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Frontiers in agri-food supply chains

Frameworks and case studies

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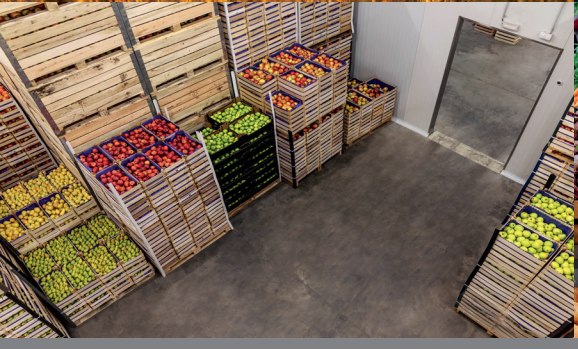

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1 Introduction

Food supply chains are an essential part of our society. From the primary production of agricultural products to the retail and foodservice settings through which food products are distributed, these extensive supply chains provide a wide range of products to satisfy the daily demands for human nutrition. In addition, these food supply chains also provide a significant contribution to the economy and to employment across the world (Beckman and Countryman, 2021).

Disturbances in these food supply chains can have significant consequences for the economy as well as for local and global food availability. The COVID-19 pandemic has clearly impacted food supply chains in 2020 and 2021. For consumers, this was mostly visible in their experiences with empty shelves in retail due to hoarding behaviour and the closure of cafes and restaurants due to regional and national lockdowns. Also, during the pandemic, the popular media often reported news on upstream supply chain impacts such as the closure of meat-processing facilities due to COVID-19 outbreaks among staff (e.g. Guardian, 2020a) or the occurrence of agricultural surpluses due to mismatches in supply and demand (e.g. Los Angeles Times, 2020; Washington Post, 2020). Due to the often-limited shelf life of food products, these surpluses cannot just be stored unlimitedly to balance supply and demand over time, but these surpluses lead to significant food waste (FAO, 2020), even though in some cases these products could be repurposed, e.g. for distribution through food banks (FEBA, 2020).

The consequences of the COVID-19 pandemic are not limited to these examples from the start or end of the food supply chain, even though these examples were the most visible to the public. The impacts were felt throughout the supply chain as for instance labour shortages and unavailability of packaging material impacted many upstream production and distribution activities. The increase in online retail sales grew significantly, but suppliers to the foodservice sector were left with inventories of products whose shelf lives expired. As food supply chains are often global, transportation systems were also affected by changing customs procedures, which in some cases caused food products waiting at borders to perish. Finally, many food-processing industries had to cope with challenges due to changes on both the supply and demand side of their businesses. The expectations are also that food supply chains will structurally change due to the experiences from the COVID-19 pandemic, even though it is still unclear how this will develop over time (e.g. Poppe, 2020) and some researchers have furthermore stressed restraint in relation to potentially damaging protectionist policies (e.g. Aday and Aday, 2020).

The COVID-19 pandemic has also been a large-scale test of supply chain resilience and a reason for increased demand for research on resilience, as has

been clearly illustrated in the increase of recent COVID-19-inspired scientific studies on supply chain resilience. Sodhi et al. (2023) discuss research topics that need to be addressed to improve supply chain responsiveness to future pandemics. Also, Craighead et al. (2020) stress that this both requires restoring supply chain processes as well as changing processes to be better prepared for future supply chain disruptions. Specifically, for the food supply chain, there are some general discussions and case studies on the impacts of the COVID-19 pandemic (e.g. Garnett et al., 2020; Hobbs, 2020, 2021; Burgos and Ivanov, 2021). For instance, Bina et al. (2022) demonstrated that relying on larger production sites (in the context of beef processing) could lead to larger disruptions. Stevens and Teal (2023) also show that horizontal diversification strategies helped increase resilience. Furthermore, Capodistrias et al. (2022) show how also food banks showed resilience in the way they acted as a food supply chain actor during the pandemic. It is beyond the scope of this chapter to provide a full literature review here.

The challenge to recover from disruptions such as COVID-19 and in building resilience to cope with future events that are similar lies in the capacity to build capabilities to reduce the impact of large-scale events such as the pandemic. Chowdhury and Quaddus (2016) argue that this requires the managerial and organizational capability to respond to and recover from such events. Such dynamic capabilities can help firms sense opportunities and threats to adapt the way they deploy resources and seize the opportunities such that needs dictated by the environment are met (Teece et al., 1997).

Dynamic capabilities are different from 'ordinary' process and operational capabilities in the sense that they can combine and adjust existing capabilities ('microfoundations') or those that focus on, e.g. expansion and new product development that take place under uncertainty (Teece, 2018). In this chapter, we focus on the dynamic capabilities employed by companies active in the food supply chain in reacting to an extreme situation – the COVID-19 pandemic – through sensing, seizing, and/or reconfiguring (or transforming) (Teece, 2007).

The recent review by Chowdhury et al. (2021) on COVID-19-related supply chain research emphasizes a lack of theoretically grounded empirical work. Our study particularly aims to understand the 'why' and 'how' behind capabilities employed to counteract the COVID-19 pandemic. This is in line with the call of Brusset and Teller (2017) who suggest to supplement the more quantitative studies populating the DCV framework with qualitative approaches to help better understand the mechanisms of why and how certain capabilities help improve supply chain resilience performance. Although there have been empirical studies focusing on how food supply chains coped with the COVID-19 pandemic, also using a DCV lens such as Kähkönen et al. (2023), a food supply chain focused study eyeing COVID-19 effects from farm to fork has not yet been published. With this study we aim to start filling this gap.

The aim of this chapter is therefore to (i) present and discuss actual supply chain management responses used by companies in the food supply chain during the recent COVID-19 pandemic, (ii) categorize these responses in terms of dynamic capabilities, and (iii) contribute to further development of dynamic capability theory and practice in relation to high-impact supply chain disturbances like pandemics. We base this research on an empirical study of stakeholders from across the food supply chain in the Netherlands. The results provide interesting insights in the practical use of resilience capabilities, and also show that despite initial concerns, food supply chains were able to use their capabilities to cope relatively well with the disruptions caused by the pandemic.

The remainder of this chapter is organized as follows. In Section 2, we first briefly discuss the relevant literature on supply chain resilience, providing the theoretical framework for our subsequent empirical study. Section 3 then introduces the research approach we used to identify, analyze, and discuss the cases in our empirical study. Section 4 subsequently discusses the supply chain responses in relation to the different supply chain resilience capabilities. In Section 5, we then present our discussion regarding the theory and practice of supply chain capabilities in food supply chains and relate these to dynamic capabilities, followed by our conclusions in Section 6.

