

Dissertation

**How manufacturing industry's supply chain has impacted during Coving-19
Pandemics (March to June) in Turkish Manufacturing industry**

MSc in Supply Chain and management

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Dedications

I am sincerely thankful to **Des Mclaughlin** for his mentoring and sharing of depth experiences throughout my research.

Abstract

This study aim is determining how the manufacturing industry has been impacted during COVID pandemic (March to June) in Turkey. The Turkish manufacturing industry has significant importance on Turkey's economy and has been contributing Turkey's %22 per cent of Gross Domestic Products. (Koç, Şenel and Kaya, 2018) These products have been contributing by 95% of Turkey's income from exports. According to the latest report of the Turkish Statistics Institute, the Turkish manufacturing industry has experienced a decreasing by 30%, illustrated in [Figure 21](#). (TUIK, 2020)

The data collected by interviewing varies industry professionals who are working or has knowledge about supply chain processes as well as have experiences. The data is collected by using “**in-depth interview**” technique. The interview questions are designed **semi-structured to queries**. The data were collected from 6 manufacturing companies through online communications tools such as Zoom, Skype.

As a result of the interviews, it is determined that the first, Coronavirus pandemic has increased the importance of domestic suppliers because companies have face problems due to regions such as Asian suppliers' common issue for industries. The second, the products, which have alternative suppliers, have impacted less than other products. The third, the companies, which have a variety of customer ranges (not a single type of product buyers) has affected less than other companies. Besides, the non-compulsory product has faced critically demand to decrease; in contrast, compulsory products have faced with high demand (Automotive pharmacy, hygiene products). This paper has revealed similar results with some other international research companies results.

Keywords: Supply Chain Resilience, Supply Chain Disruption, Covid-19

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1. Introduction

1.1 Overview

This study focusses on the supply chain disruptions and how it impacts a company's management' activities in Turkish companies.

The globalization is connecting almost everything such as people, products, money and information are flowing very fast from one part of the world to another. Today's companies want to reach with their products to the whole over the world as one entire market. The consequence of globalization f to businesses, which they are seeking many strategies to keep and increase their market share such as new technologies investment, cost reduction studies, raising revenue methods, efficient working capital, better operational systems. (Barroso, Machado and Cruz Machado, 2008)

On the other hand, these developments bring new risks and disruptions. Because global word trade and supply chains have more pieces and each part of supply chains located more complicated than before, Supply chain management is controlling each part of the supply chain. Still, interconnecting of the entire supply chain and uncertain environment due to globalization may cause significant disruptions and loss for companies. (Zainal Abidin and Ingirige, 2018)

Many disruptions have happened so far, and almost all of them happened unexpectedly. This paper will examine the world disruptions and its impact on supply chain management. The disruptions may occur due to various reasons such as natural disasters, human-made disasters, financial crisis, wars, economic recessions, and these have an impact on supply chain' and companies' activities.

The last and up-to-date disruption of supply and global trade has occurred due to Covid-19 Pandemic. This pandemic spread in few months to whole over the world. Governments, businesses have been locked down since the beginning of 2020. This pandemic impact is examined in this paper.

1.2 Research Purpose

The purpose of the research is that understanding disruptions impact on business activities such as current disruption event “Covid-19”. The data of this study collected by interviews with businesses during the Covid-19 Pandemic. The pandemic affected most of the world such as America, Asia and Europe severely. Most of the manufacturing companies have shut down temporarily because of the coronavirus outbreak. (PRNewswire, 2020)

The coronavirus pandemic is so disruptive for businesses because global sources of business make it harder to decide respond. For example, Asian suppliers help to reduce the cost of supply materials. Still, now it has disrupted, another example the safety stock level which companies want to keep the lowest stock level but companies have shut down temporarily due to lack of supply material. (Wharton, 2020)

“The impact of the coronavirus pandemic on global supply chains is a major disruption, along the lines of having an earthquake or a tsunami,”

(Morris Cohen, 2020)

The Covid-19 is transmitting very fast one person to another. This rapid spreading has pushed governments and businesses to take precautions. Governments took more extreme action than before to stopped impact of the illness. (Callaway *et al.*, 2020) The virus has a high effect on older adults, and the death rate reaches average over 13% for over 80 years past, also comparing with less than 40 years old, the death rate is around %1. (the ratios may show different level in a different region, this is an average of the world.) (WHO, 2020).

Turkey’s manufacturing industry has impacted due to Covid-19. The main reasons are;

- The demand has decreased, especially the biggest market of Turkish manufacturing industry, which is “EU.”
- The borders and docks’ activities have caused logistic delays
- The due to temporary shut down has caused inadequate supply materials.

(DHA, 2020)

Covid-19 pandemic has impacted the entire world as well as, stock markets, automotive industries, oil prices, airlines, manufacturers, service industry such as hotels and tourism, retail industries hit severely by a coronavirus. (Palumbo and Brown, 2020). The virus reached entire countries caused over 16 million cases and 650.000 deaths. Many business and governments are implementing different strategies to sustain the business. Many companies have been shut down due to lack of supply, labour shortages, regulations or low demand during a pandemic.

The focus of this dissertation is on the risks to and vulnerability to supply chains due to a pandemic. The research was carried out into how managers in manufacturing companies were able to deal with the impact of Covid-19 on their operations. Concepts such as ‘resilience’, ‘agility’, ‘supplier dependence’, ‘readiness’, ‘inadequate labor issues’ ‘demand volatile’ and ‘risk and disruptions’ are used in the literature to explain how managers can prepare for and deal with disruptions. What emerged in the research is a realization that managers need a much more precise understanding of each of these terms so that they can use actions related to those terms to put in place strategies to better prepare for the disruption caused by an event such as a pandemic.

The next step is using the research methodology to get information about the impact of Covid-19 on different industries to supply chain management to understand:

- When did companies perceive that Covid-19 might impact their business?
- When did companies start to take action to mitigate the impact of Pandemic’s disruption affect?
- How were companies affected / or what were the main issues that were raised during the period due to Pandemic?
 - For **Resilience** - how were they able to absorb the disruption without significant damage to their business?
 - For **Agility** – how were they able to change their operations to respond to the Pandemic?
 - For **Preparedness** – how well were companies prepared?
- Where are the biggest problems in supply chains due to Covid-19? (customer side, logistic, staff so on)
- What are the lessons that can be learned for the Next Pandemic?

2. Literature Review

2.1 Overview

The Turkish manufacturing industry has significant importance on Turkey's economy and has been contributing Turkey's %22 per cent of Gross Domestic Products. (Koç, Şenel and Kaya, 2018) These products have been contributing by 95% of Turkey's income from exports. Turkey's top export countries are Germany, USA, UK, Italy and Spain, which the money amount respectively; 1.2, 0.88, 0.80, 0.54, 0.5 Billion Dollars. As well as, Turkey has sold to EU Countries 48% of industry products. In terms of import rates, Germany, USA, China and Russia are the top countries and the number of products between 1.5 and 1.9 Billion Dollars. Coronavirus impacted by decreasing the ratio of exports to imports by 18%, which was 89 % in 2019 and 71 % in 2020. (AA, 2020)

The supply chain and its driver aims to reach the optimum result of customer satisfaction in terms of cost, time, quality. Supply chain management is achieving these terms by choosing the correct strategy. The supply chain management takes into account many factors before making a decision such as customers, suppliers, demand, logistics, inventory, operations so on. These all factors, impact companies' cost, profit, brand image, etc. (Morris and Pinto, 2005)

Global industries such as automotive have nearly stopped all operations due to the spread of the COVID-19 (Richardson, 2020). This unexpected occurrence, the effect of the pandemic on businesses were more than any other previous disruption caused by transport failure, strikes, 2009 financial crisis, 9/11 terrorist attack (Jonathan, 2018). Covid-19 has disrupted and exposed vulnerabilities of companies because of depending on suppliers as a country or company (Offerman, 2020). For instance over two examples, firstly, the Asian manufacturing industry dominating the world trade as China has controlled over 15% manufacturing of the world, and the lockdown situations due to COVID-19 have taken place over 100 countries. Secondly, Apple has a supplier in 43 different countries. Therefore Apple's operations have been affected. The supply chain problems caused shutdowns in many industries, such as aviation, tourism, and many other sectors already (Sheffi, 2020). Besides that, he added, "The most vulnerable companies are small and those dependent on suppliers upstream in the supply chain that is in danger of going under."

2.2 Definitions

2.2.1 Supply Chain Management

Today's business world has experienced intense competition. Businesses have become increasingly aware of the importance of supply chain management to consolidate and maintain their workplace; thus, managers have realized that they must work together with other companies in the chain as strategic partners (Ballou, 2006).

“Supply chain is a sequenced network of business partners involved in production processes that convert raw materials into finished goods or services to satisfy the consumers' demand.”

(Mensah & Merkurjev, 2012)

In this definition, each business partner is contributing the materials to have finished-goods. These partners have an essential role in the whole supply chain because of the high amount of money and significant numbers of materials flow in this process. Small changes or mistakes can cost a substantial value loss for the companies (Kopczak and Johnson, 2003).

Supply chain business partners are connected by the flow of money, materials, and information on this sequenced network which has illustrated by (Mensah and Merkurjev, 2014) in figure1.

Figure 1 A Simple Supply Chain

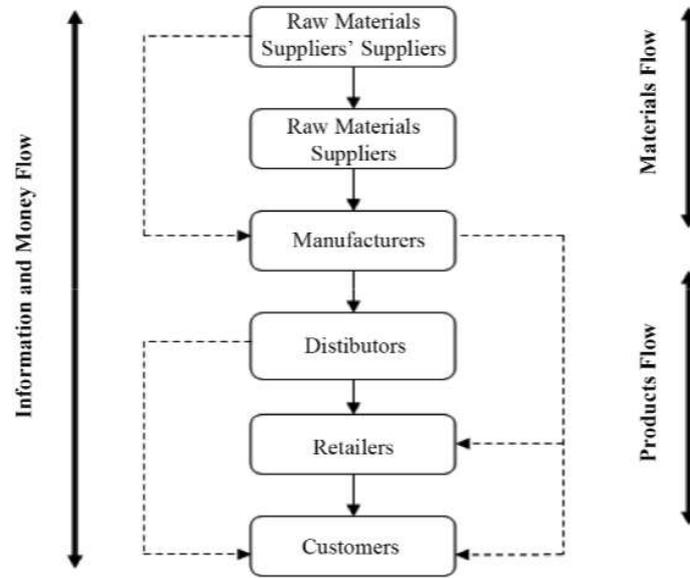


Fig. 1. Simple supply chain stages (prepared by authors)

(Mensah and Merkuryev, 2014)

Many authors have contributed to defining the supply chain and supply chain management:

“A simple supply chain includes raw materials suppliers’ suppliers, raw material suppliers, manufactures, distributors, retailers and customers.”

(Pienaar, 2009)

“A general description of the process integration involving organizations to transform raw materials into finished goods and to transport them to the end-user.”

(Lee and Billington, 1993)

“A group of inter-connected participating companies that add value to a stream of transformed inputs from their source of origin to the end products or services that are demanded by the designated end-customers.”

(Lu, 2011) ,

“The traditional supply chain process was working in a sequential line, and it was only a process of order fulfilment. All money, material and information flow on this line in order.”

(Kopczak and Johnson, 2003)

“Supply chain management many different areas it starts with raw material or first producer, and it ends with the customer. All over the period has an essential engagement with the supply chain process. So that every step of this process includes many different problems.”

(Kopczak and Johnson, 2003)

“Supply chain management seeks to achieve and coordination between the processes of other entities in the pipeline, i.e. suppliers and customers and the organization itself. The goal of supply chain management might be to reduce or eliminate the buffers of inventory that exist between organizations in a chain through the sharing of information regarding demand and current stock levels.”

(Christopher, 2016)

A supply chain is a network of manufacturers and service providers that work together to create products, or collectively through physical flows, information flows, and monetary. When the primary focus is on physical goods, much of the supply chain activity will revolve around the conversion, storage, and movement of materials and products. (Bozarth and Handfield, 2015)

The supply chain's main aim is to increase the productiveness for customers and producers (Chopra and Meindl, 2013). The Supply chain's steps contribute to cost reduction and deliver value to the customers. Therefore, supply chain management has a substantial impact on companies' activity in terms of success level. Supply chain management consists of the flow of money, information, and product. Well managed

supply chain reduces cost and reaches the maximum level of product effectiveness at the right time and right place (Chopra and Meindl, 2013).

The Supply chain process is consisting of many inputs that make this process quite complicated, and many uncertainties may occur throughout the whole steps. This uncertainty causes costs for companies so that it causes costs for customers. Supplier performance such as transportation quality, sharing information with other partners tries to catch standardization in terms of the process of manufacturing, direct impact on product quality, and productiveness. Manufacturing must pay enough attention to demand. For example, for more productive determining bottlenecks, helps increasing company productiveness. Another issue is the conditions of the product, especially natural spoiled products that have a high cost for the company, and the other one is customers' demand for more information for spoiled natural products. Customer demand is the other meaningful side of the supply chain. These can provide companies with a competitive advantage if they succeed or can challenge companies. (Davis, 1993)

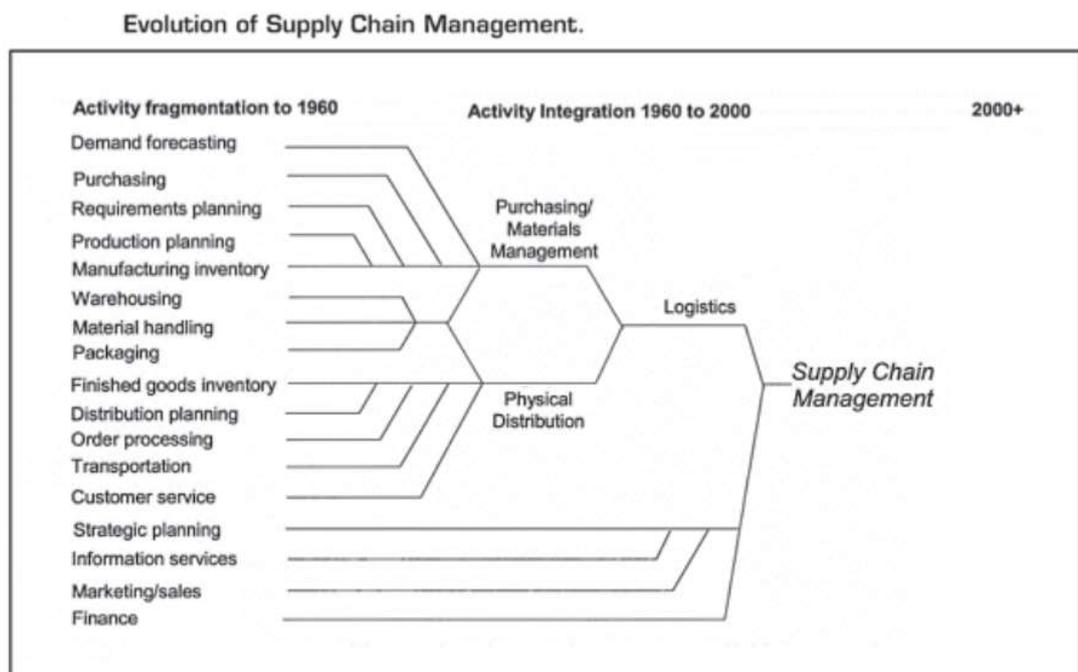
Supply chain management is an examination if each part of the supply chains (Janvier-James, 2012) thus, the stages discussed in the if not managed accordingly, organizations would find themselves underperforming that can lead to a loss in competitive advantages and profitability. Just like the supply chain, supply chain management consists of various definitions. Recently, the Council of Supply Chain Management Professionals states that *“supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers”* (CSCMP, 2013)

Furthermore, supply management and purchasing professionals should play the leading role in operations between the upper and lower levels of the supply chain as they would be able to manage and monitor costs. It should also be made clear that some of these stages are run by different companies making the flow of information vital. (Mensah and Merkurjev, 2014)

Supply chain management is straightforward for companies not to make significant errors when forecasting the demand of their customers. Such mistakes will affect the whole supply chain from the upper level to the lower level. Besides, as the competition among rivalry companies is fierce, it is quite natural for customers to switch. Moreover, there should be an accurate flow of information, materials, and product along the supply chain, as this would ensure visibility, integrity, and transparency. All of these are a stepping stone in developing a supply chain resilient strategy, which is discussed in the next section (Mensah and Merkuryev, 2014).

Supply chain management has evolved since 1960, and its context has covered more areas nowadays, which is illustrated in Figure 2. (Ballou, 2006)

Figure 2 The Evolution of Supply Chain Management



(Ballou, 2006)

This evolution proves us supply chain management has a relation to many areas and a few reasons of how vital supply chain management and as a summary;

One of the most important reasons behind this is; companies realize that the cost savings can now be achieved by managing supply chains most efficiently and it's efficient because other companies have already been doing well stimulating the different processes. If the company has a unified and experienced supply chain management, it can manage many essential parts of businesses.

The other outstanding point of the supplier reliability is consisting of goods' quality, transportation process, customers, demand and transparency, time issues, opportunity cost issues, etc. Because a business' performance depends on supplier performance and its product performance, the supply chain has always been issued by industry because it is not easy to track actions outside of the company due to expensiveness.

Consequently, from Figure2, considering the manufacturers, various business functions including research and development, operations, etc., should be capable enough to effectively manage the materials, products, money, and information flow between the upper and lower levels of the supply chain. Moreover, these business functions must be cross-functional to operate successfully in today's competitive world. (Ballou, 2006)

Managing the supply chain is quite a challenging task as supply chains are more sophisticated today. Although the operational efficiency of a well-structured supply chain is high, the risk involved is still a concern. It should not be neglected, as "in today's uncertain and turbulent markets, supply chain vulnerability has become an issue of significance for many companies." (Christopher and Peck, 2004).

Many organizations, both public and private, embraced the discipline of supply chain management (SCM). These organizations adopted several SCM- related concepts, techniques, strategies such as efficient consumer response, continuous replenishment, cycle time reduction, vendor-managed inventory systems, and so on to help them gain a significant competitive advantage in the marketplace. Companies that have effectively managed their entire supply chain, as opposed to their firm, have experienced substantial reductions in inventory- and logistic-related costs, shorter cycle times, and improvements in customer service. The retail and the traditional manufacturing industries have enjoyed great success by adopting the principles and strategies of supply chain management. More recently, project-based organizations have also realized that the use of SCM-related policy can significantly enhance value in projects.

