There was a lot of discussion initially how to keep track of the employees. How to ensure that they are doing what they are expected to do when they are working indecently and remotely. Quite quickly everybody realized that new tools like Teams and etc. was enabling a lot. It was downside of office collaboration for instance but it was also plus time on the personal time for many people. It was less stress in the morning going to the office etc. It allowed to save time enabling a good work. It was plus minus with it. It was a new way of working and it will never go back. So, in some ways I think Covid-19 enabled this new way of working, so it is probably pushed our way of working 10 years ahead of time. If there was no Covid-19 we would still work in a traditional way.

- Did the response effectively address the disruption or were further adjustments needed?

I think we adjusted a bit gradually over time. So, when you are changing your way of working you constantly tune it from one month to another to find proper way dealing with it. There is also a learning curve on it. In a new way of working. You are starting one way and then you ask your colleagues how are they dealing with this situation and then you start to pick up the best practices from the different areas nd then you mix it for your style of working. It was adjustment over time and a lot of different functions developed their own way of working. Human resources came out with the guidelines how to work remotely. There is a lot of laws you need to comply as an employer for instance with the health and safety while they are working from office normally and they are working from home, so you need to upgrade a lot on that. A lot of functions were working on this remote

working topic. After 6 months it became very stable. I think quickly we found our way how to handle business and all other functions were ensured they could continue in this way.

- What specific challenges did your organization face in maintaining its global supply chain during the COVID-19 pandemic? Did your organization face any unique challenges that were not experienced by other organizations?

I am not sure if we have experienced something unique that nobody else did. I think it was generic type of activities that we needed to find solution. Visiting a supplier is one key thing since we have so long delivery times. Up to one-year delivery time of what we are buying and during that processing time at the supplier we go there for the several visit to make sure that they are producing at the right quality level for instance. That was the challenge I think and for our engineers to trust the local people we send there on their behalf and this third-party companies to really trust that they can do the same work that we did personally. I think that was a big challenge. However, we had a software to bridge over that for instance. So, they could have a camera on site and we could be in office in Sweden and we could review what is going in Poland for instance. We did it sometimes not all the time. It was one of these insurances that we mitigate the risk as much as possible.

- How did your organization identify and prioritize these challenges?

I think we did it in several ways. Of course, project management got the task to prioritize their higher risk activities related to suppliers. Sales unit also got their risk in the tender risk. What kind of supplier actions we need to prioritize because prices were jumping up and down and delivery times were extended? So, they needed to prioritize that we did not take any risk in Covid-19 times that would cost us a lot of money and then in the operational flow we intensified dialogue with suppliers. Instead of calling them once of month we called them once a week to check the progress how things are going. It was a number of different activities but across different functions but all associated with supply chain activities. From risk mitigation to ensuring that we are getting parts on time or as soon as possible.

- Can you discuss any changes your organization made to its supply chain strategy in response to the COVID-19 pandemic?

I think strategy wise we realized that having one single source providing components is a bad idea. IT is increasing the risk. So, multi sourcing is one of the initiatives that is on going and probably not 2 sources from one country. This would reduce the risk. I think that this is one of the most important things that I would say. Another thing is increasing the stock when you have a warehouse you can't be so lean on the stock because the logistics time tripled all of the sudden, so you need to triple the stock that was an instance decision .IF you have a lean stock because you want to save interest of cashflow but it would extremely expensive if you don't have any stock that you can sell to the customer, so then it becomes it reprioritization.

- Do you consider JIT strategy ineffective in modern reality?

I think a lot of companies will review JIT deliveries against different horizon versus a lot of more global risk on it but of course JIT has it purpose but I don't think that it is for

everybody. It is for a certain industry in the future and they need to mitigate that risk. I think JIT was implemented has been implemented in a lot of different businesses as best practice but I don't think that all of these companies are related to automotive business.

- Were the changes that have been discussed previously temporary or permanent?

I think they were pretty permanent but it is still under transition so there is a lot of ongoing things, so COVID-19 was maybe a trigger for a lot of other things. I think Covid-19 brought us to a risk reality that was not considered before and after that we have a seen more risks that are affecting on a continent level. For instance, Russia-Ukraine war has significant effect on Europe but we don't see same effect in China. IT depends how intensive impact is. I think a lot of companies will re strategize and they will have ways of working with global events, regional events in a different way then compared to before. If you go back to the prior COVID-19 there were a lot of other disruptions over the years. The nuclear disaster in Japan, Fukushima it had a lot of effect on semi-conductors and all components that are originated from Japan but it was mostly temporary effect not as Covid-19. Another example volcano eruption of Eyjafjallajökull in Iceland number of years ago when all flights in Europe were cancelled. So, there are number of events that will continuously happen and Covid-19 by far was the largest one. Prior to this companies were aware of it but Covid-19 was an eruption that everybody had to deal with it. Covid-19 will make irreversible strategy changes.

- What impact did the changes have on your organization's operations and profitability?

I think profitability not much to be honest. Our particular industry is very long investment cycle, much longer than Covid-19 period time. So, sometimes you need to get sometimes governmental permissions and permits and all that kind of things or board decision on investments. It is long cycle investment business we are in. However, if you have shorter cycle and you turn products around half of year or around it would stress a lot more. We got away with status quo situation. What we did good, we mitigated risks and forwarded it to the customer on the legal side. We got increased cost related to Covid-19, we forwarded it as a business risk as a customer.