2 Supply chain resilience: identifying resilience capabilities

Supply chain resilience is a topic that has been widely studied in the supply chain literature (e.g. Christopher and Peck, 2004; Chopra and Sodhi, 2004, 2014). As in the seminal work by Christopher and Peck (2004), we refer to resilience as 'the ability of a system to return to its original state or move to a new, more desirable state after being disturbed'. In the last few decades, a lot of research has been done in relation to supply chain resilience. We do not aim to provide a full review here; interested readers are referred to the classic papers mentioned above for a more general discussion of supply chain resilience and to recent reviews on the identification of relevant supply chain capabilities supporting resilience (e.g. Kamalahmadi and Parast, 2016; Ali et al., 2017; Datta, 2017; Kochan and Nowicki, 2018). In the following, we do however provide a brief overview of the basic principles behind the supply chain resilience theory and the supply chain capabilities that have been identified in this context.

Following the definition given above, supply chain resilience is often considered to be a more reactive characteristic of supply chains. However, to be able to react to disturbances, the preparation of organizations for potential disturbances also plays a role. Ponomarov and Holcomb (2009) therefore distinguish three phases related to supply chain resilience: readiness, response,

and recovery (as illustrated in Fig. 1). In the readiness phase, the focus is on capabilities that can be developed before disruptions occur. In the response phase, the focus is on capabilities that help mitigate the impact of disturbances. Finally, in the recovery phase, the focus is on capabilities that support a quick transition back to a normal state after a disruption.

In the different phases, different resilience capabilities are required, even though there might also be some overlap. For instance, one of the most discussed resilience capabilities is flexibility, and even though this is mostly seen as a key capability during the response phase, it is clearly also a capability that needs development in the readiness phase and that support a fast recovery.

For the analysis, we perform later in this chapter, we particularly build on the core resilience capabilities identified by Stone and Rahimifard (2018), who performed a recent and comprehensive study of supply chain resilience literature. In Table 1, we summarize the main supply chain resilience capabilities to structure the discussion of our empirical results in this chapter. We chose to exclude the core capability 'security' identified by these authors, as this capability is linked to the prevention of intentional disturbances of supply chains (e.g. deliberate contamination of food as an act of terrorism), and the prevention of such intentional actions is not relevant in relation to the pandemic response activities discussed in this chapter. Table 1 presents our definitions for each of the capability categories, which are mainly based on the work by Stone and Rahimifard (2018). During our research, we also included a category 'other' to identify capabilities we could not fit to these existing categories.

3 Supply chain resilience in practice: the COVID-19 pandemic

The empirical study presented in this chapter is explorative in nature, focusing on the impact of and responses to a contemporary event, the COVID-19 pandemic,

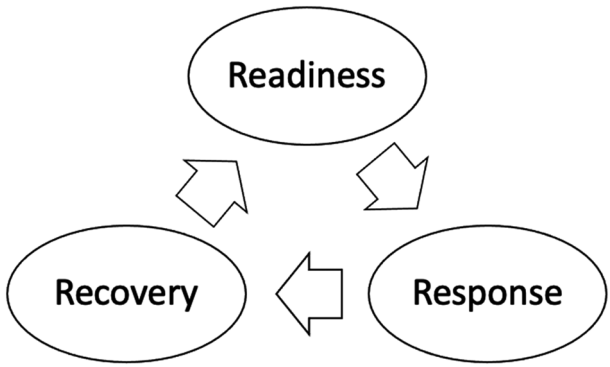

Figure 1 Three phases of supply chain resilience. Source: Based on: Ponomarov and Holcomb (2009).

Table 1 Overview and definitions of key supply chain resilience capabilities

Capabilities	Definition
Early warning	Using foresight to extend preparation time and decrease time spent on reacting to a disruption.
Flexibility	The ability of an organization or supply chain to adapt with minimum time and effort to changing operating environment and customer requests (e.g. switch suppliers, substitute ingredients, outsource processes, share materials, equipment, and staff between sites, the ability of staff to fulfil multiple roles, supply-chain-wide alternative options achieved through partnerships, and the levels of control over market position).
Redundancy	The ability to use surplus and back-up material and capacity (e.g. surplus raw materials and finished inventory, back-up production and storage facilities, surplus pathways between supply chain links, and the extent to which elements are replaceable).
Collaboration	Two or more actors working together to generate advantages that could not be achieved individually with the aim to reduce uncertainties and integrate systems (e.g. shared forecasting, postponement and risk sharing, cooperation, and partnership).
Visibility	The ability to see structures, processes, and products from one end of the supply chain to the other (e.g. channels for the sharing of risk information, IT infrastructure, frameworks guiding how information is delivered to the right people at the right time).
Agility	The ability to respond quickly to unpredictable changes in supply and demand by changing configuration at tactical level (e.g. logistics capabilities and manufacturing flexibility).
Risk-aware culture	The infrastructure a firm has in place to manage risk (e.g. using contingency planning or enterprise risk management programmes).
Adaptability	The ability of a system to adapt incrementally or to completely transform in response to a changing operating environment.

Source: Based on: Stone and Rahimifard (2018).

in the food industry. We interview stakeholders in the food supply chain and domain experts, with the aim to cover as wide a spectrum of stakeholders in the food supply chain as possible. The unit of analysis is the supply, processing, and distribution processes of an individual company (i.e. the company interviewed). We refer to these companies as 'cases'. We furthermore used expert interviews to allow for a cross-check of our findings and to inform interviews. Our investigation aims to answer 'what' and 'how' questions related to what capabilities were employed to counteract COVID-19 and how they were employed, confirming the suitability of an interview-based approach to studying these cases (Voss et al., 2002; Yin, 2018). The approach also allows us to build on the theory presented in the previous section, and potentially refine and elaborate on this theory based on our empirical findings (cf. McCutcheon and Meredith, 1993; Ketokivi and Choi, 2014). Below, we briefly discuss the details of our case selection and analysis.

3.1 Case selection

As we seek to understand the way that different stakeholders in the food supply chain were affected by the pandemic and the different resilience capabilities implemented to deal with it, our case selection aimed to include companies operating in different stages of the supply chain. Building on the general structure of food supply chains (based on Akkerman et al., 2010), we included companies operating in the primary sector, the processing industry, distribution and wholesale, retail, and foodservice. Here, the processing industry includes companies that make consumer products based on products from agriculture and livestock. This includes for instance the dairy industry and meat-processing companies, which are sometimes integrated with the activities of the primary sector. In the distribution stage, we include logistics service providers, even though many distribution activities are performed by other supply chain actors such as the processing industry and retailers, and as such also considered. With retail, we mean all supermarkets and specialty shops (such as bakers and butchers), and with food service, we imply all out-of-home food consumption and preparation, from restaurants and cafes to company cafeterias and event catering.

