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The 4Rs supply chain resilience framework: A capability perspective

Nidal Yousef Dwaikat[1] | Saad Zighan[2] | Moheeb Abualqumboz[3] | Ziad Alkalha[4]

[1]Department of Industrial Engineering, An-Najah National University, Nablus, Palestine

[2]Business Administration, University of Petra, Amman, Jordan

[3]Project and Operations Management, Manchester Metropolitan University, Manchester, UK

[4]School of Business, The University of Jordan, Amman, Jordan

Correspondence

Nidal Yousef Dwaikat, Department of Industrial Engineering, An-Najah National University, Nablus 992200, Palestine.
Email: nidal_n@najah.edu

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Abstract

During the coronavirus disease 2019 (COVID-19) pandemic, the demand and supply for many products fluctuated. Thus, many companies around the globe have repurposed their operations and reconfigured their supply chains (SCs) to switch production and produce new products. Literature provided various models and frameworks to explain the concepts of supply chain resilience. However, it remains unclear how companies could quickly and temporarily repurpose their SCs and what are the required capabilities during the COVID-19 crisis. Therefore, this study investigates the role of developing dynamic capabilities such as manufacturing, logistics, production capacity and procurement in facilitating production changeover. Based on 36 semistructured interviews conducted with multinational corporations, the study findings demonstrate four specific capabilities known as the 4Rs: retooling, repurposing, recalibrating and reconfiguring. Hence, the study provides a conceptual framework of operational resilience to understand how production changeover could be achieved. In addition, this 4Rs framework helps decision-makers to improve SC resilience and capabilities when facing a crisis such as COVID-19.

KEYWORDS

capabilities, coronavirus (COVID-19), retooling, repurposing, recalibrating, reconfiguring, supply chain resilience

1 | INTRODUCTION

In January 2020, the World Health Organization (WHO) declared a 'Global Emergency' regarding the Coronavirus pandemic, commonly called coronavirus disease 2019 '(COVID-19)'. COVID-19 is different from other previous shocks such as September 11 in the United States, the Great Recession of 2008 and the 2011 tsunami in Japan. While the similarities in economic decline, the COVID-19 was more impactful in terms of supply chain (SC) disruptions and on a larger scale around the globe due to borders closure, factories closure and other governmental procedures. Many manufacturing companies suffered significant disruptions concerning material flow caused by lockdown and border closures in many countries (Zighan, Abualqumboz, et al., 2021).

Moreover, the exponential increase in cases and death rates triggered different containment measures worldwide to stop the virus's spread (Caduff, 2020). Governments' variant suppression measures affected SC and logistics operations (Ivanov & Dolgui, 2020). The restrictions on movement during the lockdown caused a significant drop in demand for certain goods (e.g., car production, car fuel, fashion, etc.), resulting in a suspension of production, redundancies and bankruptcy fears (Harbour, 2020). In the meantime, demand has exponentially increased for other goods, such as food, facemasks and sanitizer products, which the current SCs could not meet (Paul & Chowdhury, 2020). In response to this disruption, many companies have repurposed their operations to join national and international efforts to fight the pandemic through switching operations to produce different products or deliver

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different services (Araz et al., 2020). Companies turned to operational repurposing not only to survive but also to reap the benefit of investing and producing severely demanded products (Falcone et al., 2021).

In the United States, General Motors, for example, switched operations from producing cars to producing ventilators. In Sweden, Volvo (a multinational manufacturer of luxury vehicles) started to produce personal protective equipment (PPE). Jaguar Land Rover produced 3D-printed protective visors for the NHS in the United Kingdom. In France, Louis Vuitton Moët Hennessy switched its production of perfumes and cosmetics to sanitizers. In Japan, Sharp has adapted existing production facilities to make surgical masks despite being a corporation designing and manufacturing electronic products. In China, car suppliers switched from producing textiles to making facemasks (BBC, 2020). Likewise, many airline companies switched their aviation services from passenger flights to cargo flights by changing their aircraft operations and layout. These companies relied on their distinctive competencies and operational capabilities, such as innovation and operational resilience, to manage the operational shift and SC repurposing (Betti et al., 2020). While arguably there could have been trade-offs between efficiency and effectiveness, how quickly and in what capacities the repurposing of international companies' SCs has been successful remain unanswered. That said, production changeover brings complexities and uncertainties such as temporary value creation, switching suppliers, regulatory approvals and upskilling of staff. Several research endeavours (e.g., Ponomarov & Holcomb, 2009; Scholten et al., 2019; Yilmaz Borekci et al., 2015) discuss the concept of organizational resilience for organizations to overcome the disruptions related to their operations and SCs. Following this line of inquiry, this study argues that organizational resilience is crucial to enable manufacturing companies to repurpose their operations and SC.

Developing organizational resilience could be achieved through several strategic and tactical approaches (Zighan, Abualqumboz, et al., 2021). However, despite the growing body of research on organizational resilience during COVID-19, none, as noticed, has explored resilience from an operational repurposing perspective, and therefore empirical and conceptual gaps remain. The empirical gap arises from the few studies investigating organizational resilience from a short-term perspective. For example, some organizations repurposed their operations. In contrast, many others struggled to cope, lagged behind their counterparts, or had to close down due to the inability to grasp the huge changes in the business environment (Ivanov & Dolgui, 2020; Zighan, Abualqumboz, et al., 2021). The other research gap is related to the conceptualization of SC resilience. The literature about SC resilience primarily focuses on the challenges that organizations faced during the pandemic and how organizations bounced back, explaining the key characteristics, structures, resources and processes that organizations have developed to achieve resilience (see, e.g., Abualqumboz, 2021; Dubey et al., 2021; Modgil et al., 2021; Zighan & Ruel, 2021).

