



The impact of the COVID-19 pandemic on the food and healthcare supply chain

Bachelor's Script HW

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This bachelor thesis was written during the COVID-19 crisis in 2020-2021. This global health crisis may have had an impact on the writing and processing process, research and research results that form the basis of this paper.

Preface

We are three students in Business Administration at Hasselt University. As part of the last year of this bachelor's programme, we had to write a bachelor thesis. This thesis helped us broaden our academic knowledge and helped us get to know the academic world and the process of writing scientific research papers more.

In the year 2019, the COVID-19 started wreaking havoc around the world. All of our lives got affected by the virus. As of writing this thesis in 2021, the virus is still around. In the past year, we have been following online classes, we could not go to events, and we could not visit family and friends in a normal way. Not only did the virus affect our lives and (mental) health, it also had a significant impact on the economy and society as a whole.

Because of the recency of this topic and the magnitude of the impacts, we saw the opportunity to go deeper into the effects of the COVID-19 virus on the economy. More specifically, the effects of the virus on the supply chain because we noticed these effects in our everyday lives (e.g. longer shipping times and hoarding).

Even though the topic is very current and interesting, writing about it and finding relevant literature was not an easy task. Nonetheless, we really enjoyed writing this paper, and we wish you a pleasant reading experience!

Pelt, Nijlen, Urmond,
May 10th, 2021

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With COVID-19 being an unprecedented event, many supply chains have been heavily challenged. The food and healthcare supply chains are examples of such supply chains, among others. Governments have imposed various measures to limit the spread of the virus leading to several supply and demand shocks, causing a mismatch between demand and supply. These shocks and this mismatch were further intensified by catalysts, like globalisation and efficiency policies. Also, some mitigations have been discussed to improve supply chain resilience. The purpose of this literature review is to evaluate the impact of COVID-19 on both the food and the healthcare supply chain and to propose strategies to reduce and control the effect of the pandemic.

Keywords: Supply Chain, Healthcare, Food, Disruptions, Resilience, COVID-19, Coronavirus, Supply Shocks, Demand Shocks, Catalysts, Mitigations

1. Introduction and problem statement

History has taught us that epidemics and pandemics like the Spanish Flu, Asian Flu, Hong Kong Flu, Pandemic Flu, Ebola, and the novel COVID-19 virus can have a substantial impact on society and the economy as a whole (Liu, Kuo & Shih, 2020; Baldwin & Weder di Mauro, 2020; Meltzer, Cox & Fukuda, 1999). Though past outbreaks have had a certain impact, COVID-19 is a little bit different. For instance, compared to the 'common' flu, COVID-19 has proven to be 20 times more deadly (Akpan & Elliott, 2020). The virus first appeared in Wuhan, the capital of Central China's Hubei province, in December 2019. Although these cases were quickly linked to the Huanan Seafood Wholesale Market, it is not certain if this was the real source. From there on, the virus quickly spread to other countries all over the world (WHO, 2019). The quick spread did not only result in a global tragedy for human lives, but also for the global economy. As of May 2021, according to the World Health Organization, there are 152.387.917 confirmed cases and 3.195.624 confirmed deaths globally. Obviously, not all countries measure in the same ways or report all cases, the true numbers may therefore be even larger (WHO, 2021). The virus mostly affects adults over 60 years old or people with underlying medical problems but can also affect younger adults and children. Among the most common symptoms are fever, fatigue and a dry cough. The more severe cases can result in permanent health damage or even death. Less affected people mostly suffer from a loss of taste and smell or mild colds.

Most affected people recover without any specific treatment or hospitalization (WHO, 2019; Meltzer et al., 1999).

With no vaccines available at the beginning of the pandemic, governments all over the world implemented various temporal measures to slow down the spread of the coronavirus. Personal protective measures included frequent hand sanitation and the requirement to wear face masks in public places. Additionally, there were community mitigation measures to reduce personal and social contacts like social distancing, cocooning of the elderly and vulnerable groups, travel restrictions and the closure of non-essential businesses and educational institutes (Cowling & Aiello, 2020).

Even though these measures were necessary tools to contain the epidemic, they were very disruptive for economies and society (Baldwin & Weder di Mauro, 2020). For instance, the European GDP declined by 6,4% in 2020. However, since every country has taken different measures, the impact on the countries' GDP varied. For example, during the first wave of the pandemic, in the Netherlands, there has been no mandatory closure of non-essential businesses and no travel restrictions have been implemented within the country itself. Conversely, in Belgium, a neighbouring country of the Netherlands, non-essential businesses were obligated to close and non-essential travel was prohibited. Consequently, the GDP of Belgium declined by 15,2% in the second quarter of 2020 compared to the fourth quarter of 2019, whereas the Dutch GDP only declined by 9,9% in the same period (CBS, 2020).

Apart from the more general economic consequences of these measures, like the drop in GDP, there are more specific disruptions of COVID-19 as well. The supply chain, for instance, is one part of the global economy that is heavily impacted by the COVID-19 pandemic.

According to Kirilmaz & Erol (2017), the supply chain is 'the network of all entities involved in producing and delivering a finished product to the final customer'. Despite the numerous advantages a supply chain adds to the economy, like added value and efficiency, this complexity also comes with fragility and vulnerability to risks that are exposed by COVID-19.

Research suggests that both disruptions in supply and demand can impact the supply chain significantly (Ivanov, 2020). Therefore, supply chains should be optimized and well-organized to be more resilient to a variety of disruptions or shocks, be they economic, of natural origin, accidental or born out of ignorance (Leat & Revoredo-Giha, 2013). An economic shock or disruption refers to any event that impacts the economy and which originates from outside it. Shocks are often unpredictable and can have severe consequences on the economy¹. The COVID-19 outbreak is an example of such an unexpected event, and it did have severe impacts on the economy as a whole.

Firstly, among these disruptions are supply shocks. The magnitude of these shocks can differ depending on the underlying causes. Examples of small shocks are day to day changes

¹ <https://www.nasdaq.com/glossary/e/economic-shock>.

in weather conditions or location bounded disasters like earthquakes. Alternatively, there are larger shocks that occur, mostly caused by larger and global disasters or crises. This also applies to COVID-19. The virus is not geographically bound and has spread all over the world at a tremendous rate, making it more difficult to determine the size and impact of the supply shock (Baldwin & Weder di Mauro, 2020).

Secondly, both positive and negative demand shocks appeared in the early stages of the pandemic. Some goods experienced a sudden surge in demand (Hobbs, 2020; Alexander & Qato, 2020), other sectors saw their demand decrease (Baldwin & Weder di Mauro, 2020).

In this paper, potential vulnerabilities are assessed and the impact of COVID-19 on the supply chain is described as well as a review in which is discussed how these impacts can be tackled. More specifically, this review will focus on two specific supply chains: the food and healthcare supply chains.

This paper is structured as follows. The literature review begins with a short discussion of the research methodology in section 2, followed by the effects of COVID-19 on the food supply chain and the associated catalysts in section 3. After that, the same is done for the healthcare supply chain in section 4. Hereafter, section 5 discusses some strategies to help mitigate the discussed effects. Finally, in section 6, the results are summarized in a conclusion together with limitations and suggestions for future research.

2. Methodology

The research approach is a literature review of research papers found in various databases. This search led to general papers about the supply chain and the impact of COVID-19 on it. Also, more specific research papers were selected, which focused on the impact of COVID-19 on the food supply chain and the healthcare supply chain. In addition, websites, books and web articles were consulted.

Afterwards, these papers were sorted according to the subject and marked as relevant based on the abstract, introduction and conclusion. Irrelevant papers were often outdated or had nothing to do with our topic and were therefore discarded. The remaining papers were thoroughly read and studied in their entirety. Also, during the writing process papers were found in addition to the ones found in the beginning. All used sources are summarized in figure 1.

