

# A Supply Chain Resilience Capability Framework and Process for Mitigating the COVID-19 Pandemic Disruption

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**Abstract—** This paper aims to explore the supply chain resilience capabilities of firms, focusing on their ability to respond to the COVID-19 pandemic disruption. Based on two cases each in the pharmaceutical and mineral water industries, this paper identifies various strategies managers mobilized to tackle supply chain disruptions during the COVID-19 pandemic. This research contributes to theory through a proposed double-helix framework showing the dimension of disruptions and the capabilities concept to mitigate COVID-19. In addition, an in-depth investigation of the perceived importance versus actual supply chain resilience capabilities deployed is discussed and validated with practitioners. The findings of this study also address a critical gap in the supply chain operations management literature and provide a practical approach for managers to better manage future pandemic disruptions.

**Index Terms—** Capability, case study, COVID-19, digitalization, disruption, resilience, supply chain.

## I. INTRODUCTION

THE COVID-19 pandemic has forced firms to transform their business models and supply chains (SCs), but research and guidance for managers on how to develop resilience capabilities to address the disruptions from the pandemic is limited. The SC disruptions caused by the COVID-19 pandemic have had significant global-scale impacts and have changed the marketplace, industries and firms of all sizes. The COVID-19 pandemic has unintentionally created new ‘norms’ and business environments in the marketplace, requiring firms to adjust accordingly if they are to survive. For instance, new guidelines for food production have been outlined by the FAO and WHO (e.g., FAO and WHO, 2020) concerning curbing the pandemic within and beyond the factory walls. Although digital technologies are viewed as a quick panacea for the firm in addressing the COVID-19 pandemic [2]–[4], the deployment of digital technologies also depends upon another set of firm capabilities [5]. The misalignment between firm

capabilities and digital technologies may provide a rather short-term solution, and the synergetic value between the existing capabilities residing within a firm cannot be achieved and sustained. Moreover, jumping into digital technologies is not within every firm’s capacity [5] and hence complicates the firm capabilities regarding creating resilience, especially in the supply chain. Therefore, it is important to investigate the residing supply chain capabilities that can be utilized by firms when faced with a disruption.

SC resilience (SCRes) is critical for firms to survive disruptions [6]–[9]. Ali, Mahfouz and Arisha [6] pointed out that firms need to have a strategic set of SCRes capabilities to quickly absorb, adjust, and normalize the disruption to form a new business model. In contrast, firms that are unable to deploy the correct SCRes strategy will end up in worse states and will have more difficulty revitalizing their businesses. Ambulkar, Blackhurst and Grawe [7] argued that firms must carefully align their resilience strategies with firm capabilities; hence, firms should promote the most likely, effective, and economical decisions. Due to the novelty of COVID-19 and its impact on the business environment, the previous literature on SCRes can provide beneficial tools, but when adopting these suggestions, firms should closely consider which of these suggestions are appropriate for their particular situation, as the previous research on SCRes is commonly based on conceptual or simulated disruptions that may not be applicable in all settings [8], [9].

SCRes is commonly associated with the following four phases of strategy deployment for overcoming disruptions: readiness, response, recovery, and adaptation [9], [10]. In general, the quicker the firm adapts to the disruption, the faster it will return to its normal state or even to a better condition; in contrast, the firm will continue to suffer from uncertainty [11]. Resilience is the ability of a firm to be alert to, adapt to, and quickly respond to the changes brought by SC disruptions [7],

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[12]. Ali et al. [13] argued that firms must adopt SCRes strategies while considering their firm resources/capabilities. In the context of SCRes, the three main components of SC capabilities are proactive capability, design quality, and reactive capability [14]. Brusset and Teller [15] discussed three firm resilience capabilities from the context of external practices, internal processes, and integration. In Kochan and Nowicki [16], resilience capabilities were grouped according to the phases of readiness, response, and recovery. Despite the increasing popularity of SCRes studies, there is a lack of consensus on a well-grounded definition of SCRes [11], [16], [17]. In addition, the lack of clarity about the relationships between SCRes and capability constructs may be a result of divergent concepts of theory building [18], [19].

Many studies have reviewed the SCRes literature [17], [19], [20] and have found that generalizability has not been achieved and that a lack of clarity persists regarding SCRes [16]. One of the most likely and logical reasons is the diversity of potential disruptions and the capabilities of the specific cases studied [8], [9]. There is still a lack of theoretical understanding of the connotations of both SC capabilities and resilience [14], [20]. Hence, this paper aims to propose a new model for SCRes capability in the COVID-19 context, aiming to fill some gaps that exist in the mainstream SCRes literature. Moreover, different resilience strategies may be adopted by firms depending on the SC context, the disruption and the new environment [8], [9]. Following this argument, this paper also aims to explore in-depth the SCRes capabilities that have been deployed in responding to COVID-19. In summary, the following research questions are developed for this research investigation:

RQ1: What types of disruptions arise from the COVID-19 pandemic upstream and downstream of the SC? How do these vary from one industry/firm to another?

RQ2: Which SCRes capabilities are conceptually relevant to COVID-19? How can the capabilities be matched with COVID-19 disruptions?

RQ3: Which SCRes concept is the best solution to COVID-19? Should all the SCRes capability concepts of perceived importance be equally distributed? Is the SCRes capability strategy based on the concept that is perceived important actually being deployed?

RQ4: Which capabilities are regarded as feasible for firm deployment? What is the priority for SCRes capabilities?

Through four case studies (two in the pharmaceutical industry and two in the drinking water industry) drawn from manufacturing firms in Indonesia, this research aims to characterize the COVID-19 disruption as an archetype. This archetype is matched with firm SC capabilities in terms of the firm's proactive and reactive resilience strategy. This research also discusses the firm's perceived and actual SCRes strategy for mitigating COVID-19 disruptions. Based on this research, a conceptual framework is proposed. This study makes relevant improvements to the existing gap by discussing the capabilities on both the supply and demand sides of the SC. Using COVID-19 as the research context, more specific measures of the disruption and the associated capabilities are established. The

modern SC is globalized, interconnected, complex and long, which intensifies the need to understand the nature of COVID-19 disruptions and how firms can best match their strategy and capabilities to the present problematic market conditions.

This research is organized as follows. Section 2 discusses the literature on COVID-19 and its impact on the SC and argues that SCRes can be a useful tool for mitigation. Section 3 describes the methodological phases of the case studies in this research. Section 4 proposes SCRes in the COVID-19 framework as a theoretical contribution. Section 5 validates the framework and prioritizes using the MADM technique. Section 6 concludes with the findings and suggests future research directions.

## II. GUIDELINES FOR MANUSCRIPT PREPARATION

### A. COVID-19 and The Global SC

In the first few weeks of COVID-19 in late 2019, the global community saw it as a local epidemic, as had been the case with outbreaks of Ebola and the normal flu. However, as the number of COVID-19 cases continued to grow and became uncontrollable, it became apparent that the outbreak would be far more difficult to contain because most parts of the world are so well connected. As a result, the World Health Organization (WHO) declared COVID-19 to be a global pandemic on the 11<sup>th</sup> of March 2020 [21]. With guidance provided by the WHO, governments have been taking measures to combat COVID-19, notably social distancing, self-isolation, quarantine, travel restrictions and lockdowns [22]. Efforts to mitigate the transmission of COVID-19 have impacted not only social life but also the economy. Moreover, the pandemic has shaped the way business is being carried out [23], [24]. For example, the WHO and the UN Food and Agriculture Organization (FAO) have produced new operational guidance to be followed by the food industry to address disruptions [1], and other industries are expected to be impacted by the same trends. The new norms of doing business have profoundly affected firms' capacities and capabilities.

The prevention of global spread meant that the disruption was heavier in either the upstream or the downstream part of the SC, rather than both at the same time. In contrast, the unprecedented global disruption caused by COVID-19 has affected every section of the SC. On the one hand, in the downstream sectors of some SCs, there has been a hike in product demand [25], which may be due to panic buying and the hoarding of products considered essential, such as pharmaceuticals and face masks [22], [26]. On the other hand, there have been sharp decreases in demand in other sectors. These new purchasing behaviours have created an imbalance between supply and demand. As a consequence of the sudden hike in demand and last-mile delivery problems leading to product unavailability, actors upstream in the SC have found it challenging to meet demand. Furthermore, government closures of large numbers and multiple varieties of businesses have exacerbated the situation and created SC disruptions.