Against this backdrop, this study complements current research on organizational resilience by unpacking the capabilities that organizations have developed or leveraged throughout the operational changeover. Thus, this study explores how companies reconfigured their SC to change their production lines quickly to adapt to new emerging demands throughout the pandemic. Primarily the study addresses two research questions:

Q1: What capabilities enabled quick production changeover and thus resilience?

Q2: How could organizations develop these changeover capabilities?

The study proposes a conceptual framework that includes four main capabilities: retooling, repurposing, reconfiguration and recalibrating. This study will also empirically validate the proposed framework and explore the subcapabilities necessary for each primary capability.

2 | LITERATURE REVIEW

Resilience is the capacity to overcome a critical moment and adapt after experiencing an unexpected and unusual situation (Zighan, Al-Kalha, et al., 2021). It also indicates a return to normality after suffering significant damage following natural disasters, health crises or security risks (Leitch & Bohensky, 2014). The resilience concept has been used in different contexts; it emerged in ecology to measure system tenacity, absorb environmental change and maintain relationships in the ecosystem (Jones & Tanner, 2017). Likewise, psychology discussed resilience to study the emotional recovery from loss and trauma (Bonanno, 2004). Later, the concept of resilience received considerable attention in business management due to the dynamic business environment (Zighan & Dwaikat, 2020).

Organizational resilience is a strategic imperative to thrive in today's dynamic and interconnected world (Alkalha et al., 2019). It is noticeable that many manufacturing firms had to implement manufacturing-level strategies to adopt production changeover caused by the pandemic to maintain their SC resilience and thus survive (Amui et al., 2017). Depending on the incident that causes SC disruptions, resilience strategies can be categorized into two main dimensions: proactive and reactive (Jia et al., 2020).

Proactive strategies can be defined as procedures, actions and capabilities that the focal company develops before disruptions occur (Tang, 2006). Extant literature highlights several proactive tools and frameworks that have been used in production changeover. For example, the single-minute exchange of die (SMED), total productive maintenance (TPM), and 5S method are among the most well-recognized approaches (Horzela & Semrau, 2021). On the other hand, reactive strategies are procedures, actions and capabilities that the focal company develops after disruptions occur (Elluru et al., 2019).

The following subsections review the literature by highlighting the main concepts, previous contributions and frameworks related to resilience and organizational resilience, including resilience, SC resilience, resilience capabilities and production changeover.

2.1 | Organizational resilience

Organizational resilience is the capacity to anticipate, prepare, respond, adapt, survive and thrive throughout disruptions (Williams

et al., 2017). Authors including Lengnick-Hall et al. (2011) and Kantur and İşeri-Say (2012) used the concept of organizational resilience to refer to the organizational ability to cope with change and 'bounce back' to normal. Whereas other authors, including Somers (2009), Parsons (2010), Bhamra et al. (2011), and Duchek (2020), used the concept of organizational resilience to refer to the organization's ability to anticipate disruptions, where resilience would be an indicator of the potential of renewal and development of organizational capabilities. Pede (2020) argues that this potential is qualified as proactive resilience, while reactive resilience is a postevent state that draws on decisions and actions.

According to Ponomarov and Holcomb (2009), resilience enables companies to recover from adversity such as turmoil and disasters. This is because it allows the system to absorb changes while maintaining the established order (Duchek, 2020). This underlines that organizational resilience is much broader than the simple ability to rebound after a crisis (Wieland & Durach, 2021). According to Coutu (2002), resilient companies are characterized by three aspects: (1) they are pragmatic and realistic, without showing excessive optimism; (2) they have a robust system of shared values that gives significance to the difficulties or challenges encountered; (3) they are ingenious in that they know how to use their resources to cobble together new solutions to face disruptions. Thus, resilience presupposes combining both (1) a defensive approach—considering precautionary and downstream risk management measures that make it possible to cope with the shock when it occurs—and (2) a proactive approach—being ingenious and creative to see new solutions and take actions to regenerate (Williams et al., 2017). Resilience, therefore, involves five intertwined capacities: (1) an absorption capacity, allowing the company not to collapse in the face of shocks; (2) a capacity for renewal through which it can build new futures; (3) a capacity for appropriation; (4) dynamic capacity and (5) change capacity. These capacities will be detailed in Section 2.3. Accordingly, to reach an organizational resilience level, companies need to build their internal capabilities and SC resilience (Yilmaz Borekci et al., 2015).

2.2 | Supply chain resilience

Disruption results from SC uncertainties, followed by panic-induced demand volatility, where the supply fails to meet the soaring demand (Meqdadi et al., 2020). This creates further problems in the distribution of networks, such as the failure to deliver finished goods to customers within standard lead times. (Ivanov & Dolgui, 2020). Recently, many research endeavours have focused on SC resilience from an upstream perspective, such as studying the performance, response, SC characteristics, risk mitigation capabilities and severity of SC disruptions (Yu et al., 2019). For example, Craighead et al. (2007) argue that SCs are inherently risky, and SC disruptions are unavoidable where SC with more critical nodes is more vulnerable to disruptions than that with few critical nodes. Hence, the severity of SC disruptions is related to (1) three SC design characteristics (density, complexity and node criticality) and (2) the company's SC mitigation capabilities (recovery and warning).