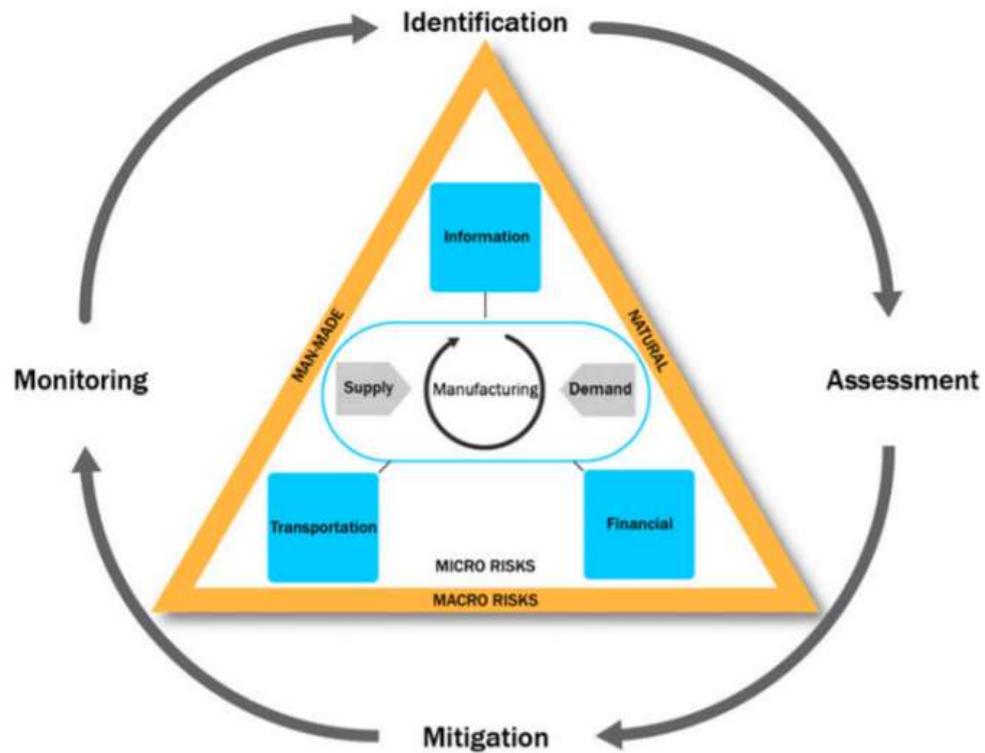
Supply chain management is a set of approaches that can be used to integrate the network of all organizations and their activities in producing and delivering a product or undertaking and completing a project so that systemwide costs are minimized while meeting or exceeding customer requirements. Given the intense global competition, the business has to embrace practical supply chain management approaches to remain viable and provide value to their customers. Significant benefits accrue to companies that effectively manage their supply chains. The benefits include lower costs, satisfaction, and higher profits. (Cottrill, 1997)

2.2.2 Supply Chain Risk

Risk is a chance or probability of injury, hazard, or loss. (Terje, 2004). Supply chain risk refers to the risks which affect the movement of an efficient process of information, materials, and products among different parts of the supply chain in an organization or a global supply chain. (Badea et al., 2014) There are only a few authors explicitly defining supply chain risk even though the supply chain risk term has been increasing its importance. (Heckmann, Comes and Nickel, 2015)

The risk may occur internally originated or externally originated, and external originated risks generally more severe impact than internal threats. (Sawik, 2018) Risks generally happen inwardly, but external risks are high impact risks which may low probability but cause significant damage when they do occur. Examples of these include disasters such an earthquake, terrorism, tsunami, SARS, etc. (Tang, 2006). Supply chain risks impact an entire chain, and these risks examples are demand, supply, materials, and information flow. (Martin and Lee, 2004). Risks interrupt the supply chain and may generate an inadequate supply to end-user due to a variety of reasons. (Mensah and Merkurjev, 2014) These risks are defined as supply-demand unbalances, security problems, customer satisfaction issues, lack of process and information efficiency, as well as, supply chain disruptions which natural or human-made disasters may have a direct impact on supply chain process. (Mensah and Merkurjev, 2014) In another definition risk defined as “*the possibility and effect of mismatch between supply and demand*” by (Heckmann, Comes and Nickel, 2015)

Figure 3 Conceptual framework of supply chain risks



(Ho *et al.*, 2015)

Risk is categorized as **Micro Risks** and **Macro Risks**. (Sodhi and Tang, 2012) The macro risk is named as **external risks** and may occur either **Man-made** (war, terrorism) or **Natural**(pandemics). Micro risks are defined as **internal risks** and divided into four subcategories: **Demand Risk, Manufacturing Risk, Supply Risk, and Infrastructural Risk**. (Ho *et al.*, 2015) Supply and demand may change after a triggering event, and it may occur at upstream and downstream flows of the supply chain. One of the biggest challenges facing organizations today is the need to respond to ever-increasing levels of volatility in demand. For a variety of reasons product and technology life cycles are shortening, competitive pressures force more frequent product changes, and consumers demand greater variety than ever before. To meet this challenge, the organization needs to focus its efforts upon achieving greater agility such that it can respond in shorter timeframes both in terms of volume change and variety change. In other words, it needs

to be able quickly to adjust output to match market demand and to switch rapidly from one variant to another. To truly agile business volatility of demand is not a problem; its processes and organizational structure, as well as its supply chain relationships, enable it to cope with whatever demands are placed upon it. (Christopher, 2016)

Flowing of materials starting from raw material to end-products on upstream line which upstream aim increase the product more related to supply and inventory. Still, at the downstream edge, finished goods flow to end-user or customers. This is more likely to refers to demand. (Quain, 2019) Manufacturing risks are related to the production process, such as quality, timing, profitability. As well as information technology, transportation, and financial management risks may reveal a supply chain disruption. (Wu, Blackhurst and Chidambaram, 2006)

Risk and Vulnerability

(Wagner and Bode, 2006) categorized the risks in similar ways which are “**Demand-Side Risks, Supply-Side Risks, and Catastrophic Risks**”. Demand risks are necessary transportation, in which the problem arises to deliver top products to the customers. The second issue is if forecasted demand and actual demand are not balance. Supply-side risks are may product design changes, inappropriate supply, or logistic delays. The authors mentioned lastly about catastrophic risks are which may economic crises, hurricanes, wars, earthquakes, terrorism. The other point is if there is a problem in a part of a supply chain, it may impact whole supply chain performance due to globalization. (Monostori, 2018)Supply chain **vulnerability** is defined as:

“The condition is caused by time and relationship dependencies in a company’s business activities in supply chains. The degree of vulnerability may be interpreted as proportional to the degree of time and relationship dependencies, and the negative consequence of these dependencies, in a company’s business activities towards suppliers and customers’

(Svensson, 2002)

Supply chain vulnerabilities’ drivers are illustrated as “*customer dependence, supplier dependence, supplier concentration (a small number of suppliers, or as extreme, single sourcing), global supply (increased uncertainty, more mediocre transparency and visibility)*”. (Monostori, 2018)

As a result of this section, risks are identified and explained in different ways. The conventional explanation of risks defined as *“the occurrence of an incident with the inability of the affected companies to cope with the consequences.”* (Heckmann, Comes and Nickel, 2015). Risks cause ambiguous and vague atmosphere for companies, and it is hard to control. So we understand there are always risks outside or inside businesses and may occur due to many reasons. (Heckmann, Comes and Nickel, 2015)

2.2.3 Supply Chain Risk Management

Supply chain risk will always exist during the life of business which we mentioned about risk types in the previous section. The risk may not be exposed, but they can be managed and reduced impact on business. In this section, we are going to focus on supply chain risk management.

Supply chain risk management has been extensively studied over the past decade. Many researcher address variety of risks such as operational, disruption risks, information risks, financial risks etc. (Gurnani, Mehrotra and Ray, 2012) Operational risks are referred to as the inherent uncertainties arising from the problems of coordinating supply and demand, such as uncertain customer demand, uncertain supply, unpredictable cost, and uncertain lead-time and delay. Disruption risks are referred to as significant disruptions. These are typical activities (disruptions of material flow, information flows) caused by natural and human-made disasters such as earthquakes, floods, hurricanes, etc. or equipment breakdowns, economic crises such as currency devaluation, labour strikes, terrorist attacks.

Supply chain risk management is *“the identification and management of risks for the supply chain through a coordinated approach amongst supply chain members to reduce supply chain vulnerability as a whole, to increase resilience”* (Ceryno et al., 2013)

”Supply chain risk management aims to minimize, monitor, and control the probability and impact of uncertain disruptive events and therefore guarantees high performance, profitability, and continuity.” (Ceryno et al., 2013)

The main of supply chain risk management “*to determine, implement, and monitor an optimal combination of measures to avoid, defer, reduce, or transfer all relevant risks*” (Hofmann *et al.*, 2014)

Supply chain risk and disruption management seeks to address and manage a firm’s exposure to supply chain risks either proactively or reactively (Craighead *et al.*, 2007) (Bode and Macdonald, 2017)

Typical supply chain decision problems focus on the supply chain network design and facility location, supplier and vendor selection, pricing and contracting as well as concepts of information-sharing regarding, for example, the bullwhip effect as well as collaborative planning, forecasting, and replenishment. (Fahimnia *et al.*, 2015) Which bullwhip effect is defined as “*the variance of orders may be larger than that of sales, and distortion tends to increase as one move upstream*” (Lee, Padmanabhan and Seungjin Whang, 2004)

2.2.4 Supply Chain Disruptions

Today’s global trade due to high-level competition reduces profit margins. Companies are seeking for lowering the cost of production. Companies are focusing on outsourcing and providing materials from fewer expensive countries in which Asian countries are providing less expensive which is around 15-20%. (Molloy, 2009). Mainly western countries’ suppliers base on Asian suppliers. Depending on predominantly Asian suppliers makes supply chains weaker, and in case of any incidents, the supply chains are disrupted easily. (Kumar and Eickhoff, 2005)

Supply chain disruption defined as;

“Unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain (Svensson, 2002) and, as a consequence, expose firms within the supply chain to operational and financial risks. (Stauffer, 2003).

(Craighead *et al.*, 2007)

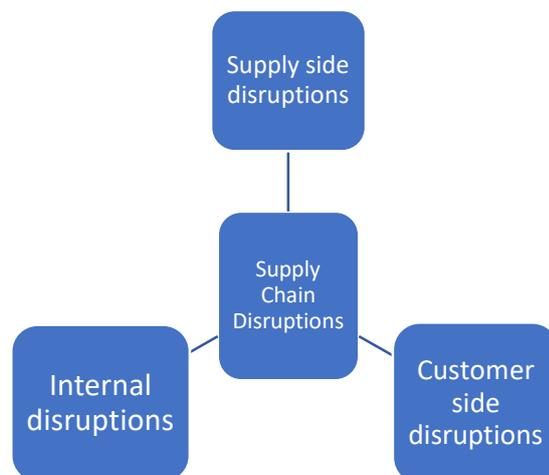
Supply chain disruptions are considered to be a combination of an unforeseen triggering event and the resulting consequences which jeopardize the flow of material and practical

business activities significantly (Wagner and Bode, 2006), and may expose risks for companies finance and operations. (Craighead et al., 2007). Disruptive triggers can be categorized into natural (earthquake, floods, fire, etc.) and man-made (terrorist attacks, accidents, supplier bankruptcy, etc.) triggers. (Fahimnia *et al.*, 2015).

Supply chain disruptions' risks have increased over the last decade due to the progress of globalization as well as outsourcing and an intensified focus on efficiency and lean management. (Stecke and Kumar, 2009) Just-in-Time is based on a 'pull' system of production in which products are manufacturing when demand occurs. Companies reduce the cost of keeping minimum level inventory as raw materials and finished products. Companies have reduced costs under normal level supply flow, but disruptive events may cause stopping manufacturing due to lacking supply. (Käfer, 2007)

Disruptive events impact the operation of a business which (Habermann, Blackhurst and Metcalf, 2015) state disruption three categories and these are; **Internal disruptions**, **Supplier** and **Customer Side disruptions** which refer to external disruptions. Internal disruptions: These disruptions occur the event hit companies' operation process, which may happen due to machine braking downs, fire, other technical problems. Supply-side disruptions: These disruptions occur on the inbound or supply-side in which a triggering event hit the suppliers, and inadequate supply directly impacted company operation. Customer side disruptions: These disruptions occur on the outbound or customer-facing side of the supply chain. (Habermann, Blackhurst and Metcalf, 2015)

Figure 4 Supply Chain Disruptions



(Habermann, Blackhurst and Metcalf, 2015)

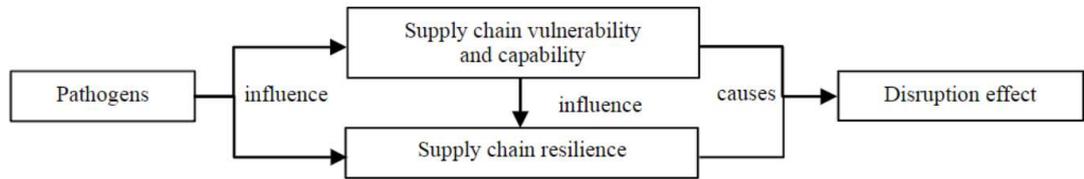
Supply chain disruption causes uncertainty for the whole parts of the supply chain. It reveals an ambiguity for everybody's actions to make decisions for company strategy. Supply chain disruption is affecting the efficiency of the supply chain because of the decision-makers have no enough information and financial drivers. (Aguila and ElMaraghy, 2019)

Supply chain disruptions jeopardize the ability of sales, profitability, costs, and stocks in a contrary way. (Hendricks and Singhal, 2005) In which these parameters may not affect the same level to different companies. Phillips's example of supply chain disruption illustrated different effects on two global companies Ericsson and Nokia. (Latour, 2001) There was a fire that happened in the microchip factory of Philips, which was the leading supplier of Ericsson and Nokia. The fire reduced the entire stock to ash. Nokia quickly sought solutions such as changing models and finding an increasing level of alternative suppliers and configure new microchips and recovered very fast.

On the other hand, Ericsson decided to work only Philips and waited for supply. Ericsson merged with Sony to remain its manufacture. Losing the only supplier has resulted in severely impacted damage. (Norrman and Jansson, 2004)

Pandemics are not only impacting people but also impacting businesses like pathogens. (Zainal Abidin and Ingirige, 2018) used the concept of pathogens for business. The author mentioned the word "pathogen" is a reason to cause breakdown or failure in the entire supply chain. In another way, the pathogens are seemed generally unexpected time and style and prevented successful supply chain flows. (Barroso, Machado and Cruz Machado, 2008) Pandemics or other triggering events influence the supply chains. If the influence level higher than supply chain capability or low supply chain resilience causes disruptions. Figure 6 illustrates the impact of pathogens on the supply chain. (Zainal Abidin and Ingirige, 2018)

Figure 5 Pathogens Cause Disruptions

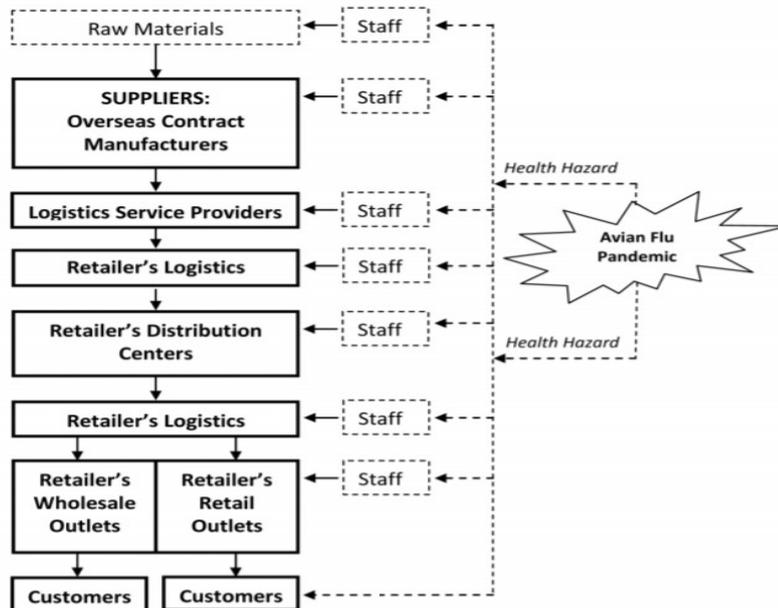


(Zainal Abidin and Ingirige, 2018)

The author mentioned the word “pathogen” is a reason to cause breakdown or failure in the entire supply chain. In another way, the pathogens are seemed generally unexpected time and style and prevented to successful supply chain flows. (Barroso, Machado and Cruz Machado, 2008)

Coronavirus pandemic has impacted business for each part of the supply chain because of people factor. Supply chain management, as mentioned before, which is covering a process raw material to end-user. Kumar and Chandra, 2010) has illustrated the human impact on supply in Figure 6.

Figure 6 Retailer’s Global Supply Chain with Avian Flu Pandemic

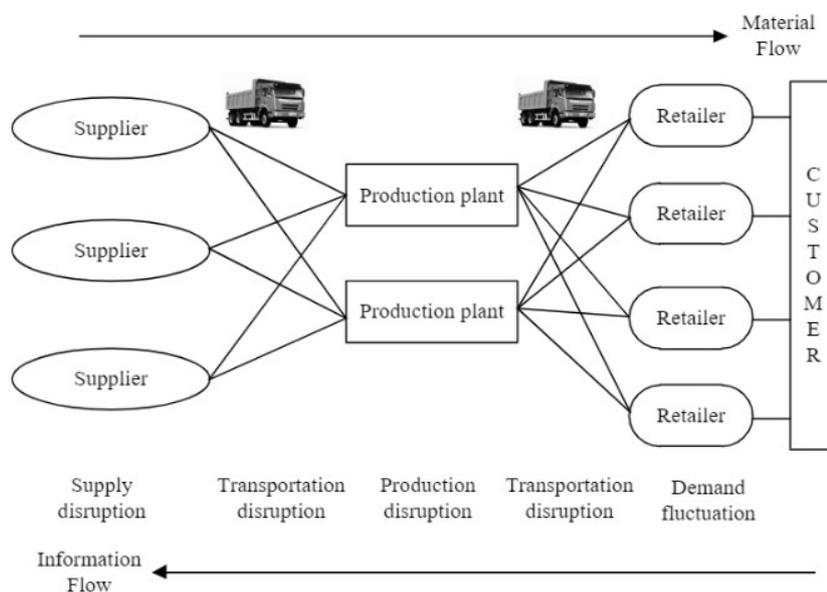


(Kumar and Chandra, 2010)

Kumar and Chandra, 2010) illustrated how the virus impacted a business such as the retail industry. Pandemics impacts the population, which consists of customers and entire supply chain staff. Governments and other responsible foundations implement regulations to mitigate the impact of pandemics. After applying rules and laws cause disruptions on the supply chain, which illustrated above Figure 6.

According to (Paul, Sarker and Essam, 2016) disruption risks divided into four categories: (i) disruption in production, (ii) disruption in supply, (iii) disruption in transportation, and (iv) fluctuation in demand, which are shown in Figure8, which each category has impacted at a different level due to impact of people.

Figure 7 Different Disruptions in A Manufacturing Supply Chain System



(Paul, Sarker and Essam, 2016)

Supply chains are more complex than before, and it includes many factors such as suppliers; retailers, manufacturers, locations complexity caused more vulnerable supply chains. Globalizations has increased diversifying of materials and marketing has impacted and supply chains because customer behaviour has a critical impact on demand

hence on the supply chain. Supply and demand balance high correlated with marketing activities. Customer satisfaction has increased importance during a pandemic because pandemics has an impact on demand, and understanding customer behaviour helps to understand the situation. *“Customer Relationship Management the first must be shaped to understand customers’ expectation and the second firm's requirements”* (Akkılıç, 2016). Disruptive events directly volatile demand for different on products such as compulsory products has increasing importance such as medical and food industry on the other hand second required products has decreased during the disasters, terrorist attacks so on. Companies have different impact level and risk throughout disruptive events. (Christopher, 2016)

2.2.5 Supply Chain Disruption Management

Supply chain disruptions are stoppages of material, information or money flowing on supply chains. There are few definitions made by authors:

(Marszewska, 2016) define as

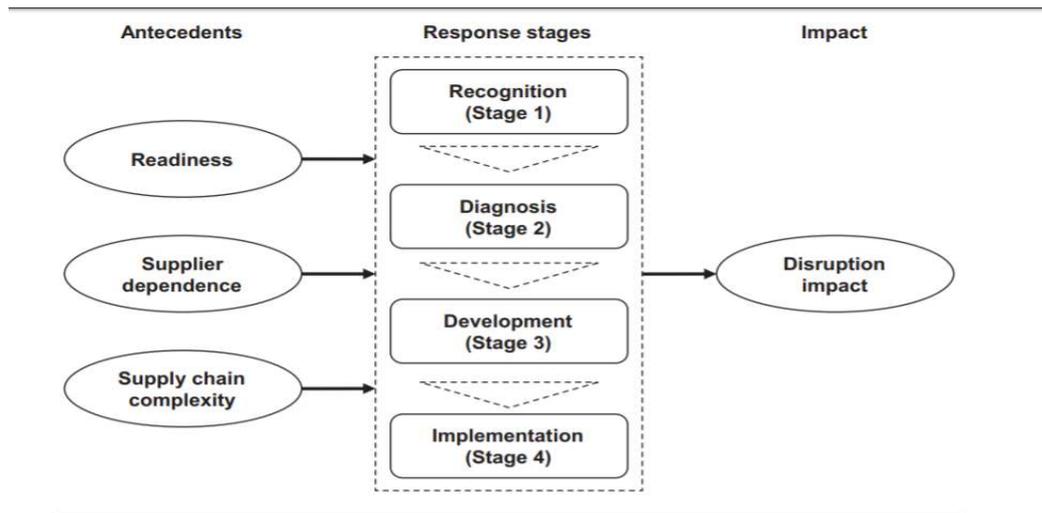
” Supply chains disruption management has become a vital part of a supply chain management strategy. The low-probability and high-impact flow disruptions and the resulting losses may threaten the financial state of firms.”

(Park, Hong and Roh, 2013) added that

“Disasters do not routinely occur; they happen unusually and extraordinarily. Thus, managing disasters requires useful risk, management models.”

(Macdonald and Corsi, 2013; Sawik, 2018) used a similar concept of definitions like above.

Figure 8 Supply Chain Disruption Antecedents



Total Response Speed “The important thing is to act and act fast,” stated (Galbraith, 1973). The companies that less impacted by disruptions can achieve success by reacting fast to the whole stage of the supply chain. Making fast decisions depends on information confidence. The lack of information increases uncertainty and hard to provide correct and quick resolutions, according to (Bode and Macdonald, 2017) as an example of a driver explain better this. A driver drives at night-time and realizes a sign which has not seen before then drivers slow down in the most situation. After checking and understanding, then the driver goes back to normal after if they solve the issues in their mind because the new case makes him slower until he understands the environment.