Databases	Topic	Number of studies selected for review
Google Scholar Science Direct Web of Science Library UHasselt	<i>General supply chain</i>	11
	<i>Food</i>	22
	<i>Healthcare</i>	26
Websites, books	<i>Other</i>	9
	Total	68

Figure 1: Sources and number of selected articles.

3. Impact of COVID-19 on the food supply chain

There are many different possible definitions of a food supply chain. According to Folinas, Aidonis, Triantafillou, & Malindretos (2013), a food supply chain is a complex network with many entities, such as farmers, suppliers, transporters, retailers and consumers, which are connected from farmer to consumer. Tsolakis, Keramydas, Toka, Aidonis and Iakovou (2014) confirm the 'farmer to consumer' principle and call it the 'farm to fork' progression. They refer to a food supply chain as an agricultural supply chain, which are largely interchangeable definitions according to them. They define the supply chain as 'the set of activities included in a 'farm to fork' progression, including activities such as farming (i.e., cultivation of land for crop production), processing and production, testing, packaging, warehousing, transportation, distribution and marketing'. Sharma, Shishodia, Kamble, Gunasekaran and Belhadi (2020) go more in-depth and define three main aspects of an agricultural supply chain, namely farming and agriculture inputs, food processing and logistics and distribution, which in turn can be divided into six phases: farming and agricultural inputs, production and harvest, storage, processing, packaging, distribution and retail. Nowadays, according to Demirci (2021), 'typical food supply chains are large, vertically integrated and controlled by multinational private and public corporations with a high degree of product diversity in which more than 80% of food is delivered through the global supply chain with a major focus on low cost and high efficiency'.

In the following section, the food supply chain will be looked into more in-depth. This will be done by examining demand and supply shocks separately, followed by a discussion of catalysts. In section 5, the mitigations will be discussed. An overview of the structure is shown in figure 2.

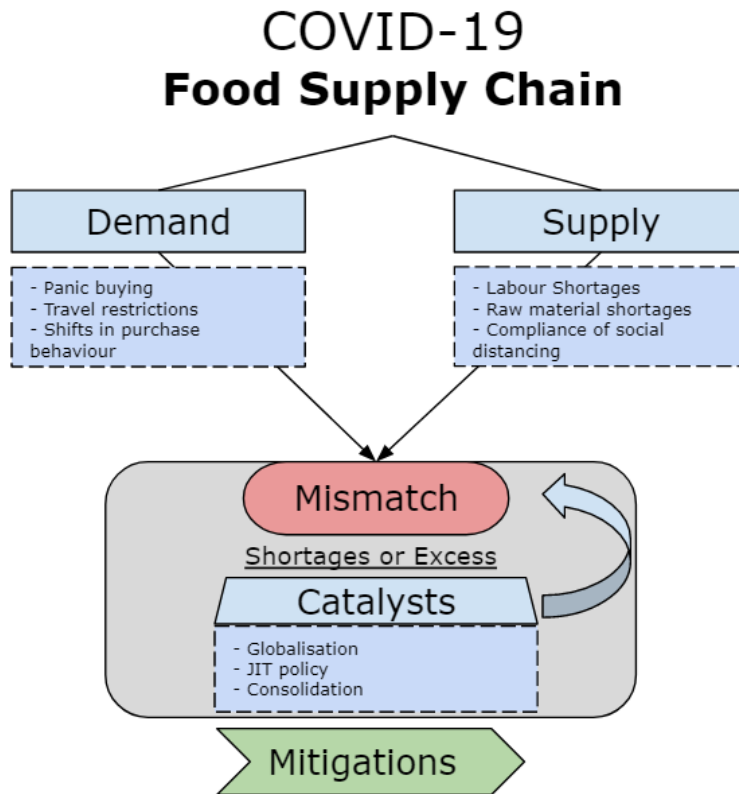


Figure 2: Visual representation of the research on the food supply chain (own construction)

3.1 Shocks / impact

This section discusses both demand and supply shocks specifically related to the food supply chain. COVID-19 affects the supply chain in its entirety: there is an impact on the whole process from the field to the consumer (Aday & Aday, 2020). Both supply and demand shocks have one thing in common: they cause a mismatch between supply and demand. More specifically, there is either an overall shortage or a shortage in one part of the supply chain and a surplus in another part (Demirci, 2021).

3.1.1 Supply-side shocks

From the literature review, three different types of supply-side shocks are evident: labour shortages, raw material shortages and reduced productivity due to social distancing.

Labour shortages impacted the continuity and feasibility of operations in the agri-food system extensively and posed significant risk on the supply of food. Research suggests that a reduction of 25% in labour will cause a reduction of 49% in food production (Luke & Rodrigue, 2008). The shortage of labour happened in two different ways. The first way relates to so-called disease-related absenteeism. The absenteeism of employees can place significant stress on food processing and trucking (Hailu, 2020). Many workforce personnel stayed at home due to a variety of reasons. People were either forced to do so due to illness, ordered to by public health institutions, or they stayed at home willingly out of fear to get sick at the workplace. This absenteeism caused plants to shut down due to a shortage of suitable workers and an undermined capacity. Absenteeism in the transport sector posed substantial risks as well. Before COVID-19, there was already a shortage in supply of truck drivers in the agricultural sector, and the COVID-19-related absenteeism exacerbated the situation. Moreover, in the transportation part of the supply chain arose an additional risk: due to the closure of service stations the risk of spreading livestock diseases increased. Lastly, absenteeism in the farm-delivery part of the food supply also caused critical risks. The first wave of COVID-19 appeared in March 2020. Normally, the spring is the period in which seed, fertilizers, fuel and other inputs are delivered and the tillage and planting proceeds, which is typically done by trained personnel. Disease-related absenteeism in these positions caused delays and impaired the seeding and crop tending operations, especially since there was already a shortage of supply in the segment of trained personnel (Al Mussell, Bilyea & Hedley, 2020).

The second way in which labour shortages were created was the shortage of foreign workers. In many countries, the agricultural and food workforce is comprised of both domestic and foreign workers. Due to the imposed travel restrictions, such as the closure of borders, it became very complicated to replace departing workers with new ones. Especially the so-called horticultural industries, which depend on both local labour as well as seasonal foreign workers, were at risk from absenteeism due to the public health and immigration regulations (Al Mussell et al., 2020).

Besides labour shortages, the shortage of raw materials also exposed supply shocks. Many businesses depend on other countries for their raw materials. Businesses suffered a shortage in supply of parts because trucks and other kinds of transportation modes were forbidden to enter the country. When there is a shortage in raw materials or supply of parts, the whole production process slows down causing supply to be smaller than demand (Hailu, 2020; Hobbs, 2020).

Also, the compliance with social distancing and hygiene measures imposed by governments contributed to supply shocks. As mentioned in the introduction, many governments implemented measures to contain the epidemic, such as social distancing, sanitation obligations

like hand disinfection and use of face masks. However, these measures impacted productivity in a negative manner: plants and distribution centres were forced to comply with these rules, meaning that workers had to keep more distance from each other and had to account for hygiene measures. Due to this, workers had to wait for each other, which caused delays in the production process (Demirci, 2021).

3.1.2 Demand-side shocks

The literature review shows there are also demand shocks. These are caused by panic buying, travel restrictions and shifts in purchasing behaviour.

A first contributor to a demand shock was the uncertainty and fear of supply disruption risks and mistrust in institutions, which caused consumers to begin panic buying and hoarding foods (Hailu, 2020). Panic buying is considered a situation in which many people suddenly buy as much food, fuel, etc. as they can because they are worried about something bad that may happen². Arafat, Kar, Marthoenis, Sharma, Apu & Kabir (2020) also mention some psychological explanations for this panic buying behaviour such as the perceived sense of losing control over the environment, perceived insecurity, social learning, instinctual behaviour, and influences of media.