Similarly, Thun and Hoenig (2011) analyse the internal and external vulnerability of SC risk management practices in the German automotive industry by analysing their likelihood to occur and their potential impact on the SC. Their results show that using a reactive approach towards SC risk management leads to higher disruption resilience and reduces the bullwhip effect (Thun & Hoenig, 2011). In contrast, preventive SC risk management is beneficial for flexibility or safety stocks (Chan et al., 2017). Leflar and Siegel (2013) focus on the strategic requirements of a resilience management system in the SC, such as creating transparency on multilevel SCs, establishing a list of critical components, determining the supply source and identifying alternative sources.

The aforementioned studies investigate supply chain resilience as a strategy to enable companies to synchronize the changes with their routines (Alkalha, Al-Zu'bi, et al., 2021; Thun & Hoenig, 2011; Yu et al., 2019). For instance, Brandon-Jones et al. (2014) conclude that information sharing and connectivity enhance SC resilience in manufacturing companies. Similarly, Scholten and Schilder (2015) highlight the importance of collaborative activities within the SC to improve the resilience of the food processing industry. Later, Polyviou et al. (2019) reveal the importance of internal social capital in interpersonal relationships in facilitating SC resilience. Thus, the current understanding of SC resilience during the changeover in production is limited, which begs further research (Betti et al., 2020; Modgil et al., 2021).

2.3 | Resilience capabilities

Extant literature advocates three key responses that characterize organizational resilience: (1) capabilities that proactively prepare companies for disruptions before they occur, (2) the efficiency and effectiveness in dealing with disruptions when they occur, and (3) the ability to recover from disruption and to learn lessons (Pettit et al., 2019). However, Burnard et al. (2018) argue that predicting disruptions or risks is not possible in some situations, and it is not rational to guarantee that minimizing risk makes an organization resilient. Instead, increasing flexibility and adaptability reduces vulnerability and increases resilience (Dwaikat, 2016; Pereira et al., 2014). Thus, to develop organizational resilience capabilities, companies need to develop organizational resilience through the whole value chain, emphasizing SC resilience and organizational operations (Babich & Hilary, 2020; Ivanov & Dolgui, 2020; Olsen & Tomlin, 2020; Tang & Veelenturf, 2019). As suggested earlier, resilience can be grouped into five categories: operational resilience, dynamic capacity, the capacity for renewal, appropriation capacity and change capacity. The previous studies investigate these capabilities in companies' regular production lines (Polyviou et al., 2019; Scholten & Schilder, 2015). Thus, there is a need to understand the role of these capabilities in facilitating resilience

during production changeover and how organizations develop these capabilities (Bag & Rahman, 2021; Betti et al., 2020).

2.3.1 | Operational resilience

At the organizational level, operational resilience can be defined as an organization's ability to pursue its mission and seize opportunities, even in adverse circumstances such as a security incident or financial crisis (Craig et al., 2018; Frost et al., 2000). The fundamental purpose is to maintain business processes and services that directly support the organization's mission (Gruchmann et al., 2019; Jiang et al., 2019). Operational resilience focuses on an organization's ability to continue offering products and services after adverse events by anticipating, preventing, recovering and adapting to the circumstances imposed by such events (Gulati, 2010). Operational resilience is a complex concept in the literature. Previous operations management studies reveal that the following terms are used interchangeably: operational resilience, responsiveness, agility and flexibility (Bernardes & Hanna, 2009). Thus, several studies have been carried out to investigate the overlapping notations of these concepts (Bernardes & Hanna, 2009; Dwaikat et al., 2018; Purvis et al., 2014). The common notion among these concepts is acting quickly to uncertainty in business settings such as market volatility, demand and supply changes (Javed et al., 2021). Therefore, there are similarities between these terms, but also there are differences. For instance, agility is a higher level strategy than flexibility and refers to a company's ability to rapidly reconfigure its system to adapt to uncertainty in the business environment (Bernardes & Hanna, 2009).

2.3.2 | Dynamic capability (DC)

DCs refer to companies' abilities to integrate, create and reconfigure internal and external competencies to cope with changes in the business environment (Teece, 2018). Capabilities are companies' abilities to coordinate different tasks to transfer input to output (Yung & Lai, 2012). The main components of DCs follow the managerial process of sensing, seizing and configuring resources (Teece, 2007) as follows: (i) sensing: learning activities that transfer knowledge to DCs (Chien & Tsai, 2012), (ii) seizing: the integration of suppliers and customers to identify customers' needs and ways to achieve these needs (Teece, 2007), (iii) resources configuration: maintaining the required routine to adopt change and reconfigure assets and structure according to these changes (Teece, 2007, 2018). Therefore, both substantial resources and routines are helpful to create DCs. According to Teece et al. (1997), this depends on; (i) technical fitness, referring to the routine that enables companies to do the job effectively and efficiently; (ii) evolutionary fitness, referring to capabilities that create, extend and change resources to deal with changes. Hence, previous studies argue the need for renewal capacity, change and appropriation capacity (Cavaco & Machado, 2015; Lengnick-Hall et al., 2011).

2.3.3 | Capacity for renewal

In major disruptions beyond the capacity to resist, organizations must adapt quickly and envisage new solutions to disruptive events (Lengnick-Hall et al., 2011). This is called the 'capacity for renewal', whereby the company seeks to develop new activities, reconsider existing ones, or experience *new ways of doing things* (Folke et al., 2003). This capacity is in line with the firm's entrepreneurial orientation and strategic regeneration processes. This makes it possible to focus on (1) proactivity in seeking opportunities, (2) aspirations beyond their current capacities and (3) the mobilization of the leadership and management team. Given the 'tense' context, these elements are accompanied by close attention to utilizing available resources and limiting risk-taking, given the 'tense' context (Volberda & Lewin, 2003).

