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Abstract

The COVID-19 crisis heavily tested grocery supply chains and supply chain management capabilities. Swift response practices proved to be more valuable than ever before, as the grocery retailers faced sudden, unanticipated, and simultaneous shocks both on the demand and on the supply side. At the same time, the virus posed a threat to manufacturers' production capacities, and new bottlenecks emerged for logistics service providers as consumers switched to on-line shopping and home delivery. For many food wholesalers and distributors demand also changed almost overnight from one delivery channel to another: not only from retail stores to online channels, but also from food services (restaurants) to grocery stores. In these circumstances, maintaining good delivery capacity and ensuring availability to the end customers called for fast operational changes of individual firms and coordinated adaptations of supply chain practices. Despite the challenges, many supply chains coped surprisingly well with the shocks and were able to keep-up good performance through the crisis. We conducted a real-time study as the COVID-19 crisis was unfolding, from the beginning of the first government issued restrictions, and all the while the pandemic was gaining speed. This setting allowed us to gain first-hand insights from interviewees considering their responses at different times and in different echelons of the grocery supply chain.

Keywords: Supply Chain, Resiliency, COVID-19, Disruption, Agile Planning, Grocery retail

Introduction

We identify four key threats to supply chain stability and performance in the COVID-19 shock to the grocery supply chain. These are: (1) outbreak of the disease in production facilities disrupts supply, (2) consumers persistently hoarding products in fear of shortages, (3) manufacturers unable to respond in an agile and effective way, and (4) bullwhip effects distorting the decision making throughout the supply chain. Each one, if realized, amplify the negative impacts of the initial shock leading to severe disruptions and persistent food shortages.

Without swift responses to the shock, the grocery supply chain that we studied would also have been tipped into a self-reinforcing crisis, like so many grocery supply chains across the globe. As the fear of stores running out of food would have been realized, the trust in the food supply chains would have been undermined and the impact of the crisis would have been far worse. Outbreaks of COVID-19 at the manufacturers would have restricted supply. Inability to reassuringly communicate security of availability would have increased consumer hoarding. Inflexible and unresponsive supply chains would have responded with delay creating a devastating bullwhip through the supply chain. Emerging bottlenecks would have been ignored leading to wasted capacity, production of unnecessary products and creating huge inventories and

backlogs in the supply chain while the consumers would have been experiencing continued shortages.

However, pandemic did not tip the grocery supply chain we studied into a crisis. With swift responses and agile planning, the supply chain participants were able to avoid the threats unleashed by the pandemic. We observed the combination of practices and capabilities that were needed to sustain the good performance level, and recover fast, without risking the health of workers.

We base our findings on interviews and observations throughout the grocery supply chain in Finland. In methodology section we describe our data collection with retailers, manufacturers, distributors and service providers about the key actions they took to adapt the grocery supply chains to the COVID-19 shock. We take a supply chain and crisis life-cycle perspective to the shock and discuss first the initiation and immediate impact of the shock and the corrective actions taken to address these. We then take a supply chain perspective and anticipate the immediate, medium and long-term adaptations firms along the supply chain are making to respond. Based on our study we then identify the working mechanisms of the responses in grocery supply chain in Finland to explain the performance and supply chain outcome.

Methodology

Our study is a real-time study as we were interviewing different grocery supply chain participants; retailers, wholesalers, manufacturers, and supply chain software providers during the first wave of the COVID-19 pandemic in the spring of 2020. We focused on the practices and capabilities needed to sustain performance and recover fast from the crisis. We gathered data from 17 interviews with key stakeholders in 12 companies, and complemented interviews with public presentations from a national supply chain interest group and, a supply-chain software provider. Six of the interviews were primarily collected for research on other aspects of COVID-19 response, but as the supply chain crisis response actions were prominent in these interviews and reiterated the patterns from our primary interviews, we included them to our sample.

We augmented the interviews with public presentation materials from the focal companies on the COVID-19 impact. The presentations included survey and aggregated demand data that supported the findings from interviews and public news outlets. Our interviews covered major companies across all the echelons of the grocery supply chain in Finland, which grounds and externally validates our data collection. We were able to increase the validity by triangulating our findings by data collected with different methods to overcome the inherent weakness of different types of data (Singleton and Straits, 2018, p. 424).