### B. COVID-19 Demands on SCRes Capabilities

The COVID-19 pandemic has created a new landscape for the marketplace and has led firms to change their SC norms. Under normal conditions, firms governed their SCs by responding to market demand to maximize profit. In general, COVID-19 has disrupted both ends of the SC. Thus, firm and SC resilience during the COVID-19 disruption is crucial for firms' survival and sustainability. As highlighted by Sá et al. [8], in the context of SC resilience, a firm that can quickly respond to a disruption has a higher chance of surviving and remaining competitive. However, there is very little guidance in the literature on the best practices for firms in situations such as the present one, and the literature on the role of SCRes in mitigating disruptions has lacked the backing of empirical evidence [8], [9]. Nevertheless, firms can embrace changes in the marketplace by adjusting their internal and external strategies to address the new COVID-19 environmental conditions. The ability of a firm to be resilient and adjust to environmental changes lies deep within its SC [20], [27]. Moreover, the firm's ability to ensure the resilience of its SC may be greater if it can draw lessons from previous cases. However, generalizing the findings reported in the literature can be difficult, especially given that resilience profiles are highly dependent upon the resources and capabilities of the focal firm [18], [28].

Pettit, Fiksel and Croxton [29] developed an SCRes framework that was constructed with SC vulnerability and SC capability dimensions. They believed that a relationship exists between each SC vulnerability and the SC capability employed to address that vulnerability. The different types of SC vulnerability will require different sets of SC capabilities to be employed [8]. Pettit, Fiksel and Croxton [30] argued that empowerment, collaboration with government and personal security are a set of SC capabilities that can be used to combat vulnerability to a pandemic. These studies discussed how the different sets of SCRes capabilities are evolving and find that they are highly dependent upon the distraction and that the models need to be improved. The SCRes dimensions of SC readiness, SC response, and SC recovery are commonly discussed in the literature [10], [19], [20], [27]. Chowdhury and Quaddus [14] constructed an SCRes framework with the following three primary dimensions: proactive capability, reactive capability, and SC design quality. The proactive and reactive dimensions were more often selected by companies to increase their readiness, response, and recovery ability levels during both the pre-disaster and post-disaster phases. Based on a literature review and qualitative study, the variables for each type of SC capability were determined. Despite the comprehensiveness of the previous literature, the majority of these studies were conducted based on a conceptual understanding of a disruption, and the model and argument of SCRes are broad and may not be relevant to real disruptions, such as COVID-19.

Hosseini et al. [31] developed three categories of SC capability in SCRes to tackle SC disruptions. They argued that

SC capability is an important dimension of the SCRes framework under conditions of uncertainty. In their SCRes framework, the three categories of SC capability, as three lines of defence (absorptive, adaptive, and restorative), were used to increase the firm's ability to handle SC disruptions. The first and second lines of SCRes were absorptive and adaptive capabilities, while the third line of SCRes was restorative capability. Based on their quantitative analysis, they determined the drivers of each SC capability, but they focused only on the upstream part of the SC and neglected the importance of the downstream, which is an equally important aspect for both SC and resilience studies.

### III. RESEARCH DESIGN

In this research, a three-phase methodology similar to that applied by Ali, Tan and Ismail [32] and Tse and Tan [33] was adopted to elicit SCRes capabilities. The first phase aimed to identify SCRes strategies and capabilities to guide the authors in the elicitation of related information during the next two phases. First, the previous studies on SCRes strategies and capabilities were reviewed to gain a better understanding of the definitions and their applicability during the COVID-19 disruption [14], [16], [34], [35]. In the second phase, the literature review was triangulated with the results of interviews with top managers from the firms in the four case studies. The objective of this phase was to contextualize the SCRes strategy and capabilities theory from the perspective of the two selected industries in the setting of the COVID-19 pandemic. The data obtained from the case studies were used to explain the related literature. During this phase, the data were analysed, and the capabilities were explained to provide further extensions of the new knowledge regarding unprecedented disruptions, with the potential for practical application by managers. The results are explained and discussed in Section 4. In the third phase, the findings were verified and are presented in Section 5. This phase extended the previous research to investigate the actual practices implemented by the case firms studied in response to the COVID-19 disruption. Furthermore, in this phase, the proposed framework was verified through follow-up interviews assisted by questionnaires and multicriteria decision making (MCDM) analysis, exploring the gap between the perceived importance of strategies and firm capabilities and their prioritization. All interviews were conducted online between the fourth week of March and the third week of April 2020.

#### A. Case Study Profiles

This study selects two industries in the Indonesian setting, i.e., drinking water and pharmaceuticals, for the following compelling reasons. First, both were considered essential industries in Indonesia, with constant demand, before the COVID-19 disruption. Second, with the arrival of the pandemic, demand proved to be unexpectedly volatile, with a decrease in the market for drinking water and an increase in that for pharmaceuticals. Third, to avoid the bias of having a single firm represent the Indonesian industry as a whole and to provide a holistic

TABLE I

## SUMMARY OF THE FOUR CASE STUDY COMPANIES

Profile	Case 1	Case 2	Case 3	Case 4
Indonesian market share	5–6%	55%	35%	20%
Number of products: stock keeping units (SKUs)	36 SKUs	4 product families, 28 SKUs	150 SKUs	120 SKUs
Sales revenue	1.9 million (IDR)	15 billion (IDR)	1.2 billion (IDR)	1.4 billion (IDR)
Number of employees	734	12,500	800	600
Plants, distribution centres (DCs), and branches/depots	22 plants and 96 depots	23 plants, 15 DCs, and 12 main distributors	1 plant and 25 branches	3 plants, 27 branches, and 1 DC
Interview length	2 hours	2.5 hours	2 hours	1.5 hours

understanding of the phenomenon, this study selected two firms for each of the two industries as depicted in Table 1.

Case 1 in this research is a national company in the drinking water industry located in East Java. The company's products included water in 250 ml cups, 330-, 550-, and 1,200-ml bottles, and 6- and 19-litre flagons, which were chiefly distributed to several cities in Indonesia. Several factories produce drinking water products from raw materials (water and plastics for packaging), and distribution centre facilities send finished products to distributors and stores. Its share of the national market is approximately 5–6%, whereas the market leader has a share of 50–60%. The interviewee was an SC manager with 10 years of experience. Case 2 is a multi-national company whose core business is drinking water, and its products include water in 240 ml plastic cups, 380 ml glass bottles, 330, 600, 750, and 15,000 ml plastic bottles, and 19-litre flagons. The company is a market leader in Indonesia, providing 50–60% of the country's drinking water. The interviewee had experience as an SC collaboration executive and primary deployment manager for 7 years.

Case 3 is a global pharmaceutical company that distributes its products to approximately 41,000 outlets in Indonesia. It provides consumer health products (e.g., vitamins and antioxidants) as well as prescription drugs. The company has seven brands, some of which are among the fastest growing and one of which (for multivitamins) is the most valuable brand for such products in Indonesia. The interviewee, a national sales director, was responsible for the sales organization, sales operation business processes, coordination with production and other departments, and other areas. He had nine years of experience in sales and operations. Case 4 is also a global pharmaceutical company manufacturing consumer health products and prescription drugs. The former product group includes several brands of multivitamins, cough medicine, constipation drugs, and others. The company has three plants, which are located in Vietnam, Bandung, and Bogor, for producing customer health products. Approximately 40% of its prescription drugs are produced in its factory in Jakarta, and the rest are imported.

#### IV. CONTEXTUALIZING SCRES UNDER COVID-19 DISRUPTIONS

COVID-19 has significantly impacted industries globally, but the disruptions are not homogenous. Therefore, the generalization and application of SCRes knowledge can be

difficult and perplexing. Moreover, the unprecedented nature of the COVID-19 disruptions means that governments have little understanding of the best policy or guidance for firms to follow. For example, the Indonesian government introduced a social distancing policy on March 17, 2020, which led to the cancellation of mass gatherings such as wedding parties, religious activities, conferences, formal meetings, and others. This greatly reduced the demand for bottled drinking water. In contrast, the distancing policy did not have a similar impact on healthcare products, such as multivitamins, herbal medicines, masks, hand sanitizers and so on. In managing an SC efficiently, environmental effects and consumer demand play a large role for the firm in setting its strategies and capabilities. Our case study companies experienced the opposite effects on demand, which provides a unique setting for investigation and for extending the SCRes literature to examine the effects of a disruption on companies with similar sets of capabilities.