2.3.4 | Capacity for appropriation

A resilient organization must learn from the shocks it faces that grow out of it and learn independently (Cavaco & Machado, 2015). Gherardi (2009) emphasizes that capitalizing on failures means recognizing their contribution to learning rather than ignoring or denying them. Mokline and Ben Abdallah (2021) argue that awareness of the crisis and its impacts is essential to put practices and routines into perspective: it is possible to carry out 'postcrisis learning' to better prepare for the future. However, this dimension of resilience capacity remains challenging to be witnessed. Whereas learning requires time for reflection that managers often do not have when a destabilizing shock torments them. This exacerbates the degree of urgency for those managers' decisions (Ley et al., 2020). However, the lived experiences are transformed and reinterpreted before reintegrating and repeated in the actors' narrations (Ngoc Su et al., 2021). In this way, organizational memory is continuously being developed, expanded and reified through time (Abualqumboz et al., 2020). Therefore, one must look at the stories repeated and told over time to find the sedimentation of past events inscribed in the management principles and the culture underpinning how a company operates (Gherardi, 2009).

2.3.5 | Change capacity

According to Crick and Bentley (2020), resilient companies face four challenges: (1) cognitive challenge because they need to be resilient in the face of change and be aware that it will affect the organization, (2) strategic challenge that requires the ability to envisage new strategic options instead of the declining strategy, (3) political challenge that requires reallocating resources to support promising activities for the future and to abandon those of the past, (4) an ideological challenge which requires instilling a proactive attitude and focuses on the continual search for new opportunities.

2.4 | Production changeover

Production changeover entails adapting to the new situation by switching production to different products. Singh et al. (2018) emphasize that manufacturing firms respond quickly to new demand. The changeover's speed of response depends on the following capabilities: Retooling, repurposing, reconfiguration and recalibrating.

Retooling is considered a part of lean manufacturing approaches, where machines can overcome the limited flexibility of manufacturing companies by increasing productivity, eliminating errors, improving the operators' safety, organizing workspace, reducing costs, reducing the elimination of errors—reducing inter-operational stocks and improving quality (Kochańska & Burduk, 2019). For instance, quick retooling of machines and production lines can reduce the lead-time and enable manufacturing firms to be more responsive to SC disruptions, thus creating more resilient operations. In addition, several studies emphasize that automation as part of the retooling strategy can enable SC resilience. For instance, Stewart and Kelley (2020) emphasize that retooling enables manufacturing firms to connect to suppliers and customers digitally.

Repurposing is defined as the ability to change products' functionality, allowing reuse opportunities with high displacement potential (Zink et al., 2014). The authors argue that repurposing facilitates production changeover. In this regard, in response to strict social distancing during the pandemic, Malik et al. (2020, p.3) suggest 'repurposing existing non-ventilator (e.g., aeroplane, jet engine, car, digger or vacuum cleaner) production to ventilator production' using robots. As new product lines are produced, repurposing requires dealing with new customers and suppliers and setting new operations and SC strategies. In addition, it may require a new layout and facility design.

Reconfiguring is the ability to reconfigure machines or production lines. Various studies define the concept from different capability perspectives. For instance, Hoellthaler et al. (2019) highlight the importance of reconfigurable machines, while other studies (Gkournelos et al., 2020) focus on flexible production systems. However, such studies have viewed the reconfiguration capability from a stable operations perspective, not a disruptive one. This begs to question how manufacturing firms could develop a set of reconfiguration competencies to switch production from a current product to a new product in response to an emerging situation.

Recalibrating is also an essential enabler of production changeover. It involves fine-tuning production function parameters to include adaptive parameters in response to the emerging disruption. This is essential, as recalibrating production functions ensure accuracy and consistency for quality assurance (Javed et al., 2021). Therefore, recalibration can improve flexibility and ensure smooth material flow in SC (Bag & Rahman, 2021).

In summary, the literature on SC resilience capabilities can be categorized into two perspectives: response strategy and timeframe. First, the response strategy can be proactive or reactive. Proactive response strategy refers to the firm's capability to take the necessary steps before the actual occurrence of a problem through risk assessment and prediction and thus builds resilience capabilities proactively. In contrast, reactive response strategy refers to the firm's ability to respond to an incident through audits and evaluations to discover the cause of the problem and thus build resilience capabilities. Second, timeframe refers to the timespan for developing resilience capability. It can be short-term or long-term capabilities.

Nevertheless, the literature has not investigated the required capabilities for temporal switching to new products (i.e., production changeover) as a short-term proactive strategy. This gap in the literature has driven the investigation of these SC resilience capabilities concerning production changeover. Therefore, the 4Rs framework provides an in-depth understanding of the necessary capabilities for production changeover as an organizational resilience strategy. In addition, it provides a short-term strategy to deal with major SC disruptions such as disruptions caused by the COVID-19 pandemic. The authors argue that these four capabilities enable manufacturing firms to switch production quickly. For example, many manufacturing firms were forced to switch production to new products during the pandemic, which required new reactive capabilities.

3 | RESEARCH METHOD

This study utilized a qualitative research methodology in which 36 semistructured interviews were conducted with multinational companies. Which allowed explore companies' opinions that have managed to tune their operations and SCs during COVID-19. The semistructured interviews facilitate collecting individual viewpoints from participants through open-ended questions (Zighan & Ahmed, 2020; Adams, 2015).

3.1 | Data collection

The evidence was collected using semistructured interviews. The interview questions are constructed based on the main concepts of operational resilience literature. Follow-up questions were asked whenever necessary for clarity. The snowball sampling technique was used to reach respondents. The data were collected when themes became visibly repetitive, which marked the saturation level, in which incoming data provided little or no new information to answer the study's questions (Guest et al., 2006).