Table 1: Data sources and interviews and days from the onset of lock-down in Finland¹

Data source	Nr of interviews/ Contacts	Days from onset of lock-down
Retail companies	2	53; 58
Wholesale companies	3	14; 17; 60
Manufacturing companies	10	24; 24; 36; 39; 45; 57; 57; 64; 70; 78
Supply chain software companies	3	7; 35; 65
Interest group presentations	2	52; 93
Total	20	

¹ Government designated emergency conditions and restrictions initiated in Finland on the 16th March <https://vnk.fi/ajankohtaista/paatos?decisionId=0900908f8068ec10>

Data Collection

We collected the data on the unfolding crisis and the responses of the supply chain participants over a three-month period between middle of March and June 2020 in Finland. The retail optimization software provider in our sample, shared insights from its global customer base and validated that the crisis impact was very similar across different markets as we had observed in our interviews of the Finnish grocery supply-chain. Our first contacts and interviews took place in less than two weeks from the onset of the acute crisis for the grocery supply chain, when the government-imposed restrictions for the movement of people, distance work and school closures had been instigated. We had preliminary conversations with the informants in March, where we captured some of the early insights of the crisis response. The documented interviews started three weeks from the onset of the crisis. At the time of the interviews, our informants had had some time to analyze the situation, while the events, interventions and response actions were still fresh in their mind.

Table 1 summarizes our data collection efforts including the informal early discussions, 15 documented interviews and complementing public presentations by interest groups on the impacts of the COVID-19 to supply chains. Each interview lasted between 45-120 minutes. During the interviews, we asked informants to describe the changes that occurred in their supply chains during the COVID-19 outbreak; the response actions and interventions taken, and if they had changed their plans or supply chain preparedness; what were the first signals of the outbreak; and what kind of outlook they have for the future. The interviews were documented with recording and transcripts or memos.

Data Analysis

We analyzed data in parallel with the interviews and continued interviews to gain sufficient coverage of the supply chains. After 10 interviews, the findings and patterns started to be repetitive and suggested saturation of the information from our sample. We used open coding to identify concepts and to classify phenomena (Strauss and Corbin, 1998, p. 103). We started by creating first order codes and generated new codes during the coding process. We grouped the first order codes to create second-order categories. We refined second order categories multiple times by different people before landing to current description and framework to explain the generative mechanisms. While combining first order codes to second order categories we asked ourselves “Why these codes are related and why they are different”.

After deciding on the interpretation of our data through the coding, we linked the data to the relevant theories on managing supply chain disruptions. The contribution of our explorative study is summarized in a hypothesis on what factors enabled good performance of the grocery supply chain during the COVID-19 crisis and how these factors lead to the good performance. We deployed CIMO framework (e.g., Denyer et al., 2008) to summarize our theoretical hypothesis from the context (C), where the interventions (I) affected through the mechanisms (M) to the observed outcomes (O).

First impacts of the Covid-19 crisis on the grocery supply chain in Finland

The COVID-19 pandemic could be referred to as a black swan – highly impactful event with low probability and low predictability (Taleb, 2007), but actually this was not the case for all parts in the world. When Covid-19 started to spread fast in China in the beginning of 2020, and Chinese government made the decision to lock-down the economy, first companies in Europe started to prepare their organizations for managing the crisis. In Europe, the pandemic hit first the northern Italy, and some weeks later it spread all over Europe. The delay in the spread of the epidemic

allowed companies located in the areas that were impacted later, such as Northern Europe or Americas, to prepare. In this respect the Covid-19 induced shock can be compared to shocks from tropical storms and hurricanes, which are common occurrences in some regions. While the disruptions and demand spikes due to storms occur regularly and can be predicted at least a week earlier, the demand surge still occurs suddenly and often leads to stockouts as normal capacity is exceeded.

Even though companies were anticipating disruptions based on the observations of the countries that were first hit by the COVID-19, no-one had been able to anticipate the magnitude and the speed of the changes created by the national government's announcement of the restrictions and the lock-down. Although many companies interviewed reported on some actions to prepare for the crisis, all interviewees were astonished of the magnitude of the sudden demand increase. The consumers were hoarding products across the board, but especially non-perishables such as hygiene products or long shelf life products to anticipate the possible lock-down. The grocery retail was the first to face the severe demand spikes, which initiated suddenly and sustained for weeks (Kärkkäinen, 2020).