According to Pettit, Croxton and Fiksel [30], there are three key types of SC disruption: supply, production, and demand disruptions. In the context of the COVID-19 pandemic, examples of supply-side disruptions include a lack of raw materials, price fluctuations, transportation problems and currency fluctuations. Production disruptions include fluctuations in the numbers of workers and machines, difficulties with outsourcing, low productivity, and the need for physical distancing in the workplace. Demand-side disruptions include demand volatility, distribution and inventory problems and large numbers of people working from home.

##### A. SC Disruptions during the COVID-19 Pandemic

Detailed notes were prepared during the online interviews, which were recorded. An interview protocol that was developed based on the triangulation of previous literature, e.g., [14], [31], [36]–[38], was used as a guideline to ensure that the interviewees elaborated on the disruptions to each end of the SC (see Appendix A). Additional material was collected on each company's market share, brands, product items, number of plants and distribution centres from the companies' websites and annual reports, as well as from newspapers and elsewhere [39]. The data comparison analysis started with transcribing the voice recording of each interview. An iterative process was used to identify key variables on each end of the SC, as Pagell and Krause (2005) highlighted that an iterative approach with multiple case studies improves the interrater reliability and data

TABLE II

## SUMMARY OF THE CROSS-CASE COMPARISON ANALYSIS

SC Disruptions	Drinking-Water Industry		Pharmaceutical Industry	
	Case 1	Case 2	Case 3	Case 4
<b>1. Supply-side</b>				
- Availability of raw materials	Supply decrease (-3)	Supply normal (0)	Supply normal (0)	Supply normal (0)
- Availability of spare parts	Spare part shortage (-2)	Supply normal (0)	Supply normal (0)	Supply normal (0)
- Fluctuation of raw material prices	Slight increase (1)	Slight increase (1)	Slight increase (1)	Slight increase (1)
- Transportation	Delay (-2)	Normal (0)	Normal (0)	Normal (0)
<b>2. Production-side</b>				
- Production fluctuations	Decrease (cups & bottles) (-2)	Decrease (cups & bottles) (-2)	Dramatic increase (4)	Slight increase (3)
- Fluctuations in production hours and workers	Slight decrease in hours of production and several workers moving to flagon production (-1)	Stable in hours of production and several workers moving to flagon production (0)	Increase in hours and shifts of production and number of workers (4)	Increase in hours of production and slight increase in number of workers (3)
- Employee productivity	Decrease (-1)	Decrease (-1)	Normal (0)	Normal (0)
- COVID-19 protocols in production	Strictly implemented (3)	Strictly implemented (3)	Strictly implemented (3)	Strictly implemented (3)
<b>3. Demand-side</b>				
- Volatility of demand	Large decrease in demand (-3)	Large decrease in demand (-3)	Dramatic increase in demand [5]	Significant increase in demand (4)
- Prices of finished products	No change (0)	No change (0)	No change (0)	No change (0)
- Stock of finished products in the warehouse	Significant increase (3)	Slight increase (1)	Significant decrease [-4]	Significant decrease [-4]
- Number of delivery trips (distribution)	Moderate decrease (-2)	Moderate decrease (-2)	Large increase (4)	Large increase (4)
- Productivity of sales and distribution of employees	Slightly reduced productivity (-1)	Slightly reduced productivity (-1)	Slightly reduced productivity (-1)	Slightly reduced productivity (-1)
- COVID-19 protocol in sales and distribution	Work from home for sales officers; COVID-19 protocols implemented for drivers (3)	Work from home for sales officers; COVID-19 protocols implemented for drivers (3)	Work from home for sales officers; COVID-19 protocols implemented for drivers (3)	Work from home for sales officers; COVID-19 protocols implemented for drivers (3)

Note: Score for degree of impact: 0= none, 1= slight, 2= moderate, 3= significant 4 = substantial, and 5= radical. A positive sign indicates an increasing impact, while a negative sign represents a decreasing impact.

analysis. A cross-case comparison analysis was then conducted to detect commonalities and differences in the patterns of SC disruption [39], [41]. A summary of the cross-case comparison regarding the SC disruption among the cases studied is presented in Table 2. In addition, COVID-19 caused both negative and positive disruptions to the operations of the case study firms. This, however, demonstrates that COVID-19 has impacted the SC in different ways and, therefore, different and unique SCRes interventions are required.

### 1.) Supply-side Disruptions

During the pandemic, the availability of raw materials and spare parts was disrupted when raw materials came from a

country seriously affected by COVID-19. This is especially true for companies that had implemented single sourcing. In case 1, plastics (for bottles) and spare parts for maintenance were in decreasing supply, as the chief suppliers of both were in China, a country seriously affected by COVID-19. Shipments from China were also delayed due to rules on the delivery of goods introduced by the Chinese authorities. Companies that used a multi-sourcing strategy, centralized purchasing, and a buffer strategy were better able to address the impact of the COVID-19 pandemic. The use of third-party logistics (3PL) services for transportation also reduced shipping delays. In case 2, which is a multi-national company, and in cases 3 and 4, which are global companies, multi-sourcing strategies, centralized

purchasing, and 3PL company services to handle transportation were all in place. In cases 3 and 4, although almost all the raw materials were imported from European countries, their normal supply was maintained. The delay in supply transportation from overseas was moderate (1–2 weeks) and could be managed through the use of buffer stock.

## 2.) *Production-side Disruptions*

On the production side, the drinking water and pharmaceutical industries saw opposite effects. In the drinking water industry (cases 1 and 2), production declined, especially for the primary finished products (e.g., 220 ml cups and 600 ml bottles). However, in the pharmaceutical industry (cases 3 and 4), production increased significantly. In cases 1 and 2, the companies slightly decreased their hours of production and maintained the number of workers by moving some employees to jobs focusing on other products (the flagons). In contrast, in cases 3 and 4, the companies had to increase their production significantly. For example, in case 3, the company increased the number of shifts each day from two to three to fulfil the dramatic increase in demand. The number of workers operating manually operated machines, such as packers also increased. In case 4, under normal conditions, three shifts were in operation only on certain days, but during the pandemic, three shifts were operated every day. There were additions to the daily workforce, mostly in the form of outsourced workers in the packing department. All four companies strictly implemented COVID-19 protocols, with body temperature checks, hand washing, physical distancing, mask wearing, and other measures. In the drinking water cases, employee productivity slightly decreased due to these protocols, but in the pharmaceutical industry, the productivity of workers remained at its normal levels because workers were already well accustomed to wearing masks, washing hands and so on.

## 3.) *Demand-side Disruptions*

The consumption of multivitamins increased greatly during the pandemic to fight infection. The demand for multivitamins for adults increased by approximately 500% in case 3 and approximately 300% in case 4. The opposite was true in the case of drinking water, where the demand for cup and bottle products, in particular, decreased sharply. While the stocks of finished multivitamin products decreased significantly, the stock of drinking water held by the companies increased significantly. The number of delivery trips to customers for pharmaceutical products increased significantly, while the number of delivery trips for drinking water decreased moderately. In sales and distribution, COVID-19 protocols were implemented by all four companies, such as a work-from-home policy for the main sales office; additionally, the companies' drivers had to follow not only the companies' protocols but also the government rules and those of their distributors. All four companies reported a slight decrease in overall productivity.

## B. *Proposed SCRes Capability Framework for COVID-19 Disruptions*

Through a thorough literature review and iterative interviews with subjects for two cases in the Indonesian drinking water and