Another critical point is the speed of individual stages decision as much as full decision speed. The first stage in which the recognition stage is essential to give overall choices. Decision-makers ' capability to diagnose fast increases the entire recovery time. (Bode and Macdonald, 2017)

This for stages of performance impact the total response of the company. One of these 4 stage's mistakes caused failing the whole process. The author resembles it as a "bottleneck". Even if other parts work perfectly, one can make it unsuccessful throughout entire supply chain management. As a given an example, the recognition delays cause whole stage delays. (Bode and Macdonald, 2017)

The first, Response Stages as Mediators of Disruption; Three crucial antecedents to the impact of disruptive events and the response formation are now considered: readiness, supplier dependence, and supply chain complexity. (Bode and Macdonald, 2017)

Readiness; Responding to the supply chain disruption mainly depends on readiness ability(Ponomarov and Holcomb, 2009), also (Van Wassenhove, 2006) added about readiness " core competency of many humanitarian organizations involved in disaster relief and an area which the private sector could draw on to improve their competitive edge". According to (Macdonald and Corsi, 2013), readiness is the main factor in recovery after a disruption. Besides, it helps to understand faced issues as much as quickly and to respond to accomplish. (Langer, 2016)

The second essential considerations are " **being dependent on supplier**" (Zsidisin and Ellram, 2003). Supplier dependence is a significant impact on companies' acts, and the managers generally have concerns about this dependence as a risk factor. The dependence of suppliers increases losses in a situation of disruption. (Manuj and Mentzer, 2008). The high level of competition and other pressures on managers causing the vulnerable and dependence supply chain because the interdependent supply chain requires more time, effort and information which may cost more in an ordinary day. Dependence of suppliers impact reveals in disruption times. (Srinivasan and Swink, 2015)

The third important factor that has a negative impact on the performance of the supply chain is "**complexity**". In this case, the meaning of this word is too many inputs, and outputs flow such as materials, monetary, and information. (Bozarth *et al.*, 2009) The complexity may occur due to stock market reactions which companies increase their level of outsourcing. If there happens a disruptive event, it will impact to directly to the company. (Hendricks, Singhal and Zhang, 2009) According to (Perrow, 2011) the complexity related to "normal socioeconomic systems" and it refers to the interactions between technical infrastructures and human. It is hard to manage under high-level

complexity. Besides this, complexity makes it harder to understand and solve the problems or disruptions, so it takes time because the disruptive events come up unexpectedly.

The examination of the response stage which (Bode and Macdonald, 2017) mentioned in his paper, reducing the impact of disruption related to acting fast like gathering information and understanding circumstance, in this case, each part of supply chain element's performance affected the result and response effectiveness.

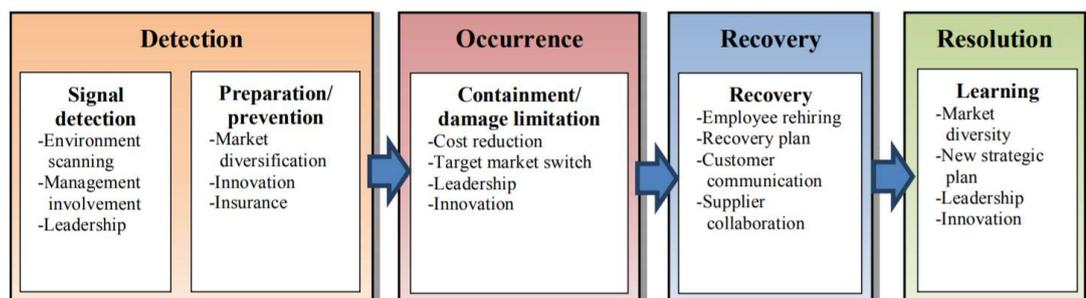
The accelerated recognition and implementation response process can reduce the disruption impact. Still, they can render less effective if the information gathered and processed as part of the diagnosis stage becomes a constraining factor and is not worked through quickly. Efforts to improve risk management often results in greater readiness, which also accelerates each step of the recovery process. (Bode and Macdonald, 2017)

The disruptions discussed here are primary and high profiled, and if occurred, the results could be catastrophic for organizations. They might end up in bankruptcy or terrible loss in profits. Additionally, "in today's uncertain and turbulent markets, supply chain vulnerability has become an issue of significance for many companies, and appropriate research on the resilient supply chains are yet to be conducted" (Christopher and Peck, 2004).

The supply chain resilience depends on how the company able to manage a crisis when it occurs. Crisis management consists of 4 stages. These are:

Detection Stage, Occurrence Stage, Recovery Stage and Resolution Stage.

Figure 9 Supply Chain Disruption Management



(Hong, Huang and Li, 2012)

In the detection stage, It is mainly understanding the environment and picking information and analyzing. Management and leadership are crucial to the impact of disruptions as preparing the company to deal with the situation with fewer losses. The detection stage, before the crisis happens or it happens but not impact the own business yet.

In the occurrence stage, the disruption or crisis is reacting to the market, companies, and whole supply chain sharers. After the impact of disruption, companies focusing on reducing costs, switching markets and suppliers. Reducing cost for companies mainly by laying-off staff, stopping other activity places if there are more than one, buying a fewer number of products.

In the recovery stage, it is time for going back to the level before disruption or crisis happens. At this stage, the action reverses to the occurrence stage, such as rehiring staff, etc.

In the resolution stage, the firms start to act at the same level as before a crisis or disruptions. This stage's important side is analyzing the whole process of resilience. Which how firm reacted and how should it have done so the management must make ready to company for next disruptions and crises (Hong, Huang and Li, 2012).

2.2.6 Supply Chain Resilience

The dictionary definition of “resilience” is “the ability of people or things to recover quickly after something unpleasant, such as shock, injury, etc.”

According to this definition, many authors make similar definitions for the supply chain.

“Resilience is the ability of a system to return to its original state or move to a new desirable state after being disturbed.”

(Husdal, 2008)

“The ability to bounce back from large-scale disruptions.”

(Sheffi, 2008).

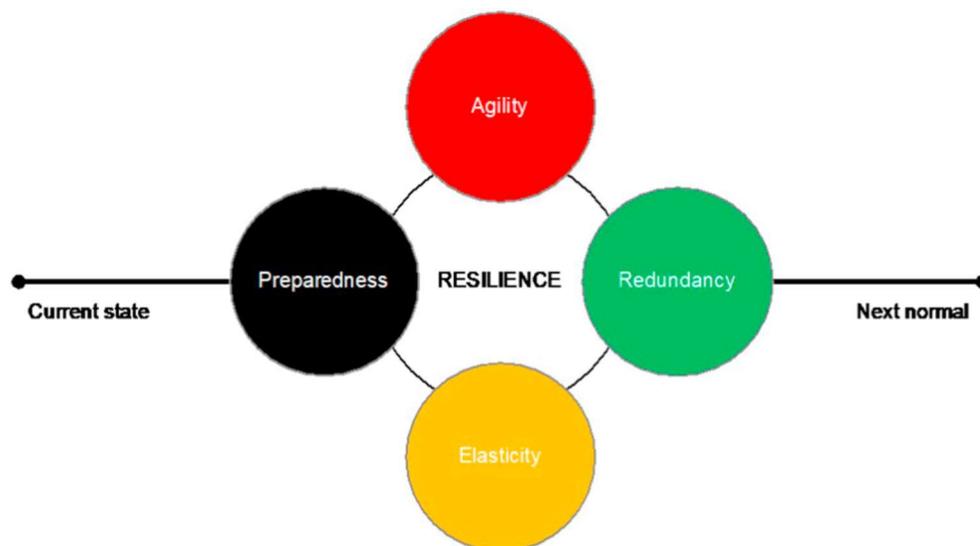
Resilience is the ability to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level.

(Ponomarov and Holcomb, 2009)

Resilience is the ability to overcome stress, and shocks also have different reactions in different areas. Some companies can manage the situation by using another resource, either local suppliers or international. But some industries such as tourism entertainment more vulnerable and disasters can cause more damage. Which impacts the business as well as the people who are working there. (Scherzer, Lujala and Rød, 2019)

According to (Rapaccini et al., 2020) supply chain resilience based on four elements and are **Preparedness, Agility, Elasticity** and **Redundancy** which are help firms to adopt the new situation and illustrated in Figure 10.

Figure 10 Supply Chain Resilience Elements



(Rapaccini *et al.*, 2020)

Supply chain management has been developing and becoming stronger day by day but, the risk is still there, and unexpected events, unfortunately, hitting companies severely. These events cause uncertainty, and the term **agility** has vital importance for companies. (Christopher, 2000).

“Agility is the ability of an organization to adapt or respond rapidly to changing environment both in terms of volume and variety.”

(Christopher, 2000); (Swafford, Ghosh and Murthy, 2006)),

In which, the agile supply chains, can react uncertain supply and demand to ensure a resilient supply chain. The notion of Agility revealed from manufacturing systems. (Nagel and Dove, 1991). Agility regards companies’ internal capabilities which respond and adapt as much as quickly to environmental changes. (Goldman, Nagel and Preiss, 1995).

One of the veterans of the supply chain, who is (Christopher, 2000), argued that Agility is an ability to respond to market changes. Agile supply chain-related with well-done market analyzing and using the tools of whole supply chain elements such as supplier, customer, technology, logistic which authors explain market changes in terms of “**Volume and Variety.**”

Another critical point is stated by (Kleindorfer and Saad, 2005) and (Sheffi, 2005), which the concept of “**early or weakest signals**” helps to increase to Agility and contribute to creating more reliable supply chains.

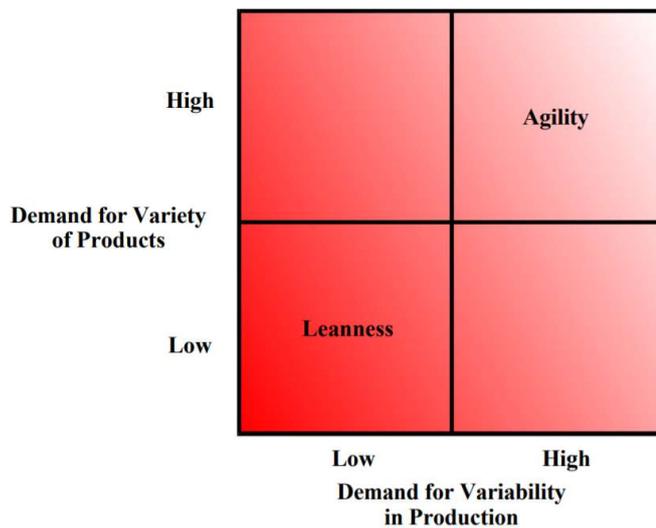
Agile supply chains are compared with lean supply chains by (Ben Naylor et al., 1999) which agile supply chains focusing market dynamics and aiming to increase the benefits under uncertain market situations. Still, lean supply chains and systems look for reducing whole complex inputs flow(material, product types, people coordination) the aim more to reach a “standard level activity” to increase profit and efficiency. The Lean system effective under low production and product volatile and cost-reducing is the priority.

The business starts to implement both approaches instead of sustaining only agile or lean systems. The term “leagile” is born using both methods to be closer to both sides. (Ben Naylor et al., 1999) illustrated agile and lean supply chain in figure 12.

“The term leagile is a combination of "lean" and "agile" and can be united for optimizing the management of the supply chain.”

(Bruce, Daly and Towers, 2004)

Figure 11 Leagile Supply chain:



(Ben Naylor *et al.*, 1999)

Lean and agile supply chain strategy work against each other. These strategies have different advantages for companies. These two edges sometimes cause crises for companies. So that man authors have suggested mixing two terms and using a leagile supply chain strategies to make a resilience supply chain which illustrated in Table1.

Table 1 Comparison of Attributes Between the Supply Chains Lean, Agile and Leagile

<i>Distinct Attributes</i>	<i>Lean Supply Chain</i>	<i>Agile Supply chain</i>	<i>Leagile Supply Chain</i>
<i>Market demand</i>	<i>Foreseeable</i>	<i>Volatile</i>	<i>Volatile and unforeseeable</i>
<i>Product variety</i>	<i>Low</i>	<i>High</i>	<i>Medium</i>
<i>Products life cycle</i>	<i>Long</i>	<i>Short</i>	<i>Short</i>
<i>Customers 'drivers</i>	<i>Cost</i>	<i>Availability and response time</i>	<i>Service level</i>
<i>Profit margin</i>	<i>Low</i>	<i>High</i>	<i>Moderate</i>
<i>Dominant costs</i>	<i>Physical costs</i>	<i>Marketing costs</i>	<i>Both</i>
<i>Inventory penalties</i>	<i>Long- term contracts</i>	<i>Immediacy and volatile</i>	<i>No storage space</i>

(Boschi, Borin and Batocchio, 2011) (Ben Naylor *et al.*, 1999) (Bruce, Daly and Towers, 2004)

The second key element is **preparedness** which is doing ready business to deal with the negative impact of disruptive events.

Preparedness is defined “reflect on the needs to re-build their businesses (bouncing back) to searching for new opportunities and enacting new ideas for development after the crisis event (bouncing forward)”

(Scherzer, Lujala and Rød, 2019).

According to the (Boschi, Borin and Batocchio, 2011), the disruptive events which are happened before is vitally important to get lessons and knowledge to be ready for the next. Companies are taking risks to be more competitive and get more profitable, but risk consequences may affect negatively and hit severely. (Svensson, 2002)

(Paton and Johnston, 2001) is pointed that argue that “*human beings tend to think that we are better prepared for any adverse circumstances than we are.*” So that before the disruptive event, the perception of the unexpected events is not the level of the expected, and it causes problems when a crisis revealed—the author points the importance of the correct level of inputs which is impacting the preparedness level.

Supply chain resilience is depending on how much the company is prepared for the crises before it happened, and it has a correlation with preparedness. (Haines, Crowther and Horowitz, 2008) Disruptive events are hitting more severe the companies which are not prepared itself before so that companies must consider their assumption under close to real probability. (Sanchis, Canetta and Poler, 2020)

The third element of supply chain resilience is **elasticity** which is defined as;

“increasing the exchangeability and flexibility of relationships among people and things within an organization and a wider ecosystem.”

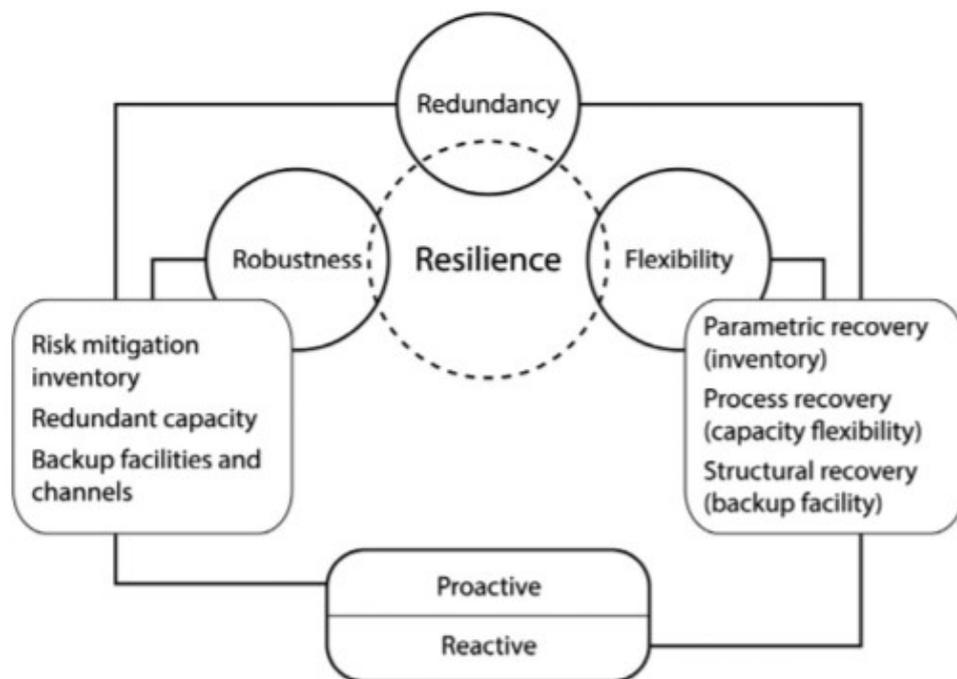
(Moldovan, Copil and Dustdar, 2018).

The elasticity is a crucial element of creating a resilience supply chain, According to (Dustdar et al., 2011) “cost, quality, people, and resource” are the main domains of the elasticity. The idea of the elasticity thinking all part as a one-piece, which is called “Collective Adaptive Systems” is named by (Anderson et al., 2013). Elasticity helps changes the system so that contributing the system to make a more resilient supply chain.

As well as, (Moldovan, Copil and Dustdar, 2018) is added: “ techniques, methods and process” of the elasticity is required for building a resilience supply chain.

Before explaining the fourth element of the **redundancy**, the similar concept of the supply chain resilience is illustrated by (Dolgui, Ivanov and Sokolov, 2018) in figure12. According to his concept of resilience is consisting of “**robustness, redundancy and flexibility**” which is are covering with similar areas with the explanation of the (Rapaccini *et al.*, 2020)’ s supply chain resilience elements mentioned above before, are preparedness, agility, elasticity and redundancy.

Figure 12 Supply Chain Resilience Elements



(Dolgui, Ivanov and Sokolov, 2018)

Supply chain resilience is elements according to these two authors definitions the elements are matched among them such as

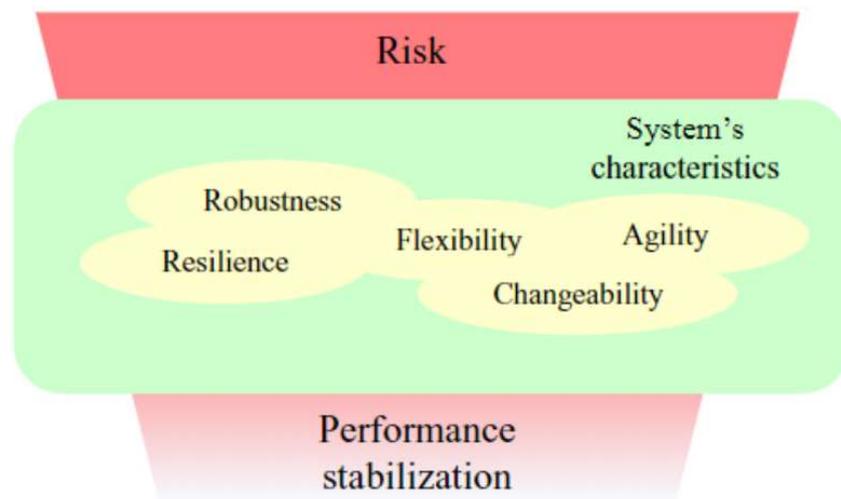
- Robustness / Preparedness,
- Flexibility / Elasticity,
- Agility
- Redundancy

Figure 12 summarizes the relationships between redundancy, robustness, flexibility and resilience.

Supply chain resilience is consisting of three elements, such as redundancy, flexibility, and robustness. Flexibility is a capability and provides to business configure and adjust the process and systems adapt to a disruptive environment in which the adaptation process is related to **recovery**. Flexible supply chains allow us to make changes to the Process, Structure of the facility, and process (Dolgui, Ivanov and Sokolov, 2018).

Supply chain resilience and its elements are illustrated in figure 14, which is called the “*supply chain system characteristics* “, and these are placed between the company’s performance and supply chain risks. (Stricker and Lanza, 2014)

Figure 13 Supply Chain System's Characteristics



(Stricker and Lanza, 2014)

Robustness is the more considering “capacity usage rate, inventory, capacity usage” during the disruptive event. The redundancy elements are “inventory, capacity, backup suppliers”. Flexibility works together with all supply chain elements, such as “planning, forecasting and replenishment”. As well as, internal manufacturing factors, such as

“process and product reconfiguration ability” is the matter under the flexibility of supply chain resilience element. (Dolgui, Ivanov and Sokolov, 2018) According to the author robustness and flexibility reduce the stress the management and respond to the new situation quickly before it causes dramatic results, reduce risks and costs and increase sales and service levels.

Supply risks are always there and supply chain management using different tools and strategies to reduce the impact of risk, which may cause disruptions. There are eight strategies to make a resilient supply chain. These are summarized by (Chopra and Sodhi, 2004) as; “*add capacity, add inventory, have redundant suppliers, increase responsiveness, increase flexibility, aggregate or pool demand, increase capability, and have more customer accounts*”. These strategies have impacts on supply chain risk at different levels. In Figure 14, the author compared all strategies and risks.