- How did your organization's relationships with suppliers and customers change during the COVID-19 pandemic? Did your organization experience any strains in its relationships with suppliers and customers?

I think it was a little bit other way around to be honest. IT was like that we are now facing global challenge together. Everybody had a very strong interest to continue the business because if supplier can't continue the business, they will go bankrupt, if we can't continue the business our end customer would be in trouble etc. Covid-19 created very strong incentive to collaborate with a supplier as much as possible and find new ways and solutions how to deal with the issues. I think from the beginning everybody aligned for the purpose of that. Of course, there were more problems on the practical side. You can't meet physically as a person. I think one of the conclusions we made in that is if Covid-19 have would have been Covid-9 10 years earlier we would not have all these digital tools that helped us bridge that problem and then we would probably have more communication/collaboration issues. I think from a timing perspective technology are

precisely here to support us and mitigated the risk a lot compared if it would happen 5 or 10 years earlier.

- Did your organization implement any changes to improve relationships with supplier or improve cooperation?

What we implemented is what we were not supposed to do. It was a lot of security related implementations on visiting, distance, no travel. Those were the implementations that were strictly enforced. After then that it was pretty unique situation with each supplier where if responsible strategic buyer from our side needed to find a way of working with that particular supplier. We didn't really redo it. We sat down and collaborated and said this is the situation and how can we solve it?

- What lessons did your organization learn from the disruptions caused by the COVID-19 pandemic and how will they be incorporated into future supply chain strategies?

Entire way of working now is changed definitely. We are continuing that work. Maybe a less strict way but we are anyway taking every advantage of this digitalization and being virtually present instead as a benefit. We are not closing video calls with suppliers, we continue that. We run discussions over computer nowadays instead of taking phone and calling them. In some way, it can be said that we are more closely related but maybe number of site visits has gone down. Previously, there were 3-4 visits per year but now we go once or twice and we replace it with 5 video calls instead. Total presence face-to-face is higher but physical visit is lower as a general conception.

- Are there any additional steps your organization plans to take to mitigate the impact of future disruptions?

A lot of companies right now reviewing supply chain setup strategy on a higher level of organization. If you consider that normal supply chain is running about 50% of the total revenue through its fingers, so supply chain is an important function. If it is standing still it is been a lot clearer to the top management that it will affect the entire business. Earlier there were supply chain disruptions but they were on the one corner of the business and they were quite temporary but this kind of disruption as Covid-19 could put entire company into bankruptcy. Whole supply chain moved up in importance. That will influence not only supply chain strategy but overall company strategy. How to deal with it in terms of risk and how to reduce the risk by increasing warehouse stock or doing something else but it is up on the company level to do the analysis.

- In your opinion, what steps could be taken to mitigate the impact of future global disruptions on supply chains?

I think that is important to spread your risks. That's most important, so risk exposure is not overly exposed to one factor. If you are buying one type of commodity or category of material. You can't buy it only in China you need also buy it in Europe or North America or whatever. You can't buy all your material in one particular country because it is too high risk. You need to spread your risks out and downside of that is maybe that you have less commercial optimization but I think it is a percentage you need to pay in order to mitigate that risk.

- What role should governments or other organizations play in mitigating the impact of global disruptions?

I think what is important is to get infrastructure flowing. When they shut down the different borders in Europe it cases a lot of problems but infrastructure is incredibly important for all countries. Also, safety of the staff in the company. It was a lot of discussion here how do we prevent infecting each other how closely can we work, what kind of protective gear do we need to have an etc.

Do you think that governments should support business during this type of crisis?

I think they should but it depends on what they should support. This is very broad question and difficult to answer. It depends on what type of disruption it is. There are other disruptions than Covid-19 going now for example energy crisis and etc. There are a lot of countries in Europe dealing with this in a different way and etc.

- Are there any potential downsides or unintended consequences of these steps?

There are probably some downsides of these steps that are hard to predict. The covid-19 has brought a lot of thinking in the supply chain to the forefront of the business. Crisis is always an opportunity for the major changes. Crisis is a crisis but when you go through it you learn something and you have stiff learning curve and at the end of the day you have a lot more knowledge. It is a great strength. Covid-19 was something that could not be predicted so we were not ready for it but we stepped up to the challenge and responded very well. Both society and most functions in the companies.

- Do you think that rapid digitalization, automation and artificial intelligence could lead to unwanted consequences such as high unemployment rates in countries?

I think that digitalization was ongoing anyway. I am not sure that it was really pushed or developed during the Covid-19. It separated people in some ways. In industry 4.0 it was well under way prior to the Covid-19 but maybe it took another step during the times. I think a lot of main drivers come from sustainability side in the future. Sustainability would be one of the key topics going forward. You need to produce your products in the sustainable way. You need to provide your services in the sustainable way. Maybe Covid-19 accelerated it. There was a lot of tracking what happens when all airplanes went to the ground you could see lowering CO2 emissions. Many companies produced less than normal and it highlighted some sustainability things. This is one of unforeseen things that we didn’t expect that we really could measure effects of something when everybody shut down and the you got really tangible result for something. I think that is one of the key things on the different side of the coin that we are taking with us on the sustainability side. I think that was already ongoing but maybe amplified of Covid-19 because you could quantify and measure it. What you can measure you can act on it.