Panic buying has been observed all over the world in countries such as Singapore, Japan, Australia, the UK and the USA (Sim, Chua, Vieta & Fernandez, 2020). Research by Loske (2020) suggests that not all foods experience shocks in demand in the same way and that some types of food aren't affected by the effects of the coronavirus and corona crisis at all. Food products that were stockpiled most by consumers were products with a long shelf life such as rice and pasta (Demirci, 2021) and non-perishable food items (Chenarides, Manfredo & Richards, 2020). This could be due to the fact these products enable people to go for new groceries less frequently (Loske, 2020). The demand shocks as a consequence of panic buying can be described as severe, but temporary. Once the people got used to the situation and were made alert by governments that there was no need to panic, the number of grocery store visits declined and the demand dampened to some degree (Al Mussell et al., 2020).

Besides consumers, retailers also showed panic buying behaviour. This behaviour can lead to potentially more shortages, as it raises demand in times that production and transportation are vulnerable (Peck & Helen, 2006). Because of this, panic buying from retailers involves the risk of the bullwhip effect (Al Mussell et al., 2020; Demirci, 2021). The bullwhip effect refers to volatility in demand and amplifying swings in inventory as one moves upstream along the supply chain. More specifically: small fluctuations in demand in downstream stages of the supply chain cause increasingly large variations in demand in more upstream stages. This, in

² <https://dictionary.cambridge.org/dictionary/english/panic-buying>.

turn, can lead to large inefficiencies like excessive levels of inventory investments and safety stocks (Moll & Bekker, 2013).

Due to the panic behaviour from both consumers and retailers, the supply chain experienced a sudden surge in demand, which they could not follow because of the lower productivity, as explained earlier (Hobbs, 2020). Moreover, as a consequence of the bullwhip effect, the storage costs downstream from supermarkets to suppliers increased as a result of a so-called domino effect (Demirci, 2021). However, additional stocks can also have a positive impact on supply chains. More about that in section 5.3.

Due to the COVID-19 pandemic, purchasing behaviour changed, which also caused a shock in demand. These shifts are a shift to online shopping, a shift to local goods, a shift from service to retail and a shift to healthier foods.

As a consequence of the COVID-19 outbreak, people are increasingly buying products online and have them delivered at home (Singh, Kumar, Panchal & Tiwari, 2020). In this way, customers can just drive by their retail store and pick up their purchase without having to enter a crowded grocery store, reducing the chances of being infected (Pantano, Pizzi, Scarpi, & Dennis, 2020).

Whereas 'click and collect' services were already used before COVID-19, at-home delivery was less common. At-home delivery can be very useful for the elderly or people with underlying diseases, because leaving your house is not necessary anymore. Because of that, retailers saw a sudden surge in demand for this service. As this system was not heavily used before the pandemic, retailers experienced a lack of infrastructure to deliver purchases at home in time, which led to longer waiting times (Hobbs, 2020).

Although problems arise using this system during times of increased demand, at-home delivery is an opportunity to be considered for the future, not only for retailers but for restaurants as well. During the pre-COVID-19-period, people were not using the 'click and collect' services and the at-home delivery as much as they do now. Thanks to COVID-19, people are discovering and getting more familiar with it. It is expected that this will cause a long-term shift in purchasing behaviour (Hobbs, 2020).

An example of increased online sales related to the food supply chain can be seen in the revenue of the German meal-kit provider HelloFresh. Their revenue more than doubled in 2020 compared to the year before.³ The pandemic plays a big part in this. Consumers increasingly opt for HelloFresh deliveries at home. By ordering these kits, consumers do not need to go to

³ <https://ir.hellofreshgroup.com/websites/hellofresh/English/3900/news-detail.html?newsID=2065500>

the supermarket as often and they can avoid long waiting lines and lower the risk of infection. The meal kits include all ingredients needed to prepare one or multiple meals.⁴

Moreover, interest in local food has increased since the start of the pandemic. Before COVID-19, most people went to supermarkets, while everything they needed was provided there. Now, people are buying more at local stores. There are two explanations. Firstly, as explained earlier, people began to panic buy and hoard while they were not confident about the security and sufficiency of food. Supermarkets were not prepared to adjust to this change, causing shelves to be empty, which was frustrating for shoppers. An important reason for this lack of resilience to adjust to higher demand is the closing of the borders. Supermarkets depend on food originating from other countries causing a shortage in the food supply. Local suppliers proved to be more agile in their supply because they did not suffer from the cross-border disruption (Hobbs, 2020; Alexander & Qato, 2020). Secondly, big events like COVID-19 affect small and larger firms disproportionately. Smaller firms experience larger liquidity risks and a bounded working capital, which, as a result, makes them suffer harder from the pandemic than larger firms (Demirci, 2021). Because of that, an initiative called 'support your locals' arose in various countries, which boosted the short-term sales of these local grocery stores. Because of these two reasons, the retail sector is experiencing a shift to local food (Hobbs, 2020; Alexander & Qato, 2020).

A third shift is a shift from service to retail. According to Chenarides et al. (2020), this shock can be considered as the most important one that appeared during the COVID-19 crisis. Most literature considers the food retail sector and the foodservice sector as two interacting sectors. According to Hailu (2020), these two are almost completely substitutable. Before the outbreak of COVID-19, 46% of the consumer expenditures in the U.S. on food was spent on food retail (FAH, food-at-home), while 54% was spent on the foodservice sector (FAFH, the food-away-from-home). Estimates indicate that the consumer expenditures on the FAFH fell by over 50% on average. Hailu suggests that the extent to which this shift took place and still takes place depends on the magnitude of the so-called NPM's (Non-Pharmaceutical Measures). In the case that these NPMs are mild, the spike in retail demand growth will be sudden, temporary and mild as well. This is logical, as with lighter NPMs the foodservice sector will not be hit hard because restaurants will remain open. As a consequence, the demand for these restaurants will only decline gently as well. In the case that the NPMs are aggressive to contain the spread of COVID-19, the foodservice demand will decline drastically. As a result, the retail demand will grow more than in the case with gentle NPMs (Hailu, 2020).

⁴ <https://www.tijd.be/ondernemen/voeding-drank/hellofresh-op-topsnelheid-door-coronavirus/10244517.html?>

These shifts from service to retail caused substantial problems, as the higher retail sales were insufficient to absorb food committed to the service channel (Chenarides et al., 2020) and many products destined for the foodservice were wasted and discarded (Hailu, 2020). At the same time, the surge in demand for grocery stores caused them to struggle, leading to shortages. This, in turn, raised people's concerns, stimulating stockpiling and panic buying, as mentioned earlier in this section (Goddard, 2020). This mismatch between food retail and foodservice was exacerbated by a lack of supply chain resilience (Hailu, 2020).

The last shift is the shift to healthier food. According to a study by Rodríguez-Pérez, Molina-Montes, Verardo, Artacho, García-Villanova, Guerra-Hernández and Ruíz-López (2020) on changing dietary behaviours during the COVID-19 lockdown in Spain, people have started eating healthier in times of confinement. Due to this, demand shifted from more unhealthy foods to healthier foods containing more bioactive ingredients. This improvement could, if sustained in the long run, have a positive impact on the immune system and consequently on the prevention of chronic diseases but also COVID-19-related issues. The food choices included higher consumption of fruits, vegetables or legumes and lower intake of red meat, alcohol, fried foods or pastries compared to their usual habits.

3.2 Catalysts

The major catalyst of food supply chain disruptions is the fact that these supply chains lack fundamental resilience. According to Ribeiro and Barbosa-Povoa (2018), 'a resilient supply chain should be able to prepare, respond and recover from disturbances and afterwards maintain a positive steady-state operation in an acceptable cost and time.' Supply chain resilience can be divided into a proactive phase, which is about preventing risks by having contingency plans (Ribeiro and Barbosa-Povoa, 2018), and a reactive phase, which is about responding to the shocks (Kamalahmadi & Parast, 2016).