From the stores the shock cascaded fast to the central warehouses both stocking out the products but also overwhelming the logistics capacity at the warehouses and for the transportation. For the retailers, the impact of demand surge was almost immediate stockouts of specific items. The overall demand volume for grocery retail increased, which led to bottlenecks in replenishing stores and shelves. The demand exceeded fast the inventory availability at the stores for the main products, but also the logistical capacity to replenish the volume and variety of products at the stores. This sudden increase in demand conveyed to the suppliers almost instantaneously after the government-imposed restrictions and the largest retail demand surge occurred. This view was confirmed in both the retailer's, as well as suppliers' interviews. One interviewee stated:

"Normally, at the beginning of the week some of our customers might order 10 to 12 pallets, but now they ordered 20 pallets. Our demand is quite stable, and we were totally surprised by this increase." – Sales Manager,
Fresh food producer

The demand peak however was directed only to a fraction of the grocery store items: according to Relex Solutions, a provider of retail optimization software, only 5 % of SKUs faced a sudden demand increase at the week when the government restrictions started (Kärkkäinen, 2020). The statistics of Relex Solutions also shows that demand started to increase already a couple of weeks before the restrictions. The consumer behavior changed, which appeared as less visits to the stores but larger one-time purchases. The demand shifted to 'cooking at home' products, and some products experienced a demand decrease, such as snacks, leading to a differentiated impact across the product assortment. The new cooking habits increased demand for pasta, bread, baking products, while the immediate stocking demand focused on hygiene products, canned foods and other reserve supplies. Figure 1 summarizes the observations of impacts and responses of the companies to the shock. Differing demand changes are depicted on the right, the initial demand spikes and drops are reverted but the longer-term changes in demand due to economic distress and enduring changes in work, movement and activities are expected by the companies.

As products were running out, the consumers' willingness to substitute from their preferred product to corresponding produces was significantly higher than during normal times. This meant that demand distributed more evenly across items in high-demand categories. This relieved pressure for the supply chains: instead of trying to uphold availability of a broad variety of products, the focus was on securing availability within a category. This meant that the retailers

could rationalize the assortment by narrowing it down and direct the bottleneck capacity to ensuring availability.

At the beginning of the crisis, the online sales channel saw the biggest and fastest impacts. There were three interlinked events happening at the same time. First, consumers started to hoard products to build stocks at their homes. Second, many consumers changed their shopping channel to online, to avoid being infected in crowded grocery stores. Third, closing of schools and sudden shift to remote work moved demand from food services to both online and traditional retail channels. These changes led to online grocery demand 'skyrocketing to tenfold in a day', as an informant reported. One informant described the situation they faced as follows:

"It has been quite a hassle; our sales volumes grew incredibly much." -
CEO of online retailer

One of the impacts on retailing was the build-up and shift of bottlenecks in logistics and supply chains to certain products and places. Especially online retailers reported that their worst bottleneck was not order picking as they first suspected, but the lack of tempered delivery capacity to satisfy the increased need. For the distributor and wholesale companies, the increase in demand from retailers and e-commerce, and disappearance of demand from the food services such as restaurants, hotels, and cafes, meant capacity shortages and slack simultaneously.

On some specific areas, such as food services, the demand plummeted extremely sharply. When government announced a closure of schools and restaurants, food service industry reported a loss of 90% of their demand in a day. Similar but not as dramatic change happened in specialty retail (Kärkkäinen, 2020).

Massive outbreak of the disease infections among production employees was identified as a major threat in our interviews. Although being automatized, grocery production facilities still need human operators in many production phases. Production is characterized by features, which are advantageous for a virus to spread further and cause widespread crisis for supply chains. These include fixed placing of machinery, which require machine operators to work in close proximity, centralizing production to handful of facilities and/or production lines, which might mean total closure of business in case of outbreak, and requirement of special skills for machine operators so that in case of sickness, training of new operators might prove out to be difficult.