In total, 18 multinational companies were interviewed, 36 interviews from the textile, automotive, perfume and cosmetics, plastic and clothing industries. The interviews were conducted and transcribed to maintain reliability (Yin, 2011). Interviews averaged between 60 and 90 min. Table 1 below provides an overview of the interviews.

3.2 | Data analysis

The analysis process was conducted sequentially between the authors in two phases; the first phase involved an individual analysis

TABLE 1 Summary of interviewees and company profiles

Interviewee number	Interviewee job title				Company main business	Size (SMEs, large)	Production changeover (in response to COVID-19)
	General manager/CEO	Operations manager	Procurement manager	Logistics/SC manager			
A1	X				Textile	SMEs	Face mask
A2		X					
B1			X		Textile	SMEs	Face mask
B2				X			
C1				X	Textile	SMEs	Face mask
C2			X				
D1				X	Automotive	Large	Ventilators
D2		X					
E1			X		Automotive	Large	Ventilators
E2		X					
F1		X			Automotive	Large	Ventilators
F2			X				
G1				X	Machinery	SMEs	Ventilators
G2			X				
H1		X			Machinery	SMEs	Ventilators
H2	X						
I1		X			Machinery	SMEs	Ventilators
I2			X				
J1	X				Perfume & cosmetics	SMEs	Hand sanitizer
J2		X					
K1				X	Perfume & cosmetics	SMEs	Hand sanitizer
K2			X				
L1		X			Perfume & cosmetics	SMEs	Hand sanitizer
L2	X						
M1				X	Plastic	Large	Face protection shield
M2	X						
N1			X		Plastic	Large	Face protection shield
N2		X					
O1				X	Plastic	Large	Face protection shield
O2			X				
P1	X				Clothing	SMEs	Overall protective clothing
P2		X					
Q1				X	Clothing	SMEs	Overall protective clothing
Q2	X						
R1			X		Clothing	SMEs	Overall protective clothing
R2		X					
Total							
36	7	11	10	8			

Abbreviations: COVID-19, coronavirus disease 2019; SME, single-minute exchange.

by each author separately, followed by all-authors discussion of the analysis where similarities and differences were marked. Then the filtered data were employed according to the study aim. Next, the template analysis approach was used to analyse the interviews scripts. Template analysis is a type of thematic analysis in which themes are summarized, and a template is designed to discover the pattern (King, 2012). This method allowed to set predefined themes to guide the analysis of key areas of the research and link multiple concepts together (Brooks et al., 2015; King, 2012). Drawing on King (2012), the analysis was conducted through the following steps:

1. The analysis started by reading the transcripts so that the researchers became familiar with the data.
2. Preliminary coding was used to identify the relevant data using priority themes identified in advance.
3. Emerging themes were clustered, and relationships between themes/clusters were identified.
4. Each author developed an initial copy of the coding template based on a subset of the data.
5. Then, each author reviewed the analysis and modified redundant codes/themes.
6. The analysis and templates were finalized.

Finally, the themes' were based on the literature or as agreed by the participants (Saldaña, 2015), as shown in Table 2.

The following section summarized and discussed findings based on responses analysis.

4 | FINDINGS

Despite the different sectors studied, this study focuses on the similarities between companies facing COVID-19 disruptions through production changeover. In answering RQ1, the following findings have been drawn.

4.1 | Production changeover capabilities

There is no doubt that the pandemic has significantly disrupted the economy. The data were collected from participants regarding their companies' resilience. According to participant H2: 'The grief over COVID-19 is complex and can become pathological if it is not worked on'. Likewise, according to participant A1: 'The crisis we are experiencing today, and all the challenges we will have to overcome collectively cannot be compared to any situation that has occurred for more than a century. Still, we have to cope and survive'. The data analysis finds that survival activities require effective and integrated actions at all organizational levels on a large scale. To achieve favourable and sustainable results, participant M2 argues: 'It is essential to monitor the direct and indirect effects of each intervention carefully, to ensure the relevance of response measures at all levels'. In answering RQ1, the following findings have been drawn.

The participants stress that stabilization and recovery plans must be considered. The challenge is to make a strong organization and quickly respond when broken. According to participant G1: 'We must all show precaution, resilience, flexibility, and courage to adapt to the situation and find the best solutions'. In this context, the need for responses and support must be commensurate with the companies' operations.

The study has identified several capabilities facilitating the organizational resilience strategy that must be developed. These capabilities were grouped into four fundamental capabilities; manufacturing capabilities, production capacity capabilities, logistics capabilities and procurements capabilities.

4.1.1 | Manufacturing capabilities

The study finds that survival's primary means is to allow the production system to produce according to market demands. This could require a change in the manufacturing system. According to participant N2, 'This time requires a customer-driven production with greater flexibility to produce goods at the rate demanded by customers and meet changing demands'. Thus, organizational resilience depends greatly on developing a flexible production system. According to participant Q2: 'Resilience is the result of the ways of doing work, creativity, and ingenuity to produce new products allowing us to reposition ourselves in the market'. According to participant E2: 'Today, there is a need for manufacturing cells, integrated and automated production lines capable of allowing quick changes'.

The manufacturing capabilities include analysing the essential elements that affect the operations system seeking simplification and standardization of production activities. According to participant F1, 'One of the important activities that make up the production process is the change of format (also called change of tools). This change of tools is the set of operations carried out on the production equipment, preparing them, and producing the new product that will enter the new productive phase. This activity must be carried out and controlled under the parameters of efficiency and effectiveness'.