The lack of supply chain resilience became most evident in the switch from foodservice to food retail as described in the previous section. Due to restrictions imposed by governments, the demand for food shifted from the foodservice to the food retail sector. Before the COVID-19 outbreak, in the phase in which proactive measures could or maybe should have been taken, the majority of the firms underestimated the likelihood of an event like COVID-19 happening, and they, even more, underestimated the probability of losing an entire distribution channel. Because of these low probabilities of occurrence, most firms did not pay attention to building a resilient supply chain (Chenarides et al., 2020). For example, a supermarket chain in the Netherlands did not have any contingency plans prepared for pandemics or other similar situations in general. They only had contingency plans for logistical problems that did occur on a regular basis (Demirci, 2021). Besides the low probability of occurrence, also the costs

involved in making a supply chain more resilient and flexible between channels withheld those companies from investing in it. Switching between foodservice and food retail namely involves considerable investments, which are quite worthless given the low probabilities of occurrence (Chenarides et al., 2020).

There are three factors that, in turn, are catalysts of the lack of resilience. These factors are globalisation, the just-in-time policy and vertical integration within food supply chains.

The first catalyst is globalisation. In the last decades, as a result of potential efficiency, supply chains have become more and more globalised (Demirci, 2021) as it allows firms to source inputs and sell final goods in many different countries all over the world (Sforza & Steininger, 2020). Although such an efficiently organized chain comes with a lot of benefits, it also makes a supply chain more complex, vulnerable and thus less resilient. Pandemics like COVID-19 are risk factors that can have a very strong and direct impact on the supply chain network design structure (Ivanov, 2020).

A consequence of globalisation is the increased cross-border traffic. Cross-border traffic forms the key link in current supply chains (Jukema, Ramaekers & Berkhout, 2021). All different steps are located at different locations, making transportation a vital part of the food supply chain, leading to a high dependency on transportation networks (Hobbs, 2020). However, the impacts of the increased cross-border transport can differ depending on what or who is transported. On the one hand, there is the cross-border traffic of cargo. According to a report of the Wageningen University and the Dutch agency of statistics, the Dutch food sector was hit less hard by the COVID-19 pandemic than the trade in other goods. This is a consequence of the fact that the food supply chain is seen as essential and necessary (Jukema et al., 2021). On the other hand, there is work-related cross-border travel. As described earlier, due to travel restrictions, there could be labour shortages of seasonal workers in some countries, leading to reduced productivity. If globalisation would not have taken place, border closures would not have had such a big influence on food supply chains and supply chains in general (Henry, 2020; Al Mussell et al., 2020).

A second catalyst is the just-in-time policy. A just-in-time (JIT) system of manufacturing is based on preventing waste by producing only the amount of goods needed at a particular time, and not paying to produce and store more goods than needed (Cheng & Podolsky, 1996). The just-in-time principle is often applied in the food supply chain. This principle has proved to be very efficient in normal times, where no large demand or supply shocks take place (Hobbs, 2020). Having inventory is expensive as you need inventory space and workers to manage the inventory. This is where just-in-time comes into play. It helps minimize inventory costs and makes the supply chain more efficient (Moll & Bekker, 2013). Specifically in the food supply

chain, this could guarantee freshness and quality of products. Even though the just-in-time system has proven to be beneficial, it is not an ideal method in times of uncertain consumer demand since there is no inventory to rely on (Vo & Thiel, 2008). Thus, businesses are forced to revise their supply chain (Baldwin & Evenett, 2020). With COVID-19 disrupting this 'system', the chain does not work as optimally and efficiently anymore.

A third catalyst is consolidation. Following previous pandemics and the current COVID-19 pandemic, the private sector is interested in making its supply chain more resilient. Although they are aware of their lack of resilience, they are still unprepared to react to disruptions (Huff, Beyeler, Kelley & McNitt, 2015). 'Typical food supply chains are large, vertically integrated and controlled by multinational private and public corporations with a high degree of product diversity in which more than 80% of food is delivered through the global supply chain with a major focus on low cost and high efficiency' (Demirci, 2021). While there is a focus on low cost and efficiency, a lot of companies in the food supply consolidated in order to cut costs (Hendrickson, 2014). In normal times, this is a decent working method from an economic point of view. A few big players will control the chain, so that high barriers of entry deter new players to enter the food market. This is beneficial for the incumbents, while the number of players and competition will not increase. However, this does not contribute to the resiliency of the food supply chain. For example, governments imposed several measures like quarantine obligations of infected people. If, in this situation with only a few large players, one company is severely impacted by the virus and in the worst case, has all its workers in quarantine, a big percentage of the food production will be on hold, with very large food shortages as a consequence (Huff et al., 2015). This shows that, while food supply chains are controlled by only a few players, lack of resilience will remain a problem.

4. Impact of COVID-19 on the healthcare supply chain

The healthcare supply chain is the sequence of processes involved in the production and distribution of various products and services related to healthcare. These products include Personal Protective Equipment (PPE), respirators, medication and medical attention among other things. The most commonly used PPE in healthcare includes gloves, aprons, long-sleeved gowns, goggles, fluid-repellent surgical masks, eye, nose and mouth protection, face visors and respirator masks (Rowan & Laffey, 2020). Medication could be the corona vaccine itself, other medication to help fight the symptoms or all other medication that is not related to COVID-19. It is not the first time that the healthcare supply chain has been disrupted. Also during the 2014-15 Ebola outbreak the health system was severely compromised due to overwhelming demand, healthcare workers deaths, resource diversion and closure of health facilities. Among the socio-economic impacts of this epidemic specifically were education loss,

reduced child protection, food insecurity and widespread job loss (Elston, Cartwright, Ndumbi & Wright 2017).

In the following section, the healthcare supply chain will be looked into more in-depth. This will be done again by examining demand and supply shocks separately, followed by a discussion of catalysts. The mitigations will be discussed in section 5. An overview of the structure is shown in figure 3.

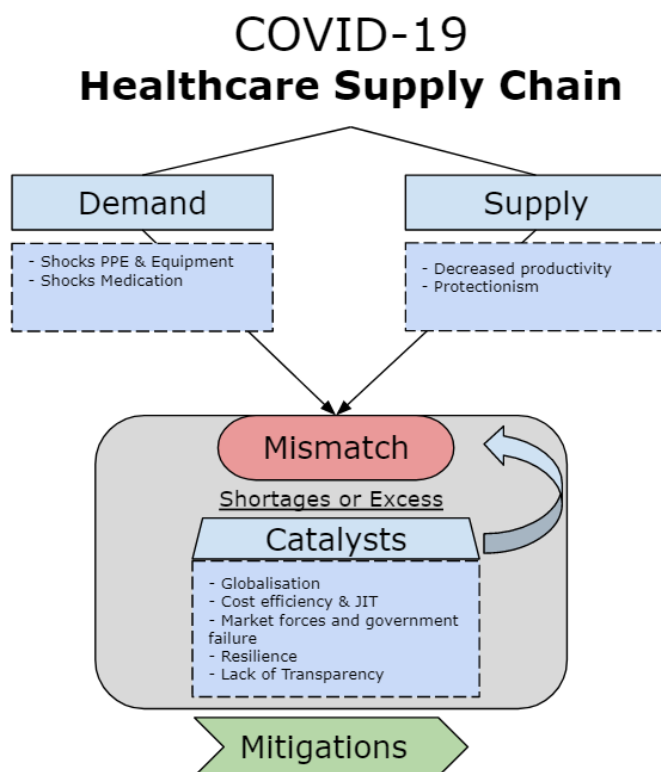


Figure 3: Structural representation of the research on the healthcare supply chain (own construction)

4.1 Shocks/ impact

This section goes more into depth on both demand and supply shocks specifically related to the healthcare supply chain. COVID-19 has had an effect on the whole supply chain, from the manufacturers of medications and personal protective equipment to the hospitals and end consumers (Govindan, Mina & Alavi, 2020; Rungsisawat & Jermisittiparsert, 2019).