The consumer demand changes were fast conveyed to the manufacturers and suppliers and the bottleneck for the product availability on the supply chain level shifted to the production capacity. At the same time, manufacturers' concerns regarding their production capability started to escalate. At some plants, many production workers were on sick leave, and firms had to fast prepare plans how to avoid loss of production capacity in case of COVID-19 incidents and the possible quarantines and how to create safe working environment for employees crucial on keeping the production on-going.

Response actions and practices

From our interviews, we identified various practices employed by the different companies at the different echelons of the grocery supply chain. We were able to triangulate the actions and perceived performance of different companies based on how their up- and down-stream partners reflected their coordinated actions. Even though each company was implementing a unique set of response actions and adjustments, there were significant commonalities across the practices. The interviews highlighted that particularly the regional and flexible fresh product supply-chains had performed well. They had responded with well-balanced and rapid actions and adapted fast to the situation to secure best possible availability of products to consumers. In the industries where the

demand has traditionally been very stable the manufacturers were not able to be responsive and react to the shock, which lead to higher number of stock outs and lower overall performance during the crisis. Two interviewees described the situation in a very similar manner as follows:

“Local manufacturers have coped with the crisis very well, especially the fresh products business, because they are used to responding fast to exceptional situations.” - Supply Chain Director, large retail company

“Fresh product supply chains are used to fast response and daily decision making.” - Head of Supply Chain, fresh product manufacturer.

We have summarized the mitigation actions and practices in Figure 1.

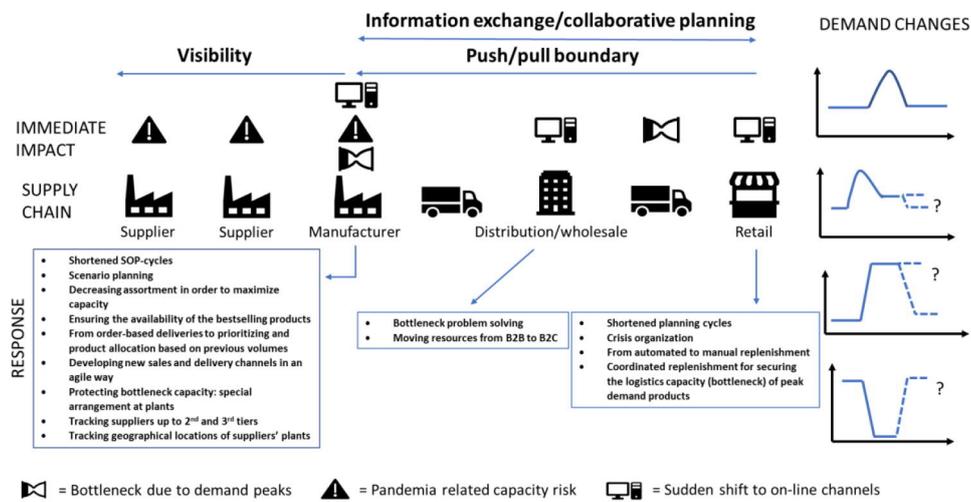


Figure 1. Summary of Covid-19 shock's impacts and responding actions in the grocery supply chain based on our data gathering.

Managing the acute crisis

The first action for many of the large companies in the grocery supply chain was to initiate a crisis decision making organization, an action prepared prior to the corona crisis or based on early signals from markets that had been hit by the corona earlier. The crisis response teams coordinated fast and reactive decision making through the company and centralized the information collecting, communication and critical non-standard decisions.

The COVID-19 induced changes in demand were unpredictable, so even sophisticated forecasting systems were rendered useless. Although there were warning signals from countries that were earlier on the “corona curve”, the consumer demand reaction and its breadth was so sudden and drastic that no forecast could cope with it. The shock turned the forecasting and previous sales data obsolete and created a need for transparency in the downstream demand. The companies across the supply chain responded by increasing radically communication and information sharing.

Together with the main suppliers, the retailers and logistics companies increased the information sharing with daily discussions and conference calls to share demand information and action plans. One major retailer also initiated point-of-sale information sharing to enable visibility through supply chain for major suppliers. As the sales data during the acute crisis is censored and unreliable, the sharing of tacit expert knowledge became important with personal communication

in key role instead of sharing data. Actors in all supply chain echelons emphasized that sharing more information about planned production and logistics volumes, capacity, and restrictions to normal assortment was essential. The focus for the well performing collaborations was not only in communicating demand information, but also in collaborative matching of demand and scarce supply.