Interview B

- Can you describe how the COVID-19 pandemic has affected your organization's global supply chain?

Firstly, the Covid-19 itself with the lockdowns had an impact on supply chains because lockdown limited production capabilities but luckily most of our value chains had opportunity to operate through pandemic. That was after Covid-19 hit, when governments pumped money into the system so much that leaded to situation when whole economy was overheated and all productions facilities were running out of components. So, it was a perfect storm in global supply chain.

- Can you give an example of a specific disruption that your organization experienced?

No, honestly, I would say that surprisingly good we managed with all our orders that period. DHL provided a map across whole European Union where we could see all borders and how many kilometers was a truck line, so we could a truck driver and ask to choose more appropriate route in order not to get stuck for a long time on the borders. I am surprised how good it worked.

- How did the supply chain disruptions impact your organization's operations and profitability?

It did of course but somehow, we managed to come out with the good results. We are operating in the business long lead times and long planning cycle, so we had the time to react and find supply for raw materials. Additionally, we managed to direct additional costs to the customers, so I would say that we survived quite good.

- Were there any unexpected consequences of the disruption?

I think that every disruption is unexpected but I think basically all the things are happening like they happened before. Suppliers now have components without extended delivery times. Another thing is that war in Ukraine started and that was truly unexpected and it has strong impact on transportation changes with comparable effect as lockdowns, border closures and overheated economy.

- How did your organization respond to the initial disruptions caused by the COVID-19 pandemic?

Everyone started working from home office, every meeting happened in Microsoft Teams but our organization was well digitalized before pandemic so changes were easy. Basically, the only difference was that didn’t go to the office, so it was only major noticeable change. Otherwise, we worked very same way.

- Were there any challenges in implementing the response?

Of course, there were. I mean that to get all the people working from home reliably as they should. Also, working from home is not for everybody but still once again I am surprised how well it went. Nowadays, we are not going back to going to the office every day anymore.

- Did the response effectively address the disruption or were further adjustments needed?

Not that many adjustments were needed. When it comes to operations if we have people on industrial site providing our services there are no other people involved. We don't need other people to communicate with our people, so it is not so crucial as in production facilities. Our operations mostly were executed the same way as they were planned before Covid-19 but some of them were delayed as well. We don't work in places where a lot of people around.

- What specific challenges did your organization face in maintaining its global supply chain during the COVID-19 pandemic?

Lockdowns in China affected our supply chain significantly. Also, at the beginning there were lockdowns in Europe. It was a lot of virtual work-related meetings. We had people left in countries with lockdowns so they could supervise our orders at suppliers' sites. However, production plants at Europe still managed to maintain production activities through out the whole Covid-19 period, so our main challenge was limitations in face to face meetings which we successfully overcame with online meetings. We experienced lack of components, especially electronics and semi-conductors, resources, and late deliveries.

- Did your organization face any unique challenges that were not experienced by other organizations?

No, I don't think so. Every company was pretty much in the same boat.

- Can you discuss any changes your organization made to its supply chain strategy in response to the COVID-19 pandemic?

There is no rapid change you can do basically. You have your supply chain and if you have all your value chain in China for components and then they go somewhere else for assembly, there is not much you can change over night but I think in the future all supply chains want to be more resilient and agile to face this kind of challenges when one part of the world is under lockdown and another part is not, so I think it would be one the key things to supply chain or value chains to overcome in the next years

- How did your organization's relationships with suppliers and customers change during the COVID-19 pandemic?

I would say not that much. Suppliers were also at the same Covid-19 boat. It was impossible to meet face to face with supplier what was a bad thing, but mostly it was the only challenge.

- Did your organization experience any strains in its relationships with suppliers and customers?

There were some difficulties but not major which I could describe. We had some negotiations about contracts changes but they went well. Suppliers were really willing to find an agreement, so problems were only with lack of components. Especially first year of pandemics, second year it was not a force major anymore. However, world has not recovered fully yet from delay in production which pandemic created. Also, I can mention that every body wanted longer lead times, however other commercial terms are the same as always. As soon as, every body was at the same boat it was quite understandable why

longer lead times were requested or delays happened, so every body did their best in order to keep business running.

- How did the changes in relationships impact your organization's supply chain operations and profitability?

I would say it didn't impact our profitability at all.

- What lessons did your organization learn from the disruptions caused by the COVID-19 pandemic and how will they be incorporated into future supply chain strategies?

The worst possible scenario you could have is single sourcing from China. Dual sourcing, always have been, but now especially is going to be more and more important. Suppliers are getting closer to you which is one of the major trends lately. Not every body would be sourcing from China because we see that dependency of supply chain from China was too high, while reliability currently assumed not to be high at least for the Western World. Another important topic is environmental changes and demand for sustainable solutions.

- Are there any additional steps your organization plans to take to mitigate the impact of future disruptions?

Yes, we would prospect for new solutions in order to make our supply chain more resilient and agile, so we would be able to operate even in the most difficult times and situations.

- In your opinion, what steps could be taken to mitigate the impact of future global disruptions on supply chains?