4.1.1 Supply-side shocks

The pandemic caused a decrease in productivity for both PPE and medication. This decrease in production is a supply-side shock. Protectionism can cause a supply shock too.

Decreased productivity of PPE occurs because of the closure of industries to enable lockdown, dismissal or temporary unemployment of workers to reduce labour costs, restriction of transportation and closure of borders. All these measures together pose a problem to fabricate enough PPE to satisfy the demand (Iyengar, Vaishya, Bahl, & Vaish, 2020).

Also in medicines, a fall in productivity caused a supply shock in some plants producing ingredients for medicines. As a result of the imposed regulations and the lockdown, some plants were obliged to (partly) shut down at the beginning of the pandemic (Iyengar et al., 2020). For example, China, which is the leading country in producing the so-called active pharmaceutical ingredients (API), decided to stop the production of these API in an effort to contain the outbreak of the virus (Zhu, Chou & Tsai, 2020). Due to this, these plants could not produce at all or were not able to produce at full capacity because they had to slow down in production. This resulted in shortages and, in turn, higher costs for the materials required to produce medicines (Iyengar et al., 2020).

Another reason for these supply-side shocks in medication is the protectionist policy of some countries. Several manufacturing countries of pharmaceutical ingredients decided to prohibit the export of these ingredients to foreign countries. The best example of this was India, whose health authorities asked the government to restrict the export of pharmaceutical ingredients and to only produce for the domestic market (Ayati, Saiarsarai & Nikfar, 2020). Based on this advice, the government decided to prohibit the export of 26 API out of fear of domestic shortages. As India is a major API supplier for the global market, this decision had worldwide implications, especially on supplies of paracetamol and antibiotics (Iyengar et al., 2020). The average increase in shortages of API in Indian trades was about 10-15%, but could reach 50% in some cases (Ayati et al., 2020).

4.1.2 Demand-side shocks

PPE & Medical Equipment

Procurement problems regarding PPE and other equipment are common during critical events. Similar outbreaks such as the Ebola outbreak in 2012 also caused issues with respect to PPE and overwhelmed healthcare operations, ultimately resulting in more deaths of both patients and healthcare workers. Something similar can be seen in the COVID-19 outbreak. Until

everyone is vaccinated, the immediate solutions to protect individuals and to control the spread of the pandemic include the use of PPE, maintaining personal hygiene and social distancing (Elston et al., 2017; Ji, Fan, Li, & Ramakrishna, 2020). The World Health Organization's guidelines concerning prevention and control of the COVID-19 outbreak recommend hand and respiratory hygiene and the use of appropriate personal protective equipment for healthcare staff (WHO, 2020). But as PPE like facemasks and hand sanitisers prove to be an effective measure to fight the spread of viruses, consumer demand for it surged as well (Jefferson et al., 2008). As a result, a huge demand shock occurred (Cohen & Rodgers, 2020).

Since the outbreak of the pandemic, the demand for surgical masks has seen a six-fold increase. Supplies can take months to deliver. The World Health Organisation estimates that 89 million face masks are required each month. For gloves used in the examination of patients, the amount needed is about 76 million. The monthly demand for safety goggles is about 1.6 million. To meet the increasing demand, WHO estimated that the industry producing this PPE needed to increase production by 40% (WHO, 2020).

The demand shocks of PPE can be divided into two separate groups, namely demand for the healthcare sector and for consumers. Both groups have different motives to buy and stock PPE. Firstly, the demand for PPE in the healthcare sector surged as a result of the increase in infected people. As a consequence, the American PPE inventories became inadequate to meet the demand from hospitals and other healthcare institutions (Cohen & Rodgers, 2020). Secondly, consumers also contributed to the demand shocks in PPE. Governments from countries all over the world implemented policies enforcing people to wear face masks and sanitize their hands, which further increased demand. However, governments failed to communicate this in an effective manner, which caused panic behaviour and panic buying (Wu, Huang, Zhang, He & Ming, 2020). The panic behaviour was also intensified at the time people realised the scale and severity of the pandemic, which caused people to start worrying about the risks involved. As a result, many consumers started buying large quantities of PPE. This, in turn, again led to panic buying behaviour and hoarding, which further intensified the demand shock. As a consequence, the American PPE inventories declined sharply (Cohen & Rodgers, 2020).

The disposable nature of most of the face masks made people buy them more often, which intensified the demand shock. In the long run, innovative masks, including reusable masks, antiviral masks, and degradable masks, will play an important role in pandemic spread prevention, environmental protection and alleviating shortages of masks (Ji et al., 2020).

Due to the demand shocks, demand and supply mismatched at the beginning of the pandemic, which led to extraordinary shortages (Ji et al., 2020). U.S. surveys reported that at the end of March 2020 about one-third of the hospitals in the U.S. had no more face masks and about 13% of the hospitals had no more stocks of face shields. As a result, in May 2020, 87% of the nurses in U.S. Hospitals had to reuse single-use masks, and 27% of the nurses

reported that they had been in contact with confirmed COVID-19 cases without wearing any PPE. The same reports link these shortages to increased morbidity and even mortality rates under nurses and show a correlation between death rates and confirmed cases under healthcare personnel (Cohen & Rodgers, 2020).

Medication

The current virus outbreak has put a lot of stress on healthcare and medical supply (Choo & Rajkumar, 2020). In fact, two different demand shocks took place, especially in the short term. The first one is related to the healthcare sector itself. Due to the novelty of the virus at the beginning of the outbreak, adequate medication was not yet available. To tackle this problem, medics started to investigate already existing medication that could also be effective against COVID-19. As a result, hospitals started buying and stockpiling medication that was investigated in trials but not yet fully approved by health authorities. Certain medicines such as respiratory treatments, sedatives and pain treatments experienced an increase in demand of 100% to 700% globally between January and May 2020 (Ayati et al., 2020). Examples of such medications proven to be effective against COVID-19, but also used against other non-COVID-19 conditions are chloroquine and hydroxychloroquine. These medications are usually used to prevent and treat malaria (Choo & Rajkumar, 2020). The second short-term demand shock was related to consumers. As with the food and the PPE supply chain, panic buying also occurred in the medication supply chain. Mostly medicines destined for chronic diseases were stockpiled. Several surveys and studies in the U.S back these observations. The overall increase in demand for medicines for chronic diseases was estimated at 8.9% by March 2020. The most needed medications were medicines for asthma and diabetes whose demand increased by 65% and 25% respectively between the 13th and the 21st of March 2020. This induced demand caused periodic shortages in the market, especially in March 2020 (Ayati et al., 2020). Medication shortages are not clearly visible during a pandemic but are still threatening not only our ability to overcome this pandemic, but also the health of patients who have other diseases. These shortages in medication were expected to increase over time (Choo & Rajkumar, 2020).

4.2 Catalysts

As described in section 3.2, the lack of resilience is the main catalyst of the described shocks. Also in the healthcare sector, a fundamental lack of resilience worsened the demand- and supply shocks. In this section, the lack of resilience is explained by four elements described below.

A first catalyst of the lack of resilience is globalisation. Often, production is outsourced to or organised in foreign countries because of lower production costs and economies of scale. During a pandemic, however, this is not a favourable situation to be in. The import of certain products can be prohibited. As a consequence, domestic production will be on hold (Henry, 2020; Alexander & Qato, 2020).