Figure 14 Mitigation Strategy



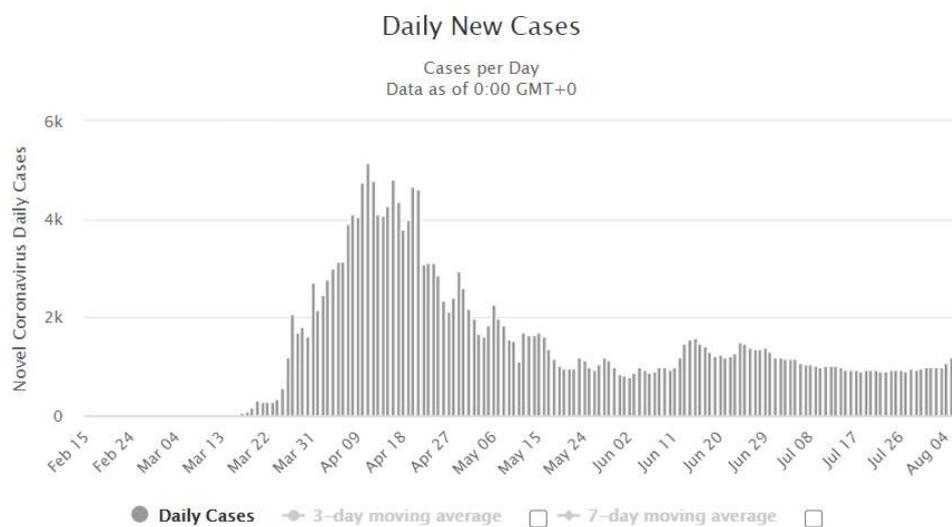
(Chopra and Sodhi, 2004)

2.2.7 COVID-19 (Coronavirus)

“COVID-19 is a new illness that can affect your lungs and airways. It's caused by a virus called Coronavirus.”(HSE, 2020). Total cases have reached almost 5 million, and 300.000 people have died so far. It is spreading fast, and the death rate is around 15%. Turkey has peaked cases in the middle of April the numbers have been reducing for the last 45 days. (Worldmeters, 2020)

Figure 15 Cases in Turkey

Daily New Cases in Turkey



(Worldometer, 2020)

COVID-19 has spread to whole countries at a different level. Corona pandemic not only impacted the health of the people also it has a significant impact on the entire part of trade sharers. According to the professionals, it will have to cause a big recession for whole countries and businesses.

The Pandemic impacted on different levels to diverse businesses due to the vitality or lack of supply and demand.

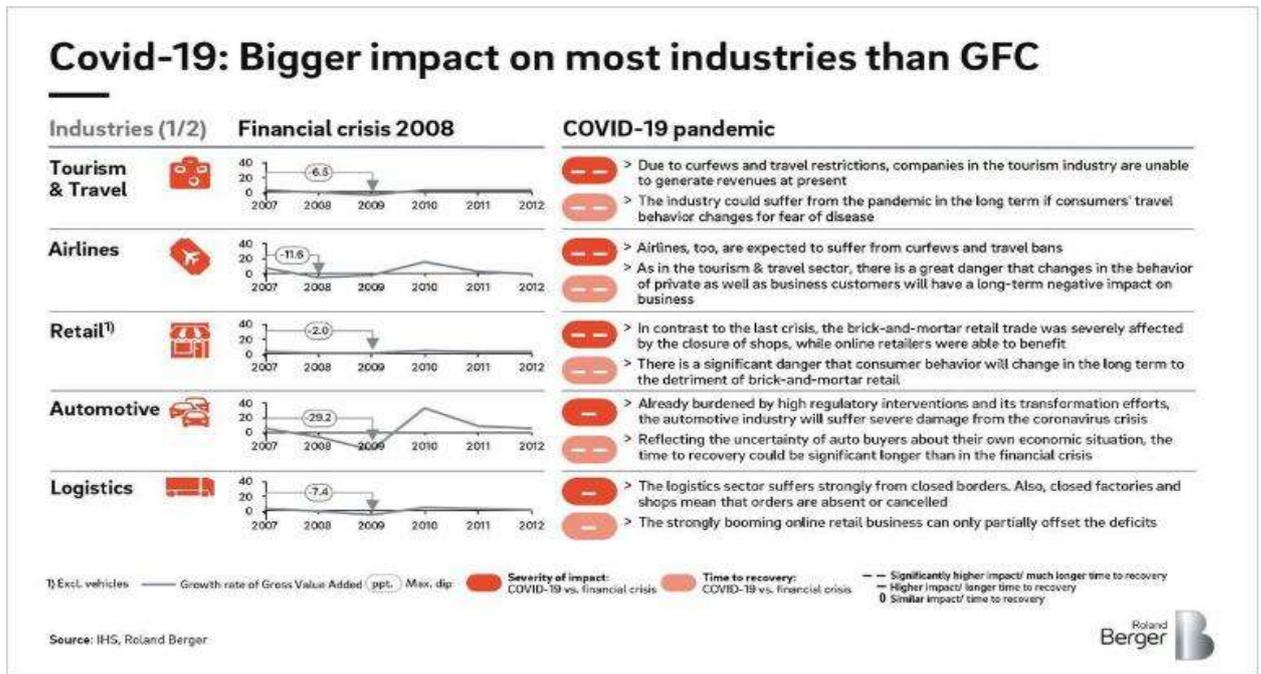
The **automotive industry** is impacted by high severity. Almost all car manufacturer shut down their business—the main reason behind this decision labor shortage and lack of enough supply—for example, Toyota, Honda, BMW, etc. (BBC, 2020) The **logistics industry** is impacted dramatically, and this weakness affected the whole global trade

flows. The sectors would be affected more if the time recovery time extended. On the other hand, some industries have vice-verso trend such as the **pharmaceutical industry** has been facing increasing demand. Still, the logistic problems and labor shortages are not allowing to answer the market. (Fuest, 2020)

The effect of the Pandemic has shown in countries. China's GDP decreased by 9.8% compared with 2019. Western countries have hit more dramatically than China, such as the EU and the US. This Pandemic will affect more industries than before, such as the 2008 financial crisis. The borders closed, airways are shut down, the Government's restrictions and other regulations due to reducing the spread of the virus. These bring the tourism industry to shut down. The pandemic impact will remain until to find a vaccine; the other options are people will immune to the virus.

In 2009, there was a global economic recession. It impacted many industries on a different level. (Berger, 2020) has compared the industries such as tourism, airlines, retail, automotive and logistics. 2009 financial crisis named as a "mortgage crisis" which caused an unbalanced economic structure. (Öztürk and Gövdere, 2010) The main reason for this crisis was the financial companies approved high-risk mortgages to lower-income people so that people weren't able to pay, and the money flow has disrupted. This crisis spread to the EU because of the high-level economic relation between US and EU, and EU regions were jeopardized. Turkey has impacted because the EU was over 50% of the export market of Turkey. This crisis impacted directly on demand. As a result of this crises unemployment level increased, the economic scale of turkey shrunk, the current account deficit increased. (Yurdakul, 2015)

Figure 16 Comparing 2008 and COVID -19 Pandemic



(Berger, 2020)

According to (DeLoach, 2000) risk for businesses categorized three different headlines that are externally-driven (it is about external factors, competitors, customers, regulations) internally-driven (operation and process risks), and decision-driven (this is related with decisions mistakes). Coronavirus more affecting because it includes risks for businesses' internal, external, and decision (information) risk.

Supply chain complexity changes the effect of disruptions on companies. Global and high number production's supply chain s makes it complex to manage, and it causes vulnerability to management. For example, the automotive industry has shut down in many countries due to the lack of supply. The point is the high number of supply materials makes supply chain complex and one-pieces of the materials may impact the whole process. (Craighead *et al.*, 2007)

(Christopher and Peck, 2004) added demand risk may cause a problem for companies such as volatility of demand. Supply risk: it may occur by disruption of supply, timing and order delays, monetary delays. Operational risk may occur due to breakdown, changes on production lines. Resource risk covering a shortage of ability to produce more

this may occur due to lack of labor, technology, etc. Security is another essential part of topic terrorism or other infrastructure breakdown problems.

Macro problems may cause a loss for companies such as economic recessions, border and customs regulations, exchange rates, cost of labor (Manuj and Mentzer, 2008).

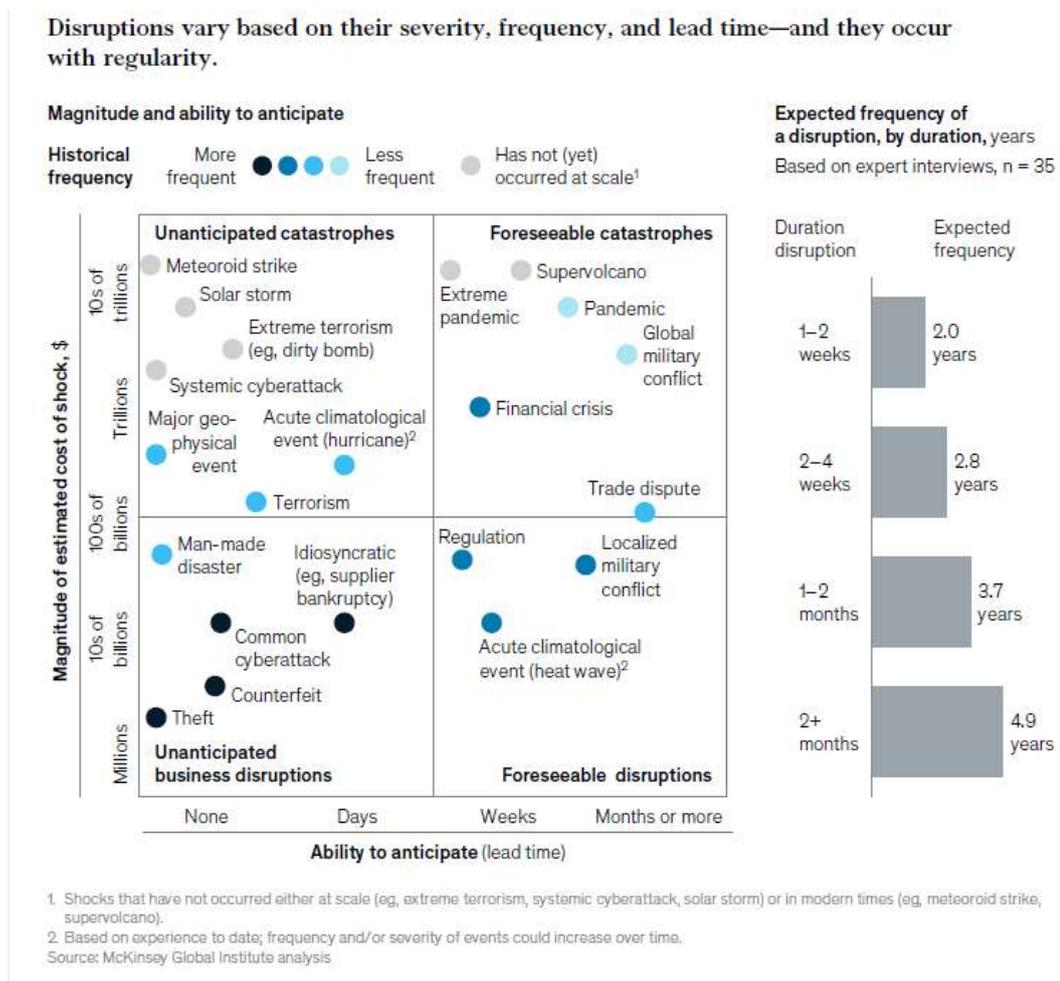
These risks are mentioned above disrupt the supply chain in our case, which coronavirus, impacted the whole part of supply chains, and at the same time, the supply chain threatened by complete risk factors. Because the leading resource of the entire chain is people, so that demand, supply, transportation, the manufacture is under the pressure of Coronavirus and whole part become a bottleneck.

In the KPMG expectation of coronavirus impact on supply chains and make vulnerable supply chains. Many countries applied many regulations to slow down the spreading of a pandemic. These regulations change in many areas. And supply chains under one of the large impacted parts. Limitation on travel, restriction on going out, shutting down shops, stopping the manufacturing, late delivery of supplies, decreasing or changing of demand, customer payment problems, logistic problems, borders, and transportation problems. (KPMG, 2020)

2.2.8 Conclusion

The coronavirus has caused massive a big scale disruption after world war 2. There is a new situation has still been going. There are many disruptions happened at near past such as 2001 – 11 September Terrorism Attack 2003-SARS Pandemic,2008 Financial Crisis, 2011 Japan Earthquake and Tsunami. These impacted supply chain jeopardies, but events affected short term. This time, the world experienced the most significant disruptive incident which is illustrated in figure17. Coronavirus pandemic hit supply and demand at the same time, and it spread globally. (Sheffi, 2020)

Figure 17 Supply Chain Disruption Classification



(Mckinsey, 2020)

The supply chains of companies have stressed under the impact of pandemics. There are many disruptive events causes stoppages on the supply chain. These stoppages may reveal from a variety of reason such as people, logistic, restrictions, demand changes, supply materials issues. Companies have taken actions after each supply chain disruptions, and today supply chains are more flexible.

Coronavirus pandemics impacted everything in the world, which has related to people. Supply chain risk is separated into two main headlines external and internal. Coronavirus pandemic affected directly internal and external factors.

Low labour, the complexity of supply chains, readiness to disruptive events, supplier dependence issues, government and other regulations (travel restrictions) (Marsh, 2020), demand changes (customer side problems), monetary issues (exchange rate, delaying payment) are the primary focusing and expected areas related with coronavirus. (Chain and Consultancy, 2016)

When disruption occurs, companies apply for new strategies to reduce the impact of disruptions, for example, focusing on other suppliers. Sometimes it is hard to find the same level suppliers. In 2011 after the earthquake and tsunami of japan hit Toyota's leading semiconductor supplier "Renesas Electronics" which have half of the market share of the world trade, then Toyota sent its staff to help and increase the recovery time. This help reduces to 5 months instead of 8 months. (Matsuo, 2015)

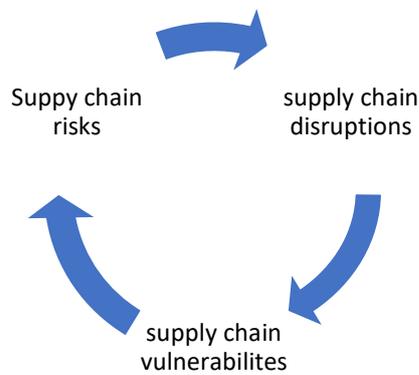
The differentiation between supply chain risk and supply chain disruption risk (SCDR) is necessary since supply chains, in general, encompass plenty of companies dispersed across the globe and only threats which jeopardize normal business activities crucially are relevant. SCDR's can be defined as the subset of all supply chain risks with potential consequences that impede the supply chain at least temporarily of achieving its operational goals and jeopardize the existence of one or more supply chain partners (Heckmann, Comes and Nickel, 2015)

Risk, Vulnerability and Disruption relation

The primary outcome of the literature review section is to clarify the risk, vulnerability and disruption relations. These three terms have already defined by different aspects and authors. Risks are incidents which impacted on the process by reducing efficiency. (Badea

et al., 2014) Supply chain risks impacted companies on their vulnerable sides, which means there are always supply chain risks, but these risks have not always impact or disturbance on companies. Supply chain risks arise from supply chain vulnerabilities. (Cranfield University, 2002) Risks have more meaning if they don't have an impact on companies. If companies have no vulnerabilities, these means they are resilience and capable. At this point, Supply chain disruption unexpected event causes stoppages on supply chain flows. Supply chain disruptions have an impact on vulnerabilities and may expose risks (Meyer, 2020). Similarly, disruptions happen when risk and vulnerabilities match at the same points. As my understanding, these terms' relations have illustrated in as in figure 18.

Figure 18 Risk, Vulnerability, Disruption Relation



3. Methodology and Research Design

3.1 Overview

This paper explained understanding supply chain management, its disruptions and, the latest arising issue for industries “Covid-19”. This chapter illustrates the research methodology, which was used for collecting and analyzing and the process of this analysis. Mainly the research methodology is followed the “onion framework”.

Research can be defined as “an activity that involves finding out, in a more or less systematic way, things you did not know” (Walliman, 2017). This research is looking for impacting of different coronavirus types of industries and obtaining findings as a result.

“Methodology is the philosophical framework within which the research is conducted or the foundation upon which the research is based” (Brown, 2006) While considering this framework this paper is conducted “in-depth interview” techniques achieve the objectives of the research.

According to the table, which is shown below, the dissertation’s research methodology framework is:

Research Philosophies: Interpretivism – Pragmatism

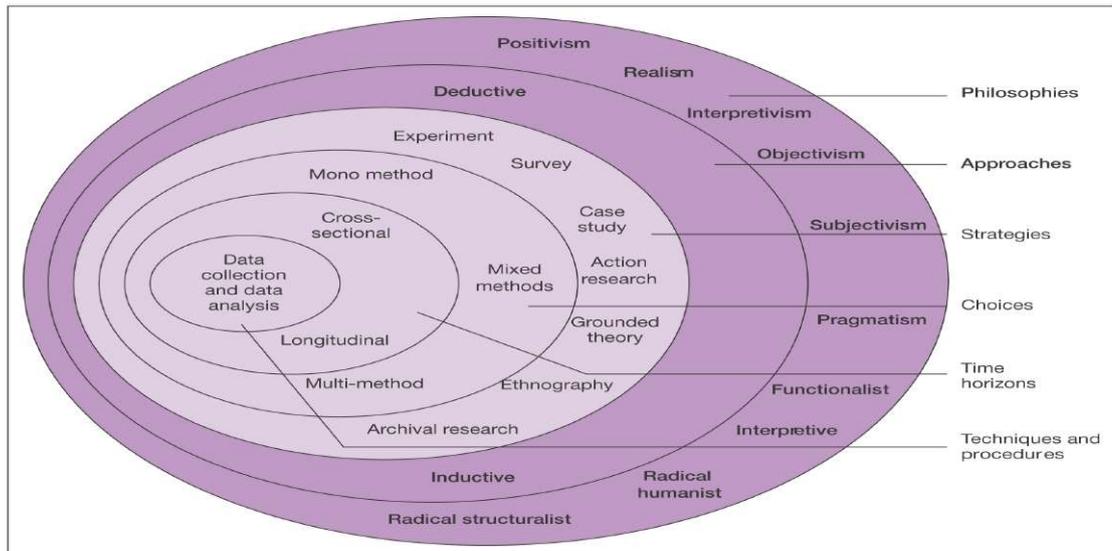
Research Approach: Inductive

Research Strategy: Survey

Research Time Horizon: Cross-Sectional

Research Choices: Mixed Methods

Research Data Collection and Data Analysis: In-Depth Interview – Narrative Data analysis



(Saunders, Thornhill and Lewis, 2009)

3.2 Research Philosophy and Approach

The research philosophy refers to collecting analyzing and using data which is consisting of primary and secondary. There are many aspects of the philosophy in the framework which is illustrated above. But mainly in this paper conducted this process by mixing interpretivism and pragmatism. Interpretivism assumes an inductive research approach, which is focusing on reality. In this paper's approach understanding the impact of coronavirus on industry base on the inductive interview results. As well as, the pragmatism approach supported this paper by looking at different industries and exploring a different aspect of supply chain management and industry reactions and how it impacted supply chain by coronavirus pandemics. These two paradigms are the main research philosophies. (Saunders, Thornhill and Lewis, 2009)

3.3 Research Strategy

In this paper, the data collected by interviewing varies industry professionals who are working or has knowledge about supply chain processes as well as have experiences. The data is collected by using “**in-depth interview**” technique. The interview questions are designed **semi-structured to queries**. The interview method is semi-structured interviews which means same questions asked to participants, but during the meeting, the context may reveal different aspects. In other words, the main issues are asked to **professionals** and new items are done during the interview. In-Depth Interview methods are combining of participants ideas, expectations and interpretations of the situation. This technique has advantages such as detailed information on contrast participant may have biases and may not be comfortable due to shortage of time. Before interviews happened, I identified the focus needed and person and disadvantages situations are disposed(Boyce and Neale, 2006)

The paper articulates of supply chain and supply chain management, and supply disruption risks, supply chain resilience. Secondly, the paper interviews with the business supply chain professionals, lastly the paper aim is finding results and critically discuss.

3.3.1 Collection Data

The interviews revealed qualitative data. Each interviewer common side is “supply chain management”, but each participant is in a different industry. Due to the different context, the primary data is reviewed and analyzed. Therefore, narrative data is revealed from interviews.

The interview method is semi-structured interviews which means the same questions asked to participants, but during the meeting, the context may reveal different aspects.

The data, which is required for this research, is collected between 01/06/2020 - 07/06/2020.

Collecting data by interview technique has advantages such as getting more details throughout the interview, organizing the meeting, such as taking participants' time is not always easy.

The primary data is categorized under a current context, and the most common aspects of each interview are sentenced. The primary data and literature review are discussed. At the and the findings are assessing. (Dudovski, 2011)

In terms of time horizon, this study is a cross-sectional study which means the data is collected in a fixed period from different industries due to time considerations. (Saunders, Thornhill and Lewis, 2009)

Research questions have been developed by making use of (Park, Hong and Roh, 2013) 's research.