In total, 26 cases were selected, representing primary producers (8), processing industries (9), distributors (3), retailers (2), and foodservice companies (4). Some of the cases represented here cover more than one stage of their activities. This specifically concerns companies in the primary sector also performing a significant amount of processing (e.g. in the meat sector) and many processing industries managing their own distribution activities. Within the first supply chain stages, organizations with different product groups were selected to allow for potential differences in the impact of the pandemic or the resilience capabilities used for different product types. The list for instance includes meat, dairy, and vegetables in terms of primary products, as well as beverages, sauces, and snacks in terms of the processing industry. We did not specifically select small or large firms, but both ended up being present in our selection. To ensure anonymity, we do not specifically refer to individual companies in this chapter but will often refer to companies in a certain supply chain stage when discussing the results.

3.2 Data collection

During the months of October and November 2020, semi-structured interviews of 1 h long were conducted with the individual case companies described above. These interviews were conducted with staff expected to be familiar with the supply chain impacts of the pandemic. Due to COVID-19 restrictions, the interviews were held online, except for 1 interview where we were allowed to interview in person within the restrictions set. Interviewees were mostly senior

managers from supply chain departments but also included general managers or company owners in situations where a supply chain department did not exist (e.g. in some cases in the primary sector).

In these interviews, we discussed the impact of the COVID-19 pandemic on the flow of goods through the company (from sales and distribution back to purchasing), during different stages of the pandemic. We discussed both the impact of the pandemic as well as the strategies that the companies employed in response. We particularly focused on the strategies used to deal with the changing environment to be able to analyze the results from the perspective of supply chain resilience. To assure attention for research ethics procedures, a literature-based case study protocol was used for consistent coverage of categories. The semi-structured approach allowed interviewees to provide extra information as appropriate and enabled freedom of expression.

3.3 Data analysis and validation

After collecting the data, qualitative content analysis was performed (Mayring, 2014). Qualitative content analysis alleges to incorporate two conflicting methodological principles, by applying both theory-guided investigations while maintaining openness. This allows us to deploy categories that emerge out of data (Bryman, 2016), a technique also known as 'open coding' (see also Hendry et al., 2019) or 'deductive category application' (Mayring, 2014).

To validate the findings of the analysis, preliminary results were shared with two organizations with a more general overview of the Dutch food supply chain. Specifically, this concerned a senior sector expert from a Dutch bank with a significant focus on agriculture and food business, as well as a director of a Dutch non-profit federation focused on the food industry. Feedback from these industry experts was used to add to and refine the preliminary outcomes. In addition, a workshop was organized in collaboration with TKI Dinalog, the Dutch Institute for Advanced Logistics that sponsored the research. In this workshop, which was held in January 2021, the preliminary outcomes of this research were presented to and discussed with an audience of representatives from universities and companies. Feedback from this workshop has been incorporated into the findings.

With the previously defined categories and the feedback provided by the two expert organizations, we started to analyze the content of the conducted interviews in a more detailed manner. We compiled a list of all the individual mitigation strategies and structured them so that they could be easily categorized. To this end, we defined a coding scheme based on existing literature on supply chain resilience capabilities, which would allow us to conceptualize the different mitigation strategies in a way that would highlight their similarities (i.e. we used the capabilities shown in Table 1 as categories). Three different

researchers, independently of each other, coded the strategies according to the predefined categories and then compared their results. Initially, only a subset of the methods was coded. In doing so, we used the suggestion for the inter-rater reliability process of Hallgren (2012). The differences between the codes given were minor but did lead to an insufficiently low level of agreement. After an in-depth discussion, most disagreements were resolved, allowing for a more comprehensive understanding of the nonagreements, and improving the quality of the coding scheme (as suggested by Burla et al., 2008). As a consequence of this discussion, we agreed to add an additional category to the coding scheme. While the additional category was not initially a part of the existing literature, we decided that it was a valuable addition to the coding scheme. This process took place in line with our deductive category application process and recent contributions to method development that also emphasize that unanticipated mechanisms can be revealed in case study research (Eisenhardt, 2021) and that categorization can and should be used more actively, for instance by using the empirical evidence to elaborate on existing theory (Grodal et al., 2021). To be able to capture the range of strategies employed by companies in response to the pandemic, we then also extended the framework of core supply chain resilience capabilities we use. This framework is presented in the next section.

Once all the mitigation strategies were coded, further discussions of the results and the removal of disagreements resulted in a Fleiss' kappa value of 0.929. While indicating an excellent fit, we do acknowledge that this Kappa value is the result of a few rounds of discussion. Fleiss' Kappa has been suggested as an appropriate alternative to Cohen's Kappa for 3 or more coders (Fleiss et al., 2013).[1]

4 Supply chain resilience capabilities in response to COVID-19: early warning and flexibility

In this section, we discuss how companies responded to the COVID-19 pandemic. Since the interviews were held between September and December 2020, we cover both responses during both the first wave of the pandemic in the Netherlands (March–April 2020) and the second wave (after the summer holidays of 2020). This section is structured around the supply chain resilience capabilities identified in Section 3, Table 1. We discuss how each of these capabilities played a role in the companies' responses to the pandemic.

1 Both Cohen's kappa and Fleiss' kappa are statistical measures to assess the level of agreement between respondents or raters. Cohen's kappa only works for at most two raters, whereas Fleiss' kappa works for any number of raters. A kappa value of 1 for Fleiss' kappa would mean complete agreement, and any value between 0 and 1 would represent an increasing scale of agreement.

4.1 Early warning

The essence of 'early warning' systems is that certain information (i.e. foresight) can be obtained in advance and used to better prepare for a forthcoming supply chain disruption. After COVID-19 was widely spread in China, the pandemic subsequently affected other countries with various time delays, making it possible to learn from what happened in regions that were affected earlier.

By 9 March 2020, Italy had, for instance, registered 7375 cases while in the Netherlands there were fewer than 500 registered cases at that time (Statista, 2020). International companies with activities in China and the south of Europe made use of knowledge and experience acquired from their early affected locations. For example, one multinational food processing company organized online meetings in April 2020 with responsible managers in Italy so that the lessons learned could be communicated to managers of locations in Northern Europe. During these meetings, attention was paid to the management lessons related not only to individual facilities but also to the whole supply chain. However, as stated by a supply chain manager of a multinational company: 'We mostly learned about how to manage problems at the plants, but not enough about the supply chain perspective.' This clearly demonstrates that although at that time useful information was available at the level of individual facilities, the full supply chain impacts were still unclear.