The pandemic initially caused a lockdown in the Chinese province Hubei, where the virus first appeared. Hubei is of high importance for pharmaceutical industries, while many firms who produce pharmaceutical products are located there. The dependence of other countries on China is high (Baldwin & Evenett, 2020). For example, 70% of the API is produced in China, and about 80% in China and India together (Zhu et al., 2020). Furthermore, almost three-quarters of blood thinners imported by Italy come from China. This is also true for 60% of antibiotic components imported by Japan and 40% of those imported by Germany, Italy, and France. This created supply problems for China itself, but also for other countries all over the world (Baldwin & Evenett, 2020).

Figures 4 and 5 show an example of the high dependency on China regarding the PPE market. As the graphs show, China is one of the main export countries of face masks and eye protectors, with the U.S. being one of the main importers. This implies a high dependency from the U.S. on China, causing vulnerability of the U.S. to disruptions in China (Cohen & Rodgers, 2020).

We have taken globalisation for granted because of low prices and well-regulated trade policies. Now, because of the combination of COVID-19 and trade policy shocks, as for example the trade war between the U.S. and China, the strong belief in the advantages of globalisation disappears. While COVID-19 exposes the problems of being dependent on other countries and especially China, countries are thinking about being more self-sufficient (Baldwin & Evenett, 2020). More on that in section 5.5.

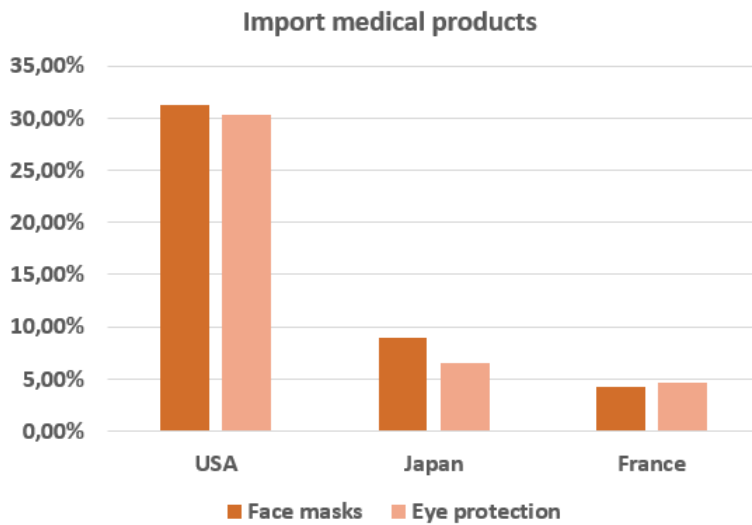


Figure 4: Import of medical products of the U.S.A, Japan and France

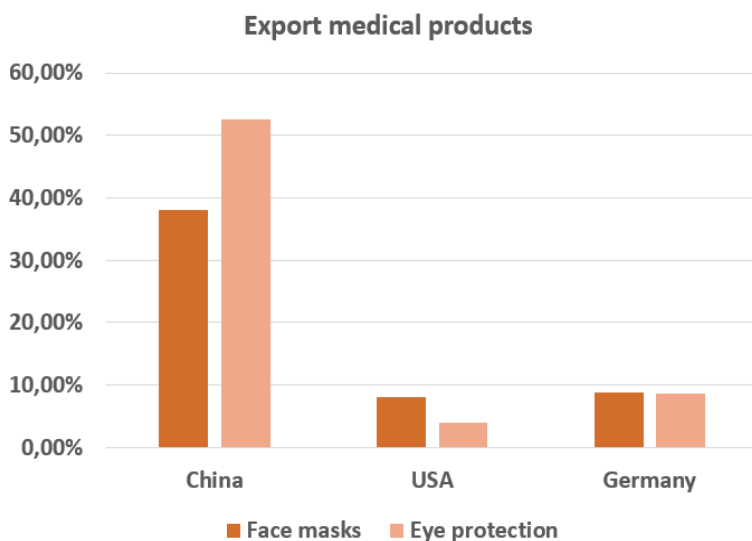


Figure 5: Export of medical products of China, the U.S.A. and Germany

Cost-efficiency is a second catalyst of lack of resilience in the healthcare supply chain. Since US hospitals are responsible for their own financial health, they usually opt for strategies to maintain revenues and profit. As a result, hospitals, who mostly consider PPE and medication as expenditures and thus costs, adopt cost-effective behaviour by minimizing these costs and keeping budgeting models efficient. The major way for hospitals to keep these costs low is by relying on the lean principle, which means that PPE and medication are manufactured with a focus on minimising costs and just-in-time delivery. As a consequence, there will be no excess inventory of PPE and medication and no buffers in time of surging demand in the hospitals. This

cost-effective budgeting model is sometimes inadequate even for predictable situations. As a result, it is especially troublesome in times when demand increases sharply (Cohen & Rodgers, 2020). The increased demand for PPE, equipment and drugs exposed the fragility in the healthcare supply network (Zhang, 2020) due to a reliance on these just-in-time systems and failure to effectively manage inventories. The lack of resources will ultimately lead to inconsistent production processes and disrupt healthcare operations (Leite, Lindsay & Kumar, 2020). COVID-19 exposes these problems arising from using lean production (Iyengar et al., 2020). While medication and PPE can save lives during a pandemic, the lean production system in this industry is something that has to be revised for the future (Zhu et al., 2020). A possible solution is increasing safety stocks, described in section 5.3.

The problem described in the previous paragraph is especially problematic in the PPE market compared to other healthcare markets. This is due to the fact that costs of PPE cannot be passed through to patients and insurers. This reinforces the cost-effective way of thinking by hospital managers (Cohen & Rodgers, 2020).

A third catalyst of lack of resilience is market forces and government failure. Unprecedented worldwide demand for face masks and other protective equipment has created potentially dangerous shortages for those who need them most (Zhang, 2020). Supplies (i.e. medication, PPE etc.) can take months to deliver and market manipulation is widespread, with stocks frequently sold to the highest bidder (WHO, 2020). In March 2020, during the first wave of the pandemic, 750.000 medical-grade masks went up for online auction. Some boxes of 16 masks, usually sold for around 3 dollars went for an astonishing 170 dollars. Large companies commissioned the auction website to sell highly demanded medical gear. Among the buyers were both hospitals and non-hospitals (Mosendz & Turton, 2020). It is a normal phenomenon in economics that if demand rises, as was the case for medical equipment, the prices rise as well. Prices were up to 20 times higher than normal (Zhang, 2020). Instances have been seen where 50-millimetre bottles of hand sanitiser were sold for over \$400 and thermometers sold for more than \$500. Also on Amazon, surgical mask prices were 166% higher at the end of February 2020 than their 90-day average (Farivar, 2020). All of this means that not only regular people but also hospitals need to pay high prices if they can manage to even find equipment.

According to Cohen & Rodgers (2020), examples, as described in the previous paragraph, show that the market mechanism is not appropriate to organise the production and distribution of health inputs, especially in times of problems in the supply. Referring to the COVID-19 pandemic in the U.S., they say that the government failed to tackle the problems by lacking both proactive and reactive measures. Prior to the outbreak, there already were shortages of PPE which were not made up for by the government. Consequently, the crisis already began with a shortfall in medical supplies. During the pandemic itself, governments failed to

coordinate the situation properly, for example by providing guidance and taking initiative by raising production and taking a leading role in the procurement of PPE for the country as a whole instead of leaving this for the hospitals. In this manner, competition between hospitals for purchasing PPE would have been dropped causing prices to stay at a normal level. However, due to the lax government, mutual competition persisted, leading the inflated prices in supplies to stay up, worsening the already existing problems.