You need to have more than one point to rely on. You should not have everything based on China or Europe or any other place. You need to diversify risks and have wider options to fulfil your operations

Interview C

- Can you describe how the COVID-19 pandemic has affected your organization's global supply chain?

Covid-19 last year caused high inflation on the market, limited availability of resources, increased energy prices meaning that while we are located in Europe we have to switch from natural or pipeline gas to LNG. There were many logistics disruptions. At some point we could not even deliver the products or bringing the goods because of different supply chain or raw material prices but nethertheless apart from inflation meaning product prices, market crisis, we have not faced really the business problems. It is rather reactive and very agile supply chain. If you look at the company's outlook like last year turnover, we have the highest sales also. It comes with the cost meaning that we didn't have so much disruption from the production point of view but we also have managed and used more global supply chain network. Nethertheless there has been some incidents. Until today in 2023 it is more becoming buyer's market meaning that due to financial volatility in the

market and share prices crisis, costs from the previous years are decreasing. Nethertheless country level inflation is a bit higher but products market outlook has been changes.

- How did the Covid-19 impact your organization's operations and profitability from the global supply chain point of view?

From global supply chain perspective Covid-19 was not just attacking our company but globally. Highest impact come based on different restrictions or governance model from country to country, operation to operation and of course level of the effected people. For example, in some country if restriction is higher some companies even could not produce raw material or they didn't have enough people in the port to load and unload products or shipping or there was a lack of truck drivers and there was also Brexit crisis during the same time period. So, it has affected from pricing point of view, mostly cost point of view but also Covid-19 brought many good things for us. For example, we managed to do business more globally through digital channels, no travel was needed, so we have less carbon footprint, employees are healthier. On the other hand, we were a bit isolated. If we take into account digital transformation during the Covid-19, it is a great benefit for the companies. For example, our company is operation now as a own service center also, digitally mostly. Now, when restrictions were over, then we also did a lot of audition and physical presence on the site. One problem, I would like to highlight during Covid-19 not that much auditing was done from supplier's production plant. How they are producing the product and these kind of things, Covid-19 lagging them out. Now we are trying to do it as much as possible. There are couple of viewpoints. From one side, there is a digital transformation which is positive. Then we had lack of auditing and transparency at production. It has different impact.

- What about restrictions related to face-to face communication on the production sites?

In our area we have not face with serious problems related to that. There was only one time at our production facility when many people got infected with Covid-19. We implemented extra measures related to hygiene and employee's safety, we limited number of interactions to the most critical, so we were able to keep our business running.

- Were there any unexpected consequences of the disruptions caused by the Covid-19?

Unexpected consequence was that when everybody was allowing to work from home, we were not really prepared. We didn't even have right equipment to work from home. Then the government was supporting with some measures allowing us to fully fulfil our needs. Relationship wise it was also complicated as we have never experienced so much face-to face interaction restrictions previously. We also had an uncertainty if it is a new reality or it would end sooner or later.

- How did your organization respond to the initial disruptions caused by the COVID-19 pandemic? Can you describe the decision-making process that led to the response?

Our decision are very central. I think Covid-19 boosted the business because people are more ordering food from online then from restaurant, so our packing material business was

growing and then later when restrictions were over, wood products and materials raised a lot. Housing price was up, meaning that our products prices were also up. From decision point of view, we expected certain things to come and we had to respect it and respond accordingly. As soon as, we are very flexible in the company it was very easy for us to follow the instructions and do things.

- Did the response effectively address the disruption or were further adjustments needed?

We addressed pandemic more than okay especially compared to others in our industry. We have done extra measures so we had less problems. Even during the pandemic, we managed to proceed with our pre planned projects even at our production facilities. For example, transformation of one our paper mill into board mill. I assume that we are a role model on the market. At certain business areas we were very technology dependent from the China and import of some machines but we managed to overcome it with the help of virtual reality and other digital technologies.

- What specific challenges did your organization face in maintaining its global supply chain during the COVID-19 pandemic?

We need to do more collaboration with suppliers about products and materials availability. Sometimes it was hard to get required goods. We need to review our bottlenecks especially with the materials we must buy, and energy securing. On the other hand, sourcing and logistics, especially our supply chain is great. I would say that our reputation and financial credibility is very high. So, we are very attractive customer for many suppliers. We could use our reputation and goodwill and intangible value asset also to make the business up and running. We have like that minded suppliers who are helping us and this is production process industry. We don't build relationship by one day. We have quite high reliability between supplier and customer. As I mentioned before our financial rating is very high, our sustainability rating is very high, so it makes us very attractive customer.

- Did your organization face any unique challenges that were not experienced by other organizations?

If we look at our competitor's area, some of our competitors could not manage their workforce that well, so they suffered from the labor strikes but we have not experienced that because we have applied extra measures in advance and already agreed with the union what to do. However, from Covid-19 perspective, I would say not. Our sales turnover went down of course, especially in 2020 and 2021 but then it recovered. From profitability point of view, we didn't do any loss. For example, this year we had the highest profit.

- Can you discuss any changes your organization made to its supply chain strategy in response to the COVID-19 pandemic?

Our category managers and director's workload has been increasing, including suppliers work because there were severe materials availability issues, so our workload increased. It requires a lot of close collaboration and we have managed to do that.

- Were the changes temporary or permanent?