“Communication with the retailers has improved and intensified, now we are communicating with our main customers daily or almost daily, and we get better information on what is going on” – Supply chain director, major manufacturing company

To benefit from the increased transparency, the well-performing retail companies increased the frequency of planning with their upstream partners significantly and moved to a more agile planning mode. This was incorporated with expert and judgment-based prioritization of orders and replenishments. As in addition to inventory availability, the logistics capacity at the warehouses and in-store replenishments were bottlenecks, the successful retailers coordinated replenishments by creating new product category level prioritization rules to protect the bottleneck capacities. These retailers used advanced planning systems to rapidly translate the planners’ expert knowledge into planning rules and replenishment plans for the whole assortment. The retail companies quickly switched their operational planning to an expert/judgmental planning mode, where the logistics capacity bottlenecks and availability of supply from suppliers was dictating the operations instead of the automated forecasting-based planning mode.

Also, the manufacturers realized frequent, even daily S&OP planning cycles so that the planning enabled focusing bottleneck capacity on correct products, as well as protecting the manufacturing bottleneck from unnecessary variation. To maximize capacity, the manufacturers focused the production to a restricted assortment of key products. This was coordinated with the retailers and based on actual customer demand. One change in planning was including key package material suppliers into the S&OP planning process and adjusted the production plans according to the material availability constraints.

“First we restricted assortment, secured volume products, then the important job was to communicate with customers both on demand information and availability of supply” – Operations director, major manufacturing company

However, the radical increase in communication and transparency was focused between the large key partners in the supply chains. The smaller suppliers and companies could not be included in the daily personal communication. Enabling increased communication towards the smaller suppliers would be useful planning systems development in preparation for future shocks.

“When the crisis first started, we didn’t get any advance warning from our customers, but the first signal was a sudden doubling of orders.” – Sales Manager, small supplier

The companies that performed well during the crisis, also dynamically re-organized and mobilized resources to serve the surging demand in the retail and online retail customers. To generate new sales the companies moved rapidly to increase existing or introduce new consumer online sales channels, which meant moving resources from B2B to B2C. The demand surge for online retail created bottlenecks in the warehouse logistics, transportation, and distribution logistics. The companies responded with several practices to increase the capacity through reorganization and acquisition of new capacity. As the retail companies, they also responded with bottleneck protection tactics to maximize throughput by decreasing variety offered and increasing batch sizes in coordination with the retail customers. After the initial shock, the companies also

reported that they continued agile planning with scenario planning to map out the potential next bottlenecks.

The fact that demand was not surging similarly for all product categories, required specific actions. Simultaneously to facing production capacity bottlenecks for some products like bread, cream in consumer packaging sizes, and other cook at home essentials, the manufacturers faced vanishing sales for some product categories. To minimize the losses through obsolescence, the manufacturers responded by innovative opening, or increasing existing direct-to-consumer online channels, such as drive-in bread sales, home-delivery of online ordered products, and increase in focus on the branded online shops. As these B2C channels are competing with the retailers, it will be interesting to follow-up how the manufacturers will be developing the channels as we transition to normalcy. One take-away for the companies on different levels of the grocery supply chain from the crisis, is that diversification is more valuable than what had been assessed in the good times.

“For years we have been criticized for lack of focus in any individual customer segment, mainly in food service, but today it proved out to be extremely valuable that we still had several other segments to support the loss of food service business.” – Controller, large wholesaler

One essential activity for the retailers was to assure consumers about product availability. Careful communication to the public was in key role to dampen the demand surge from scarcity induced hoarding behavior. Some informants pointed out that they took responsibility on what to communicate in newspaper and media interviews to avoid prolonging hoarding of products from their outlets. Although they knew that they would run out some items, it was their deliberate judgement to give out positive outlook about the reality of the performance of their supply chains and product availability.