Lack of transparency is a last catalyst of lack of resilience. 'Supply chain transparency comprises of disclosure of information on suppliers' names, sustainability, and social responsibility at each of these suppliers, to all parties in the supply chain, i.e., governments, trading partners, consumers, and other stakeholders' according to Zhu et al. (2020). More specifically, transparency here means supply chain visibility and sharing information with all entities involved within and outside the chain. Supply chain visibility refers to the fact that players have to be able to track their product going from raw materials to finished goods. Both supply chain visibility and sharing information are a problem within the healthcare supply chain, for medicines but for PPE as well (Zhu et al., 2020; Dai, Zaman, Padula & Davidson, 2021). Bateman and Bonanni (2019) explain that healthcare supply chains were often constructed in a way that transparency was just not possible. The intention of this was being able to maintain competitive advantage if needed, which results in fragmentation of the supply chain (Bateman & Bonanni, 2019; Zhu et al., 2020). With highly fragmented supply chains, governments and healthcare providers like hospitals and pharmacies, have no basic information about the healthcare supply chain. Often pieces of essential information like the origin of PPE and medication, data on the risk of late delivery or shortages are either held back or kept as a trade secret (Rowan & Laffey, 2020; Dai et al., 2021). As a consequence, a lot of parties involved are not able to check if they are going to be supplied the right amount and on time. This causes problems when parties that do not have access to this essential information, have promised others to deliver on time. The whole healthcare supply chain could be disturbed because of that. One condition to be transparent, sharing information, is therefore nearly impossible. Also, supply chain visibility, another condition of transparency, can be difficult if the information is kept within the suppliers' silo (Dai et al., 2021). Now, COVID-19 shows that this supply chain should focus more on collaboration and adequate information for all players involved in the healthcare supply chain (Dai et al., 2021). More on that in the mitigations section.

5. Mitigations and solutions

In this section, the most important mitigation strategies for the effects caused by COVID-19 on the food and healthcare supply chains are discussed. In general, these mitigations can be

divided into six different topics, namely: cooperation, transparency, safety, rethinking product lines, self-sufficiency and diversification and mitigation plans.

5.1 Cooperation

Cooperation is one of the main mitigation strategies that can be implemented. Cooperation can be achieved in two different ways, namely by collaboration between supply chain partners and by global governance.

According to Demirci (2021), collaboration consists of four important components. Firstly, there is 'support', which in this context means the fact that different food supply chain members help each other if needed. The clearest example of this was catering wholesalers which had to close their own business and therefore offered their services to the supermarkets and distribution centres. Secondly and thirdly, 'interaction' between different companies in the vertical chain and 'information sharing' strengthened the collaboration. Day-to-day contact ensured the investigated company to get what it needed. Information sharing could be facilitated to be smooth and fast by using techniques that automatically send information from the supermarkets to the distribution centres. More about technology in section 5.2. A last component is collaborative decision making, which also contributed to trying to keep the supply chain resilient. Demirci found that different supply chain partners avoided disruptions by adjusting their orders to each other.

Collaboration can also help ensure fast delivery of medical equipment in times of COVID-19, times when they are needed the most. Such collaboration was widely followed during the manufacturing of ventilation equipment. In the United Kingdom, a group of companies working together resulted in the design and manufacturing of ventilators within a couple of weeks which would have taken multiple years of development in normal circumstances (Cambridge Consultants, 2020). Not only companies of sectors specialized in medical equipment joined forces. Non-medical companies from the public and private sector and charitable organisations from around the globe united to address worldwide PPE, sanitization products and ventilator shortages. Examples of such proactive supply chain collaborations include Airbus, Diageo and Rolls-Royce realigning their product offerings, production processes and even part of their supply chain to manufacture essential items for healthcare operations (Davies, 2020).

Global governance is a last aspect of cooperation. As described in section 4.2, bidding against each other for medicines and healthcare equipment causes prices to rise significantly. Often, wealthy countries overbid less developed countries to obtain enough supplies for themselves. As a consequence, poorer countries suffer from shortages of medication and PPE, which is not favourable during a health crisis. Global governance policies can solve this problem. By sharing

the same ethics all over the world, crisis response will be more effective for everyone and will therefore increase the resilience of the healthcare supply chain (Dai et al., 2021).

5.2 Transparency

As described earlier in section 4.2, the lack of transparent information is a problem within the healthcare supply chain, especially in times of a pandemic. This issue is significantly bigger in the healthcare supply chain than in other ones, because the healthcare supply chain is designed to be non-transparent. Entities want to protect their intellectual properties or are just hesitant to give out information in general (Rowan & Laffey, 2020; Dai et al., 2021).

Transparency can be reached by intensifying the use of technology, such as AI and big data. This can help reduce supply shortages, detect demand shocks and improve the resilience of the supply chain. Automated order systems, for instance, enable players in the chain to use real-time data. Information about big surges in demand or shortages in supply can be detected and transferred immediately to others who need this information enabling quick responses to these disruptions (Demirci, 2021).

5.3 Safety

Increasing safety levels in the supply chain can help cope with the problems discussed in this paper. This can be done in four different ways: multiple sourcing, building up safety stocks, providing additional storage and transport and increasing the personnel.

Single sourcing, having only one supplier, is often used in businesses to cut costs. Managers know the risks that come with depending on only one supplier, but for them, cost efficiency is more important. When companies rely on just one supplier, the risks of not being supplied in times of COVID-19 are extreme. If their single supplier has to shut down production, because of a lockdown or a shutdown, consequences are severe. Zero supply will be delivered, also causing their production process to be on hold. For this reason, it is advisable to have multiple suppliers. This may cost more than having a contract with only one supplier, but costs are higher if production is on hold (Linton & Vakil, 2020). In contrast, according to Costantino and Pellegrino (2010), when the costs of having an extra-contractual relationship have been made, the cost of sustaining the relationship with multiple suppliers is approximately the same as with one. They also claim that multiple sourcing is always the better option to be prepared for uncertain events, such as COVID-19.

Obtaining safety stocks and additional margins is another way to increase safety and thus to meet demand shocks in the food sector. Normally, the hoarding by firms of safety stocks is a

proactive measure. However, as mentioned before, the lean principle and the just-in-time policy offers considerable advantages in times of stable demand, making it less attractive to keep high inventory levels. As a result, most safety stocks were built by companies during the pandemic instead of in advance. By quickly anticipating, shortages could be avoided (Demirci, 2021).

Also in the healthcare sector, a lack of safety stocks exists. As described in section 4.2, this lack of safety stocks and the persistence of the just-in-time policy is because of efficiency reasons. All this is prompted by minimizing costs and increasing profits. As a result, a more rigorous solution could be the removal of the profit motive in the healthcare sector (Cohen & Rodgers, 2020).

Additional storage and transport is another way to become more resilient (Demirci, 2021). Disruptions in the food supply chain, for example, emerged due to a temporarily non-operating source warehouse or a lack of truck drivers in infected areas. A study of Singh et al. (2020) shows that the integration of backup warehouses helps to fulfil demand in case that the source warehouse cannot be used. As described by Demirci (2021), supermarkets had to be delivered more often, sometimes even twice a day due to the increase in demand. To make sure that the products could be transported from the distribution centres to the supermarkets, additional locations had to be rented to stock inventory but also extra transport needed to be available. As mentioned in section 5.1, catering businesses were willing to help with this transport if necessary.

The last way to increase safety is to increase the available working force. This is a measure worth considering because the unavailability of personnel due to illness, restrictive measures or migration limitations is one of the biggest reasons for supply-side shocks (see e.g. Demirci 2021).

5.4 Rethinking product lines

Another strategy to mitigate is to reconsider the product lines in the supply chains. Possible ways to do this are: focussing on key products and producing more recyclable and reusable PPE.

A reactive strategy to keep up with the demand is to focus on the key products. Demirci (2021) describes that the supply chain he investigated cut in the product range. They started to focus on important and high-volume products so that they could quickly adjust to changes in demand. This strategy proved to be effective: 'Suppliers that cut in the product range bounced back earlier to their regular performance than suppliers that tried to deliver all products' (Demirci,

2021). In addition to that, Demirci (2021) states that in the Dutch food supply chain new products were introduced to keep up with demand. Besides that, they used alternatives to meet the demand during the crisis. An example of this is the use of another packaging for the same products.