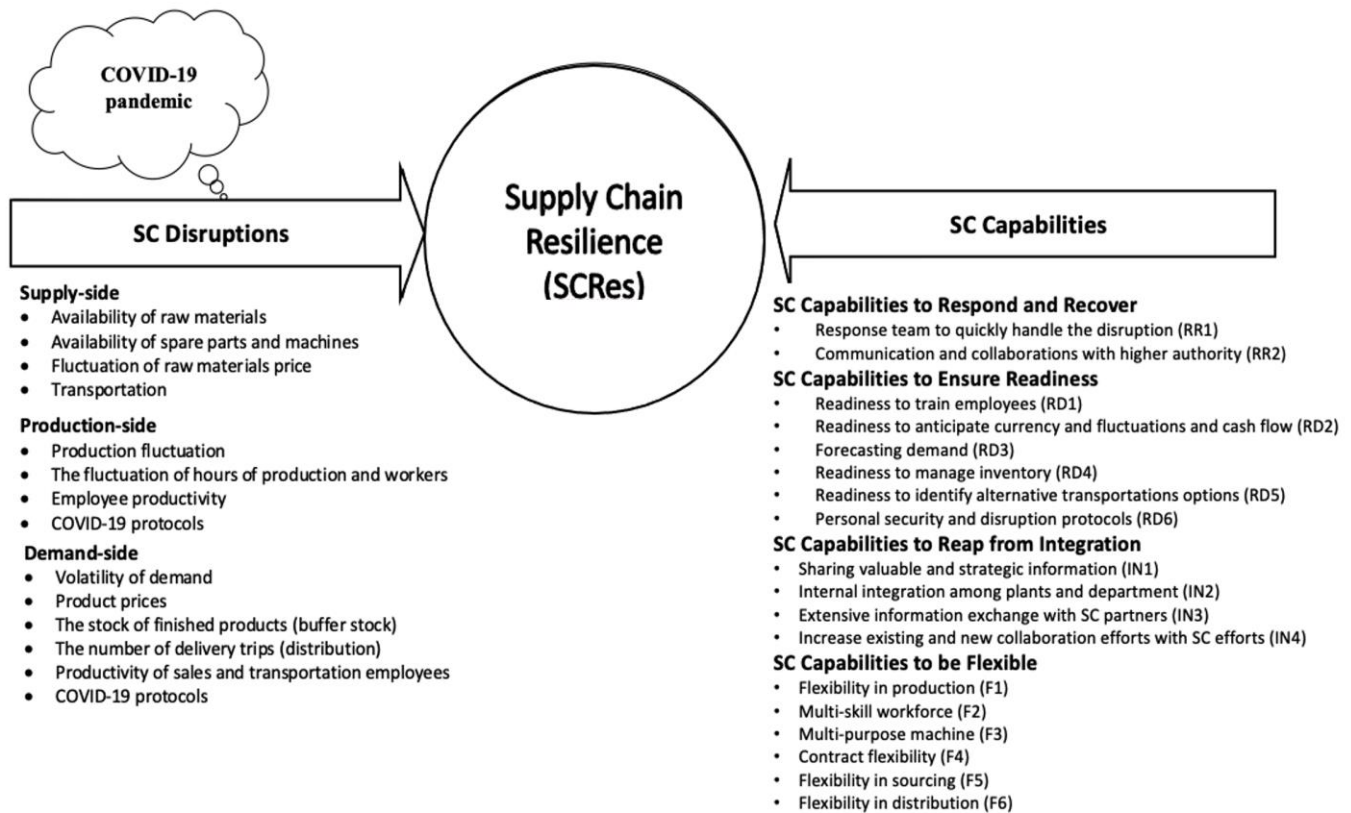
pharmaceutical industries, this research proposes an SCRes framework for tackling the disruption caused by the COVID-19 pandemic based on [30], [31]. Pettit et al. [29] proposed the concept of disruptions as the influencer of SC changes, where capabilities are viewed as continuous interactions in the SC, as derived from systems theory, where SCs are viewed as open systems [42]. This framework is supported by Hosseini et al. (2019), who note that disruption factors influence the resilience capacity, where the latter is the ability to reduce the impacts from disruptions, minimize their consequences and recover the previous level of performance. The variables relating to SC capabilities are categorized along proactive and reactive dimensions in the present study, as suggested by the literature review. Their relevance to the resilience of SCs during the COVID-19 outbreak was verified. The proposed framework, as shown in Figure 1, incorporates SC disruptions and SC capabilities. The disruptions are categorized as supply side, production side, and demand side; these categories were derived from the interviews. The SC capabilities in the proposed framework consist of four dimensions: flexibility, SC readiness, SC integration, and SC response and recovery. The variables used to reflect SCRes capabilities were obtained from the systematic review of the literature and were confirmed in the interviews. It is important to note that the proposed framework focuses on the proactive SC capabilities used to address the SC disruptions stemming from the COVID-19 pandemic.

### 1.) *Capability of the Firm to Respond and Recover*

The interviews showed that two of the seven variables in the response and recovery dimension identified in the literature were especially important. These were quick responses and communications with the government. The ability of the firm and the SC to respond and recover during disruption is crucial, especially for achieving an equilibrium between supply and demand [14], and this ability is essential for developing SCRes [9], [43]. The capability to quickly respond to a crisis and disruption is an important determinant of SCRes [44], [45]. Recovery from a SC disruption is a unique ability in companies and their SC [14], and a quick recovery from a disruption can reduce the disruption's impact [10] and facilitate a return to the company's original position or to a better state [11]. According to the literature, the variables related to SC response and recovery include quick response, the establishment of a response team, quick recovery, loss absorption, reduction of impact, and recovery costs. A company that responds quickly to a SC disruption can solidify its leadership position [44]. A response team in a company and in the SC is needed to mobilize resources [30]. The findings from the interviews revealed two variables in the response and recovery dimensions. All the case companies created formal response teams to handle the COVID-19 pandemic (RR1).

*[...] We formed a formal team that specifically handled COVID-19 in our company and made COVID-19 protocols, procedures, and policies. [...] Workers and guests who enter the production area must be checked for body temperature with a thermal scanner. [...] (Case 2, primary development manager).*





**Fig. 1.** The proposed SCRes framework for firms during the COVID-19 pandemic.

In the face of unprecedented COVID-19 disruptions and their global impacts, communicating and cooperating with the government were crucial abilities for firms to possess (RR2). The use of digital technologies should be deployed to allow timely and relevant communication with actors along with the SC. An important note that needs to be taken regarding this ability is that although not all firms are endowed with the latest technologies, the social media platform can be optimally utilized. To ensure their survival and competitiveness, firms were required to follow the rules and policies introduced by the government, such as restrictions on social gatherings, but a creative and supportive approach is nevertheless required that is suited to the firm's resources. Moreover, during the COVID-19 disruptions, the behaviours of people, communities, and employees differed from their normal behaviours. In the interviews, it was noted that social distancing was one of the most prevalent COVID-19 mitigation measures, thus forcing work-from-home policies for certain departments within the firms. For the production sectors, however, working from home was not viable, as these workers need to be physically present; instead, they had to observe protocols on physical distancing and frequent handwashing, for example. In responding to the uncertain demand caused by COVID-19, close contact with the government was deemed necessary, especially concerning SC distribution activities. In this light, the interviewees indicated that two of the variables in the SC response and recovery dimensions were especially significant. For example:

*[...] in the head office, including the sales and distribution department, work from home (WFH) policies are applied in my*

*company. [...] In the production area, in addition to implementing COVID-19 pandemic protocols, such as physical distancing between employees, encouraging all workers to frequently wash their hands and others [...], we also monitor and coordinate with the government for our production and distribution activities. (Case 3).*

## 2.) Capability of the Firm to Ensure SC Readiness

The literature on SCRes shows that SC readiness is another critical dimension for dealing with disruptions [14], [46]. SC readiness is defined as an upfront capability to reduce the occurrence and impact of SC disruptions [14]. A firm needs an SC capability to reduce its susceptibility to disruption [30], [35], [46]. The results indicated six practices used to address the COVID-19 pandemic. First, as argued by Pettit, Croxton and Fiksel [30], SC readiness can be achieved through training (RD1). This result corresponds to a firm capability that is driven through human resources and eventually leads to SCRes [13]. Second and third, the anticipation of currency fluctuations and cash flow (RD2) [29] and demand forecasts (RD3) [44], [47] suggest that the ability of firms to look into the future was important in dealing with the pandemic. This, however, was being done on a more short-term basis, even day to day, because of the high degree of uncertainty surrounding COVID-19. The usage of the latest technologies, such as big data analytics, can be one of the capabilities that will enable readiness capabilities. For example, Tan et al. [48] argue that big data can be harvested and used to quickly sense the elasticity that exists during uncertainties.

Fourth, appropriate inventory management (RD4) that suits the conditions is needed [30], [49]. Due to the impact of COVID-19, in particular, due to the effects on suppliers in China, the issue of inventory was very challenging. The respondents highlighted the great value of the ability to source from alternative suppliers. Fifth, alternative transportation options can also increase firm readiness (RD5) [9], [14]. The respondents noted that during the COVID-19 disruptions, they made more use of third-party logistics. This was due to movement restrictions; moreover, the rules and regulations on transport seemed to change daily. Sixth, personal security, along with protocols to counter the pandemic (RD6) [50], was another variable in the readiness dimension. The interviewees said their firms were adhering to the preventive measures by not allowing any personnel with symptoms to access the premises. The readiness of the firms to address personal security was given high priority, as observed in the additional standard operating procedures implemented in the daily routines of the firms.