Companies operating in China were able to use lessons learned at an even earlier stage. One of the interviewed companies working in the fruits and vegetables sector indicated that their crisis consultations had taken place already in January 2020 because they expected Europe to face the same situation as China. Based on its experiences in China, this company conducted a risk inventory study and initiated preparations (including discussions on production volume decisions for crops that had to be sown in March).

Although lessons could be learned from experiences in other countries, predictions still proved difficult to make. Many companies felt they were still forced to act in a reactive manner. Various Dutch trade associations however provided information with estimates of market developments (such as expected sale volumes in different markets) to their members. Several interviewees argued that these estimates were relatively accurate, and they were widely appreciated in the sector. In some cases, it was even the only available source of information. Consolidating knowledge thus helps during times of crisis.

4.2 Flexibility

Flexibility is among the most cited capabilities in the supply chain resilience literature. Indeed, many of the responses to the COVID-19 crisis collected from the interviews are also related to flexibility. In the interviews, we encountered

flexibility in (i) sourcing, (ii) workforce, (iii) logistics, and (iv) product mix. Below, we elaborate on each of these aspects.

4.2.1 Sourcing flexibility

Multi-sourcing is a well-known strategy to achieve supply chain resilience under disruptions. Some examples of sourcing flexibility came up in the interviews, but in situations in which this flexibility was not already there, it turned out to be difficult to set up on short notice. Clearly, for agricultural products, this is also challenging due to the lead times involved in adjusting production volumes.

In some cases, differences in national policies were beneficial. An interviewed international meat-processing company stated that they did not experience supply shortages during the pandemic because when a lockdown was imposed in Germany, their Dutch supplier managed to deliver the requested volume.

Nevertheless, implementing a multi-sourcing strategy affects not only the sourcing costs factor but also other supply chain processes. Adding suppliers during a pandemic can be challenging. An interviewed company expressed that even though specifications are the same, glass from another supplier often causes issues in production and packaging lines, and the process of streamlining such operations might take too long in relation to the supply chain disruption. Several interviewees mentioned that during the pandemic their companies did however have to start using new suppliers, particularly ones located in Europe.

4.2.2 Workforce flexibility

During the pandemic, supply chain activities mostly had to be carried out with the available existing workforce. In some companies, part of the workforce had more work than others due to the pandemic. As a result, people sometimes carried out different functions during the crisis.

For example, one of the interviewees indicated that there were not enough people to apply floor marking to set physical distancing between workers, so management staff did that themselves. At another company, account managers had less to do for a while and were temporarily added to the customer service team. In another case, management, sales, and technical staff could not visit customers and were therefore deployed on the production floor. In addition to solving capacity issues, this also impacted employee morale, as exemplified by a supply chain manager's remark that 'It has a positive impact if the CEO is standing next to you, pouring the powder in the tank'.

At other companies, office staff were sent home as much as possible. Several companies invested early in equipment for working from home (e.g. laptop computers), and systems were expanded to make this possible. One of

the interviewees also acknowledged the role of technological development in the realization that 'if this crisis would have happened two years ago, we would have had a problem'.

Many companies tried to balance their capacity across production lines and even production sites by re-distributing workers across sites. It was however acknowledged that this flexibility might not have been possible without the lack of urgency caused by the pandemic and that this might have not been possible to ask from employees under normal circumstances. In the reallocation of employees, transportation sometimes turned out to be a bottleneck. Additional buses were needed to maintain a safe distance among passengers.

There are also differences between the first and second waves of the pandemic in terms of human resource capacity. Companies indicated that there were fewer staffing problems in the first wave than in the second wave because there were more infections in the second wave: many workers employed on flexible contracts went back to their home countries and full-time workers were more likely to get tested and quarantined in the second wave; thus, staffing became increasingly problematic.

4.2.3 Logistics flexibility

For most of the companies that were interviewed, customer demand increased significantly due to the shifts from food service to retail, which also led to increased demand for logistics capacity. Depending on the flexibility of the specific capacity, this often turned out to be challenging to deal with.

Particularly in the first weeks of the crisis, many companies had to scale up tremendously with workers and transportation resources to compensate for additional demand. It also meant that workers had to work more on weekends and public holidays; several companies therefore gave (financial) bonuses to staff for these situations. Transport capacity that was no longer needed in the foodservice channel could partly be used in the retail channel. Some companies that had their own trailers had to hire extra trailer capacity during peak times. Smaller companies and in particular self-employed drivers were hired for this purpose. Also, supporting infrastructures were sometimes insufficient, as demonstrated in a statement such as, 'We added additional portable toilets due to the increasing number of drivers passing through our distribution centre'.

Several distribution centres saw opportunities to scale up their capacities. Some interviewees indicated that work schedules for workers needed to be significantly changed, for example with increases from three to five shifts. There were however significant differences between types of workers in terms of flexibility: workers for specialized work such as forklift drivers in warehouses or equipment operators in the processing industry proved difficult to scale up. Order pickers were however reasonably flexible in terms of hours and shifts.

The urgency of the situation also helped, as one of the interviewed supply chain managers noted that 'fortunately the staff is aware of the seriousness of the situation, and they are very flexible'.

When the situation returned to somewhat more normal circumstances after the first pandemic wave, just before summer 2020, there was an upward demand trend in the foodservice industry. Finding staff for distribution centres in this industry became a challenging task. As one interviewee stated, '...retailers were doing well and many of our flexible staff had gone there'.

The crisis also made some companies think about planning for a permanent pool of employees and a flexible pool with a temporary employment agency – with the crisis putting more emphasis on the flexible pool.

4.2.4 Product mix flexibility

Many companies were forced to reconsider their product mix during the pandemic, as demand for different products experienced significant shifts. For instance, the industry saw a decrease in demand for products and packaging sizes used in the foodservice sector. This was often complicated by the fact that food supply chains rely on agricultural raw materials that have long lead times, meaning that adjusting the supply to shifts in demand is impossible in the short term.

In industries where demand decreased significantly, which was mostly related to the drop in demand from the foodservice sector due to lockdowns, raw materials were processed into more generic products with longer shelf life if possible. In the dairy industry, for example, milk that would normally have been processed into products for the foodservice sector (e.g. whipped cream, mozzarella) was now processed into milk powder. Also, butter was converted into butter oil. In the meat industry, beef was ground instead of sold as a steak. This type of flexibility was sometimes limited by production line capacities or market opportunities.