A possible solution that can lower the shortage of PPE could be the reprocessing or recycling of the PPE. Properly designed and reusable PPE such as face masks can protect people during similar future outbreaks, further prevent the spread of viruses and save resources. Reusable masks will play an important role in pandemic spread prevention and control in similar circumstances (Ji et al., 2020). In 2020, manufacturers of one-time-use PPE have provided information on possible methods for reprocessing (Rowan & Laffey, 2020). As of March 2021, however, it is still single-use masks that are most commonly used and they cause severe environmental problems (Peters, 2021). The problem with single-use masks is that they are heat sensitive and not intended for reprocessing by their manufacturers. Additionally, available sterilization methods used by hospitals cannot effectively reprocess PPE due to the nature and severity of the sterilization modalities. To come up with reprocessable equipment, companies should involve and share information with the rest of the PPE supply chain. In doing so medical device manufacturers, sterilization industries can address the recycling problem together and work towards a solution. In practice though, information sharing in the medical technology sector is limited by means of protecting their intellectual property rights given the competitive nature of the sector (Rowan & Laffey, 2020). As discussed and stated in section 5.2, transparency is key in creating a resilient supply chain.

5.5 Self-sufficiency and diversification

As described in several previous sections, problems can potentially arise when different stages of the supply chain are located abroad. More specifically, there are two different issues that come into play, namely: dependency on foreign countries in general and dependency on specific foreign countries. These can be mitigated by becoming either more self-sufficient or diversifying to more countries.

Firstly, there is the issue of being dependent on foreign countries in general. As mentioned before, this issue became visible by travel restrictions and cross-border disruptions. A way to tackle this is to make the supply chain more resilient by becoming more self-sufficient. In doing so, the cross-border disruptions could be resolved. Being self-sufficient means being able to produce enough kinds of foods, medications and PPE by yourself and for yourself as a country instead of relying partly or completely on other countries. Also, the point of production will be closer to the point of consumption so that cross border travelling is not necessary. In order to

be more self-sufficient, governments can, for example, implement restrictions on the import of goods, obligating their country to be more self-sufficient (Henry, 2020). Besides, governments and industries can promote this self-sufficiency through strategic industrial policies (Cohen & Rodgers, 2020).

Secondly, there is the issue of being dependent on a specific foreign country. As described in section 4.2, the healthcare sector is an example of this because it is to a large extent dependent on China. This issue can be tackled by diversifying the supply chain. A commonly used and preferred approach for making the supply chain more resilient is the 'plus one diversification approach'. This strategy states that diversifying investments in different countries instead of in one particular country abroad is a suitable approach to manage the risks of being dependent on a specific country. According to this approach, diversification should happen in countries near the head production country. For example, when the main production takes place in China, diversifying should happen in the surrounding countries in East Asia such as Vietnam. Besides the risk-spreading, this approach offers another benefit, namely by spreading risks over countries in proximity to each other, supplier competition increases, leading to enhanced production efficiency (Zhu et al., 2020).

Self-sufficiency and diversification can also reinforce each other. In the short term, self-sufficiency can be the most practical solution to supply chain disruptions. In the long run, diversification seems more useful, because it is very likely that, when the pandemic is over, low-cost strategies (e.g. just-in-time policy) will become leading again (Zhu et al., 2020).

5.6 Mitigation plans

As described in section 3.2 a lack of contingency planning can intensify economic shocks. Therefore, having a contingency plan can help mitigate this. Lozano Díez, Marmolejo-Saucedo, & Rodriguez-Aguilar (2020) state it is necessary for supply chains to work out a health contingency plan to ensure the chain can quickly respond and coordinate between sectors involved. This can help guarantee the supply of medical supplies, human and financial resources. The intervention considers the following as basic stages: preparedness, outbreak, investigation, response and evaluation. For this to work, it is necessary to define the number and location of distribution and collection centres, unloading places and the location of demand centres that ensure optimal network performance. Besides that, the plan needs to define required optimal inventory levels, replacement policies, transportation and distribution (Lozano Díez et al., 2020).

6. Discussion and conclusion

6.1 Key Findings

From this literature review can be concluded that both the food and healthcare supply chains have been heavily affected by the global COVID-19 health crisis. The impacts are either a supply or a demand shock. Some impacts are solely present in one of the two supply chains, others can be seen in both of them.

Looking at the supply shocks there are both reduced productivity and restrictions on export in both the food and healthcare supply chains. These shocks are consequences of government measures imposed to slow down the spread of COVID-19. Since these measures limit the ability to do business as usual, the productivity on the work floor decreased significantly leading to insufficient levels of supply. Moreover, labour shortages impacted productivity negatively as well. Also, export restrictions lead to supply shocks, as some countries prohibited the export, because of either protectionism or closure of borders, leading to shortages in other countries.

Also, on the demand side, there has been a similar impact in both supply chains, namely panic buying. People and businesses started hoarding both food and medication/PPE as a consequence of fear and as a precaution, resulting in peaking demand which the supply could not meet.

Besides similarities, there are also differences between the two supply chains in terms of impacts. With regard to the demand side, it were again measures imposed by governments that had a notable effect. The most important measure here is travel restrictions. In this literature review, only the evidence of the impact of these restrictions on the food supply chain could be found. Furthermore, again only in the food supply chain, shifts in purchasing behaviour can be noted, namely: a shift to online shopping, a shift to local goods, a shift from service to retail and a shift to healthier foods.

The supply and demand shocks described in this dissertation were intensified by catalysts. These show many similarities between the food and healthcare supply chain, with globalisation and just-in-time being the most important ones. Globalised supply chains are complex, making them less resilient which worsened already existing shocks. To solve this, there is a variety of possible mitigation strategies with self-sufficiency and diversification being the most evident ones.

Just-in-time has proven to be a cost-efficient way of organising supply chains in normal times, but during increased demand, it can intensify deficits in supply. A major solution for this is increasing safety stocks.

Another important catalyst, only present in the food supply chain but also driven by cost-efficiency, is consolidation and vertical integration. Even though this has proven to be cost-efficient in normal times, in times of global health crisis this higher market concentration and lack of diversification has posed risks. Other catalysts that differ between the two studied supply chains are lack of transparency and market failure. Only in the healthcare supply chain evidence could be found that non-transparency affected operations due to protective behaviour. Plausible solutions are cooperation and more intense use of technology.

Apart from this, there is only proof in the healthcare supply chain that market mechanisms are inappropriate to cope with surges in demand. The higher the degree of privatisation in a healthcare system, the stronger the effect of this catalyst. Furthermore, governments lacked to respond adequately right after and during the outbreak to this problem by not anticipating the resulting deficits.

6.2 Limitations and suggestions for future research

One limitation of this thesis is that it is written during the COVID-19 crisis, causing the topic to quickly evolve, risking the used but also now available content to be quickly outdated. Also, there could be post-pandemic effects on supply chains that cannot yet be anticipated upon. Additionally, the COVID-19 pandemic was an unprecedented event on a global scale making it very hard to compare with or even incomparable with past influenza pandemics. As a result, little literature was available at the beginning of the writing process with COVID-19 still at large. A suggestion for future research is to examine effects of COVID-19 on the supply chain on the longer term.

Another limitation is the fact that this review only discusses two supply chains in-depth. Some of the discussed impacts may be applicable to other supply chains while others could be supply chain specific. Due to the limited literature available on other supply chains this distinction could not be made, making generalisation to other supply chains impossible. Future research can be conducted on other specific supply chains, which may make generalisation possible.

A last limitation is the limited scope of the reviewed literature. Most of the literature focuses on one specific country or region. Some of the described effects might be country-specific, making it difficult to generalise the results of this paper on a global level.

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