*[...] Due to the increasingly worrisome condition of COVID-19 in Indonesia, our company conducts work from home at the head office. [...] In the production and distribution area, all our employees and guests may not enter the production and distribution area if they have a body temperature higher than 37 degrees. [...] our main raw materials except water are plastics and resins, which are imported. The increase in the value of the dollar is quite high (10–15%), affecting the cost of raw materials. The amount of plastics and resins needed can still be fulfilled. Until now (25 March 2020), nothing has been significant because we have enough buffer stock. [...] Indeed, most vendors of raw plastics in China were affected by COVID-19, but the purchasing team section was able to make purchases from providers that were not affected by COVID-19 and assisted with 3PL delivery for transportation to our country [...] An increase in the value of the dollar can be anticipated on a daily basis by the team in the relevant department which is focused on managing this. (Case 2) [...]*

### 3.) Capability to Reap SC Integration Benefits

Brusset and Teller [15] defined SC integration as “the degree to which a manufacturer strategically collaborates with their SC partners and intra- and inter-organization”. The objective of SC integration is efficiency and effectiveness in the flows of products and services, information, money, and decisions to provide high-quality customer service at low cost and high speed [51]–[53]. The capability of the firm to regulate its SC integration enables it to adjust to disruptions; that is, this capability increases the SCRes [15], [54]. The SCRes literature noted that the SC integration capabilities during the disruption included the ability to coordinate responses between plants and departments within the firm [30], the sharing of valuable and strategic information (IN1) within and beyond the factory walls [31], [55], [56], and transformation to a new collaborative landscape with SC partners [30], [47].

Internal integration refers to inter-functional and interdepartmental integration to coordinate in response to market changes and disruptions [57]. In the interviews, internal integration between plants and departments (IN2) was found to be an important practice in ensuring the firm’s effectiveness in combating the disruptions from COVID-19. For a large country

such as Indonesia, some departments are separated by great geographical distances, so the cohesiveness of the practices and strategies of plants and departments can be achieved only via internal integration that is driven by digital technologies. However, the interviews indicated that during the disruption, information sharing and exchange were equally important between all SC partners in response to the pandemic, which may extend beyond the digital network of the firm. More extensive information exchange through digital technologies with all actors in the SC (IN3) enables risk analyses for better decision making during, before and after disruptions [50]. In short, the ability to increase and develop existing and new collaborative effort with SC partners (IN4) during uncertainties is seen to be an output of SC integration during the disruption. Firms should focus on preventing further negative impacts from the disruption and on reducing the probability of SC disruptions recurring upstream in the SC [47], especially when all SC-related information has been carefully stored and analysed.

### 4.) Capability to be Flexible

Flexibility is a significant dimension of SCRes defining the ability of companies to respond to changes in the external market and within the SC [58]. Moreover, flexibility can be viewed as the ability to access alternative options in the SC to obtain the desired output [20]. The case study indicated six flexibility practices that were applied to combat COVID-19 disruptions. In agreement with the literature, the flexibility capability variables that enhance SC resilience mentioned by the respondents were having flexible production [14], [31], [58], a multi-skilled workforce [18], [59], multi-purpose machines [11], contract flexibility [10], [30], flexibility in sourcing [60], and flexibility in distribution [46]. Of these variables, the capability to be flexible in production (F1), having a multi-skilled workforce (F2), and having multi-purpose machines are arguably under the control of the firm (F3), in that no external parties are directly involved.

*[...] During COVID-19 time, we do whatever we can to survive. We identify and focus on our internal resources because everyone is impacted. Whatever we have (internally), we utilize...we need to adjust our resources; we need to change it because it is easier...yes, now (COVID-19) is challenging time, we need to take care of each other. It is important to make our resources ready and flexible enough...[...] (Case 1)*

*[...] Since our country has been affected by COVID-19, we are facing problems increasing production, and we are unable to fully speed up receipt of our main raw materials and the distribution of our products to customers. We realized that our flexibility level is not good enough to respond to the dramatically increasing demand for our customer health products, such as multivitamins and others. [...] (Case 3)*

On the other hand, having flexibility regarding contracts (F4), sourcing (F5) and distribution (F6) is deemed to be more challenging for firms to achieve, as these involve external parties. The competition currently tends to be between SCs rather than between firms, and the capability of SC actors to work as a unit provides competitive advantages. However, the impact of a disruption forces firms to react differently, even within a single SC [8], [9]. Furthermore, the strategy and approach of each firm in embracing the disruption may be restricted by firm-specific limitations and resources. In light of



this, the ability of a firm to dictate or even influence its SC partners, such as through revising a written contract to suit the business environment during and after a disruption, may affect the firm's short- and long-term resilience planning. In addition, having the flexibility to find alternative sourcing enables the firm to ensure supply and production. The case study results indicated firms' dependence on importing raw materials from China, and these imports were heavily impacted by the disruption. This underlines the importance of having the capability to access alternative sourcing. Similarly, during a distribution, a plant's inability to increase output to meet demand from consumers makes a firm likely to lose sales to competitors. A higher technology interface provides higher flexibility in the SC. In particular, with the involvement of the SC actors that are also impacted by COVID-19, real-time data are more valuable relative to the previous data. Digitally interconnected SCs are better informed during a time of uncertainty and, hence enhance the capability to be flexible [61].

#### V. PRACTICAL GUIDANCE ON SCRES CAPABILITIES DURING COVID-19 DISRUPTIONS

The second phase of the research was conducted in three stages to obtain practical guidance regarding the capabilities utilized during the COVID-19 disruptions, such as determining the feasible variables for SCR capabilities on the SC side, perceived importance and actual capabilities, and prioritizing the dimensions and variables of SCRes capabilities.

##### A. Determining the Feasible Variables of SCRes Capabilities on the SC Side

The first stage aims to determine the feasible variables for SCRes capabilities in the SC (supply, production, and demand side). A vast amount of information on SC capabilities was available, and both broad agreement and controversial feedback were recorded. As depicted in Table 3, the informants expressed their opinions connecting the nexus between the SCRes capabilities and SC stages. The informants provided their opinions regarding the perceived importance of each variable (0 = not sure, 1 = to some extent, and 3 = important). In the results, the cells containing SCRes capability variables that do not impact stages of the SC are marked with grey; for example, flexibility in production and multi-skilled workforce effects are only found to impact the production stage. Meanwhile, readiness to manage inventory impacts both the supply and demand sides, and personal security with the COVID-19 pandemic protocol has an impact on all three sections of the SC. In total, there were six variables for SCRes capabilities that were not selected for inclusion in the next phase because they were believed to be insufficiently relevant and lacked a significant effect, namely, COVID-19 disruption detection, quick response to the COVID-19 pandemic, quick recovery, loss absorption, impact reduction, and recovery costs.

##### B. Perceived Importance and Actual Implementation of SCRes Capabilities in Mitigating the Business Disruptions Caused by COVID-19

In the second stage, the perceived importance and actual implementation of SCRes were investigated to gain a better understanding of firms' SC capabilities regarding mitigating COVID-19 disruptions. Using Likert scale (1–5) questionnaires, an in-depth analysis of the conceptual understanding of SCRes addressed the gap between perceived and actual implementation that lacks empirical evidence [20]. The objectives of the questionnaire were (1) to find the perceived important dimensions (theory) and variables (practice) of SC capabilities that were identified as valuable in tackling the COVID-19 disruptions and (2) to understand the actual SC capability level of the firm. The meanings of each of the SC capability dimensions and variables were explained thoroughly to the participants.

From the results, the average score for each dimension and variable reflects the managers' perceived importance regarding the various SCRes capabilities that theoretically could be deployed to tackle the business disruption caused by the pandemic (see Figure 2). As depicted in Figure 2, the SC capability dimension (a) SC response and recovery (4.25) scored highest on perceived importance, followed by SC integration (4.00), flexibility (3.71) and readiness (3.61). The top four SCRes capabilities (b) were RD6: personal security with a COVID-19 protocol that includes policies on working from home, checking body temperature, and physical distancing (4.75); RR2: communication and collaboration with the government (4.50); F6: flexibility in distribution to customers (4.25); and IN2: internal integration between plants and departments (4.25). All 18 variables were given ratings of more than 3.00, indicating that the participants believed that the SC capability variables had a significant impact on their ability to tackle the SC disruption brought about by COVID-19.