	Criteria / Firms	Firm A
1	What type of company? Products manufactured?	
2	During Covid19, is there any issues about “Inadequate Labor “? If yes, what / how is impacted? Direct – indirect) how changed?	
3	During Covid19 has any issues happen about Cessation of production? If yes, how long and how much the volume changes? (Robustness related question)	
4	During Covid19, is there any issues due to the complexity of supply chains?	
5	During Covid19, is there any issues due to Readiness for disruptive events? What are readiness preparations?	
6	During Covid19, is there any issues due to Supplier dependence issues? (redundancy related question)	
7	During Covid19, is there any issues due to Government and other regulations (travel restrictions)?	
8	During Covid19, is there any issues because of Production Volume? How much does it change? (Agility-Elasticity)	

9	During Covid19, is there any issues due to Demand changes? Volatility (customer side problems)	
10	During Covid19, is there any issues due to Delay in component supply? (freight delaying)	
11	During Covid19, any issues have happened on the supply materials like particular/General parts? If yes, any reason? (redundancy)	
12	Is there any precaution to mitigate the impact of Covid19 Pandemic? If yes, how does it happen? Logistic reasons? (robustness, preparedness)	
14	During Covid19, is there any issues because of monetary issues (exchange rate, delaying receivables)? If yes, how does it impact?	

3.3.2 Access and Ethical Issues

This research is conducted under ethical issues. The achieving objectives were provided considering ethical issues whole part of this research. Before gaining data time and the aim is informed to each participant and the interviews conducted by protecting their privacy and rights, which anonymity of each interviewer ensured. The participants consented to the interview and honesty. During the interview, the questions are reviewed attentively.

3.4 Conclusion

This chapter is about the methodology, and research design which is explained which process and methods are followed and considered throughout preparing this dissertation. Besides, ethical issues are assessed. The primary data is collected In-Depth interview Method and analyzed Narrative data technique. This research is qualitative research and inductive approach.

Findings and Discussions

This paper is researching pandemic impacted on the business because it is impacted directly on people's health. Supply chain management has affected due to people who are in each part of the supply chain.

The interviews are done with supply chain experienced managers/supervisors. Different types of manufacturing industry critically analyzed. Each meeting took around 75-90 minutes. The questions asked as a topic and detailed during the interview. At the end of the interview, interviewees comments and additional pieces of information requested.

3.5 Findings

1	Criteria / Firms	Firm A: Glass Manufacturer
1	What type of company? Products manufactured? Customer portfolio?	<p>The company is producing the whole kind of glass products to the discount markets (supermarkets), other retail industries, the automotive industry, and so on. The products must be packaged for painting or shipment. The company has pulled, and push production types, which means production depends on on-demand (pull) or manufacture products and stocking the kind of glasses are demanded ordinary. The interviewee has been working there for over three years in the Supply Chain department.</p>
2	During Covid19, is there any issues about “Inadequate labor “? If yes, what / how is impacted? Direct – indirect) how changed? 14 days	<p>Yes. Few cases happened in the production area, and office personal which they did come to work and who connected with the was sent quarantine for 14 days. So that production capacity reduced to around 5% per cent for two weeks for the related production line. As well as, Lay-off Staffs expenses has supported by Government.</p>
3	During Covid19 has any issues happen about Cessation of production? If yes, how long and how much the volume changes?	<p>No. This factory has to work without stopping because of Owens. If they stop glass will freeze in the production Owens which they are so significant and valuable. The production level fell to 60%. This decrease started after the virus spread to the EU, which before Turkey’s first case. “I can say the production level has been decreasing to 60 % since February</p>
4	During Covid19, is there any issues due to the complexity of supply chains?	<p>No. Our company is manufacturing types of glasses, but mainly the raw materials do not so complicated and hard to find. So, we didn't have any issues with complexity during pandemics or before. There are many local suppliers for us.</p>

5	Were your company ready as disruptive events like Covid19? What are readiness preparations?	The company implemented some rules preventing the spread of viruses before the first case happened in Turkey, for example, home office work infrastructure was set up, masks and disinfectants provided, common areas closed, and food has been distributed in paper boxes.
6	During Covid19, is there any issues due to Supplier dependence issues?	The company has an internal and external supplier in geographical areas. Sand and Boron is available in turkey, and we don't have issues about this—other unique materials coming on different suppliers. Price is important to get articles but purchasing small parties' raw materials are provided by a variety of suppliers to reduce supply risks. The company has been working a very long time, and I can say that because Suppliers have a long-term history background which I am working with them. For example, Asian suppliers have problems to provide materials on time and our other suppliers ready to recover it. But our stock level is getting higher level than before, so we don't have any supply issues. Which our company is using railways and vessels, but we can make it faster by using airways and land routes—besides, some problems raised on the boxing supply chain. Because boxing/container companies are not big enough to produce over demand, which they especially have at the food, medical, and retail industry, we must delay two weeks. It didn't cause any problem so far due to our stock level, but it may cause.
7	During Covid19, is there any issues due to government and other regulations (travel restrictions)?	The travel restrictions impacted on delivery products and supply receive time. Checkpoints on the roads, shipping points are caused by three to fourteen days of delays. Payment always happens after delivery, so the payment balance has been delayed for a few companies. Especially in EU countries has strict shutdown and they didn't want to unload ships to delay payment period. And Some of them already put the products in

		their inventory, but we postponed the payments to protect them.
8	During Covid19, is there any issues because of Production Volume? How much does it change?	Yes. Production volume is changed. Some of the production lines are closed or slow down. We lost some workers due to pandemic it impacted on production. Still, we change the shifts to another part of workers and try to keep manufacturing, So our production was 40 % less than last year this time and 5% of this reduction is about employee issues.
9	During Covid19, is there any issues due to Demand changes? Volatility (customer side problems)	We have high volatility on demand. We must cancel some types of products, for example, car glasses. And the other glassware and drink have been decreasing. So, the company still producing, but our end product-stock level increase by 20% at the same time our inventory stock cycle reduced from 25 days to 7 days.
10	During Covid19, is there any issues due to Delay in component supply? (freight delaying)	Yes. We have delays a few supplies around two weeks. The main reason shipping point checking process longer than before. It caused delays but didn't impact our production because we have less demand, and our production capacity decreased by 40%.
11	During Covid19, any issues have happened on the supply materials like particular/General parts? If yes, any reason?	Yes, we have some delays containers and boxing supply because this industry is producing more other products. We already have safety stock and lower production levels not allowed arising a crisis about this. Especially some discount markets (supermarkets) has advertised a discount product on their monthly or weekly journal. If we are not able to deliver it, we must pay punishment, but we didn't have that level problem yet.
12	Is there any precaution to mitigate the impact of	We have alternative suppliers, internal and external. We have a chance to accelerate the delivery process. We transferred staff

	Covid19 Pandemic? If yes, how does it happen?	from the decreased production line to others which line needs more team. Allow the home office working and lay off workers payments from the government
14	During Covid19, is there any issues because of monetary issues (exchange rate, delaying receivables)? If yes, how does it impact?	The lockdown situation of countries and businesses reduced demand. As well as, many companies shut down. These companies were not able to pay. We postponed payments. Our customers are generally international and influential national companies we have not got any loss so far, but we have postponed. Our company is exporting %50- 60 of products as well as % 40-60 import. Exchange rates not impacted much but the impact of higher exchange rates slightly beneficial due to higher export percentage.

2	Criteria / Firms	Public and private transportation seats manufacturing
1	What type of company? Products manufactured? Customer portfolio?	We are manufacturing public and private transportation seats (trains, buses, ships, cars) we are working for big wholesales companies they are selling prominent manufacturer or retailers, and we are selling the manufacturer or other services directly.
2	During Covid19, is there any issues about “Inadequate Labour “? If yes, what / how is impacted? Direct – indirect) how changed? 14 days	One hundred eighty people are working in our facility. 40 staffs are white-collar, and 140 staff are blue-collar. When the first case happened in Turkey, we send the people homes who have chronic diseases and vulnerabilities. Twenty people were impacted and hadn’t come to work since March. Another suspicion 20 people didn’t go in there different 14 days since the first case raised in Turkey.
3	During Covid19 has any issues happen about Cessation of production? If yes, how long and how much the volume changes?	We stopped working for one week in April, and we have been working for two days a week since then. We are expecting to work like that until July.
4	During Covid19, is there any issues due to the complexity of supply chains?	We didn’t have face issues due to complexity. We have only protection part of materials which is from Asian markets. And as local suppliers metal industry works by prepayment and we already ordered metals, so our metal stock cost has increased.
5	Are your company ready as disruptive events like Covid19? What are readiness preparations?	We diversity our suppliers we have alternative suppliers for 98 % of our materials. When demand started to decrease, we checked suppliers and customers. We reduced the stock from 7 days to 2 3 days, if we don’t have issues with suppliers to reduce costs.
6	During Covid19, is there any issues due to Supplier dependence issues?	Our 95% of suppliers are from Turkey and the rest 5% of the supplier from China. The 5% is about the standards of the products in which customers ask for this, and it is specific products.

7	During Covid19, is there any issues due to government and other regulations (travel restrictions)?	The government regulations caused a delay in the logistics industry, and our supplier's supplier has a shortage of yarn and fabric materials. Delaying of these products would cause problems. But we have hundreds of suppliers, and we didn't face a shortage of contents directly.
8	During Covid19, is there any issues because of Production Volume? How much does it change?	We don't need serial production because we are working on project bases. But a few types of materials we are using always we are making ready for the next demand. Our production volume decreases by 60% for the last months when we compare with the previous year's results. The company was going to expect working only two days until the end of June.
9	During Covid19, is there any issues due to Demand changes? Volatility (customer side problems)	There was no demand in the middle of April due to the automotive industry shut down. We are working for local customers and two days is enough now. Our production, not car seats we are focusing on more specific products and tourism has an impact on us too. Caravan industry and public transport need to be used more. Our import customers consist of 30% America,30% Middle East, and the rest is the EU. We have ordered only from America at the moment.
10	During Covid19, is there any issues due to Delay in component supply? (freight delaying)	Our supplier has alternative suppliers. Only a few types of products from china suppliers which special orders. Our suppliers are stocked before the crisis happening from Asian markets in our industry supplier's supplier has a shortage because of dependent on Asian markets.
11	During Covid19, any issues have happened on the supply materials like particular/General parts? If yes, any reason?	China has been delayed our materials for one month because of logistic issues. The specific materials are delivered late but did not cost us any extra charges.

<p>12</p>	<p>Is there any precaution to mitigate the impact of Covid19 Pandemic? If yes, how does it happen? Logistic reasons</p>	<p>We didn't work home office, but we have been coming to work one by one for white-collar people. Our management decided to keep blue-collar, and if it is wrong, we won't be here but keep the whole precaution very serious. We didn't apply for "short – term work" because we want to save as much as work and not just lean on government. Social distance and mask rules protect us so far.</p> <p>We know the supplier's supplier is importing materials from Asian markets. We started to check tier 2 suppliers when the first case raised in Wuhan.</p>
<p>14</p>	<p>During Covid19, is there any issues because of monetary issues (exchange rate, delaying receivables)? If yes, how does it impact?</p>	<p>The local suppliers impacted by exchange rates, and they all wanted to change the Turkish Lira agreement to the Euro because they weren't able to sustain it. This has cost us because we need to protect our suppliers. Exchange rates increase our profitability because of our general expenses paying by Turkish Lira.</p>

3	Criteria / Firms	Automotive supplier: seats and plastic pieces
1	What type of company? Products manufactured? Customer portfolio?	I have been working at planning the apartment since 2011 in the automotive industry as a supply chain planning engineer. Our job is designing supply and demand stock levels. Old company customers are the biggest automotive one of factors such as Ford Hyundai Mercedes we have for manufacturing plant in Turkey mainly our products are car plastic pieces and painted pieces and seats. The main task is making ready the stock level before the production.
2	During Covid19, is there any issues about “Inadequate Labour “? If yes, what / how is impacted? Direct – indirect) how changed? Fourteen days	we have 200 office workers (white colour) and 850 blue colour production, employees.so one pandemic arises 250 people had to go back home due to days health weakness some of them has kidney problems, another one has a liver problem and over 50 years, old staff. On the production side, 100 people caused 10% low labour. It didn’t impact us because our production level was reduced too.
3	During Covid19 has any issues happen about Cessation of production? If yes, how long and how much the volume changes?	Our company is producing seats and internal plastic pieces. We are the leader in our sector. All factory shut down for three weeks as planned. Because main customers shut down, for example, Ford shut down for 45 days, and it causes lower demand for us.
4	During Covid19, is there any issues due to the complexity of supply chains?	Our suppliers in terms of products amount %50 from turkey and the other 50%is from other countries which our import mainly from Korea by 75% and 20% from India and another counties % 2. As monetary import cost increased by75% due to more specific pieces, when the first case happened in China, we expanded our china suppliers’ products and provide safety stock up to 100 days. But Indian suppliers caused the problem it didn’t directly impact us because we already increased share. Still, our customer gets

		products from the same company, but because of that, we could not manufacture. There was a negative indirect supplier impact on us. We can make until the end of June under these conditions, but the supply chain goes back to normal, and it won't be an issue.
5	Was your company ready as disruptive events like Covid19? What are readiness preparations?	Pandemic hit many companies in terms of the supply chain. For example, seat pieces on the right side and driving side are the same products. But we are buying from different suppliers to protect the supply chain. After the first cases happened in china, we started to check each supplier due to whether they can provide or not. Then we checked the suppliers' supplier. And we began to increase stock level before pandemic arrives in Turkey. We were ready in term of the supply chain, but customer demand has severely impacted.
6	During Covid19, is there any issues due to Supplier dependence issues?	Indian suppliers couldn't deliver the products because of shutting down their company. We would have a problem if it goes until the end of June, but our safety stock and lower demand didn't show any problem because of the supplier.
7	During Covid19, is there any issues due to government and other regulations (travel restrictions)?	The logistic period has increased by two weeks. Shipping points and customs staff was not enough, so it caused delays in the supply chain. there was a lockdown period in turkey as well, but the government allowed to run businesses, so regulation didn't impact to businesses directly
8	During Covid19, is there any issues because of Production Volume? How much does it change?	Our production level decreases 30% in May, %70 In April, and %30. It is about our customer demand. For example, some of the companies shut down, but they ordered and stocked for production.
9	During Covid19, is there any issues due to Demand changes? Volatility (customer side problems)	Our company is working for too big automotive industry companies, and we are providing materials to the local call manufacturers so I can say 90% of our products are selling to

		<p>local—still, the car manufacturers exporting 90% of their products. So, our customers are indirect export customers.</p>
10	<p>During Covid19, is there any issues due to Delay in component supply? (freight delaying)</p>	<p>For general parts: Internal transportation period increased few more days due to the inadequate driver and internal transportation increased up to 2 weeks due to checking point and insufficient custom officers.</p>
11	<p>During Covid19, any issues have happened on the supply materials like particular/General parts? If yes, any reason?</p>	<p>Yes. For specific materials, only Indian suppliers have reflected delays due to their shut down process.</p>
12	<p>Is there any precaution to mitigate the impact of Covid19 Pandemic? If yes, how does it happen? Logistic reasons</p>	<p>The supplier is checked more often than before. Sometimes we checked daily to find solutions. Safety stock level is increased to 40 days for internal 100 days for external. Suppliers' suppliers (tier 2 suppliers) are checked and find answers. We have enough stock now until September, but we are talking to our suppliers and planning December. Because the world automotive industry collapsed and everybody's expectation going back to normal this summer. We are working with suppliers alternatively, but Indian was the only supplier of has reflected shortage. Now we are working local suppliers and local suppliers almost ready to manufacture Indian suppliers' products.</p> <p>The other precautions: before entering the facilities, everybody has been checking before the virus arrive in Turkey because our customer is external and supplier are from Asian countries. Mask has to be used in facilities. Common areas closed and food has been serving in sealed boxes. Protecting office employees, two in-office other two work in their home. The shutdown process is used to configure for new car models, and machines and facilities are maintained.</p>

14	<p>During Covid19, is there any issues because of monetary issues (exchange rate, delaying receivables)? If yes, how does it impact?</p>	<p>Lower production level increased whole stocks, and Stock cost has grown already. Our employee payment and other general expenses are paying with Turkish Lira, and our income is euro so that exchange rates increased our revenue, but this time the ratio between stock cost and exchange rates closer. We are expecting full capacity in June so it if we ca reduce stock level then exchange rates will be beneficial for our company.</p>
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4	Criteria / Firms	aluminium Company
1	What type of company? Products manufactured? Customer portfolio?	Our company is producing flat-rolled and sheet aluminium products. They are seven organization, and I am the manager of one organization. We have food products we have automotive products we have other industry products. we are producing aluminium can food contact boxes and aluminium containers I have been working for five years as a department manager
2	During Covid19, is there any issues about “Inadequate Labour “? If yes, what / how is impacted? Direct – indirect) how changed? 14 days	<p>We have 1500 employees, 1200 blue-collar workers, and 300 office workers. Our business requires to travel much. Pandemic directly stopped travels. The first days arrive pandemic turkey we office workers started to work in the office. The Technology infrastructure was good, but online meetings cause longer working hours because online working is not secure. Our customers affected because pandemic demand changes too much. For example, some customers working with hotels but some of the customers increased demand, markets, and the food packaging industry. We should have adapted to this period, so this demand volatile makes harder and reduce efficiency. Before 50 people were using but now 300 people and this development configured by our It teams.</p> <p>When China's first case happened, our holding started to adapt processes because they have many different types of industries, so it was an advantage to get precautions before pandemics. After 15 of the march, we started to work from home.</p> <p>Before entering fewer checked started before the first case in turkey. People who have chronic disease sent home and not</p>

		<p>allowed to work for 14 days. Physical workers are fully healthy. So other health problem people can able to home. Ten cases happened, and 60 people were under quarantine for 14 days, and they came to work after 14 days. It may affect, but 40 per cent demand already decreased, so it didn't impact. We should have considered the cost we have to configure our price, so loss staff was beneficial. Some delays happened in few product types, but it was not impacted due to the lack of an employee.</p>
3	<p>During Covid19 has any issues happen about Cessation of production? If yes, how long and how much the volume changes?</p>	<p>Our company has been working since the pandemic raised in Turkey. Our production level decreased, especially automotive industry change and delayed their orders, so we used these workers on the other production lines.</p>
4	<p>During Covid19, is there any issues due to the complexity of supply chains?</p>	<p>Leading supply companies are 30% Russia, 30% far east, 20% EU and 10% domestic, 10% South America, and buying raw aluminium blocks and we are buying from first 300.000 product tones a year.</p> <p>Some companies shut down, and we have delays around two months due to their shut down. And the logistics process has spent more time on shipping points. The Far East has more risk, and they were so strict and more affect us considering the pandemic. Asian countries changed by 80 %.</p>
5	<p>Are your company ready as disruptive events like Covid19? What are readiness preparations?</p>	<p>We have flexibility in the 2009 financial crisis time we have depended on Asian supplier's %70 per cent, and company production level decreased severely due to supply chain and lack of materials.</p>

6	During Covid19, is there any issues due to Supplier dependence issues?	The purchasing team got actions and diversify our suppliers. Hence, we can swap our supply chain very quickly. We were ready for this pandemic in terms of the supply chain.
7	During Covid19, is there any issues due to government and other regulations (travel restrictions)?	<p>When China's first case happened, our holding started to adapt processes because they have many different types of industries, so it was an advantage to get precautions before pandemics. After 15 of the march, we started to work from home.</p> <p>After coronavirus reveals in china, we are stopped to travel to other countries, and if there are our workers already abroad, they sent to quarantine for 14 days</p>
8	During Covid19, is there any issues because of Production Volume? How much does it change?	Our %40 production is reduced when we compared last year's results. Some customer has shut down and material already on the way, and we put the materials to their warehouse. Import rates reduced in turkey and export trucks coming back empty, and it caused more cost. Drivers, when got into the country 14 days, cannot drive again, so driver shortage has caused problems and increase the value of logistics. Custom checking caused delays, and due to lack of custom staff and payments are delayed.
9	During Covid19, is there any issues due to Demand changes? Volatility (customer side problems)	We are doing B to B business. Our customers are manufacturers and wholesale business. For example, the EU customer is the most significant player in EU Plastpack. 60 % of total customer is EU customers 20% America %20 local Due to demand volatility we have some shutdown in different products line.