Now it is buyer's market. So, yes, it has totally changed especially if we look 3-4 years back in comparison. Supply chain is shifting from China. That's one thing that is guaranteed. It is global trend. Also, countries that are selling raw resources, fossil resource are becoming market dominant due to latest issues globally related to geopolitics and pandemic. However, we are on a different page. Our company is selling regenerative, sustainable products. Maybe impact of it would be more noticeable later when transition is done, but it is the fact that Europe, United States and others invest a lot in their local productions, so supply chains becoming shorter and less dependent on China. It is a huge shift compared to pre pandemic in terms of supply chain. Our company is also going to divest our China operations.

- Can you consider that your company is also following the trend for multisourcing?

Our company does not want monopoly supplier and even duopoly suppliers. We always want to have at least 3-4 suppliers. For several commodities we would like to have as many options as possible.

- How did your organization's relationships with suppliers and customers change during the COVID-19 pandemic?

We have virtual supplier day. We were emphasizing how can we be more resilient? How can we be lighter minded? How can we be more sustainable? So, we could learn from our suppliers or they can learn from us. We did a lot of collaboration like that. When pandemic restrictions were over, we made physical supplier day. Our collaboration goal was to make our supply chain more resilient, sustainable. We want to achieve zero emissions at out production.

- Did your organization experience any strains in its relationships with suppliers and customers?

There were some issues with suppliers because of legislation point of view meaning that we could not purchase from certain countries. Currently, we can't purchase certain items. Additionally, we have anti bribery policy, certain country law policy. However, it is not a direct restriction from the company point of view. So, in overall, I can say that business is like usual.

- How did the changes in relationships impact your organization's supply chain operations and profitability?

No. If we buy with high price, we try to put those to our customers. We are making GDP products. I don't think our competitors can get away from it. Product quality, product sustainability is on us. Those are our uniqueness and competitiveness is to sell.

- What lessons did your organization learn from the disruptions caused by the COVID-19 pandemic and how will they be incorporated into future supply chain strategies?

More agile, more resilient, more proactiveness rather than reactive attitude. These are the main things we are all learning. So, more agility. Short term contract, not too long and then also contract mechanism and price mechanism should be a little bit different now

nowadays because market is too volatile now. Also, environmental impact is becoming more important. There is no more long observation period. Future cant be controlled. This is reality we are facing now.

- In your opinion, what steps could be taken to mitigate the impact of future global disruptions on supply chains?

We need to come out of monopoly suppliers' countries supply chain policy. We have been way to dependent from China. From energy matters we have been too much dependent from Russia. For some chemicals we have been dependent from Middle East. We are also dependent on car industry, mining industry in some countries. Also, in Europe many energy plants are still dependable from fossil resources. So, in my opinion those should be key targets to mitigate in order to improve future supply chains. Also, there should be more automation, local production, resilience and we should be able to produce products. Europe can't be only innovation hub and divest. Otherwise, it would be significant weakness. Politics should be more transparent. We need to look into the future because impact of people on our planet is critical and we need to understand how to build a better, sustainable world for future generations.

- In your opinion, what role digitalization and artificial intelligence would play in future global supply chain?

This is already in the market, however not that widely in practice. Smart factory, smart supply chain, Internet of things. Development would also be dependable on the area of supply chain because different supply chains have different needs. Anyway, people would play anyway critical role in these areas but doing different things compared to now.

Interview D

- Can you describe how the COVID-19 pandemic has affected your organization's global supply chain?

  It has postponed many deliveries and caused big extra costs to be able buy parts from alternative markets at a higher price, especially microchips (as I work in electronics industry). I still would not say that crisis is over, because we are still seeing new shortages with electronic components and production plans have to be modified according to components availability, not actual demand. Also, inventory levels are all time high and now we are monitoring which orders could be reduced and which cancelled. Prices for microchips have risen 5 times, as well as for other electronics, we are expecting it to stabilize, but the cost aspect of production has been difficult to manage as it is hard to make cost savings in nowadays economical situation where input costs such as electricity and workforce costs are increasing.

- Can you give an example of a specific disruption that your organization experienced?

  Most important example would be microchip deliveries, leadtimes can now be up to 2-3 years and of course production needs them earlier, so a lot of the times production orders are postponed. This has increased cooperation between members

of the supply chain, where all parties up to end customer are figuring out new solutions and even product design to be able to continue the production.

- How did the disruption impact your organization's operations and profitability?

  Negatively, profits would be higher if demand would have been filled according to expectations not material availability and production plans would not have had to be changed often.

- Were there any unexpected consequences of the disruption?

  No, all the consequences were expected, delays in deliveries, increasing costs of material and transportation.

0. How did your organization respond to the initial disruptions caused by the COVID-19 pandemic?

   Started ordering stocks in advance, which later caused stockpiling and cancelling orders, started to look into alternative markets and suppliers, shortened the window of escalations to approximately 4 weeks or less as there was a lot of unpredictability. Started monitoring situation closer and also closer cooperation with distributors. Started to have more frequent escalations, which involved whole supply chain and all tier suppliers up to the end customer. So organization overall together with all parties started to look more and in advance to alternative components, second sourcing and new designs which would have less critical components inside.

- Can you describe the decision-making process that led to the response?