Supply chain adaptations

Initial supply chain level response

The *agile planning* actions were focused on enabling maximized throughput on supply chain level, as the demand surge for retail created a moving bottleneck for the whole supply chain. The prioritization and protection of bottleneck logistics capacity was accompanied by dynamic resource re-allocation and addition by the agile companies. The flexible companies fast moved personnel from the low demand areas to the retail stores, pick & pack of online grocery retail and increased their personnel in logistics. To increase the logistics and transportation capacity, the retailers could coordinate with large suppliers to use suppliers' transportation capacity to deliver directly to stores and by-pass the logistics hubs; best performing companies could utilize this supplier transport capacity for shared shipments.

For some retail chains, the *decision-making power and responsibility* shifted during the acute phase of the crisis. The decision making was centralized to enable effective control of shared bottleneck resources in logistics capacity and inventory of scarce products. This shift to a more centralized decision making from a more entrepreneurial normal mode was an interesting response action, necessitated by the lack of information and predictability and need for rapid decisions and coordinated action.

Based on our interviews covering the supply chain echelons from retail to major manufacturers, we can summarize the supply chain level response practices to the shock. The demand surge in many product categories in the grocery retail gave rise to several supply bottlenecks, first in the logistics closer to consumer and then moving to the production capacity at the manufacturers as the distribution warehouse inventories had been exhausted.

The operations of the supply chain were subordinated temporarily to the emerging global bottlenecks of the supply chain in manufacturing. In effect, this meant that temporarily the supply chain moved from order-based deliveries to production capacity allocation and availability driven delivery mode. The *push-pull boundary of the supply chain was moved up-stream* to manufacturers, who started pushing the products down-stream towards the consumers. As the demand in many categories overwhelmed the supply, the supply chains were in effect pushing the products to the market based on communicated demand signal from the retailers and product portfolio that was determined by the objective to maximize throughput of the production. During normal operation, the orders from the retailers and distributors pull the products from the manufacturers and consumer demand drives the supply chain operation. At the production facilities the manufacturers took several process measures to secure production capacity at the key process steps, these included health and safety measures and assigning extra personnel where available.

The supply chain partners enabled this change in operating logic through agile planning changes and with increased communication and information sharing. The importance of information sharing has been long established to be important factor in effective supply chain planning, but the value of information sharing, and visibility is context dependent. In environments that are characterized by stable and predictable demand, inflexible capacity, or long lead times, the companies do not invest in sharing real-time demand information (e.g. de Treville et al., 2004; Kaipia et al., 2017). The corona crisis raised the awareness of the value of information sharing and coordinating actions around shared demand understanding during high uncertainty of demand and constrained supply.

Supply chain adaptations for the medium- and long-term

After the acute phase of the COVID-19 induced shock to the grocery supply chain, the companies were returning to normal operations and adapting to the lasting changes in the environment. In addition to the short-term crisis respond practices that enabled the food supply chains to avoid more severe crisis, some readjustments to the operations and design of the supply chains are highlighted.

In our interviews, the companies along the food supply chain mentioned information exchange with supply chain partners and overall information sharing across the industry peers as a development item and a key take-away from the corona crisis. As noted, this is nothing new to supply chain research or practice but together with advanced and automated planning software it is a capability that should be invested in to enable efficient and fast reaction to future disruptions. When considering information exchange, it should be noted that during the severe disruption the demand data is not necessarily valid. The information exchange practices should enable a process for sharing informal, judgmental signals and enable coordination of execution in a seamless way.

Take-aways from this crisis in the retail echelon, was that forecasting is not important in managing demand and supply shocks in retail; the key is responsive logistics and production, fast replenishment adjustment, control, and prioritization of the bottleneck capacity. As the companies had marked benefit from shorter planning horizon, they are reluctant to move back to more infrequent planning. Establishing capability for increased frequency of planning is an adaption from the crisis. In the preparations for future disruptions the retailers will also focus on safety stocks and replenishment capacity with agile planning instead of forecasting. As a part of the agile planning practices capability to run scenario planning and translating the scenarios into detailed capacity requirements and execution plans, is an important capability that was highlighted by the current experience.

Upstream of the retail, for the distribution and logistics from the central warehouse to the store level replenishment designing supply chains with capacity for surge logistics and production

capacity is a key supply chain development take-away from the COVID-19 crisis. The crisis highlighted two aspects to automation for logistics in food supply chains; the automated warehouses and logistics are not flexible to enable capacity surge. But on the other hand, automated capacity is not susceptible to social distancing restrictions and epidemic outbreak amongst the personnel.