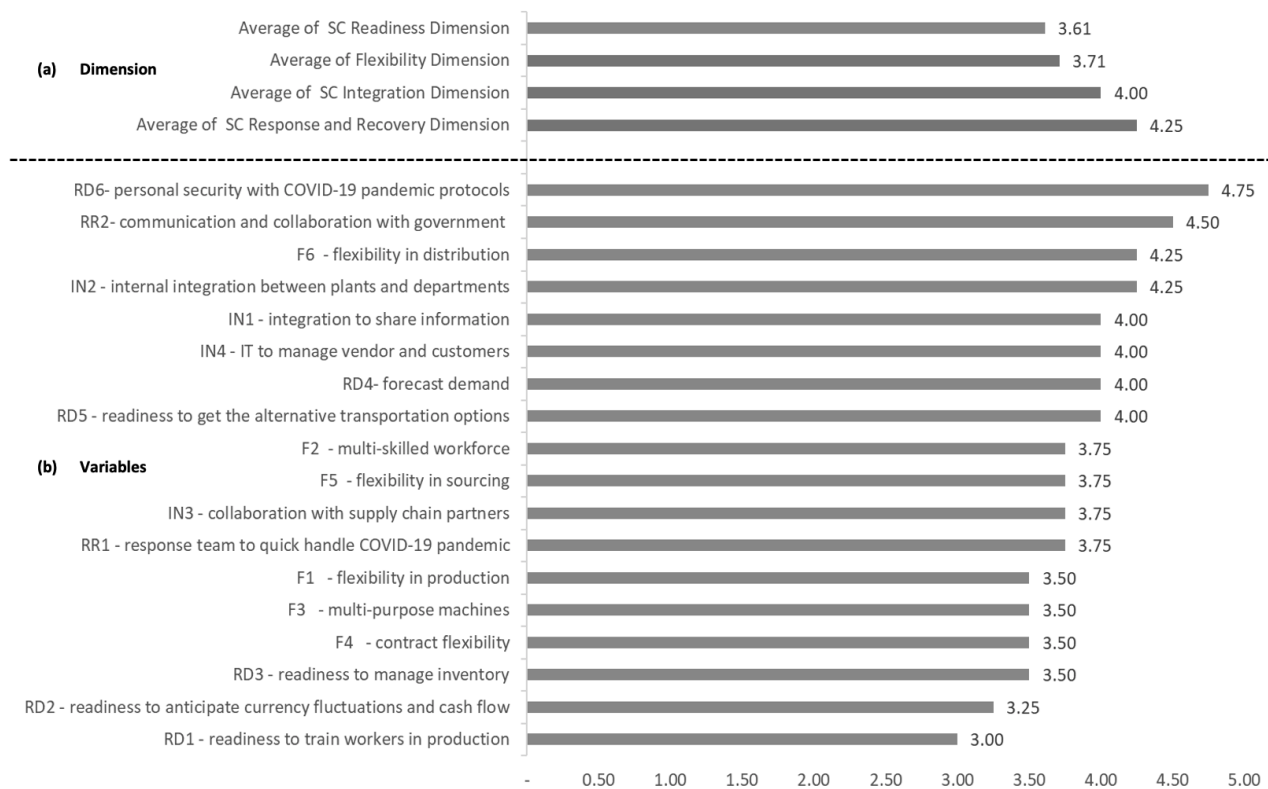
The ratings given to the actual SCRes capabilities differ significantly from the ratings for the perceived importance of the SCRes capabilities in tackling the disruption. Figure 3 shows the average scores for the actual levels of the SC capability dimensions (a) and variables (b). The respondents highlighted that the SC response and recovery dimension (4.13) was the most important area, followed by SC readiness (3.11), SC integration (3.08) and flexibility (3.04). Among the variables, mitigating the COVID-19 disruption commonly relied on RD6: personal security with a COVID-19 protocol (4.50), RR2: communication and collaboration with the government (4.25), RR1: having a response team (4.00), and IN2: internal integration between plants and departments (4.00). Two variables were rated below 3.00 on average, including F3, multi-purpose machines (2.50), and RD2, readiness to anticipate currency fluctuations and cash flow (2.75). That is, the impossibility of changing the installed production machinery and the inability to anticipate currency fluctuations were the factors that were perceived to cause the least problems.

TABLE III  
DIMENSIONS AND VARIABLES OF SCRES CAPABILITIES IN THE FACE OF COVID-19 DISRUPTIONS FROM THE QUALITATIVE STUDY

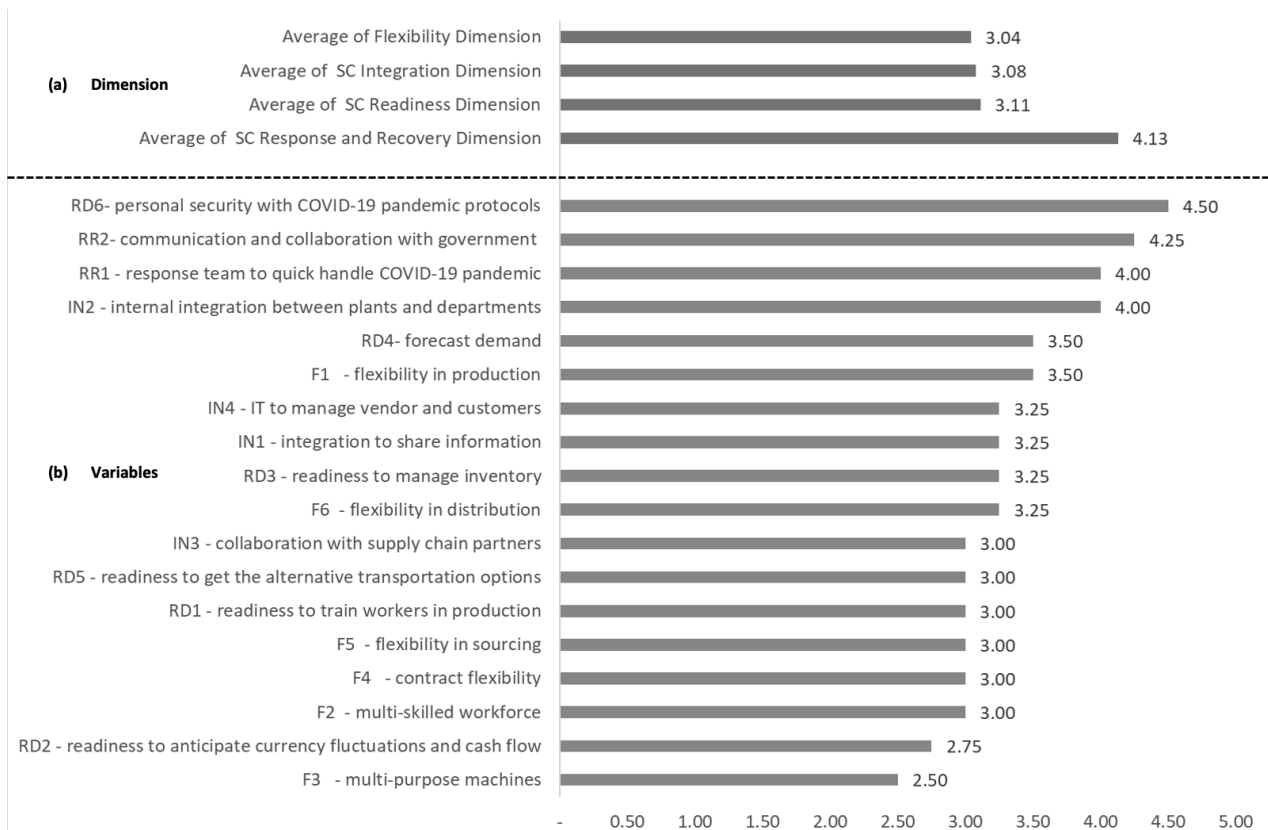
Dimensions of SCRes Capabilities	Variables of SCRes Capabilities	Supply				Production				Demand				Average	Decision	
		1	2	3	4	1	2	3	4	1	2	3	4			
Proactive SCRes Capabilities																
Flexibility	(F1) Flexibility in production <sup>1, 2, 3, 4</sup>					3	3	3	3					3.00	Feasible	
	(F2) Multi-skilled workforce <sup>1, 2</sup>					3	3	3	3					3.00	Feasible	
	(F3) Multi-purpose machines <sup>5</sup>					1	1	3	3					2.00	Feasible	
	(F4) Contract flexibility <sup>6, 7</sup>	3	3	3	3									3.00	Feasible	
	(F5) Flexibility in sourcing <sup>1, 7</sup>	3	3	3	3									3.00	Feasible	
	(F6) Flexibility in distribution <sup>1</sup>									3	3	3	3	3.00	Feasible	
SC Readiness	COVID-19 disruption detection <sup>8, 9</sup>	0	0	1	0	1	1	1	1	0	1	1	0	0.58	Not feasible	
	(RD1) Readiness to train workers in production <sup>7, 10</sup>					1	3	3	3					2.50	Feasible	
	(RD2) Readiness to anticipate currency fluctuations and cash flow <sup>7</sup>	3	3	3	0									2.25	Feasible	
	(RD3) Forecast demand <sup>12, 13</sup>									3	3	3	3	3.00	Feasible	
	(RD4) Readiness to manage inventory <sup>7, 11</sup>	3	3	3	3					3	3	3	3	3.00	Feasible	
	(RD5) Readiness to identify alternative transportation options <sup>13, 14</sup>	3	3	0	3					3	3	3	3	2.63	Feasible	
	(RD6) Personal security with a COVID-19 pandemic protocol <sup>7</sup>	3	3	3	3	3	3	3	3	1	1	1	1	2.33	Feasible	
SC Integration	(IN1) Sharing valuable and strategic information <sup>2, 7</sup>	3	3	3	0					3	3	3	0	2.25	Feasible	
	(IN2) Internal integration between plants and departments <sup>2, 7</sup>					3	3	3	3					3.00	Feasible	
	(IN3) IT to manage vendors and customers	3	0	3	3					3	0	1	3	2.00	Feasible	
	(IN4) Increasing existing and new collaboration with SC partners <sup>2, 7</sup>	3	3	0	3					3	3	0	3	2.25	Feasible	
Reactive SCRes Capabilities																
SC Response and Recovery	Quick response to the COVID-19 pandemic <sup>12</sup>	0	0	1	0	1	1	1	1	0	0	1	0	0.50	Not feasible	
	(RR1) Response team to quickly handle the COVID-19 pandemic <sup>7</sup>	3	3	3	3	3	3	3	3	3	3	3	3	3.00	Feasible	
	Quick recovery <sup>12</sup>	0	0	1	1	1	1	1	1	0	1	0	1	0.67	Not feasible	
	Loss absorption <sup>13</sup>	0	1	0	1	0	1	0	1	0	1	0	1	0.50	Not feasible	
	Reduction of impact <sup>13, 14</sup>	0	0	1	1	0	0	1	1	0	0	1	1	0.50	Not feasible	
	Recovery costs <sup>13</sup>	1	1	1	0	1	1	1	0	1	1	1	0	0.75	Not feasible	
	(RR2) Communication and collaboration with the government <sup>7, 15</sup>	3	3	3	3	3	3	3	3	3	3	3	3	3.00	Feasible	