Companies working with vegetables as raw materials also used flexibility in product mix and composition as much as possible. These companies were able to build on a significant level of existing flexibility based on having to deal with uncertainties resulting from fluctuating harvest yields. For instance, it is customary that in years of high yields, certain vegetables are included in larger quantities in packages of pre-cut mixed vegetables. This flexibility was used to its full extent during the pandemic. Interviewees also indicated that the product mix was changed or even enlarged. They indicated, among others, that during COVID more tomatoes were being processed into pasta sauce than under normal circumstances and bell peppers were being processed into wine.

In terms of packaging, several interviewees also indicated that they altered the product packaging in response to the crisis. Although an increasing

number of vegetables was delivered to retailers and sold to consumers with limited – and often no – packaging material before the pandemic, COVID-19 resulted in a resurgence of plastic packaging in shops for hygiene reasons (regardless of the discussion of whether and how long the virus can survive on the packaging or on the food products themselves). Just as fewer unpackaged vegetables were offered for hygiene reasons, there was a decrease in the practice of in-store slicing of meat products in retail environments to reduce contamination. Interviewed companies indicated that, at least for meat products, the centralization processing of a wide product range is a development that has been going on for some time and was accelerated by the COVID-19 pandemic.

5 Supply chain resilience capabilities in response to COVID-19: redundancy

Redundancy refers to the ability to deploy additional capacity, materials, or end products. At the level of an individual organization, this may relate to having additional inventory or capacity. In terms of a supply chain, redundancy can also relate to the presence of alternative transport routes. Like some of the types of flexibility, redundancy was used when possible but increasing redundancy as a response to the pandemic was often difficult.

Several of the interviewed companies did have some form of strategic inventory. One meat-processing company was able to get by during the first wave of the pandemic because it had sufficient buffer stock. During the summer period (after the first wave of the pandemic), production was scaled up further to bring the buffer inventory back up to the initial level. In fact, it is a common strategy for some processing companies (even in non-crisis situations) to hold considerable buffer inventory to cope with the high demand volatility due to the prevalence of promotions and marketing campaigns in food retailing. As stated by one of the interviewees, 'the fact that promotions are so common in our sector has resulted in an overcapacity that has helped us in our response to this crisis.'

Several companies also attempted to order extra products from suppliers yet indicated that those suppliers also had their own problems during the crisis. In some cases, these were secondary products (additives such as spices and sauces), for which new suppliers sometimes demanded large minimum order quantities. These additional purchases in turn led to the need to rent additional storage space, which was not always possible.

In some cases, companies were also forced by the market to store extra materials and products. Due to delivery problems, the lead times at suppliers of packaging materials increased, for one of the interviewees from 1 week to 8–10 weeks, whereupon they decided to immediately store packaging materials and labels for 6 months. Many companies were also proactive to coordinate

this with their customers. For example, one retailer indicated that a strategic partner immediately stepped up by stocking, where possible, products and packaging materials, as well as the protective equipment needed for personnel to handle the product. If possible, retailers temporarily increased their stock levels, partly to help regular suppliers that suffered from decreased demand from the foodservice sector. Similarly, in the processing industry, stock levels were increased where possible.

However, in many cases, it also proved impossible to build up inventory: high demand usually meant that all production output was sold immediately. For some product categories such as fresh meat, there was additional demand during the initial lockdown due to an increase in barbecue activity caused by a combination of people staying at home and the nice Spring weather during that period. Shifting demand patterns also led to prolonged shortages for some other product categories, e.g. bakery raw materials such as yeast because many people had taken up home baking during lockdowns.

In some situations, customers were forced to order ahead or build up stock to ensure their long-term survival. In the wine supply chain, for example, products really must move downstream in the supply chain at some point. Also, barley that is still in storage because of decreased demand for beer must eventually make way for the new harvest. Smaller companies in such situations were especially affected; they were more quickly forced to get rid of stock to make room for new stock.

Finally, for many food products, interviewees also acknowledged that even if it would be worth the efficiency losses or higher costs of redundancy, buffering is limited by typical shelf-life constraints found in the food industry.

6 Supply chain resilience capabilities in response to COVID-19: visibility and collaboration

6.1 Visibility

Visibility refers to the extent to which structures, processes, and products are visible in the supply chain. In our study, interviewees discussed a need for increased visibility in the form of intraorganizational (i.e. between departments in a company) or interorganizational (i.e. with suppliers and customers) consultation and coordination.

In most of interviewed companies, there was regular (often daily) coordination between production and sales departments as well as with customers or suppliers to be able to better forecast and meet demand. Sales and operations planning (S&OP) cycles were accelerated, typically from 4-weekly cycles to weekly cycles. A few interviewed multinational companies even set up international 'control towers' in addition to frequent meetings and calls between purchasing, production/packaging, and sales. In retail, demand

was even tracked on an hourly basis to adjust ordering/replenishment decisions based on the latest information.

Not all companies were able to move fast enough with such changes to their supply chain planning and monitoring. One interviewed foodservice company indicated that there was a late switch to daily inventory monitoring, even though their decreased sales volume made inventory management more critical, especially for perishable products.

Due to the time-intensive nature of the shorter planning cycles and more frequent consultations, it quickly became relevant to also consider when to stop these activities, as they required a lot of time from the involved parties. Another consequence of these frequent consultations was that sometimes high-level checks were built into working flows. One company shared that even the country director had to frequently approve air shipments for products that normally came by truck. About 10 weeks after the start of the crisis, several interviewed companies stopped these frequent meetings and calls. Other companies did not stop until after the 2020 summer, depending on how strongly the company was related to changes in market demand.

6.2 Collaboration

Collaboration here refers to two or more parties carrying out joint activities to achieve goals that could not be achieved on an individual basis. In the previous sections, good existing supply chain relationships were sometimes the reason a certain kind of flexibility could be achieved, and as such it is also a capability that strengthens other capabilities (which our interviewees might not always have connected to each other). Our interviews specifically revealed an increase in the contact between buyers and suppliers.

During the interviews, it was indicated multiple times that increased efforts were made on supply chain planning together with suppliers and/or customers. More importantly, the frequency of this planning process increased dramatically: forecasts were discussed more regularly, and priority lists were determined. As stated by one of the interviewees, 'due to the pandemic, we are now in contact with our suppliers on a daily basis, sometimes even two or three times per day.'