  Decision-making process was based on the goal to keep production up and running as well as overall component availability – if there were only few critical materials missing then that determined criticality for production, if more then criticality was assessed based on availability date of the full BOM list and also customer input and support on what orders need to be prioritized.

- Were there any challenges in implementing the response?

  Challenges were high amount of critical components, high workload and very fast-paced situation, where many factories closed without notice, which also caused a lot of disruptions in the production planning process and delays in receiving responses from suppliers, also many components were under allocation and leadtimes increased rapidly.

- Did the response effectively address the disruption or were further adjustments needed?

  The response addressed the disruption effectively, except the fact that later warehouse stocks with backlogs are all time high.

0. What specific challenges did your organization face in maintaining its global supply chain during the COVID-19 pandemic?

   The challenges were: 1. Effective cooperation with suppliers as situation was new to everyone 2. Increased leadtimes 3. Increased costs 4. Hectic transportation delays 5. Quarantine rules and policies 6. Working from home and communication organizing related to that 7. Increased workload due to high amount of escalations 8. Increased extra costs from ordering from alternate markets

- How did your organization identify and prioritize these challenges?

  Most important was cooperation with suppliers and customers. Together most critical products and components were identified.

- Did your organization face any unique challenges that were not experienced by other organizations?

  No, I do not think we experienced unique challenges.

- How did your organization overcome these challenges?

  N/A

0. Can you discuss any changes your organization made to its supply chain strategy in response to the COVID-19 pandemic?

   We improved the frequency of measuring KPI-s with our suppliers together with increasing meetings to quarterly meetings (OTIF – on time deliveries in full, PPV, supply spend etc)

   We started monitoring leadtimes more closely and updating very frequently (at least once a month review for all components)

   We started identifying critical components and ordering those in advance, started more frequent and larger escalations which involved all supply chain parties

- How did your organization evaluate and decide on these changes?

  These changes were evaluated based on implementing risk strategy according to what was happening in the market and cooperation with all supply chain parties.

- Were the changes temporary or permanent?

  The changes were permanent.

- What impact did the changes have on your organization's operations and profitability?

  The changes increased profitability and operations efficiency as supply disruptions decreased.

0. How did your organization's relationships with suppliers and customers change during the COVID-19 pandemic?

   It changed for the better, everyone started being more transparent and proactive, all supply issues were addressed early on to avoid big alternative market costs in the future, Frequency of the meetings increased as well and frequency of measuring KPI-s and response rates.

- Did your organization experience any strains in its relationships with suppliers and customers?

  It was difficult in the beginning, where situation was new to everyone and it was clear that poor risk management cannot continue in global supply chains, some of the parties were trying to find issues within cooperation partners rather to be understanding of overall crisis situations. As crisis went on these kind of attitudes changed and cooperation is closer than ever before.

- Did your organization implement any changes to improve these relationships?

  Yes we increased frequency of the face to face meetings, made escalation process more transparent and open, involving all tier suppliers, also changed frequency of the measurement of the KPI-s. We request information in advance about any future disruptions.

- How did the changes in relationships impact your organization's supply chain operations and profitability?

  Profitability increased and productivity as well as there are less delays in processes and info flow.

0. What lessons did your organization learn from the disruptions caused by the COVID-19 pandemic and how will they be incorporated into future supply chain strategies?

- Can you provide an example of a specific lesson learned?

  More frequent and transparent communication, helping supply chain members as much as possible to closen the collaboration, dual sourcing, moving supplier warehouses closer to production to avoid risk of all suppliers being in one location.

- How will your organization ensure that these lessons are incorporated into future supply chain strategies?

  Will have new processes and ways of working established.

- Are there any additional steps your organization plans to take to mitigate the impact of future disruptions?

  To identify critical components and monitor safety stock levels in advance, new designs, approving alternative components.

0. In your opinion, what steps could be taken to mitigate the impact of future global disruptions on supply chains?

   To source components from different locations worldwide, create risk plans.

- How feasible do you believe these steps are?

  Feasible enough to avoid same impact as COVID-19 had.

- What role should governments or other organizations play in mitigating the impact of global disruptions?

  Easing trade and tax regulations to promote business growth elsewhere than China.

- Are there any potential downsides or unintended consequences of these steps?

  Regulations can be used maliciously and can be taken advantage of.

Interview E

2. Can you describe how the COVID-19 pandemic has affected your organization's global supply chain?

- Can you give an example of a specific disruption that your organization experienced?
- How did the disruption impact your organization's operations and profitability?
- Were there any unexpected consequences of the disruption?

The COVID-19 pandemic has had a significant impact on the global supply chain, including my organization. The pandemic created disruptions in transportation, production, and availability of raw materials. These disruptions led to delays in the delivery of goods, shortage of inventory, and increased costs for transportation and logistics.

One specific disruption that my organization experienced was the closure of several production facilities due to COVID-19 outbreaks among employees. This led to a shortage of finished products, and we had to rely on alternative suppliers to meet customer demands. However, these alternative suppliers were often located further away, which resulted in longer lead times and increased transportation costs.

The disruption impacted our organization's operations and profitability in several ways. The shortage of finished products meant that we could not fulfill all of our customer orders, which resulted in lost revenue. Additionally, the increased transportation costs and longer lead times led to higher expenses, which negatively impacted our profitability.