10	During Covid19, is there any issues due to Delay in component supply? (freight delaying)	Government regulations supported to continue working we have issues mainly on the logistic side. The domestic market has illustrated a few days of delays due to checkpoints. Supply chain delay has caused delaying money. They are changing financial balance.
11	During Covid19, any issues have happened on the supply materials like particular/General parts? If yes, any reason?	We some issues overall supply chain due to checking points and it caused delays, but diversity suppliers didn't cause any lack of material problems .
12	Is there any precaution to mitigate the impact of Covid19 Pandemic? If yes, how does it happen? Logistic reasons	Demand decreases caused lower-income, and we directly focused on reducing costs. We change our production level and stock level. The stock cost was the first action we took, and we cut our stock cost by 30%.
13	During Covid19, is there any issues because of monetary issues (exchange rate, delaying receivables)? If yes, how does it impact?	In EU counties such as Italy and Spain some customers shut down, and they cannot afford to pay, so we keep the materials in their warehouse, and we postponed some customer payments and protected. We are buying the dollar and selling euro exchange rates reduced to 1.06 from 1.1, and we lose money but in terms of other production costs is Turkish Lira, so we have advantages due to increasing exchange rates.

5	Criteria / Firms	Automotive materials manufacturer
1	What type of company? Products manufactured? Customer portfolio?	I am a production manager. Our company is based in Germany, and they have been working since the rubber founded, which is 170 years old. We are making an automotive sub-part which is about petrol tanks and its materials. We are working to local 90% to Ford and the other 10% to export to Germany.
2	During Covid19, is there any issues about “Inadequate Labour “? If yes, what / how is impacted? Direct – indirect) how changed? 14 days	If we worked the same as after pandemic, we would feel inadequate staff because we send home the people who have a possible sick or chronic illness such as asthma. Our primary customers already shut down, so we didn't feel directly impact of labor.
3	During Covid19 has any issues happen about Cessation of production? If yes, how long and how much the volume changes?	Ford has shut down for 45 days, and this shutdown impacted our manufacture, and we shut down for 21 days other days. We produce our stocks. We are working %50 of our capacity when we compare with last year.
4	During Covid19, is there any issues due to the complexity of supply chains?	Our supply chain is not complicated. We need raw materials, and it is not much as we compare our customers. We didn't face any issues due to complexity.
5	Are your company ready as disruptive events like Covid19? What are readiness preparations?	We were working with mainly EU customers, and so far, our supply chain has not faced a severe problem. But Pandemic impacted EU countries, and it has directly affected us. So, we were not ready to be supplying materials from the EU. Because our company is from Germany and EU transactions were not prepared for this and not expecting. We started to work to provide from local.

6	During Covid19, is there any issues due to Supplier dependence issues?	Our whole supply chain is based on importing products from Bosnia, Germany, Italy, and Israel. Israel and Italy have a locked-down period, and we could get materials, so the production was stopped, so we changed the production line to other products manufacturing it caused a 20% loss.
7	During Covid19, is there any issues due to government and other regulations (travel restrictions)?	The government permitted manufacturers, so we have checked everyone by government, and travel limits impacted us. The home office work reduces efficiency due do online connection takes time.
8	During Covid19, is there any issues because of Production Volume? How much does it change?	After corona arrive 22 days was average, then Ford shut down, and our manufacturing level reduces more than 50%. Then in April, we shut down for 21 days, and there was no production. After that, we work for our stock because the automotive industry expecting to recover after June which they started to order materials
9	During Covid19, is there any issues due to Demand changes? Volatility (customer side problems)	Ford was producing 400.000 cars in a year, but they are planning 250.000 vehicles until the end of this year. This demand directly impacted us. We are creating 160.000 pieces for Ford and other 20.000 pieces for other countries. Forty-five days ford was shut down, so we just worked for other countries.
10	During Covid19, is there any issues due to Delay in component supply? (freight delaying)	We supply from Bosnia, Italy, and Israel. There was a big problem in which we face the customs and shipping points because of the more checking requirements and less staff extended the logistic period. Our supply materials' shipping periods increased by one moth more. As internal logistics is delaying, we ordered a piece of our machinery but over 20 days, and we still didn't get. When we called the logistics company, they said we intense now and the order in the queue. We fixed solutions using old pieces, but it may cause a problem too.

11	During Covid19, any issues have happened on the supply materials like particular/General parts? If yes, any reason?	The Italian company was providing specific materials, and when they stopped, our production was stopped. And their elements are critical for us. We have stock for this, and there was no demand. But if the demand were the same, we wouldn't be able to be produced. The main reason they shut down their facility.
12	Is there any precaution to mitigate the impact of Covid19 Pandemic? If yes, how does it happen? Logistic reasons	Germany has impacted before Turkey, and we started to take action before them, and it helps us to protect our employees. Production. We are working daytime shifts, but we divided our production and started to work on two changes to protect our employees. Blue-collar employees shifted in other sections. Due to Italian supplier dependence, we began to work on local suppliers. We are going to start to supply soon from local suppliers.
13	During Covid19, is there any issues because of monetary issues (exchange rate, delaying receivables)? If yes, how does it impact?	Exchange rates not impacted on purchase and sales because both are on euro, but our general expenses are Turkish lira, so the exchange rate increases add more profit. We are getting our money when we get orders; we don't have issues about receivables. Because our customers are globally and very big, our debtors never bother them.

6	Criteria / Firms	Steel and aluminium manufacturing company to the construction
1	What type of company? Products manufactured? Customer portfolio?	I have been working for eight years as a supply chain manager. My department consists of five departments, such as manufacturing planning, purchasing, Quality, and logistic departments. We are selling our other companies' branches whole over the world. Orders are coming from Germany, and we are producing and sending the customer any part of the world. We are selling or renting our products.
2	During Covid19, is there any issues about “Inadequate Labour “? If yes, what / how is impacted? Direct – indirect) how changed? 14 days	<p>The whole company includes 9500 workers full over the world. In our department, 230 people are working. 36% of our employees working from their homes. We have 180 blue-collar works, and 30 of them are not working due to age, pregnancy and some vulnerabilities.</p> <p>In production areas, we had one suspicion staff we stop manufacturing two days, and the result was negative, and we started again. And another case happened on the logistic side, and one week we stopped entire logistic actions, so we have delays on our orders and supply.</p>
3	During Covid19 has any issues happen about Cessation of production? If yes, how long and how much the volume changes?	Changing and cancelling demand, our sales reduced by 50-60% when we compare with last year this time. We didn't shut down, but we just work for our stocks and some customers didn't stop we work for them.
4	During Covid19, is there any issues due to the complexity of supply chains?	We are getting material from 85 % from local suppliers and 15 % from external suppliers. 500 supply material we need and 200 from other countries. And 30-40 is critical components which we need.
5	Are your company ready as disruptive events like	The coronavirus pandemic was not expected for any industry. Still, Turkey is a developing country, and we have a financial crisis

	Covid19? What are readiness preparations?	sometimes as well as the world crisis impacted industries, so 2009 financial crises were a good lesson for everybody. We have high diversified suppliers, and we are focusing on supply from local companies. But still, we have some materials from Asian markets, and their price provides more profitable projects. The pandemic has hit severe at the same time the whole world some business is busier than before, but others have lost their activities. Our industry has lost 60% of its demand. I can say our company is stopped not because we are not ready, but if the demand was the same as before it would be different results such as employee and suppliers' issues coming up more.
6	During Covid19, is there any issues due to Supplier dependence issues?	China and India's plants are closed. The virus mainly hit Asian plants. We are dependent on a Chinese supplier in terms of a product, and they produced, but they couldn't send it. So, we waited for this product we paid extra money for airways cargo. At this time, we change our production line to another product, and then when we got the materials, we broke again. There was a loss of human power. And we couldn't change our sales price, so we have a decline in this project.
7	During Covid19, is there any issues due to government and other regulations (travel restrictions)?	Government issues impact our customers because the construction industry stopped and shipping and logistic periods one month longer for Asian countries, for EU countries two more weeks. So, we started to use Flight cargo. It increased our costs, for example, the shipping cost was 5000 euros but the same materials coming 25000 euros by airways. These government regulations increase our value of around 15 %.
8	During Covid19, is there any issues because of Production Volume? How much does it change?	Our production volume decreased by 60%. The main reason demand has reduced by 50-60%. Secondly, we lost around 30 employees. We already order some materials, and we are manufacturing the star products which they are always sold.

9	During Covid19, is there any issues due to Demand changes? Volatility (customer side problems)	Many countries have a lockdown. We have been cancelling our demand has reduced by 60%. Many orders have delayed for three months already. The other essential things online meeting reduces interactions among customers, suppliers and us. We have international conferences we always have high orders and new customers on this event, but we lost these opportunities.
10	During Covid19, is there any issues due to Delay in component supply? (freight delaying)	The import materials 45% from India 40 from EU (Germany - Poland) and 15% from China. The average shipping period us 45 days. We have alternative suppliers for whole supply materials. But china suppliers providing high quality and cheap products if we get these products from somewhere else it cost us more money.
11	During Covid19, any issues have happened on the supply materials like particular/General parts? If yes, any reason?	Our general materials from Turkey but we have some unique supply materials which china and other countries have the standards we want to use it. For china suppliers, we have face issues. Our customers are giving us a date to deliver because their functions depend on our delivery. For example, an 80.000-euro order if you don't deliver on-time it caused each day 1.000-euro punishment and brand image and the 80.000-euro receivables cancelling too. We have some damaged because of china. Because one month delayed will cause more damage, so we change logistic type sailing to flight cargo. Some delays happened in Turkey, too because of logistic delays. Still, our customers were not working at the same time due to lockdown, so they were not impacted because of our backlog, and they ignored it and protected our project's profitability.
12	Is there any precaution to mitigate the impact of Covid19 Pandemic? If yes, how does it happen? Logistic reasons	The first case happened at the beginning of the march in Turkey, but we started precaution in January. Closing common areas, compulsory mask implementations, fewer checkpoints in facilities, if someone not feels good, we sent home and checked before returning. We add another entrance door to keep the social distance. We have been increasing supplier portfolio and diversify

		suppliers before the pandemic, and we had face issues only single supply products—logistics delays.
13	During Covid19, is there any issues because of monetary issues (exchange rate, delaying receivables)? If yes, how does it impact?	<p>Exchange rates didn't fix before we started projects. Our general expenses are paying with Turkish Lira, so we have a profit here but. Delays, reduce demand, working %50 capacity, other taxes and delay punishment's, the stock cost has impacted our budget, which last three months we are working for loss.</p> <p>We are expecting the same level of production by the end of July. We applied for "short term working" which government helps companies. We are in this process until July.</p>

3.6 Discussion - Conclusion

This paper is looking for "how coronavirus has impacted manufacturing businesses during COVID pandemic in terms of supply chain aspects. The supply chain is a process starting from raw material and finishing with customers for manufacturing companies, as we mentioned above in the literature review section.

This paper has conducted to find answers to questions. These questions have helped to get more in-depth knowledge about supply chain disruptions and resilience elements.

Disruptions cause problems on companies' functions, which some disruption examples proved us such as 9/11 September had changed logistic delays and disruptions. Another example is mentioned before, which is the 2009 financial crisis impacted supply chains.

- **When did companies perceive that Covid-19 might impact their business?**

Global trade provides a high-level connection among all business in the world. Turkish manufacturing managers have already experienced the supply chain disruptions in the 2009 financial crisis, which impacted on the Turkish economy.

- **When did companies start to take action to mitigate the impact of Pandemic's disruption affect?**

Turkish all manufacturers started to take precautions when the first cases arise in Wuhan because Turkey has experienced Bird Flu in 2007 and Swine Flu in 2009. So that Companies has adopted the situation quickly, this time is different because the previous pandemics had a local impact, but COVID Pandemic impacted globally.

- **How were companies affected / or what were the main issues that were raised during the period due to pandemic?**

Companies ha face many types of problems since pandemic raised in Wuhan. These are detailed below. But in terms of Agility and preparedness, so companies have more impact than others. **Resilient** companies never stopped. Some companies have many products, many suppliers and different production lines, which have advantages by switching one supplier to another, or one product to another product. This resilience term was succeeded by being **agile**.

The companies learnt few lessons recent disruptive event 2009. Using technology and early precatons helped keep businesses running. Turkish government and manufacturer started to take action before pandemic raised in Turkey. Other supply material stocking and health and safety precautions are **Preparedness** activities.

- **Where are the biggest problems in supply chains due to Covid-19? customer side, logistic, staff so on)**

All faced issued will be explained below but the biggest problem for companies as a summary;

*Lack of Demand

*Stoppages on Flowing Critic Supply Materials

* Companies have lost workforce, but it didn't impact on companies because of the production level wasn't enough.

*Logistic issues cause problems (delays)

- What are the lessons that can be learned for the next pandemic?
The lessons are explained in section 4.2.

Glass manufacturer:

Pandemic impacted on the blue-collar workforce by decreasing 5-10 %. The company applied a home-office working to reduce the spread of the virus. Home office working prevented the impact of the coronavirus. The production level decreased by 60% due to lack of demand. Some industries have severe hits than others such as Automotive lines are shut down. People shifted other departments, and the company works for star products and stocking. (star products standard products and always customers ask) Supplier diversity did not impact the company because of alternative suppliers. Company has an **elastic** production line to switch people on lines. Still, the company's production has to keep producing glass products to protect machines. They have advantages due to many customer and products (**Agility**). Other countries' lockdown periods, lack of inadequate staff, and more shipping point cause delays in the supply chain. Due to different industry products, demand has been increasing, and some of the unique supply materials cause delays. Pandemic impacted the take-away and home logistics industry, so boxing companies are not able to deliver materials internal logistics, and supply chain has two weeks delaying period. (**dependence on supplier**) The regulations extended the internal logistic period of the supply chain. The company acted before the virus cause crisis. Exchange rates have advantages because of general expenses are paying by the Turkish lira.

*Company has issues on suppliers because suppliers are not enough to respond to requirements.

Public and private transportation seat manufacturer:

Pandemic impacted by decreasing 10% of blue-collar workforce. The coronavirus influenced in April mostly which three weeks shut down and after that two days, a week working period has been started. (**Preparedness**) Asian suppliers couldn't send products, so production and delivery were delayed for a month. Internal distribution has a few days of delays, but it didn't affect much because the company increased its safety stock level. (**Readiness/ Robustness**). The company's supply chain management teams increased connection with suppliers and customers. Tier1 suppliers have stocked to answer orders, but tier 2 suppliers have been working with Asian countries. If the manufacturing level was the same as last year, raw materials shortage might stop production. The company is focusing on finding local suppliers. Asian and EU countries have a shutdown period supply, and demand decreased by 90%. The American countries have still been working, and they are the only import customers.

*This company has a vulnerability on the customer side because they have a scarcity demand. They must set a more agile supply chain to have a resilient supply chain. (**agility**)

Seats and plastic pieces manufacturer

The coronavirus has impacted by decreasing 10% of the workforce, and the company has been successful so far in term of supply chain management. The leading suppliers of the automotive industry directly affected by decreasing demand. The company shut down for three weeks because the main customers are shut down for 45 days. (**Agility**) Other days the company prepares production lines for new model cars and produces star products and stock. The company has been working with many different suppliers for the same products and has started to check tier 1, tier 2 suppliers. Some specialized product stock levels have increased for Asian suppliers so that stock cost has already improved.

Another critical point is the interviewed company's customer working with the same supplier, and they didn't have enough stock to manufacture which the supplier from Asian countries. The company's supply chain management decided to alter suppliers from distant locations to local suppliers. (**Redundancy**) Asian suppliers providing excellent product in terms of price and quality, but this pandemic proves that is the best scenario has a one-month delay. Exchange rates have impacted positively.

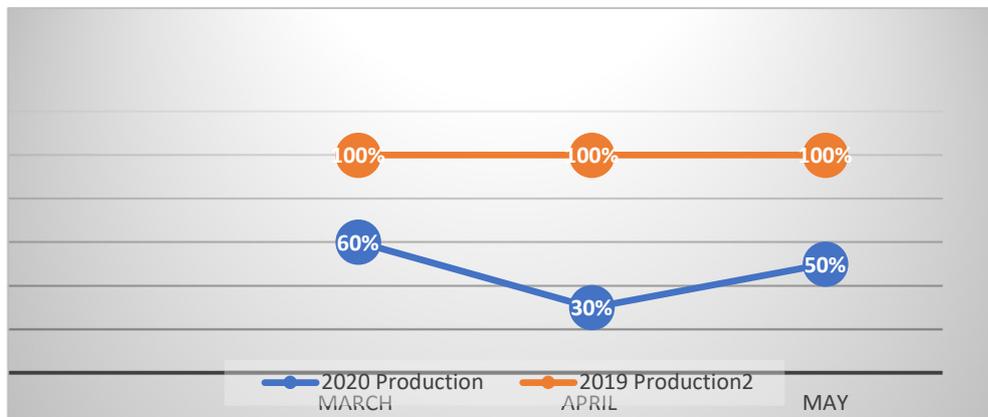
Aluminum Company

The aluminium industry lost demand from the automotive industry. The same precaution is implemented to prevent the spreading of coronavirus pandemic, such as around 10% of labour has not been able to work. The food industry packaging products has increased, but overall demand decreased by approximately 50%. The logistics industry has delayed internal up to 1 week and external a month. Asian suppliers could not send products and supply materials that stock on the points where the government lockdown. Home office works reduce efficiency and increased working time but helped to keep business as same as other companies (**Preparedness**). EU customers have problems due to lockdown, so it caused payment issues. The company looked forward to finding solutions to protect businesses, such as postponed payments. (**Agility**) The logistics industry has illustrated inadequate staff issues. 2009 financial crisis helped the company to mitigate the impact of pandemics. (**Preparedness**)

Automotive materials manufacturer

Company has successfully prevented spreading virus among employees and divided employees in 2 shifts to reduce interactions, and 10% of employee has not worked because of precautions. (**Preparedness**) Demand has lost by 60%- and three-weeks shutdown appeared in April. The production capacity is half of the last years. The company was ready in terms of the supply chain, but some specific material has caused problems. This issue was not expected for companies because at the same time suppliers and customers, and we impacted by a coronavirus. Businesses can manage for a few months, but If it goes further, the companies couldn't stand. The company has high stocks for raw materials and finished products. Ford has reduced the target car number of manufacturing from 400.000 to 250.000 pieces Pandemics will cause labour dismissals. We are expecting to go back to normal in June. Italy has impacted the production of the company.

Figure 19 Production Level



Steel and aluminium materials manufacturer

The home office working style is implemented for office workers. 15% of blue-collar didn't work in the last three months. The company started to take actions when pandemic started in China. The company faced the shutdown for a few days were stopping some production line due to suspicion virus cases. Demand has decreased %60 hence production level decreased. The company has been working on increasing stocks. The company works with many suppliers to reduce supply chain risks, but there are some materials dependent on suppliers who are from Asian countries. Asian countries caused delays for shipping, and it caused delivery and cost company more than the project amount and impacted brand image. So, the company paid more and changed logistic methods from seaways to airways which five times more expensive. **(Elasticity)** The company started activities for localization for each supply material. Asian countries will be the leading suppliers, but localization will reduce supply risk. Supply chain logistic period has increased between 30 and 45 days. **(Robustness)**

In conclusion, the companies have faced a supply chain disruption due to coronavirus pandemics. Different manufacturing companies have lost average %10-15 of their workforces besides drivers has lockdown for 14 days every travel abroad. Companies have impacted more external labour forces due to delivery drivers.

Pandemic impacted customer behaviours which demand has illustrated different for product types. Priority products demand has increased, such as medical equipment and

disinfectants, food boxing material. In contrast, non-compulsory products have significantly faced decreasing demand which aluminium products as an example of they have a high requirement on food and medical materials but automotive lines shutdown.

Companies have configured their online communication infrastructure, and they were ready to move on home office working. The standard-issue about the home office working is reducing efficiency. In-office communication faster and more apparent to analyses information, so that office staff spent more time at their homes than the office. Home office working is informal and distracting after a few weeks. People have lost their concentration.

Travel restrictions impacted companies' activities. For example, meeting with customers and events in other counties are contribute to new opportunities, but these events are cancelled.

Government restrictions in Asian and EU countries caused cancelling orders and severe decreases for demand. Companies have lost their 50% of production. According to the interview results, demand has decreased the production level for the last three months.

When we consider the entire supply chain, which starts with raw materials to customers, Asian suppliers caused problems for whole recognized industries. The main reason for this, government regulation has shut down companies. Another red alert is on the logistic side which materials arrived extra between 30-45 days late.

Companies have already focused on diversifying their supplier portfolios. One interviewee mentioned expanding the number of suppliers has more critical after the 2009 financial crisis. Coronavirus pandemic has increased the importance of localization because companies have face problems due to regions such as Asian suppliers' common issue for whole industries.

Customer demand impacted business activities. Single type manufacturer companies or one customer portfolio has stopped due to customer stayed their manufacturing. Automotive sub material manufacturers face with these problems.

In terms of readiness, companies' supply chain has readily dealt with Covid-19 pandemics. There are a few types of products that have been delayed, especially Asian

suppliers' materials. Another critical issue has raised about the stock level. Companies' stock levels and the stock cycle has increased.

Logistic delays caused payment delays, and monetary balance is disrupted. Companies can deal with finances, but the common idea is pandemic impact has lost its effect after April. Companies, Suppliers, and customers have helped each other, but if the pandemic impacted longer, businesses would have damaged dramatically.