The interviews also revealed that there are various ways of organizing supply chain collaboration. A few interviewed companies deliberately avoided hard contractual agreements so that, for example during this pandemic, they had fewer purchase obligations in case of decreased demand and consequently less surpluses and food waste within the company. This strategy did however lead to losses at their suppliers, which were partly (but voluntarily) compensated by the companies.

7 Supply chain resilience capabilities in response to COVID-19: agility

Agility-related responses during the COVID-19 pandemic concern the quick changes of configuration at the tactical level to be able to cope with changes in supply and demand. Several adjustments to, especially, logistical processes and sales channels were mentioned in the interviews.

Many of the interviewed companies indicated that adjustments were made to their logistics processes. For instance, retailers adjusted frequencies and time windows for their deliveries to stores to increase flexibility for stores. This prevented backroom storage at the store level from becoming overfull. In addition, more responsive ordering became possible in this way. In several interviews, it was indicated that such operational changes in logistics were possible without much discussion or explanation because everyone understood such needs. For example, requests from logistics service providers for extra steps in order preparation at shippers (more than the standard preparation under normal circumstances) that could speed up the process were also honoured by shippers. However, at some point during the pandemic, the expectation was that the logistics situation would return to normal, and as one interviewee expressed 'COVID will soon not be a sufficient reason for deviations'.

Adjustments were sometimes also needed in terms of international distribution networks. For instance, when South Africa went into lockdown, alcohol sales were also banned, as this was expected to lower the non-COVID-related demand for health care (Guardian, 2020b). This meant that shipments of alcoholic beverages that were on their way to South Africa had to be rerouted and sold to customers in other countries.

Furthermore, it was also important to be able to switch quickly between types of sales channels: if demand from one country or sector falls away, it may be necessary to try to supply additional products to other countries or sectors because of products otherwise perishing or limited storage capacity. For instance, in the case of the meat processing industry, there was insufficient capacity to freeze the surplus resulting from the demand fallout in the foodservice channel, so there was constant attention to being able to sell surpluses. Some processing companies were successful in negotiating with retailers to take over surplus volumes from the foodservice channel because retailers had a high increase in demand. For other products, higher sales were generated in already existing channels. For example, a larger volume of eggs from the Netherlands was sold to the pharmaceutical industry for use in vaccine development. Retailers also witnessed an increased demand for eggs as their sales increased due to the popularity of home baking. Shifting product flows from food service to retail was possible for products that can be sold through both channels. This was, however, not possible for all products, such as

brand-specific sauces used in restaurant chains, which created problems with product expiration and waste.

One solution specific to the Netherlands was that wholesalers were given the opportunity to sell their products directly to consumers; this absorbed part of the loss in demand caused by the diminishing of sales to foodservice customers. This was appreciated by consumers because it gave them access to products that were normally more difficult to obtain. However, not all wholesalers were equipped for such direct sales to consumers. In addition, many packages are bulk packaging that is not suitable for consumer use.

Bringing surplus food to food banks was also considered by some companies. However, in the case of refrigerated products, this proved to not always be desirable due to the possibility of food safety issues resulting from interruptions in the cold chain.

8 Supply chain resilience capabilities in response to COVID-19: risk-aware culture and adaptability

8.1 Risk-aware culture

Our interviews showed that supply chain resilience has been always a point of attention by companies in food supply chains due to the high demand and supply volatility in this sector. However, disruptions caused by the COVID-19 pandemic surpass every past disruption in terms of complexity.

As stated by an interviewee from a multinational company, 'very unlikely scenarios do not normally get much attention'. Several interviewees however mentioned that the crisis has initiated discussions about resilience strategies. The most discussed strategy was about establishing local and regional supply, exemplified in statements such as 'if a product is slightly more expensive but comes from a location nearby, it might be worth considering it after all.'

Risks are however not limited to the supply side, and a few interviewed companies also considered risk on the demand side, inspired by the dramatic demand shifts from the foodservice sector to the retail sector. A logistics service provider indicated that it is necessary to think about how the customer portfolio should be set up: 'if most of a production site is dependent on a single customer, which in turn is largely dependent on one market, the question is whether such a situation is desirable'.

Another notable example was the duck meat supply chain, in which the foodservice sector is by far the largest sales channel. In this specific case, a drastic choice was made to stop the entire production pipeline, even no new eggs were hatched to prepare for future sales, due to a high volume of existing stocks in the pipeline that could cover demand for a long time.

8.2 Adaptability

The degree to which a company can structurally adapt supply chain processes to changing market conditions, i.e. adaptability, was also important in relation to digitalization of workplaces, process automation, and the move to online sales channels.

Many interviewed companies invested in hardware and software to support working from home. It remains to be seen in the future whether this will become a more normal part of working environments.

In the packaging industry, a lot of attention has been paid to innovation in the use of materials for the benefit of existing but also new sectors. For example, this has led to the use of cardboard for separation screens or new boxes for e-commerce, but also to the development of personal protection equipment. Investments in automated processing of products have taken off to decrease the dependence on manual labour in processing (e.g. peeling machines for shrimp).

Many companies, especially in the foodservice industry, have been looking for an increased presence in online food sales. For example, one of the foodservice companies we interviewed launched an aggregator website for its restaurant customers, supporting local restaurants with an online portal. McDonalds partnered with the food delivery service Uber Eats to increase the number of locations from which meals can be ordered online and delivered. Not everyone relied on large platforms; many smaller restaurant chains and independent restaurants actively pursued online ordering and delivery by themselves. For some companies and product categories, the move to online ordering or other markets was difficult. For example, in a case of wine supply chains, an interviewee stated that the wine trade is so set in stone and used to face-to-face contact that the volume of online sales was limited. However, the need to make this switch was acknowledged by these companies and the pandemic was a catalyst for the start of a discussion about such a change.

Adapting to situations with different supply-demand dynamics was not always easy. According to an interviewee, it is for instance important to design product (re)allocation or rationing rules in such a way that there is not one country or customer that pulls everything away. In retail environments, we also saw that some companies were forced to ration products with limited supply (in terms of a maximum number of units or packages to be ordered per store).

9 Supply chain resilience capabilities in response to COVID-19: rationalization

The previous sections discuss different resilience capabilities that have been defined in previous literature. In the analysis of our empirical results, an additional capability appeared: the ability to rationalize supply chain operations.