Note: 0 = not sure, 1 = to some extent, 3 = important; *the capabilities in italics were removed for not being feasible*

Note: <sup>1</sup>Swafford, Ghosh and Murthy (2006); <sup>2</sup>Braunscheidel and Suresh (2009); <sup>3</sup>Chowdhury and Quaddus (2017); <sup>4</sup>Hosseini *et al.* (2019); <sup>5</sup>Tukamuhabwa *et al.* (2015); <sup>6</sup>Lummus, Vokurka and Duclos (2005); <sup>7</sup>Pettit, Croxton and Fiksel (2013); <sup>8</sup>Burnard, Bhamra and Tsinopoulos (2018); <sup>9</sup>Burnard and Bhamra (2011); <sup>10</sup>Hohenstein *et al.* (2015); <sup>11</sup>Alicke, Azcue and Barriball (2020); <sup>12</sup>Sheffi and Rice (2005); <sup>13</sup>Blackhurst, Dunn and Craighead (2011); <sup>14</sup>Khalili *et al.*, 2016; <sup>15</sup>Kamalahmadi and Mellat-Parast (2016)



**Fig. 2.** The perceived importance of the SCRes capability dimensions (a) and variables (b) in the context of the COVID-19 pandemic.



**Fig. 3.** The actual levels of the SC capability dimensions (a) and variables (b) in the context of the COVID-19 pandemic.

### *C. Prioritizing the Dimensions and Variables of SCRes Capabilities*

The prioritization of dimensions and variables was carried out using MCDM analysis in Microsoft Excel 2020 software following the protocol in Triantaphyllou [65]. Since the deployment of SCRes is not universal and depends on multiple aspects [8], this study exemplifies the SCRes capability prioritization process using Case 1. There are compelling reasons for selecting Case 1. First, the informant (SC manager) had relatively better experience with and understanding of the budgets of SCRes capabilities. Second, the firm size of Case 1, which was smaller and had limited resources, could yield better guidance for firms with limited resources. The weighted sum model was used to calculate the score and determine the rank of each SCRes capability variable. Three attributes of decision making (perceived importance, perceived actual, and perceived costs) were used to determine four alternative dimensions/atypes of capability strategies, i.e., increasing flexibility, SC readiness, SC integration, and SC readiness capabilities. The weights of the three attributes were subjectively determined based on the opinions of the respondents.

The score of each variable was calculated followed by a ranking of the dimensions and variables of the SCRes capabilities, as depicted in Figure 4. The results show that the SC response and recovery (0.76) and SC flexibility (0.57) variables were ranked as the top two priorities and would represent the best decision regarding the SCRes capability dimensions to tackle the COVID-19 disruption. In prioritizing the SCRes capability variables, three attribute decisions were also used. Figure 5 indicates the SCRes capability priority. Communication and collaboration with the government (0.86) indicates that firms should work closely with governments in combating COVID-19. Both firms and the government must invest a concerted effort, as COVID-19 remains difficult to control and full of uncertainty. The ability to forecast demand (0.72) is also important, especially when disruptions occur in the SC. Forecasting demand enables a strategic evaluation of material sourcing and a focus on the highest-value production line of the firm. The flexibility in distribution (0.71) is a valuable SCRes capability and a valuable tool to address the restricted movement required during COVID-19.

## VI. CONCLUDING REMARKS

This research sheds some light on the SCRes capabilities that can help firms resist disruptions, particularly those from COVID-19. This research proposed a research framework that was developed based on the existing literature on SCRes. The framework was scrutinized under the COVID-19 disruption settings by identifying and understanding its real impact on the SC; hence, more appropriate SCRes capabilities are elicited for investigation. The SCRes capabilities in the proposed model are further validated with an empirical investigation, in which the feasibility, importance, and prioritization are highlighted. In other words, this research begins with the proposed theoretical framework, which is then operationalized into its possible applications. The model development and testing used data from the Indonesian healthcare and drinking water supply

chain. In concluding this research, the implications for theory and practice will now be provided.

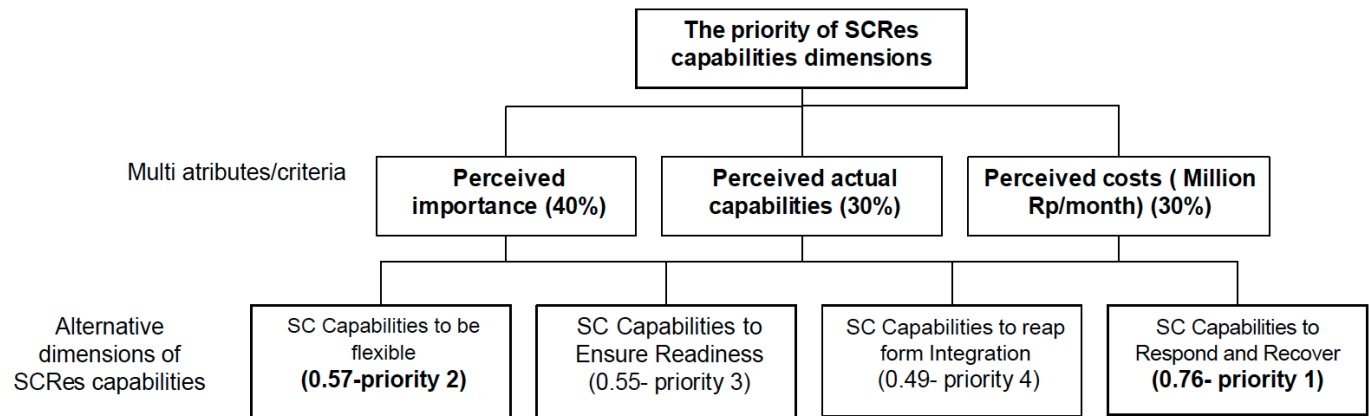
### *A. Implications for Theory*

The COVID-19 pandemic is unprecedented and novel. The disruptions to SCs have been enormous, as highlighted in this research. COVID-19 has changed the business landscape [66], [67], resulting in new norms in the SC that require firms to reconstitute their capabilities. The results indicate differences between the perceived importance and the actual strategy and practices involved in SCRes. These differences provide some theoretical contributions. First, this research provides empirical evidence for the applicability and relevance of all SCRes elements in all SCs [8], [9]. The previous literature highlighted the importance of SCRes during disruptions; however, limited research has been conducted in real case scenarios. This research has provided empirical evidence that is based on real case scenarios. The newly proposed framework provides a holistic SC disruption map that includes SCRes capabilities and provides deeper insight into the SCRes literature.