4.1.2 | Capacity management capabilities

Company survival largely depends on the decisions made by managers. Organizations have taken short-term actions to pursue stability and have made long-term strategic decisions looking at a new promising future. Participant H1 said, 'The current and future viability depends on the leaders' action. We all face a cycle of short-term actions for stability and strategic moves that will create new futures for businesses and industries'. Operational restrictions, shortage of containers for maritime transport, and a decrease in the supply of flights for cargo transport are two of the most

TABLE 2 Thematic analysis

Label/tag	Frequency	Type of the companies	Sub code	Code	Theme
Smart manufacturing system, flexible manufacturing system, automation, adjustable machinery, hybrid manufacturing approaches	22	Textile, automotive, perfume & cosmetics	Smart and flexible manufacturing	Adaptable manufacturing capabilities	Manufacturing capabilities
Machine capabilities to quickly respond to environmental changes, immediate customers satisfaction	20	Automotive, perfume & cosmetics, plastic, and clothing industries	Quick response to changes		
Machine capacity, working shifts, forecasting, inventory buffers, material flow, information flow, changing track, safety stock and inventor, forecast accuracy, capacity constraints	30	Textile, automotive, perfume & cosmetics, plastic, and clothing industries	Improve workflow and production activities	Capacity improvement activities	Capacity capabilities
Reducing wastes and costs capacity, minimizing errors	21	Perfume & cosmetics, plastic, and clothing industries	Reduce waste and errors		
Closeness to suppliers, local suppliers, mode of transport, delivery flexibility, delivery time	32	Textile, automotive, perfume & cosmetics, and clothing industries	Fast logistics services	Logistics enhancement	Logistic capabilities
Use full truckload, economies of scale in transportation and packaging	34	Textile, automotive, perfume & cosmetics, plastic, and clothing industries	Reduce logistics costs		
Switching suppliers, suppliers base, SC re-design, SC reconfiguration, strategic items	18	Cosmetics, plastic, and clothing industries	Managing suppliers	Procurement development	Procurement capabilities
Build a procurement plan and link the plan with a supply chain strategy to manage supplier relationships	24	Textile, automotive, perfume & cosmetics, and plastic	Procurement plan		
Leadership, objectivity, knowledge management, sense of belonging, Human resources	19	Textile, automotive, and perfume & cosmetics	Managerial skills	Internal skills	Organization's resilience
Environmental scanning, business intelligence tools, analysis capabilities	20	Automotive, perfume & cosmetics, and clothing industries	Environmental intelligence		

substantial impacts on international cargo transport. According to participant I1, 'It depends on the consequences of the crisis in terms of inventory availability in some industries and the decline in economic activity, driven by the decline in consumption'.

According to participant P2: 'For decades, we have put efficiency at the centre of strategy - we have run operations as close to full capacity as possible…. To survive times of crisis and prosper in the long-term, companies will have to shift their strategic thinking from "just in time" to "just in case"'. In times of crisis, it is important to develop recovery and growth mechanisms. The lessons learned from the COVID-19 crisis signpost how companies could better position themselves to take advantage of growth and resilience. According to participant R2: 'Reposition the operation system and evaluate where the crisis will leave the company, including the need for sustained capacity that an organization should have at any time to execute on what it needs to do, and how efficient it can be at that execution'. According to participant D2 this includes, 'Ongoing repurposing decision, deciding what should be paused, what should be organized and what should be stopped'. While repurposing seems to have offset the adversities of the current pandemic, it may serve the company on the long run. According to participant J2, 'While some changes are temporary, other things will never be the same - the new normal will be "never normal"'.

4.1.3 | Logistics capabilities

To achieve resilience while maintaining competitiveness, organizations have to understand logistics as a strategic tool that reduces the impact of adverse situations. According to participant K1, 'All eyes are on the logistics activities, carried out in total anonymity by several companies and collaborators globally; whether in production plants, packaging plants, distribution centres, salesrooms, or ports airports worldwide'. The findings show that one key adversity in operations and logistics was the transport delay. This was caused by the lack of operators, cancellations of a weekly ship, suboptimal inspections, delays in routes, blank sailings, smaller scale port operations, factories operating at less than 50% capacity, and logistics offices operating with less than 50% reduced staffing. According to participant C1: 'At present, influential countries worldwide have applied health measures restricting the habitual movement of individuals, measures of social isolation that have had a great impact on a social, productive and consumer level; impacting on a commercial and logistical level to various industries'. According to the study interviewees, logistic resilience largely depends on national infrastructure, where current restrictions have increased logistics costs and complicated operations. Therefore, the logistics activities should be refocused on adapting to change, taking advantage of the environmental difficulties to be more competitive, and proactively forecasting activities. According to participant O1, 'Resilience in logistics is the capacity that organizations have to be strengthened in all trade operations, whether national or international. It should also be refocused on analysing risks and a vision for the future to face adverse situations such as COVID-19'.

According to the study participants, challenges to logistics can be met with careful and measured response coupled, occasionally, with SC redesign. Besides, organizations will have to create more predictive models for demand schedules, consider risk factors and implement cutting-edge technology to provide transparency. Participant Q1 said, 'It is a fact that the situation we are experiencing will force many companies and entire industries to rethink and transform their logistics model. Those that invest in mapping the supply networks so as not to operate blindly will be the best prepared to cope with a crisis since they will have better visibility of their logistics structure'. Also, according to participant M1: 'In the future, key performance indicators related to logistics recalibrating should be considered in addition to cost, quality, and delivery'.