Rationalization refers to the process of organizing a (part of a) business according to a scientific management principle to increase efficiency and effectiveness. Often, rationalization leads to a reduction of variety, for example of products or services offered. Standardization relates to rationalization and aims to reduce variety as well, albeit from a different perspective; standardization is aimed at increasing repeatability and thus doing things the same way as much as possible. Simply speaking, rationalization is about making the same things, standardization about making things the same. When speaking about assortments, for example, rationalization implies the reduction of the variety of packing sizes. Standardization refers to ensuring that a product that is similar in terms of characteristics such as pack type or pack size has the same appearance everywhere (same colour of caps, for example), or that such a product is made in a standardized manner.

Many of the interviewees utilized rationalization to simplify operations, improve capacity utilization, and increase the extent and effectiveness of abovementioned sources of flexibility. In supply chains with increased demand during the pandemic, the emphasis appeared to be mainly on increasing output and improving capacity utilization. Several interviewed companies, especially in the processing industry, indicated that they were limited by their production capacity, and that attention was focused on making more efficient use of this capacity. This was illustrated by statements such as "you want to run large batches in this situation" and "[high-volume] product A is just more important than [specialty] product B now". Labour-intensive and other inefficient production lines were sometimes even stopped in favour of increasing capacity elsewhere. Many interviewed companies offered a smaller assortment and focused on increasing the overall production output.

Less choice in packaging was also offered. One of the interviewed companies indicated that the number of packaging variants was reduced to one size and a total of three SKUs instead of the 20 SKUs in use before the pandemic. This sometimes also led to offering larger packages: with consumers more often having meals at home, there was an opportunity to sell larger packages of products that would normally be sold in relatively small packs.

Rationalization not only happened in the processing industry, but also at in the retail and foodservice sectors. One retailer indicated that the focus was on critical products (e.g. flower sales stopped for a short time) and in case of insufficient transportation capacity, product groups with longer shelf lives were deprioritized (e.g. beer versus fresh products). For restaurant chains, the rationalization extended to the complexity of menus: more menu choices lead to more international transportation or specific ingredients, and thus the more difficult it becomes in a situation like the COVID-19 pandemic.

Organizationally, marketing departments usually determine which products must be produced, often resulting in complex product portfolios.

Several interviewed companies saw a change: flexibility can be achieved by simplifying portfolios, making it easier to scale up in volume. As one of the interviewees put it, "COVID has been an accelerator in the rationalization of our product assortment". In some cases, this type of rationalization also affected supply chain relationships: customers who buy smaller volumes or smaller SKUs no longer had much influence.

Many companies indicated that the focus was on being able to deliver and therefore there was no time for projects such as new product introductions. This reduction in new product introductions was important for the processing industry to be able to use their capacity as much as possible on production to cover demand. However, this was not only an initiative by the processing industry, as retailers also limited or cancelled product introductions and promotions where possible and encouraged suppliers to at least supply a core product range. After all, new products require a great deal of time and attention for both processing industry and retailers.

Some companies also indicated that rationalization was not only focused on increasing production efficiency but also on an increased focus on products that generate the highest margins or offer the prospect of winning market share.

COVID led to a standardization of product packaging. In some cases, retailers adjusted products with neutral packaging as well as packaging that showed multiple (or even other than regular) languages. Under normal circumstances, retailers would require customized packages, but supply shortages resulted in a more lenient approach. Several interviewed companies in the processing industry indicated that they were now able to standardize packaging on more points, for example, by giving all bottles the same colour cap, saving on changeover times in production. In the past, this was a more difficult discussion point with customers as well as between production departments and marketing departments. However, according to one supply chain manager the pandemic resulted in the fact that "...it is now ok for marketing to have small changes, such as using the same cap for multiple SKUs, which would normally not be the case. A cap is a cap."

Not only packaging was considered for standardization. One of the companies interviewed indicated that the crisis was an important push for the use of the same recipe for products across countries. This type of standardization offers the possibility to cope with current and future capacity problems in production by making the shifting of production volumes between locations more feasible.

10 Discussion: dealing with COVID-19

The analysis above shows that the impact of the COVID-19 pandemic was omnipresent in the food supply chain and that companies used a broad array of

strategies to cope with the effects of the pandemic. Interestingly, most strategies were reactive. Not many organizations had specific plans readily available for coping with such lasting supply chain disturbances. Possibly, most companies did not pay attention to scenarios as unlikely as the COVID-19 pandemic (as indicated by one of our interviewees), and thus no contingency plans for such unlikely but impactful events were in place. Nevertheless, even well-prepared companies are expected to feel some level of unpreparedness as the COVID-19 pandemic is novel; an effective way to deal with such levels of complexity is very often not known (Sodhi and Tang, 2021; Ali et al., 2021).

Many companies we interviewed used a variety of capabilities to cope with the crisis, though it is interesting to observe the dominance of flexibility and agility capabilities (which underlines the reactive nature of the capabilities used). In fact, we observed companies tapping into sources of flexibility that would not be possible or at least be very difficult to leverage under normal circumstances. Tapping into these capabilities (or further developing these) was now possible due to the urgency experienced during the pandemic. An example is the reallocation of personnel, which would normally have led to employee resistance, but was now seen as a collective effort to deal with the exceptional circumstances. Also, changes to product packaging to ensure supply were possible, which would normally not have been accepted by the marketing department.

The need to increase flexibility and agility to improve preparedness is clear from our analysis. Our research shows that most company responses were highly reactive, and initiatives to decrease or spread risks might require more attention. This could for instance involve an analysis of dependencies on specific suppliers or supply regions, as well as customers or sales channels. For smaller companies, this might be challenging, since building such supply chain resilience capabilities requires substantial time and effort for which human resources might not be available (Ali et al., 2021). For larger companies, this might be easier to accomplish. Larger companies might also play a role in helping smaller suppliers or customers deal with supply chain disturbances, as there is a clear overall supply chain benefit.

Even though the resilience literature emphasizes the use of early warning signals (e.g. Christopher and Peck, 2004; Pettit et al., 2010), especially signals enabled by big data systems (Spieske and Birkel, 2021; Modgil et al., 2022), this was only mentioned sparsely by our interviewees (and particular in relation to learning from operations in countries where the COVID outbreak occurred earlier than in Western Europe). A limited use of early warning signals has also been reported by van Hoek (van Hoek, 2020). Possibly no historical data was relevant at the time because no past disruptions can be comparable to COVID-19 crisis, although the financial crisis of 2008-2009 also had disruptive effects on the supply chain (see e.g. de Leeuw and Wiers, 2015).