4. Concluding Thoughts on the Contribution of this Research, its Limitations and Suggestions for Further Research

4.1 Contributions and Limitations of the Research

Collecting data didn't happen in-personal because the process was disrupted due to Covid-19 Pandemic. The information we're collecting by Zoom, Skype and other Video Calling tools. The pandemic process reduces the workload on facilities, but people are spending more time on their homes and computers, so interviews were interrupted sometimes due to Covid-19 pandemic data collected online. Focusing on manufacturing companies in Turkey has limited research.

The other issue is the online tool reducing trust and people have some worries about sharing their information. During the interview, they asked for keeping their names and numbers in private. It is provided in this dissertation.

4.2 Recommendations for Practice

First, online communication tools helped companies to sustain their business as the desired level while keeping employees' health safe. Companies must use more technology to control business when their employees away from the workplace. Automation and computing technology will reduce the required employees for production. Using technology and reducing the human workforce in manufacturing will increase robustness and preparedness for the next disruptions, which have a direct impact on employee's health.

There are many suppliers on the chain, and all materials flow on these chains. Companies have already started to check their suppliers. Turkish manufacturing industry experienced a supply chain disruption in 2009 and realized the importance of localization of suppliers and customers. Sometimes a local supplier may not provide enough adequate supply materials because suppliers' supplier may base on far regions. So that checking tier 2 suppliers have protected companies' supply flows. Companies who have checked supplier's supplier (tier 2), impacted less than other companies. In terms of readiness/preparedness/redundancy, the checking other supplier layer increases readiness and robustness so that impact on the resilience of the business.

After the 2009 financial crisis, Companies has taken many precautions to prevent supply chain disruptions—the essential issues raised, which is depending on customers. Companies who have single customers have stopped their business because of lacking demand. In contrast, companies who have various products and customers, they swapped their product lines or not stopped completely.

Lean production companies have provided lower-cost under normal conditions, but when a disruptive event occurs, the companies face supply problems. Companies must consider lean supply chain advantages, and global supply chains require more agile supply chains. For this situation, companies must use a supply chain type which must be placed between agile and lean supply chains. Leagile supply chain helps to set a more resilient supply chain. Agility has increased to respond to instant changes to the producing process and very important to build a resilience supply chain.

The Turkish manufacturing industry has always faced with exchange rates. Companies are using different types of financial tools to reduce exchange rates. If companies have enough stocks that will be advantages companies under crises situation. Because Turkish Lira loses value again foreign money, so companies must consider have optimum stock to get advantages.

Stocks always have cost for companies. So that companies want to keep their stock at a minimum level. (storage cost, opportunity cost, security cost, waste and expired date products costs) but some supply materials have vital importance on companies activity. So, companies must keep different level of stocks.

The interviewed companies have faced with unstable payment situations. There are a few late received payments. These companies had enough financial strength to cope with this situation, but companies must consider about this situation for the next disruptive event.

Companies doubled their production shifts by divided staff in two shifts as night and daytime to protect the health of their staff.

Other essential problems raised for all companies which these problems are customs and borders which were caused delays for supplying materials. This problem wasn't for specific regions, because of all regions of world companies faced with these problems. Some companies have faced deliberately unloaded shipments due to delay payment periods. Because payment periods start after holding supply materials. Companies have already faced many disruptions on their supply chains due to various reason, for example, fire on supply chains or sunk ship. But this time, companies have a delay on all type products which one of the interviewed companies' managers said that governments want to delay shipments periods to protect their companies.

One company took a lot of precaution to have resilience supply chains, but still, it is not easy to make full resilience supply chains. During the pandemics, they stopped a manufacturing line lack of original supply material. This material was a particular supply material and was imported from India. Lean supply products must be stocked when a disruptive event becomes a crisis—primarily single and far distance suppliers. This strategy makes a robust supply chain and helps to keep the required manufacturing.

4.3 Recommendations for Future Research

Different type of industries and different countries may compare due to the impact of Covid-19

Analyzing the effects of Covid-19 on industries may study.

5. Bibliography

- AA (2020) *Dış ticaret istatistikleri açıklandı*. Available at: <https://www.aa.com.tr/tr/ekonomi/dis-ticaret-istatistikleri-aciklandi/1823888> (Accessed: 27 August 2020).
- Aguila, J. O. and ElMaraghy, W. (2019) ‘Supply chain resilience and structure: An evaluation framework’, *Procedia Manufacturing*. (7th International conference on Changeable, Agile, Reconfigurable and Virtual Production (CARV2018)), 28, pp. 43–50. doi: 10.1016/j.promfg.2018.12.008.
- Akkılıç, M. E. (2016) ‘101 soruda pazarlama’, *İstanbul: Türkmen Kitabevi*.
- Aronson, Brassey and Mahtani (2020) “When will it be over?”: An introduction to viral reproduction numbers, R_0 and R_e , *CEBM*. Available at: <https://www.cebm.net/covid-19/when-will-it-be-over-an-introduction-to-viral-reproduction-numbers-r0-and-re/> (Accessed: 26 May 2020).
- Badea, A. *et al.* (2014) ‘Assessing Risk Factors in Collaborative Supply Chain with the Analytic Hierarchy Process (AHP)’, *Procedia - Social and Behavioral Sciences*, 124, pp. 114–123. doi: 10.1016/j.sbspro.2014.02.467.
- Ballou, R. H. (2006) ‘A evolução e o futuro da logística e do gerenciamento da cadeia de suprimentos’, *Production*, 16(3), pp. 375–386. doi: 10.1590/S0103-65132006000300002.
- Barroso, A. P., Machado, V. H. and Cruz Machado, V. (2008) ‘A supply chain disturbances classification’, in *2008 IEEE International Conference on Industrial Engineering and Engineering Management. 2008 IEEE International Conference on Industrial Engineering and Engineering Management*, pp. 1870–1874. doi: 10.1109/IEEM.2008.4738196.
- BBC (2020) ‘Almost all UK car production paused amid virus fears’, *BBC News*, 18 March. Available at: <https://www.bbc.com/news/business-51944301> (Accessed: 12 May 2020).
- Ben Naylor, J. *et al.* (1999) ‘Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain’, *International Journal of Production Economics*, 62(1–2), pp. 107–118.
- Berger, R. (2020) *This crisis is different – Comparing the coronavirus crisis with the financial crash*, Roland Berger. Available at: https://www.rolandberger.com/en/Point-of-View/Point-of-View-Details_65664.html (Accessed: 12 May 2020).
- Bode, C. and Macdonald, J. R. (2017) ‘Stages of Supply Chain Disruption Response: Direct, Constraining, and Mediating Factors for Impact Mitigation’, *Decision Sciences*. Wiley-Blackwell, 48(5), pp. 836–874. doi: 10.1111/dec.12245.
- Boschi, Borin and Batocchio (2011) (2) (PDF) *Leagile - The new framework for the supply chain management*, *ResearchGate*. Available at:

https://www.researchgate.net/publication/287606433_Leagile_-_The_new_framework_for_the_supply_chain_management#fullTextFileContent (Accessed: 9 July 2020).

Boyce, C. and Neale, P. (2006) 'CONDUCTING IN-DEPTH INTERVIEWS', p. 16.

Bozarth, C. B. and Handfield, R. B. (2015) *Introduction to Operations and Supply Chain Management*. Pearson Education.

Bozarth, C. C. *et al.* (2009) 'The impact of supply chain complexity on manufacturing plant performance', *Journal of Operations Management*, 27(1), pp. 78–93. doi: 10.1016/j.jom.2008.07.003.

Brown, R. (2006) *Doing Your Dissertation in Business and Management*. 1 Oliver's Yard, 55 City Road, London England EC1Y 1SP United Kingdom: SAGE Publications Ltd. doi: 10.4135/9781849209069.

Bruce, Daly and Towers (2004) (2) (PDF) *Lean or agile a solution for supply chain management in the textiles and clothing industry?* *International Journal of Operations and Production Management*, 24(2), 151-170, *ResearchGate*. Available at: https://www.researchgate.net/publication/242348933_Lean_or_agile_a_solution_for_supply_chain_management_in_the_textiles_and_clothing_industry_International_Journal_of_Operations_and_Production_Management_24_151-170 (Accessed: 10 July 2020).

Callaway, E. *et al.* (2020) 'The coronavirus pandemic in five powerful charts', *Nature*. Nature Publishing Group, 579(7800), pp. 482–483. doi: 10.1038/d41586-020-00758-2.

CCEA (2015) *Case study: Tohoku, Japan - Earthquakes - CCEA - GCSE Geography Revision - CCEA, BBC Bitesize*. Available at: <https://www.bbc.co.uk/bitesize/guides/zg9h2nb/revision/6> (Accessed: 27 April 2020).

Ceryno, P. S. *et al.* (2013) 'Supply chain risk management: a content analysis approach', *International Journal of Industrial Engineering and Management*, 4(3), pp. 141–150.

Chain, P. T. L. | S. and Consultancy, L. (2016) 'How Exchange Rates Impact Supply Chains | Paul Trudgian', *Paul Trudgian Ltd*, 8 August. Available at: <https://www.paultrudgian.co.uk/how-economic-uncertainty-and-exchange-rates-impact-supply-chains/> (Accessed: 28 May 2020).

Chopra, S. and Meindl, P. (2013) *Supply Chain Management: Strategy, Planning, and Operation*. Pearson.

Chopra, S. and Sodhi, M. S. (2004) 'Supply chain breakdown'. Available at: https://www.academia.edu/8415877/Supply_chain_breakdown (Accessed: 17 July 2020).

Christopher, M. (2000) 'The Agile Supply Chain: Competing in Volatile Markets', *Industrial Marketing Management*, 29(1), pp. 37–44. doi: 10.1016/S0019-8501(99)00110-8.

Christopher, M. (2016) *Logistics & Supply Chain Management*. Pearson UK.

Christopher, M. and Peck, H. (2004) 'Building the Resilient Supply Chain', *The International Journal of Logistics Management*, 15(2), pp. 1–14. doi: 10.1108/09574090410700275.

Cottrill, K. (1997) 'REFORGING THE SUPPLY CHAIN', *Journal of Business Strategy*. MCB UP Ltd, 18(6), pp. 35–39. doi: 10.1108/eb039895.

Craighead, C. W. *et al.* (2007) 'The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities', *Decision Sciences*. Wiley-Blackwell, 38(1), pp. 131–156. doi: 10.1111/j.1540-5915.2007.00151.x.

Cranfield University (2002) *supply chain vulnerability - Cranfield University* www.cranfield.ac.uk › centres - Google Search. Available at: https://www.google.com/search?q=supply+chain+vulnerability+-+Cranfield+Universitywww.cranfield.ac.uk+%E2%80%BA+centres&rlz=1C1CHBD_enIE838IE838&oq=supply+chain+vulnerability+-+Cranfield+Universitywww.cranfield.ac.uk+%E2%80%BA+centres&aqs=chrome..69i57.2448j0j9&sourceid=chrome&ie=UTF-8 (Accessed: 9 August 2020).

CSCMP (2013) *SCM Definitions and Glossary of Terms*. Available at: https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx (Accessed: 5 May 2020).

Davis, T. (1993) 'Effective supply chain management', *Sloan management review*, 34, pp. 35–35.

DHA (2020) *Corona virüs otomobil sektörünü nasıl etkiledi?*, *Milliyet*. Available at: <https://www.milliyet.com.tr/otomobil/corona-virus-otomobil-sektorunu-nasil-etkiledi-6170733> (Accessed: 26 July 2020).

Dolgui, A., Ivanov, D. and Sokolov, B. (2018) 'Ripple effect in the supply chain: an analysis and recent literature', *International Journal of Production Research*. Taylor & Francis Ltd, 56(1/2), pp. 414–430. doi: 10.1080/00207543.2017.1387680.

Dudovskiy, J. (2011) *Research-Methodology - Necessary knowledge to conduct a business research*. Available at: <https://research-methodology.net/> (Accessed: 17 May 2020).

Fahimnia, B. *et al.* (2015) 'Quantitative models for managing supply chain risks: A review', *European Journal of Operational Research*, 247(1), pp. 1–15. doi: 10.1016/j.ejor.2015.04.034.

Fuest, K. (2020) *Three scenarios for how Coronavirus may affect economies and industries*, *Roland Berger*. Available at: <https://www.rolandberger.com/en/Point-of-View/Three-scenarios-for-how-Coronavirus-may-affect-economies-and-industries.html> (Accessed: 12 May 2020).

Galbraith, J. R. (1973) *Designing complex organizations*. Addison-Wesley Longman Publishing Co., Inc.

- Goldman, S. L., Nagel, R. N. and Preiss, K. (1995) *Agile competitors and virtual organizations: strategies for enriching the customer*. Van Nostrand Reinhold New York.
- Gurnani, H., Mehrotra, A. and Ray, S. (2012) *Supply chain disruptions: Theory and practice of managing risk*. Springer.
- Habermann, M., Blackhurst, J. and Metcalf, A. Y. (2015) ‘Keep Your Friends Close? Supply Chain Design and Disruption Risk’, *Decision Sciences*. Wiley-Blackwell, 46(3), pp. 491–526. doi: 10.1111/dec.12138.
- Haren, P. and Simchi-Levi, D. (2020) ‘How Coronavirus Could Impact the Global Supply Chain by Mid-March’, *Harvard Business Review*, 28 February. Available at: <https://hbr.org/2020/02/how-coronavirus-could-impact-the-global-supply-chain-by-mid-march> (Accessed: 8 May 2020).
- Heckmann, I., Comes, T. and Nickel, S. (2015) ‘A critical review on supply chain risk – Definition, measure and modeling’, *Omega*, 52, pp. 119–132. doi: 10.1016/j.omega.2014.10.004.
- Hendricks, K. B., Singhal, V. R. and Zhang, R. (2009) ‘The effect of operational slack, diversification, and vertical relatedness on the stock market reaction to supply chain disruptions’, *Journal of Operations Management*, 27(3), pp. 233–246. doi: 10.1016/j.jom.2008.09.001.
- Ho, W. *et al.* (2015) ‘Supply chain risk management: a literature review’, *International Journal of Production Research*. Taylor & Francis Ltd, 53(16), pp. 5031–5069. doi: 10.1080/00207543.2015.1030467.
- Hofmann, H. *et al.* (2014) ‘Sustainability-related supply chain risks: Conceptualization and management’, *Business Strategy and the Environment*. Wiley Online Library, 23(3), pp. 160–172.
- Hong, P., Huang, C. and Li, B. (2012) ‘Crisis management for SMEs: insights from a multiple-case study’, *International Journal of Business Excellence*. Inderscience Publishers Ltd, 5(5), pp. 535–553.
- HSE (2020) *Coronavirus*. Available at: <https://www2.hse.ie/public/en/landing-pages/coronavirus/> (Accessed: 12 May 2020).
- Husdal, J. (2008) ‘Robustness, flexibility and resilience’, *husdal.com*, 28 April. Available at: <http://www.husdal.com/2008/04/28/robustness-flexibility-and-resilience-in-the-supply-chain/> (Accessed: 4 May 2020).
- Käfer, R. (2007) ‘Advantages and disadvantages of a Just in time/Just in sequence production’, p. 3.
- Kanamori, H. (1995) ‘The Kobe (Hyogo-ken Nanbu), Japan, Earthquake of January 16, 1995’, *Seismological Research Letters*. GeoScienceWorld, 66(2), pp. 6–10. doi: 10.1785/gssrl.66.2.6.

- Kazama, M. and Noda, T. (2011) *Damage statistics (Summary of the 2011 off the Pacific Coast of Tohoku Earthquake damage)* | Elsevier Enhanced Reader. doi: 10.1016/j.sandf.2012.11.003.
- Kleindorfer, P. R. and Saad, G. H. (2005) 'Managing disruption risks in supply chains', *Production and operations management*. Wiley Online Library, 14(1), pp. 53–68.
- Koç, E., Şenel, M. C. and Kaya, K. (2018) 'Türkiye'de Sanayi Sektörünün Genel Durumu-Sanayi Ciro Endeksi', *M. C.*, p. 18.
- Kopczak, L. R. and Johnson, M. E. (2003) 'The supply-chain management effect', *MIT Sloan Management Review*, 44(3), pp. 27–34.
- KPMG (2020) *Covid-19'un Tedarik Zinciri Üzerindeki Etkilerini Yönetmek İçin Olası Stratejik Hamleler - KPMG Türkiye*, KPMG. Available at: <https://home.kpmg/tr/tr/home/gorusler/2020/03/kovid-19-tedarik-zincirine-etkilerini-yonetmek.html> (Accessed: 22 May 2020).
- Kumar, S. and Chandra, C. (2010) 'Supply Chain Disruption by Avian flu Pandemic for U.S. Companies: A Case Study', *Transportation Journal (American Society of Transportation & Logistics Inc)*. American Society of Transportation & Logistics Inc, 49(4), pp. 61–73.
- Langer, E. J. (2016) *The power of mindful learning*. Hachette UK.
- Lee, H. L. and Billington, C. (1993) 'Material management in decentralized supply chains', *Operations Research*. INFORMS: Institute for Operations Research, 41(5), p. 835. doi: 10.1287/opre.41.5.835.
- Lee, H. L., Padmanabhan, V. and Seungjin Whang (2004) 'Information Distortion in a Supply Chain: The Bullwhip Effect', *Management Science*. INFORMS: Institute for Operations Research, 50, pp. 1875–1886. doi: 10.1287/mnsc.1040.0266.
- Lenain, P., Bonturi, M. and Koen, V. (2002) 'The Economic Consequences of Terrorism'. OECD. doi: <https://doi.org/10.1787/511778841283>.
- Lu, D. (2011) *Fundamentals of supply chain management*. Bookboon.
- Macdonald, J. R. and Corsi, T. M. (2013) 'Supply Chain Disruption Management: Severe Events, Recovery, and Performance', *Journal of Business Logistics*, 34(4), pp. 270–288. doi: 10.1111/jbl.12026.
- Manuj, I. and Mentzer, J. T. (2008) 'Global Supply Chain Risk Management', *Journal of Business Logistics*, 29(1), pp. 133–155. doi: 10.1002/j.2158-1592.2008.tb00072.x.
- Marsh, A. (2020) 'HSBC Says Pandemic May Cause Share Suspensions, Asset Writedowns', *Bloomberg.com*. Bloomberg, L.P., p. N.PAG-N.PAG.
- Marszewska, J. R. (2016) 'Implications of seismic hazard in Japan on toyota supply chain disruption risks', in *Proceedings of 13th International Conference on Industrial Logistics*, pp. 178–185.

- Matsuo, H. (2015) 'Implications of the Tohoku earthquake for Toyota's coordination mechanism: Supply chain disruption of automotive semiconductors', *International Journal of Production Economics*, 161, pp. 217–227. doi: 10.1016/j.ijpe.2014.07.010.
- Mckinsey (2020) *McKinsey & Company | Global management consulting*. Available at: <https://www.mckinsey.com> (Accessed: 7 August 2020).
- Mensah, P. and Merkuryev, Y. (2014) 'Developing a Resilient Supply Chain', *Procedia - Social and Behavioral Sciences*. (The 2-dn International Scientific conference „Contemporary Issues in Business, Management and Education 2013“), 110, pp. 309–319. doi: 10.1016/j.sbspro.2013.12.875.
- Meyer (2020) *7 Steps for Minimizing Supply Chain Disruptions + Prevention Tips*, *The BigCommerce Blog*. Available at: <https://www.bigcommerce.com/blog/supply-chain-disruptions/> (Accessed: 9 August 2020).
- Moldovan, D., Copil, G. and Dustdar, S. (2018) 'Elastic systems: Towards cyber-physical ecosystems of people, processes, and things', *Computer Standards & Interfaces*, 57, pp. 76–82. doi: 10.1016/j.csi.2017.04.002.
- Monostori, J. (2018) 'Supply chains robustness: Challenges and opportunities', *Procedia CIRP*. (11th CIRP Conference on Intelligent Computation in Manufacturing Engineering, 19-21 July 2017, Gulf of Naples, Italy), 67, pp. 110–115. doi: 10.1016/j.procir.2017.12.185.
- Morris Cohen, F.-D. C. for S. and O. M. P. of O. (2020) *Morris Cohen, Knowledge@Wharton*. Available at: <https://knowledge.wharton.upenn.edu/faculty/cohen/> (Accessed: 26 July 2020).
- Morris, P. W. G. and Pinto, J. K. (2005) 'The Wiley Guide to Project Technology, Supply Chain & Procurement Management', p. 411.
- Nagel, R. N. and Dove, R. (1991) *21st century manufacturing enterprise strategy: An industry-led view*. Diane Publishing.
- Norrman, A. and Jansson, U. (2004) 'Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident', *International Journal of Physical Distribution & Logistics Management*, 34(5), pp. 434–456. doi: 10.1108/09600030410545463.
- OECD (2004) *Large-scale Disasters: Lessons Learned*. OECD. doi: 10.1787/9789264020207-en.
- Öztürk and Gövdere (2010) (2) (PDF) *KÜRESEL FİNANSAL KRİZ VE TÜRKİYE EKONOMİSİNE ETKİLERİ*, *ResearchGate*. Available at: https://www.researchgate.net/publication/310465483_KURESEL_FINANSAL_KRIZ_VE_TURKIYE_EKONOMISINE_ETKILERI#fullTextFileContent (Accessed: 25 August 2020).