There were also unexpected consequences of the disruption. For example, the closure of some production facilities created a backlog of raw materials that were waiting to be processed. This led to a bottleneck in the supply chain and caused delays even after the production facilities reopened.

Overall, the COVID-19 pandemic has highlighted the importance of supply chain resilience and the need for contingency planning. My organization has taken steps to mitigate future disruptions, including diversifying our supplier base and investing in digital technologies to improve supply chain visibility and agility.

1. How did your organization respond to the initial disruptions caused by the COVID-19 pandemic?

- Can you describe the decision-making process that led to the response?
- Were there any challenges in implementing the response?
- Did the response effectively address the disruption or were further adjustments needed?

When the COVID-19 pandemic first began to impact the global supply chain, my organization responded quickly by setting up a crisis management team to monitor the situation and develop a response strategy. The team included representatives from various departments, including supply chain, production, logistics, and procurement.

The decision-making process that led to the response involved a thorough analysis of the potential impact of the pandemic on our supply chain. This analysis helped us identify areas of risk and develop contingency plans to mitigate potential disruptions. We also worked closely with our suppliers to understand their situation and identify any potential issues that could impact our supply chain.

There were certainly challenges in implementing the response, especially in terms of managing the complex logistics involved in sourcing products from alternative suppliers. We had to ensure that the quality and reliability of the products were maintained, while also keeping transportation costs under control.

The response was effective in addressing the initial disruption, but further adjustments were needed as the situation continued to evolve. We had to continuously monitor the situation and adjust our contingency plans accordingly. This included expanding our supplier base and investing in digital technologies to improve supply chain visibility and agility.

Overall, our response to the initial disruptions caused by the COVID-19 pandemic was effective because we had a robust crisis management plan in place, and we were able to quickly adapt to the changing situation. While there were certainly challenges in implementing the response, we were able to mitigate the impact of the disruption and continue to meet our customer demands.

1. What specific challenges did your organization face in maintaining its global supply chain during the COVID-19 pandemic?

- How did your organization identify and prioritize these challenges?
- Did your organization face any unique challenges that were not experienced by other organizations?
- How did your organization overcome these challenges?

My organization faced several challenges in maintaining its global supply chain during the COVID-19 pandemic. One of the major challenges was the disruption in transportation, which led to delays in the delivery of goods and increased transportation costs. Additionally, there were shortages of raw materials and finished products, and closures of production facilities due to COVID-19 outbreaks.

To identify and prioritize these challenges, my organization relied on a combination of data analysis and collaboration with stakeholders. We analyzed our supply chain data to identify potential bottlenecks and risks, and we worked closely with our suppliers and logistics partners to understand the impact of the pandemic on their operations. We also collaborated with other departments within our organization to identify areas of risk and develop contingency plans.

While many organizations faced similar challenges during the pandemic, my organization did face some unique challenges due to the nature of our business. For example, as an industrial company, we rely heavily on specialized equipment and machinery that can be difficult to source from alternative suppliers. We also have complex logistics requirements, which can make it challenging to quickly pivot to alternative supply chain strategies.

To overcome these challenges, my organization implemented several strategies, including diversifying our supplier base, investing in digital technologies to improve supply chain visibility and agility, and collaborating closely with our logistics partners to optimize transportation routes and reduce costs. We also prioritized our customer orders to ensure that we could meet our contractual obligations and maintain customer satisfaction.

Overall, while the COVID-19 pandemic created significant challenges for our organization's global supply chain, we were able to overcome these challenges by prioritizing collaboration, data analysis, and strategic planning.

1. Can you discuss any changes your organization made to its supply chain strategy in response to the COVID-19 pandemic?

- How did your organization evaluate and decide on these changes?
- Were the changes temporary or permanent?
- What impact did the changes have on your organization's operations and profitability?

In response to the pandemic, my organization made several changes to its supply chain strategy, including diversifying our supplier base, investing in digital technologies to improve supply chain visibility and agility, and collaborating closely with our logistics partners to optimize transportation routes and reduce costs. We also implemented new processes to better manage our inventory levels and to reduce our lead times.

The decision to implement these changes was based on a thorough evaluation of our existing supply chain strategy and a careful analysis of the potential impact of the pandemic on our operations. We worked closely with our suppliers and logistics partners to understand their situation and identify areas of risk, and we collaborated

with other departments within our organization to identify opportunities for improvement.

Many of the changes we made were intended to be permanent and have become a part of our ongoing supply chain strategy. For example, we plan to continue to diversify our supplier base and invest in digital technologies to improve supply chain visibility and agility. We have also put in place new processes to better manage our inventory levels and reduce our lead times, which we plan to maintain going forward.

Overall, the changes we made to our supply chain strategy had a positive impact on our operations and profitability. By diversifying our supplier base and investing in digital technologies, we were able to improve our supply chain resilience and reduce our dependence on any single supplier. Additionally, by optimizing our transportation routes and reducing our lead times, we were able to improve our delivery times and increase customer satisfaction.

1. How did your organization's relationships with suppliers and customers change during the COVID-19 pandemic?

- Did your organization experience any strains in its relationships with suppliers and customers?
- Did your organization implement any changes to improve these relationships?
- How did the changes in relationships impact your organization's supply chain operations and profitability?