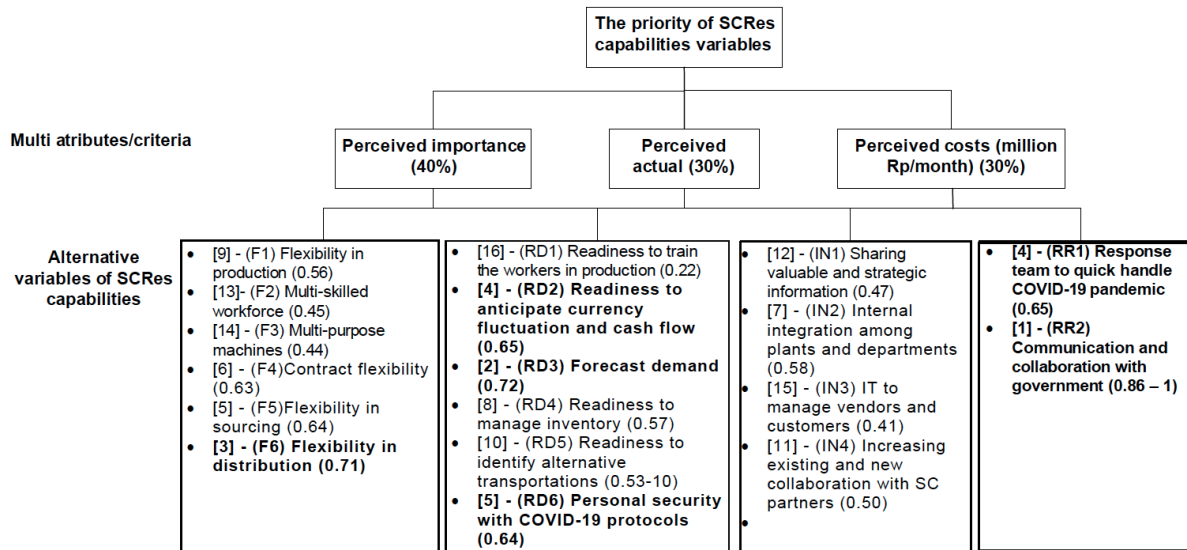
Second, a gap between theory and practice is found for SCRes. For example, even though flexibility is one of the most popular strategies in the SCRes literature [20], this research provides an example of how the most popular strategy may not be the best strategy for different disruptions, firms and capabilities. Therefore, this research enriches the understanding of how the SCRes literature needs to be carefully generalized by future research and practitioners. This research has opened up the possibility for a more insightful discussion on SCRes, especially on firm capabilities. Third, this research suggests that the SCRes profile of a firm is highly dependent on the firm's resources and capabilities [13], [28]. Furthermore, the results have shown that the aspects perceived as important in responding to the disruption may not be the best solutions for firms. A validation using case 1 in this research has shown that the SCRes capability plays an important role in creating a more sustainable SCRes strategy, hence suggesting that the discussion of SCRes needs to be in tandem with the firm's capabilities.

### *B. Implications for Practice*

This study provides practical managerial guidance with a framework for SCRes to mitigate the SC disruption stemming from the COVID-19 pandemic. First, this research sheds light on how firm managers use SCRes strategies to combat disruptions such as COVID-19. Practising managers can use this research as a guideline to understand the relationship between posited disruptions and possible capabilities in different SC contexts. Second, firms that have characteristics similar to those of the cases studied in this research should be aware of similar conditions and alternatives that lie within their firm and SC. Thus, firms should be more prepared and proactive when preparing for possible disruptions in the future. Third, this research unravels a set of applicable capabilities that can be beneficial in establishing a reactive SCRes strategy. Managers can benefit from prioritizing SCRes capabilities



**Fig. 4.** The decision-making structure and results for the priority of SCRes capability dimensions in case 1.



**Fig. 5.** The decision-making structure and results from prioritizing the SCRes capability variables in case 1.

when it is clear that not all capabilities are equally important and efficient. Some SCRes capabilities are perceived as important but may not be feasible, and some may seem to be feasible, but their effectiveness can be a hurdle that should be taken into account. In short, each trait needs to be considered in the selection of the SCRes capabilities to be deployed during a disruption. Through a detailed discussion and examination of the COVID-19 disruption and the provided firm capabilities, this research offers important information to policy makers and governments to help firms survive global disruptions such as COVID-19.

### C. Limitations and Future Research Agenda

The study does have limitations. The four dimensions and accompanying sets of variables of SC capabilities within the SCRes framework for the COVID-19 pandemic are interrelated. However, these interrelations have yet to be explored. Moreover, guidelines on how to operationalize SC capabilities are needed. Research on the interrelations among the dimensions and variables would provide a more comprehensive understanding of SC capabilities. The uncertainties and complexities of different countries (e.g.,

developed and developing countries) and industries (e.g., automotive, cement, oil and gas, food processing) are likely to differ greatly from those of the drinking water and pharmaceutical industries, and firm sizes (e.g., multi-national corporations, small and medium-sized enterprises) will also have an effect. Future research is needed to strengthen the validation of the proposed framework. Yin (2009) recommends replication and extension to different types of industries. Therefore, more cases are needed to add value to the proposed SCRes framework.

### APPENDIX

In this section, we presented the sample questions from the interview protocol.

TABLE IV  
SAMPLE QUESTIONS FROM THE INTERVIEW PROTOCOL

<p><b>Questions related to the supply-side</b></p> <ol style="list-style-type: none"> <li>1. <b>Availability of raw materials:</b> What are the main raw materials in your company? From which country is the raw material sourced? Please explain the availability of your raw materials as your country is affected by the COVID-19 pandemic.</li> <li>2. <b>Availability of spare parts:</b> Where is the source of spare parts for your company? Please explain the availability of spare parts.</li> <li>3. <b>Fluctuation of raw material price:</b> Is the price of your raw materials increasing or decreasing? Please explain the reasons that prices are decreasing or increasing, such as raw material prices, currency fluctuations, transportation costs, and others.</li> <li>4. <b>Transportation:</b> Please explain the transportation of your main raw materials.</li> </ol>
<p><b>Production-side</b></p> <ol style="list-style-type: none"> <li>1. <b>Production fluctuations:</b> Please explain your finished products and fluctuations in the amount of production.</li> <li>2. <b>The fluctuation of production hours and workers:</b> Please explain fluctuations in the number of hours of your production and the number of workers as your country is affected by the COVID-19 pandemic.</li> <li>3. <b>Employee productivity:</b> Please explain the productivity of your workers in production as your country is affected by the COVID-19 pandemic.</li> <li>4. <b>COVID-19 protocol in production:</b> Did your company implement protocols for the COVID-19 pandemic on the production floor, as recommended by WHO and your government? Please explain the protocols and procedures implemented for the COVID-19 pandemic on your production floor, such as wearing masks, physical distancing, etc.</li> </ol>
<p><b>Demand-side</b></p> <ol style="list-style-type: none"> <li>1. <b>Volatility of demand:</b> Please explain the volatility of customer demand for your finished products</li> <li>2. <b>Prices of finished products:</b> Is the price of your finished products increasing or decreasing? Please explain the reasons that the price of your finished product decreased or increased, such as production costs, delivery costs, and others</li> <li>3. <b>Stock of finished products in the warehouse:</b> Is your stock of finished products (including buffer stock) increasing or decreasing? Please explain why your stock of finished products is decreasing or increasing</li> <li>4. <b>The number of delivery trips (distribution):</b> Please explain the number of delivery trips to your customers and the condition of your distribution system as your country is affected by the COVID-19 pandemic</li> <li>5. <b>Productivity of sales and distribution employees:</b> Please explain the productivity of your employees in sales and distribution as your country is affected by the COVID-19 pandemic</li> <li>6. <b>COVID-19 protocol in sales and distribution:</b> Has your company implemented protocols for the COVID-19 pandemic in your distribution channel? Please explain the protocol and procedure for the COVID-19 pandemic in your distribution channel for sales employees and drivers, such as working from home, wearing masks, physical distancing, and others</li> </ol>

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