4.1.4 | Procurement capabilities

One of the initial reflections of the research participants on the pandemic was the decision to diversify suppliers. Many companies accelerated this decision and restructured their supply processes to avoid existing supplier dependency. However, many of these initiatives have been reactive. The data analysis finds that the pandemic accelerated this trend towards less globalized supply and encouraged domestic supplies. According to participant N1: 'The production chain could become regional again with the need for an industry close to the place of consumption. Global trade was perceived as a source of savings; however, it is now seen as the source of unbearable costs'.

Our research participants revealed that their companies sought alternative approaches such as:

- Contracting services from tertiary providers to compensate for the lack of delivery from primary providers.
- Advancing visibility into the SC to obtain information on critical components as quickly as possible.
- Redefining inventory strategies to avoid shortages.
- Restructuring production systems to make different products (diversification). Some companies have dedicated themselves to developing products to mitigate the spread of the virus.
- Leveraging technologies such as the Internet of Things, Artificial Intelligence, Robotics and 5G to anticipate and face future challenges.

The findings reveal that operational resilience capabilities are the set of actions, measures and decisions before (proactive/preventive) or after (reactive/corrective) an incident may have taken place at one or more nodes in the SC network to adapt to a new situation or switch production to new products (changeover). This depends on the product complexity and response agility, upon which the following framework has been proposed and validated with study participants, as shown in Figure 1.

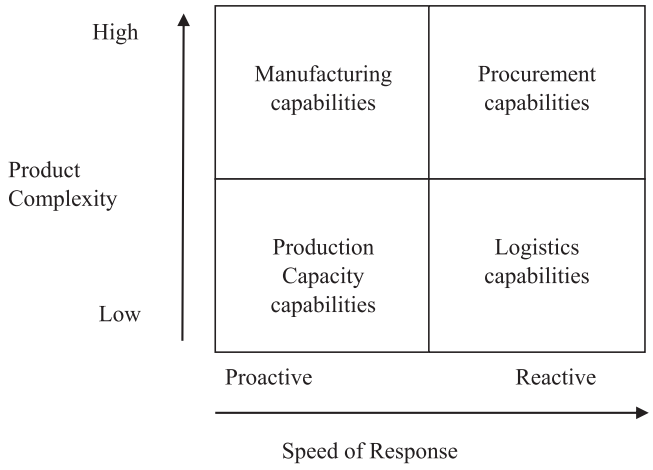

FIGURE 1 Operational resilience capabilities framework

The framework consists of two dimensions: product complexity and response speed. Switching for less complicated products can be efficiently implemented. For example, participant L1 argued that a detergent or perfume factory could easily switch production to produce hygiene products and sensitisers. Textile factories can also easily switch production from clothing to facemask products. Participant A1 confirmed that products with less complexity require quick response (i.e., rapid shift of production) and high logistics capabilities to deliver the new products to the market in a short time. However, switching to complex products is relatively complicated. For example, participant F2 explained that car manufacturers such as General Motors might need more adjustments in their equipment and production lines to produce ventilators. In addition, vacuum machine producers require high adjustment capabilities to produce ventilators. Therefore, such factors require high manufacturing capabilities, such as a flexible manufacturing system.

In answering RQ2, the following findings have been drawn.

4.2 | The development process of production changeover capabilities

Resilience is the organizational ability to anticipate critical events related to emerging trends, constantly adapt to change and recover quickly after disasters and crises. Based on the thematic analysis in Table 2 and interviews transcripts, the study participants outlined several measures to develop an organization's resilience. These have been grouped into four primary measures: *Retooling*, *Repurposing*, *Recalibrating*, *and Reconfiguring*.

- *Retooling* is the most frequently mentioned approach to achieving manufacturing capabilities among the CEO participants. For instance, according to participant H2, 'Retooling works best when factories are already equipped with smart, flexible manufacturing systems and machinery automation'. Therefore, it can be referred to as equipping a factory with new or adjusted tools, machines and equipment to temporarily switch production from one product to another in response to the SC disruption. In addition, participant B3 stressed that a flexible manufacturing system and automation were the main two important manufacturing capabilities that enabled their firm to switch production through retooling quickly. Therefore, a flexible manufacturing system and Smart Manufacturing/automation are the main manufacturing capabilities for retooling.
- *Repurposing* is the most frequently mentioned approach to achieving production capacity among the operations manager participants. For instance, according to participant E2, 'Repurposing works best when factories can readjust production capacities, which means can manage demand uncertainty of the new products, and also manage material and information flow, ensuring the availability of safety stock and inventory buffers, so they target new markets and new customers quickly'. Thus, repurposing can be referred to as the business temporarily switching from the existing products and markets to a new or different one (that has not been produced before in the factory) in response to the SC disruption. Thus, managing demand, materials and information flow are key capabilities for repurposing.
- *Recalibrating* is the most frequently mentioned approach to achieving logistics capability among the operations manager participants. For instance, according to participant R1, 'Logistics capability requires recalibrating the SC to be able to deliver products in different quantities, different products, and to different destinations'. Recalibrating can be referred to as optimizing the logistics system to enable the company to minimize the total delivery time by utilizing efficient modes of transport, closeness to suppliers and delivery flexibility. Thus, delivery time and transportation modes are the main logistics capabilities for recalibrating.
- *Reconfiguring* is the most frequently mentioned approach to achieving procurement capabilities among the participants. According to participant B2, 'Reconfiguring procurement is becoming essential to maintaining maximum control over key raw materials and operations inputs, thus internalizing core competencies as a competitive advantage'. Besides, participant A2 highlighted that 'The pandemic demonstrated the potentially catastrophic dangers of just-in-time strategy, and have highlighted the need for a strategy that could best be called by case, that puts much more emphasis on resilience and fast reconfiguration'. In this context, participant M1 confirmed that 'Today we have to think about sourcing in ways that involve a focus on building resilient multi-relationship networks rather than linear SCs'. According to participant G1, 'In the coming years, this will profoundly change the nature of procurement between the global and domestic suppliers'. Reconfiguring can be referred to as redesigning SC planning to respond to high supply-demand volatility and increase SC responsiveness. Supply and demand fluctuations are widespread when the SC is exposed to colossal disruption, such as the lockdown caused by the pandemic. Therefore, companies need to secure a smooth supply of their incoming material, plan for and