Also, for many companies, a more explicit strategy for prioritization and rationing would be beneficial in preparation for situations in which it is not possible to fulfil all demands. Rationing strategies have a long history in the supply chain management literature (e.g. Cachon and Lariviere, 1999), but the sudden need to ration products because of the pandemic turned out to be challenging for many companies, as trade-offs between e.g. profitability and fairness were not straightforward. Including an analysis of prioritization and rationing strategies in supply chain risk assessments would therefore be beneficial.

In contrast, for situations in which supply exceeds demand, the perishable nature of the products in food supply chains provides an additional complexity: you can't just stop material flows in a supply chain and store intermediate product temporarily like in several other industries. Chicklets grow into full grown chickens, just like corn seed becomes corn after a specific time. This leads to situations in which the lead time for potential supply adjustments is quite long, and resilience strategies might require more attention to the identification of alternative markets for products. Essentially, this would provide more flexibility and agility on the demand side of supply chains (e.g. the ability to quickly reallocate products between the foodservice and retail channels as also discussed by Chenarides et al., 2021).

The financial impact of changes in supply chains due to the pandemic was not always equally distributed in supply chains, and the impacts were highly influenced by the type of agreements and contracts between buyers and suppliers in the supply chain. For instance, more flexible supply contracts meant that some companies could easily deal with reduced foodservice demand, but that their suppliers had to deal with surplus products. From a societal perspective, the design of contracts that share the impact of supply chain disturbances in a way that limits the impact on the overall performance of the food system would be beneficial (Duong and Chong, 2020).

Interestingly, companies indicated that governmental measures and guidelines were often not detailed enough for direct implementation, such that a significant amount of time was spent discussing how to implement the measures in their specific company context. Also, in many cases, interaction with the authorities was required to be able to decide more precisely what was and what was not allowed. This calls for more clear guidelines for companies that provide more detail on the measures that have been installed by the government. The ideal time to develop such guidelines would be now since knowledge of the supply chain disturbances caused by the pandemic is still fresh in people's minds.

Finally, it is interesting to observe that the operations and supply chain function was at the forefront in most companies, while, e.g. product development and marketing were getting less attention. This was clearly visible

in the rationalization and standardization of product assortments by many of the interviewed companies. Sometimes, such assortment rationalizations were being discussed before the pandemic, but the implementation became essential due to the pandemic. Whether or not these changes to product assortments will remain in place after the pandemic is not clear at the time of writing. Neither is it clear to what extent the classic discussion about conflicting objectives from operations and marketing will change permanently due to the lessons learned during the pandemic.

All in all, it seems that learning from a crisis and capturing that knowledge in actionable plans is difficult. The financial crisis of 2008–2009 showed a considerable drop in turnover across the board, not as severe as some sectors experienced during the COVID crisis (notably the food services) but still considerable. Empirical research on learnings from that financial crisis showed that in such a disruptive situation preparation through flexible planning strategies may be more productive than relying on (reactive) operational flexibility to counteract disruptions after the fact (de Leeuw and Wiers, 2015).

11 Conclusion and future trends

This study provides empirical evidence of how food companies responded to supply chain disruptions during the first (March–April 2020) and second (after summer holidays 2020) waves of the COVID-19 pandemic. Using semi-structured interviews with companies based in the Netherlands, covering all stages of the food supply chain, we collected and mapped the responses to different supply chain resilience capabilities. The findings show a dominance of flexibility and agility-related responses. It also demonstrates the inherent challenges and opportunities to employ specific resilience capabilities due to the long lead times of primary food production and the perishability of food products. Furthermore, our results indicated the increasing importance of rationalization as an effective way to increase supply chain resilience. In several of the cases we analyzed, rationalization was a key strategy in the response phase, used to mitigate the impact of the pandemic on supply chain operations. In our deductive category application process, we therefore also added rationalization as a key resilience capability in the context of the pandemic responses in food supply chains, complementing the capabilities we identified in the literature.

Our research reveals several interesting avenues of future research. First, future research could investigate the development of supply chain contracts that consider the sharing of risks resulting from disruption, especially during long-term supply chain disruptions like the COVID-19 pandemic. Whereas many existing studies discuss revenue-sharing contracts, a risk-sharing contract

during disruptions can enhance trust among firms and financially facilitate a fair supply chain collaboration (Duong and Chong, 2020).

Second, we suggest to further investigate two specific capabilities that were identified in our empirical results but do not receive much attention in the supply chain resilience literature: (1) prioritization and rationing strategies, and (2) rationalization and standardization strategies. Both of these strategies are on the operations-marketing interface within companies and would thus require intra-organizational goal alignment. Also, in terms of timing, it would be beneficial to already consider such strategies in an early stage as part of initiatives to increase the readiness to supply chain disturbances. In the pandemic response studied in this chapter, many of the decisions related to these capabilities had to be made on extremely short notice.

Third, we observe limited employment of data and information systems in food companies for disruption management, even for large multinational companies. Real-time information on supply chain activities at all stages is crucial to overcome challenges during a disruption (Belhadi et al., 2021). Furthermore, given the long lead-time of food production and the impossibility to increase primary sector production volumes in the short term, research attention should also be given to digitalization and the use of data in supporting farm business decisions considering extreme disruptions.

Fourth and finally, even though supply chain collaboration only came up explicitly in a few interviews, it did seem to also have an important role in facilitating other capabilities (such as an increased sourcing flexibility in a case where a good relationship with the supplier existed). This mediating role of supply chain collaboration and good supplier relationships in relation to other supply chain resilience capabilities has been identified before in the literature (see e.g. Scholten and Schilder, 2015), but it is an aspect worth mentioning here and worth further investigation.

Our study collected empirical data from interviewees located in the Netherlands. Because different parts of the world experienced the pandemic at different times and food supply chain structures can be quite between markets (e.g. developed countries vs. developing countries), we realize that this is a limitation and that our findings might not generalize to any kind of food supply chain. However, several of the interviewed companies were multinational companies with operations in different continents, and our results therefore still partly reflect global responses. Another possible limitation is that we only report on the situation in 2020, meaning that we are not able to capture any long-term impacts. A future longitudinal study could therefore provide additional insight on food supply chain resilience in relation to long-term disturbances like the COVID-19 pandemic.

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13 Where to look for further information

Since the COVID-19 pandemic, there has been quite some attention to supply chain resilience in light of major disturbances like the one caused by the pandemic. The references used in the introduction of this chapter provide a good starting point for readers interested in this stream of research. Since the finalization of this chapter, many more interesting studies have been published. To complement this chapter, we for instance suggest Ali et al. (2023) and Zhao et al. (2024) for perspectives based on empirical studies in other countries.

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