The branded manufacturers had to take actions with the upstream actors, such as raw materials and packaging material suppliers to ensure availability. The COVID-19 crisis was a wake-up in all industries for manufacturers to track and trace their supply networks to 2nd and 3rd tier for increasing the visibility to risk exposures in their upstream supply chains. Responsive and local manufacturing capacity of the fresh product manufacturers contributed to the ability to secure availability and cope well with the crisis. Trusted supplier relationships are increasing in importance, as is investing in supply chain visibility and transparency. As one large manufacturer stated, “Local, large packaging suppliers with long and collaborative relationships has been a strength in the current crisis to secure good service and supply of materials.” According to our interviews, the COVID-19 crisis increases the emphasis on the strategic flexibility of capacity, diversifying, and adding second supply sources for materials from regional suppliers.

The capability for flexible end-to-end planning changes and optimization of production plans according to differing constraints proves to be valuable during the unpredictable disruptions. The agile planning enables optimized production and sales mix according to the emerging capacity bottlenecks and availability of materials. Next, we synthesize the identified practices and capabilities into propositions that describe how the practices activate mechanisms leading to the improved performance over severe supply-chain crisis.

Synthesis: What did we learn?

We may conclude from our observations that COVID-19 shock put the grocery supply chains in a situation that they never have faced before. Many consumers made grocery shopping in a panic and changed their buying behavior almost overnight, which was followed by empty shelves in many grocery stores and long delays in e-grocery home deliveries. At the same time, the supply of many items was in risk if the pandemic would have spread at the plants and distribution centers causing capacity losses. In this situation, long lasting stock-outs at the store could have led to a vicious circle: uncertainty about product availability could have fueled further panic buying that would have led to extended and prolonged stock-outs at the grocery stores. However, firms in the grocery supply chains undertook rapidly several measures and were able to keep the stock-outs in the store short and restore consumers’ confidence so that panic buying did not escalate. We found that the effective response of the supply chain to the COVID-19 shock called for simultaneous actions in resource planning, plant management, communication, sales and operations planning, and supply chain control.

We next synthesize our findings of these measures in the supply chain to a design theory to outline how grocery supply chains can maintain high availability for decreasing the likelihood of panic shopping in the context of sudden demand increase and simultaneous heightened supply risk. When taken together, we present five propositions on the generative mechanism explaining how the grocery supply chain that we studied was able to maintain availability and avoid bullwhip-effect (Figure 2). In the context of the multiple shocks that COVID-19 created to both demand and supply in the studied supply chain, we will in the following introduce each proposition on mechanisms.

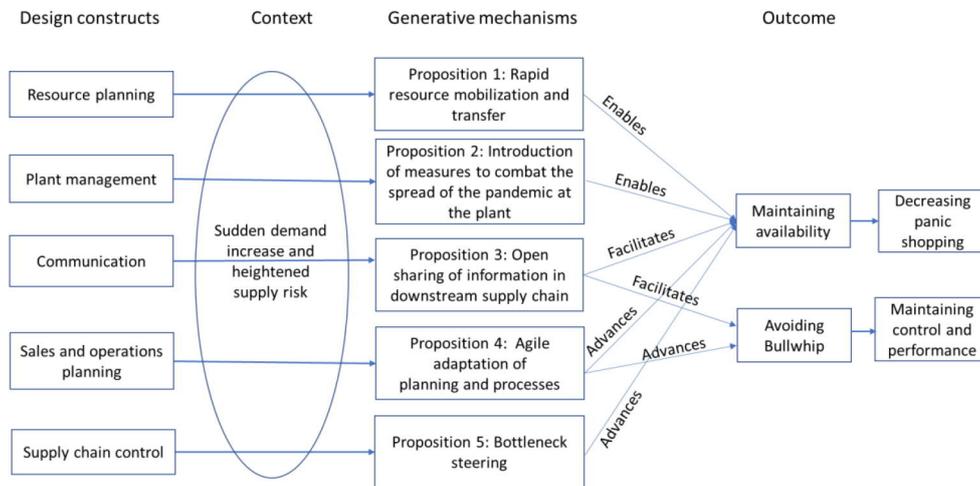


Figure 2: Generative mechanism of maintaining availability for decreasing panic shopping in the context of sudden demand increase and heightened supply risk

The sudden increase of demand of some products and demand shift from food services to grocery stores and from physical stores to online channels called for rapid resource mobilization and transfer particularly at the wholesaler and supplier phases of the grocery supply chain. The wholesalers and suppliers undertook several measures to increase the capacity through reorganization and acquisition of new capacity. These measures were prerequisites for the maintaining the availability in the new situation. These observations lead us to the first proposition:

Proposition 1: Rapid resource mobilization and transfer enables maintaining availability that decrease the likelihood of panic shopping in the context of sudden demand increase and heightened supply risk.