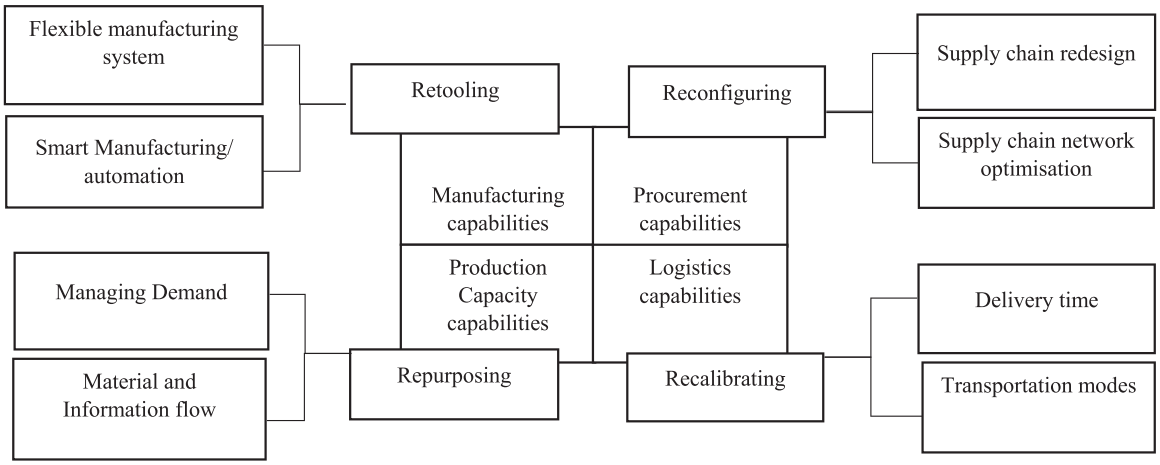

FIGURE 2 The 4Rs operational resilience framework

engage with multiple suppliers, switch to local suppliers and minimize the number of SC tiers. Hence, reconfiguring requires an efficient and rapid procurement process to easily switch from current suppliers to others. Therefore, SC redesign and SC network optimization are the main procurement capabilities for reconfiguring.

Figure 2 below depicts the matching between the four capabilities and the 4Rs as drawn from thematic analysis and findings.

5 | DISCUSSION AND CONCLUSION

The COVID-19 pandemic required robust, resilient SCs to deal with the interruptions and fluctuations in supply and demand using the power of adaptability, responsiveness and flexibility. In this regard, resilience is a term with multiple interpretations, depending on the science or discipline that applies it; however, in its etymological sense, it means 'returning to normality, to the natural state, especially after some critical and unusual situation'. Similarly, in management, resilience is part of the change management processes. The study complements the literature on organizational resilience given DC that are typically deployed in rapidly changing environments. While Teece's DCs focus on the long-term capabilities, they are utilized in this study within the 4Rs perspective to conceptualize them in the short-term resilient SC. The study argues that the 4Rs better understand the temporal capabilities required for production changeover. It also explores the required capabilities for companies during the changeover, such as manufacturing capabilities, production capacity capabilities, logistics capabilities and procurements capabilities.

This study provides decision-makers with a framework for increasing their SC resilience and coping capabilities when facing a crisis such as COVID-19. It also introduces the 4Rs framework, which encompasses four concepts: retooling, repurposing, recalibrating and reconfiguring. First, retooling is a tactical strategy for increasing firm responsiveness through flexible manufacturing systems. This may entail hybrid manufacturing approaches (e.g., combining conventional mass production and additive manufacturing techniques) (Babich & Hilary, 2020). Second, repurposing is identified as a tactical strategy for increasing production capacity capability. Third, recalibrating is a tactical approach to increasing a firm's responsiveness in terms of delivery flexibility, such as the logistical capability to reduce delivery times and utilize alternative modes of transportation. Finally, reconfiguring is a tactical approach for increasing a firm's procurement responsiveness. This requires a redesign of the SC and optimization of the SC network to establish new partnerships and alliances with suppliers that facilitate the purchasing process.

In this study, the researchers argue that manufacturers should develop more adaptable SC and logistic capabilities to maintain adequate responsiveness to demand and supply. In this line of argument, the study's contribution lies in the conceptualization of production changeover as a means to resilience that draws on four capabilities, that is, 4Rs. The 4Rs framework enables an in-depth understanding of the capabilities required for production changeover as an organizational resilience strategy. In addition, it enables rapid response to major SC disruptions, such as those caused by the COVID-19 pandemic.

This study has a few limitations that should be considered in future research. First, a limited number of companies participated in the study due to lockdown when conducting the study. Therefore, it is highly recommended to conduct a large-scale study. Second, this study could not include any financial implications of production changeover due to difficulties accessing financial results. Hence, future research is recommended to investigate the financial implications of production changeover.

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DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

ORCID

Nidal Yousef Dwaikat http://orcid.org/0000-0002-2070-3075
Ziad Alkalha http://orcid.org/0000-0001-8321-3252

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