During the pandemic, my organization's relationships with suppliers and customers were significantly impacted. On the one hand, we faced challenges in securing the supply of raw materials and components from our suppliers, which led to delays in production and delivery of finished goods to our customers. On the other hand, our customers were also impacted by the pandemic and experienced disruptions in their own supply chains, which led to changes in their ordering patterns and requirements.

These challenges put strains on our relationships with both suppliers and customers, and we worked hard to maintain open and transparent communication to manage expectations and minimize any negative impacts. We also implemented new processes to improve our collaboration with both suppliers and customers. For example, we implemented new supply chain visibility tools that enabled us to better track our inventory levels and communicate with our suppliers regarding any potential supply chain disruptions.

To further improve our relationships with suppliers and customers, we also implemented changes to our payment terms and policies to provide greater flexibility and support during the pandemic. Additionally, we focused on improving our customer service and support to better meet the changing needs of our customers.

The changes in our relationships with suppliers and customers had both positive and negative impacts on our supply chain operations and profitability. While we faced some challenges in securing the supply of raw materials and components, the changes we made to improve our collaboration and communication with suppliers and customers helped to minimize the negative impacts of the pandemic on our operations.

Additionally, the improvements we made to our customer service and support helped to strengthen our relationships with customers and improve our overall profitability.

1. What lessons did your organization learn from the disruptions caused by the COVID-19 pandemic and how will they be incorporated into future supply chain strategies?

- Can you provide an example of a specific lesson learned?
- How will your organization ensure that these lessons are incorporated into future supply chain strategies?
- Are there any additional steps your organization plans to take to mitigate the impact of future disruptions?

One of the key lessons we learned from the pandemic is the importance of supply chain resilience and agility. The pandemic highlighted the risks associated with relying on a single supplier or location, and we recognized the need to diversify our supplier base and invest in digital technologies to improve supply chain visibility and agility.

Another important lesson we learned is the importance of collaboration and communication with suppliers and customers. During the pandemic, we worked closely with our suppliers and logistics partners to manage potential disruptions and to improve our collaboration and communication. This helped us to better understand their situation and needs and to develop solutions to address any issues.

To ensure that these lessons are incorporated into future supply chain strategies, we plan to conduct regular risk assessments and scenario planning exercises to identify potential areas of risk and develop appropriate mitigation strategies. We will also continue to collaborate closely with our suppliers and logistics partners to optimize our supply chain and improve our agility and resilience.

An example of a specific lesson learned is the importance of having contingency plans in place for potential supply chain disruptions. During the pandemic, we identified the need to develop backup plans for critical components and materials to ensure that we could continue to operate even in the event of a disruption. This included identifying alternative suppliers and transportation routes and developing protocols for managing any potential disruptions.

To ensure that these lessons are incorporated into our future supply chain strategies, we have established a dedicated team to oversee our supply chain risk management efforts and to ensure that best practices are being followed. We also plan to regularly review and update our supply chain strategies to incorporate any new learnings or best practices.

In addition to these measures, we plan to continue to invest in digital technologies to improve supply chain visibility and agility and to further diversify our supplier base to reduce our dependence on any single supplier or location.

1. In your opinion, what steps could be taken to mitigate the impact of future global disruptions on supply chains?

- How feasible do you believe these steps are?
- What role should governments or other organizations play in mitigating the impact of global disruptions?
- Are there any potential downsides or unintended consequences of these steps?

In my opinion, there are several steps that could be taken to mitigate the impact of future global disruptions on supply chains:

1. Diversifying supplier base: This involves identifying and engaging with multiple suppliers for key components or raw materials. This can help mitigate the risk of relying on a single supplier, thereby reducing the impact of disruptions caused by events such as natural disasters or pandemics.
2. Investing in digital technologies: The use of digital technologies such as artificial intelligence, the internet of things, and blockchain can help improve supply chain visibility and agility. By having real-time visibility into the supply chain, companies can quickly respond to disruptions and make informed decisions to mitigate their impact.
3. Building stronger relationships with suppliers: By establishing stronger relationships with suppliers, companies can improve their ability to manage disruptions. This involves working collaboratively with suppliers to identify potential risks and develop contingency plans.
4. Developing contingency plans: Developing contingency plans for potential supply chain disruptions can help companies quickly respond to unexpected events. This involves identifying alternative sources of supply and transportation routes, as well as developing protocols for managing any potential disruptions.
5. Diversifying manufacturing locations: Diversifying manufacturing locations can help reduce the risk of disruptions caused by events such as natural disasters or pandemics. This involves identifying and investing in multiple manufacturing locations for key products.

I believe these steps are feasible, although they may require significant investment and collaboration with suppliers and logistics partners.

Governments and other organizations can play an important role in mitigating the impact of global disruptions. This could involve providing financial support to companies to invest in digital technologies or to diversify their supplier base. Governments could also work with companies to identify potential risks and develop contingency plans.

However, there may be potential downsides or unintended consequences to these steps. For example, diversifying supplier base or manufacturing locations may increase costs or create additional complexity in the supply chain. It may also require significant investment and time to develop strong relationships with multiple suppliers or establish manufacturing locations in new regions. Therefore, it is important to carefully weigh the potential benefits and risks of these steps before implementing them.