In the manufacturing plants the pandemic formed a threat of losing capacity if the virus would enter the plants and several workers would be on sick leave or in quarantine. In the food industry the plants have high hygienic standards also during the normal times, and therefore they had good capabilities to implement further measures to prevent the virus from entering the plant and spreading among the workers. This was critical at the specialized and automated plants, whose products and production lines are difficult to substitute. We crystallize this observation to the second proposition:

Proposition 2: Introduction of measures to combat the spread of the pandemic at the plant enables maintaining availability that decrease the likelihood of panic shopping in the context of sudden demand increase and heightened supply risk.

The sudden demand changes and the uncertainty of how the pandemic situation will continue and affect the consumer behavior in the future, combined with the uncertainty of supply made the transparency of the supply chain more important than ever before. In particular, the situation called for effective communication in the downstream supply chain between retailers, wholesalers and suppliers of the products that were most affected. The information exchange in the observed supply chains was more open and frequent than ever before, which facilitates maintaining availability at the stores and avoiding bullwhip-effect in the supply chain.

Proposition 3: Open sharing of information in downstream supply chain facilitates maintaining availability that decrease the likelihood of panic shopping and avoiding bullwhip-effect in the context of sudden demand increase and heightened supply risk.

It turned out quite soon that all parties in the supply chain need to adapt fast their sales and operations planning principles and practices to effectively respond to the COVID-19 shock. Grocery retailers replaced the forecast-based automatic replenishment systems with manual planning and prioritization of replenishment of the products that were most affected and adjusted the planning and prioritization rules of the products using advanced planning systems. All parties in the supply chain shortened their planning cycle and horizon for being able to make rapid adjustments to plans according to incoming information. They also implemented scenario planning to be prepared for alternative demand situations. For some peak demand products, the push/pull boundary was also shifted from the retailer to the supplier. For example, the supplier of the bakery products no more delivered based on orders from the retailers but started to allocate the high demand products to the retailers based on their past demand. The several complementary adaptations of the sales and operations planning processes and practices in the supply chain helped substantially to keep the stock-outs of the most affected products short in the grocery stores.

Proposition 4: Agile adaptation of sales and operations planning principles and processes advances maintaining availability that decrease the likelihood of panic shopping and avoiding bullwhip-effect in the context of sudden demand increase and heightened supply risk.

The sudden demand changes created bottlenecks to the supply chain that needed to be addressed for ensuring the efficient flow of the critical items. Bottlenecks were identified both at suppliers' production and in logistic operations. Both retailers and suppliers limited the product assortment for ensuring the availability of the most important items. The retailers and wholesalers also changed their planning principles to ensure logistics capacity of the peak demand items.

Proposition 5: Bottleneck steering of the supply chain advances maintaining availability that decrease the likelihood of panic shopping in the context of sudden demand increase and heightened supply risk.

Conclusion

Responding to a shock such as COVID-19 to the grocery supply chain, requires multiple and simultaneous measures in resource planning, plant management, communication, sales and operations planning, and supply chain control. If the grocery supply chain that we studied had lacked in the required capabilities, and failed to undertake the swift response measures, the panic shopping would have escalated, and the performance of the supply chain would have been significantly compromised by bullwhip effect. As a conclusion, we argue that COVID-19 shock uncovered the value of specific supply chain management capabilities, and how these enable, facilitate and advance good performance. As a conclusion, we argue that COVID-19 shock uncovered the value of specific supply chain management capabilities, and how these enable, facilitate and advance good performance. Agile planning and adjusting the supply chain to bottleneck steering mode made the grocery supply chain resilient in facing the COVID-19 crisis.

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