- Palumbo, L. J., Daniele and Brown, D. (2020) 'Coronavirus: A visual guide to the economic impact', *BBC News*, 30 April. Available at: <https://www.bbc.com/news/business-51706225> (Accessed: 26 May 2020).
- Park, Y., Hong, P. and Roh, J. J. (2013) 'Supply chain lessons from the catastrophic natural disaster in Japan', *Business Horizons*, 56(1), pp. 75–85. doi: 10.1016/j.bushor.2012.09.008.
- Paton, D. and Johnston, D. (2001) 'Disasters and communities: vulnerability, resilience and preparedness', *Disaster Prevention and Management: An International Journal*. MCB UP Ltd, 10(4), pp. 270–277. doi: 10.1108/EUM0000000005930.
- Paul, S. K., Sarker, R. and Essam, D. (2016) 'Managing risk and disruption in production-inventory and supply chain systems: A review', *Journal of Industrial & Management Optimization*, 12(3), p. 1009. doi: 10.3934/jimo.2016.12.1009.
- Perrow, C. (2011) *Normal Accidents: Living with High Risk Technologies - Updated Edition*. Princeton University Press.
- Ponomarov, S. Y. and Holcomb, M. C. (2009) 'Understanding the concept of supply chain resilience', *The International Journal of Logistics Management*. Emerald Group Publishing Limited, 20(1), pp. 124–143. doi: 10.1108/09574090910954873.
- PRNewswire, R. and (2020) *Impact of COVID-19 on the Global Manufacturing Industry, 2020*. Available at: <https://www.prnewswire.com/news-releases/impact-of-covid-19-on-the-global-manufacturing-industry-2020-301042150.html> (Accessed: 26 July 2020).
- Rapaccini, M. *et al.* (2020) 'Navigating disruptive crises through service-led growth: The impact of COVID-19 on Italian manufacturing firms', *Industrial Marketing Management*, 88, pp. 225–237. doi: 10.1016/j.indmarman.2020.05.017.
- Sanchis, R., Canetta, L. and Poler, R. (2020) 'A Conceptual Reference Framework for Enterprise Resilience Enhancement', *Sustainability*. Multidisciplinary Digital Publishing Institute, 12(4), p. 1464. doi: 10.3390/su12041464.
- Saunders, S., Thornhill and Lewis (2009) *Research methods for business students 5th edition 2009 (Mark N.K. Saunders, Adrian Thornhill, Philip Lewis)*. Available at: https://www.academia.edu/40208075/Research_methods_for_business_students_5th_edition_2009_Mark_N.K._Saunders_Adrian_Thornhill_Philip_Lewis_ (Accessed: 16 May 2020).
- Sawik, T. (2018) 'Selection of a dynamic supply portfolio under delay and disruption risks', *International Journal of Production Research*. Taylor & Francis Ltd, 56(1/2), pp. 760–782. doi: 10.1080/00207543.2017.1401238.
- Scherzer, S., Lujala, P. and Rød, J. K. (2019) 'A community resilience index for Norway: An adaptation of the Baseline Resilience Indicators for Communities (BRIC)', *International Journal of Disaster Risk Reduction*, 36, p. 101107. doi: 10.1016/j.ijdr.2019.101107.

- Sheffi, Y. (2005) 'The resilient enterprise: overcoming vulnerability for competitive advantage', *MIT Press Books*. The MIT Press, 1.
- Sheffi, Y. (2008) 'Resilience: What it is and how to achieve it', p. 5.
- Sheffi, Y. (2020) 'Commentary: Supply-Chain Risks From the Coronavirus Demand Immediate Action', *Wall Street Journal*, 18 February. Available at: <https://www.wsj.com/articles/commentary-supply-chain-risks-from-the-coronavirus-demand-immediate-action-11582054704> (Accessed: 26 May 2020).
- Sodhi, M. S. and Tang, C. S. (2012) 'Modeling supply-chain planning under demand uncertainty using stochastic programming: A survey motivated by asset–liability management', *International Journal of Production Economics*, 121(2), pp. 728–738.
- Srinivasan, R. and Swink, M. (2015) 'Leveraging Supply Chain Integration through Planning Comprehensiveness: An Organizational Information Processing Theory Perspective', *Decision Sciences*, 46(5), pp. 823–861. doi: 10.1111/dec.12166.
- Stauffer, D. (2003) 'Risk: The Weak Link in Your Supply Chain', *Harvard Management Update*. Harvard Business School Publication Corp., 8(3), p. 3.
- Stricker, N. and Lanza, G. (2014) 'The Concept of Robustness in Production Systems and its Correlation to Disturbances', *Procedia CIRP*. (2nd CIRP Robust Manufacturing Conference (RoMac 2014)), 19, pp. 87–92. doi: 10.1016/j.procir.2014.04.078.
- Svensson, G. (2002) 'A conceptual framework of vulnerability in firms' inbound and outbound logistics flows', *International Journal of Physical Distribution & Logistics Management*. MCB UP Ltd, 32(2), pp. 110–134. doi: 10.1108/09600030210421723.
- Swafford, P. M., Ghosh, S. and Murthy, N. (2006) 'The antecedents of supply chain agility of a firm: Scale development and model testing', *Journal of Operations Management*, 24(2), pp. 170–188. doi: 10.1016/j.jom.2005.05.002.
- Tang, C. S. (2006) 'Robust strategies for mitigating supply chain disruptions', *International Journal of Logistics Research and Applications*. Taylor & Francis, 9(1), pp. 33–45. doi: 10.1080/13675560500405584.
- TUIK (2020) *Türkiye İstatistik Kurumu, Sanayi Üretim Endeksi, Haziran 2020*. Available at: <http://www.tuik.gov.tr/HbGetirHTML.do?id=33801> (Accessed: 27 August 2020).
- Van Wassenhove, L. N. (2006) 'Humanitarian aid logistics: supply chain management in high gear', *Journal of the Operational research Society*. Taylor & Francis, 57(5), pp. 475–489.
- Wagner, S. M. and Bode, C. (2006) 'An empirical investigation into supply chain vulnerability', *Journal of Purchasing and Supply Management*. (Conference 2006, the Fourth Worldwide Symposium in Purchasing & Supply Chain Management), 12(6), pp. 301–312. doi: 10.1016/j.pursup.2007.01.004.
- Walliman, N. (2017) *Research Methods: The Basics: 2nd edition*. Routledge.

Wharton, B. (2020) *Coronavirus and Supply Chain Disruption: What Firms Can Learn, Knowledge@Wharton*. Available at: <https://knowledge.wharton.upenn.edu/article/veeraraghavan-supply-chain/> (Accessed: 26 July 2020).

WHO (2010) *WHO | What is a pandemic?, WHO*. World Health Organization. Available at: http://www.who.int/csr/disease/swineflu/frequently_asked_questions/pandemic/en/ (Accessed: 26 May 2020).

WHO (2020) *WHO | Update 49 - SARS case fatality ratio, incubation period, WHO*. World Health Organization. Available at: https://www.who.int/csr/sars/archive/2003_05_07a/en/ (Accessed: 26 May 2020).

Worldmeters (2020) *Coronavirus Update (Live): 4,287,176 Cases and 288,239 Deaths from COVID-19 Virus Pandemic - Worldometer*. Available at: <https://www.worldometers.info/coronavirus/> (Accessed: 12 May 2020).

Worldometer (2020) *Turkey Coronavirus: 167,410 Cases and 4,630 Deaths - Worldometer*. Available at: <https://www.worldometers.info/coronavirus/country/turkey/> (Accessed: 5 June 2020).

Wu, T., Blackhurst, J. and Chidambaram, V. (2006) 'A model for inbound supply risk analysis', *Computers in Industry*, 57(4), pp. 350–365. doi: 10.1016/j.compind.2005.11.001.

Yurdakul (2015) '2008 KÜRESEL EKONOMİK KRİZİ VE TÜRKİYE'YE ETKİSİ', *Sahipkiran Stratejik Araştırmalar Merkezi - SASAM*. Available at: <http://sahipkiran.org/2015/01/12/kuresel-ekonomik-kriz/> (Accessed: 25 August 2020).

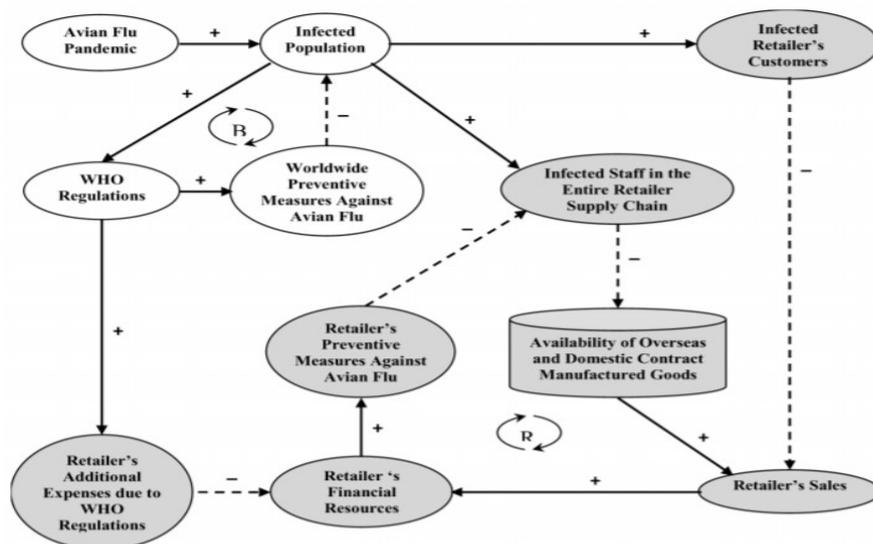
Zainal Abidin, N. A. and Ingirige, B. (2018) 'Identification of the "Pathogenic" Effects of Disruptions to Supply Chain Resilience in Construction', *Procedia Engineering*. (7th International Conference on Building Resilience: Using scientific knowledge to inform policy and practice in disaster risk reduction), 212, pp. 467–474. doi: 10.1016/j.proeng.2018.01.060.

Zsidisin, G. A. and Ellram, L. M. (2003) 'An Agency Theory Investigation of Supply Risk Management', *Journal of Supply Chain Management*, 39(2), pp. 15–27. doi: 10.1111/j.1745-493X.2003.tb00156.x.

6. Appendix

Figure 20 is explaining the virus spreading point and how it would affect supply chain parts.

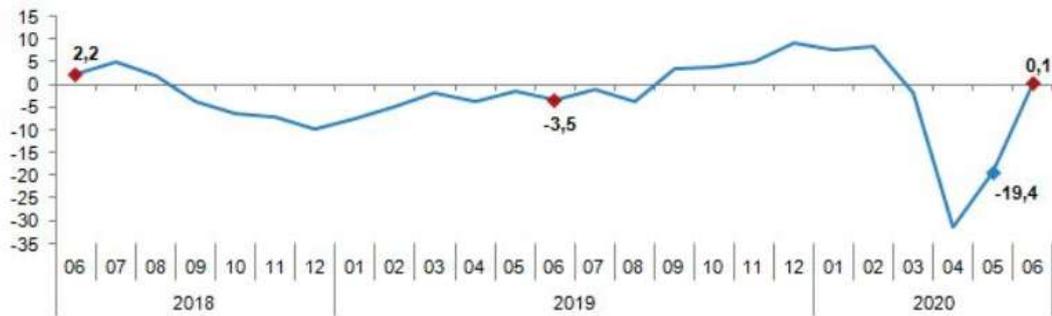
Figure 20 The Effect of Avian Flu Pandemic on the Retailer's Global Supply Chain



(Kumar and Chandra, 2010)

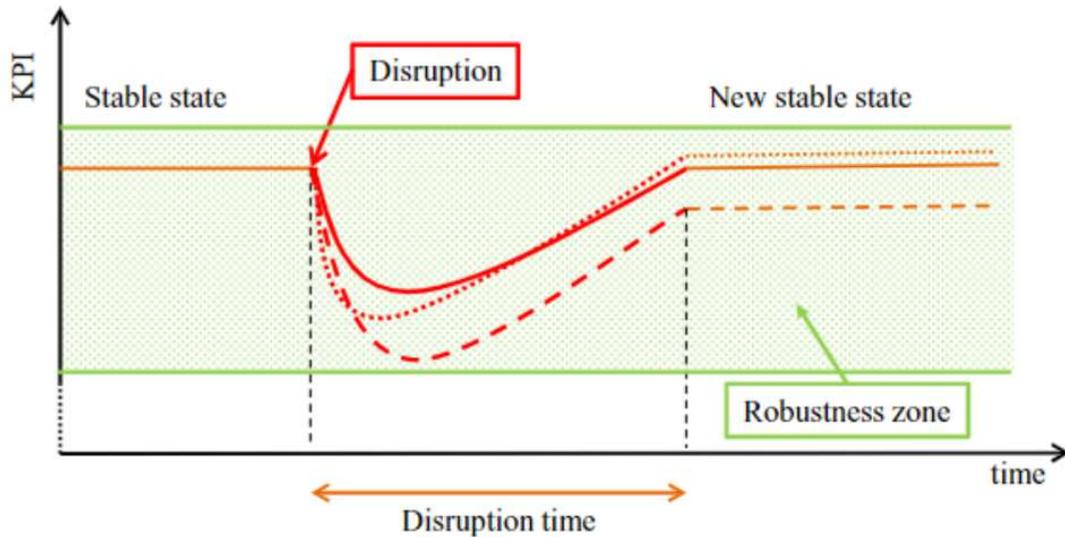
Figure 21 compares the Turkish manufacturing industry production level by monthly based in June of 2018. Production level showed the most in-depth performance when the virus reached its peak level.

Figure 21 Turkey's Manufacturing Industry Performance



(TUIK, 2020)

Figure 22 Supply Chain Disruption Timing



(Monostori, 2018)

What is different about supply chain disruption caused by a pandemic?

The epidemic is a disease and impacting individuals in a short period with high-level contamination throughout spreading overpopulation in the area. Still, a pandemic is a type of plague and spreading over many countries. (WHO, 2010) There are many pandemics in history so far.

Table 2 Example of Pandemics

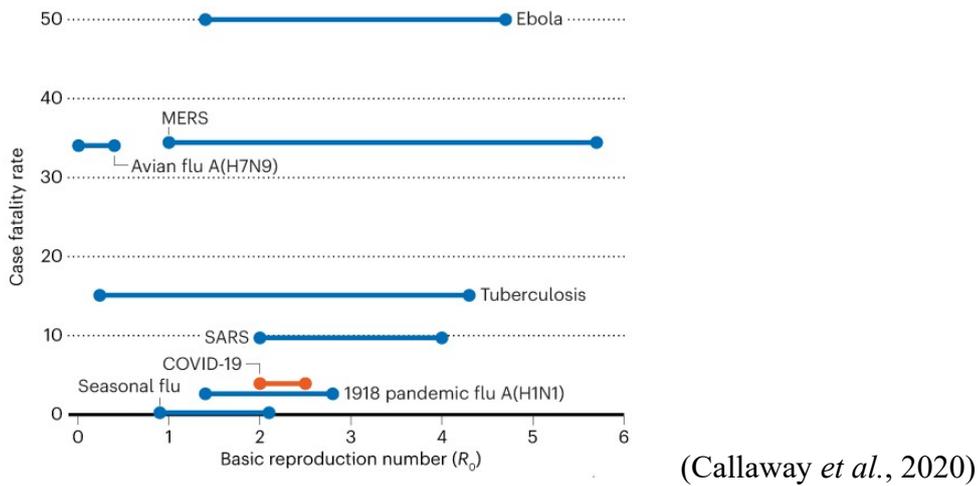
Pandemic	Death Toll:	Cause:	Region	Period
<u>Sixth Cholera Pandemic</u>	800,000+	Cholera	The Middle East, North Africa, Eastern Europe and Russia	(1910-1911)
<u>Flu Pandemic</u>	20 -50 million	Influenza	Across Globe	(1918)
<u>Asian Flu</u>	2 million	Influenza	Mostly China, Singapore, United States	(1956-1958)
<u>Flu Pandemic</u>	1 million	Influenza	Across Globe	-1968
<u>HIV/Aids Pandemic</u>	36 million	Hiv	Across Globe	At Its Peak, (2005-2012)

(OECD, 2004)

When we look at the Covid-19 impact and level of contamination is not as big as another pandemic which has shown a closer level impact on people; however, the coronavirus pandemic hit economies more than other epidemics. (Haren and Simchi-Levi, 2020) compared with SARS and stated that this time financial results would be more destroyed because the world trade and economic ecosystem has changed dramatically. China GDP level has increased by 4.31% to 16%. The world more interconnected and more depended on China supplies. Besides, Covid-19 infected ten times more than SARS in the same period.

The horizontal part of the Figure one refers to the “Basic Reproduction Number” which the level of the infection due to individuals are spreading to another. (Aronson, Brassey and Mahtani, 2020)

Figure 23 Comparison of pandemics



World disruption and Pandemic examples:

1995 The Hyogo-ken Nanbu earthquake - Japan

This earthquake caused to 6.430 people’s life. 105.000 house destroyed and 140.000 damaged. Over 300.000 people lost their homes. The city infrastructure collapsed, and almost 3 million people were striving due to lack of gas, electricity, transportation, telecommunication or water.

Economic damage: USD130 billion.

80% decrease in freight transport (imports + exports)

Fiscal impact: USD 70 billion in 1994, USD 100 billion in 1995 (1.3%and 1.9% of GDP respectively). (Kanamori, 1995) (OECD, 2004)

17 August and 12 November The Marmara earthquakes

1999; Two earthquakes happened Northern-West of Turkey, which earthquakes were caused 18.873 people's life as well as 110.000 houses collapsed, and 249.000 houses damaged. Result of this 600.000 people lost their homes.

The area of earthquakes is an essential location for government revenue and population.

The affected area concentrates 23% of the population, 34% of Gross National Product, and 46% of total industrial output and provides 16% of total government revenues.

The earthquakes cost around \$ 10 billion. GNP level reduced to %4.9 from %7.6. (OECD, 2004)

The Chernobyl Nuclear Accident

1986, Chernobyl, Ukraine. A meltdown of Unit 4 of the Chernobyl nuclear power plant caused 31 people's life at the time of incidents. But it impacted over 23 million people's life which they live in the affected area. 135.000 people have directly impacted.

In terms of the economic aspect, the result is \$2.8 billion. The following five years, the accident caused \$18 billion to in terms of fiscal budget of the Soviet Union, which meant %20 GDP. The Chernobyl impacts are still going on the areas' county as financial. (OECD, 2004)

The 11 September terrorist attacks

2001 It was a hijacking which plane crashed the trade centre of New York and caused 3000 people's life. As an economical result, \$16 billion costs to the USA and 200.000 people lose their job. The unemployment rate increase %0.8 to %5.8. according to the OECD report, the attack costs between \$40 and 450 billion. (OECD, 2004) (Lenain, Bonturi and Koen, 2002)

The 11 September terrorist attack caused the evolution of supply chain strategy, which made more efficient supply. The increased security process requires more detailed information for each part of the supply chain process. The supply chain sharers which especially shippers, hand-off points, data flow process, agencies, industries and Government collaborate to keep the efficiency of supply chain and not to cause any disruption while they are sharing more data to the related establishments.

After the terrorist attack, there are many developments in supply chain management. For example, Customs started to check containers before they reached the docks. Besides, the Government began to track the containers' route, whether it is in the same direction or not as well as, Government set a certification to control whole sharers of the supply chain. (Tang, 2006)

The Earthquake of Tohoku, Japan

2011 the earthquake of magnitude 9.0 at 43 miles from Japan. It continued 6 minutes and caused a tsunami which the wave heights reached over 40 meters.

The earthquake caused 1.5894 people's life, and 6.152 people injured as well as 2.562 people have not found yet.

Japanese Government spent a colossal amount of money to dispose of the effect of coming tsunamis. Still, this one was overestimated, and the whole preparing was not useful because the defensive walls were only meters against tsunamis.

To sum up, 332,395 buildings, 2,126 roads, 56 bridges, 300 hospitals and 26 railways were not able to use them again or collapsed.

When we look at the other impacts: it was the worst damage in term of monetary, which was \$235 billion. The nuclear leaking caused damage which was eight times higher than expected. (Kazama and Noda, 2011) (CCEA, 2015)