Achieving supply chain resilience in an era of disruptions: a configuration approach of capacities and strategies

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Abstract

Purpose – The COVID-19 pandemic and recent disruptive events are affecting firms' operations and supply chain networks on a large scale, causing disturbances in supply, demand, production and logistics activities. Although supply chain resilience (SCR) research has received large attention in recent years, the purpose of this paper is to offer an original contribution by exploring how complex configurations and interactions between SCR strategies and capacities can lead to resilience.

Design/methodology/approach – This study investigates the configurations of SCR strategies and capacities using a fuzzy-set qualitative comparative analysis.

Findings – First, the findings reveal different SCR strategy configurations through the lens of absorptive, reactive and restorative capacities to achieve resilience. Second, this study applies the contingent resource-based view (CRBV) perspective to interpret how organizations can achieve resilience before, during and after a disruptive event. Third, it offers an analysis of different groups of organizations, based on the adoption of different SCR strategies and capacities.

Originality/value – This study identifies a set of equifinal SCR strategies and capacity configurations that can be implemented to cope with a disruptive event and lead to resilience. It also enriches the research addressing the consecutive phases of SCR investments, developing the CRBV perspective. In our results, five solutions describe organizations that invest in absorptive capacities, representing an *ex ante* readiness.

Keywords Qualitative comparative analysis, Resilience strategies, Supply chain disruptions, Resilience capabilities

Paper type Research paper

1. Introduction

The COVID-19 outbreak is one of the most severely disruptive events over the past decades (Wieland and Durach, 2021). Like the recent conflict between Ukraine and Russia, the pandemic has three characteristics that can be associated with dramatic disruptive events (Ivanov, 2020): it is a long-term and global disruption with unpredictable scaling; it generates simultaneous disruption propagation among firms, societies and economies; and it generates disruptions in supply, demand and logistics infrastructure (Araz *et al.*, 2020). As the structures of many companies' supply chain (SC) networks are growing complex and globalized, they are more likely to be exposed to the detrimental effects of such events (Wieland, 2021; Suryawanshi and Dutta, 2022; Birkie *et al.*, 2017).

The pandemic and recent disruptive events are getting SC managers to ask how their SC can be affected by severe events, and which might be the effective lines of defense. The COVID-19 pandemic has affected firms' operations, global trade (Mena *et al.*, 2022) and SC network design on a large scale (Liu *et al.*, 2020). In 2020, 94% of Fortune 1,000 companies were facing SC disruptions due to COVID-19 (Sherman, 2020). The pandemic has hit SCs significantly and differently (Altman, 2020; Rushe *et al.*, 2021), causing multi-faceted disturbances in supply, demand, production and logistics activities on the global and local

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scales (Ivanov, 2020). Recent research has focused on the notion of organizational resilience (Dormady *et al.*, 2019; Parker and Ameen, 2018) and supply chain resilience (SCR) (Wieland and Durach, 2021; Chowdhury *et al.*, 2019), offering in-depth literature reviews on the COVID-19 pandemic and how to invest in SC strategies (El Baz and Ruel, 2021; Sharma *et al.*, 2022). However, despite the rich literature on SCR strategies, the discipline is still failing to describe different successful paths to SCR, to increase relevance to practice (Darby *et al.*, 2019). According to the interpretive research perspective described by these authors, where a phenomenon is a "holistic structure that is continuously changing and more than the sum of its parts" (p. 397), SCR should be investigated considering the different proactive or reactive lines of action that different organizations can act to achieve their goals. In fact, as Wieland and Durach (2021) pointed out:

> Clearly, a supply chain often does not behave like an engineerable system. Machines, power plants, or subway systems might be complicated, but they are usually not complex in the sense of complexity theory and, thus, they are not erratic in their behavior. This, however, is the case for a supply chain, because of its open-system character that it has in common with an ecological system.

This study aims therefore at contributing to the recent literature on how some companies obtain better performance than others – in terms of SCR – under conditions of severe disruptions by investigating the configurations of strategies adopted by companies and their SCs to respond to the pandemic. In particular, this study aims to move a step forward, by investigating the complex configurations of SCR strategies that can be differently adopted by companies and their SCs to achieve SCR strategies, grounded in the framework of three resilience capacities – absorptive, adaptive and restorative capacities – as proposed by Hosseini *et al.* (2019).

The "resilience capacity" of a system (e.g. an SC) has been defined as:

> A new and important dimension of system performance under uncertainty which consists of the resilience enhancement features that could increase the ability of a system to absorb, adapt, and restore itself after disruption (Ivanov, 2020, p. 9).

According to this meaning, we focused on the concept of SCR, as described by Wieland and Durach (2021), and resilience capacities (absorptive, adaptive and restorative), addressed by Hosseini *et al.* (2019) and Biringer *et al.* (2013) as different "lines of defense," having different temporal attributes (before, during and after a disruption), under which addressing SCR strategies. These authors then divided SCR strategies into three main groups, based on the three lenses of absorptive, adaptive and restorative capacities, depending on their implementation before, or in response to, disruptive events. The concept of resilience capacity with three categories introduced by Hosseini *et al.* (2019) and Biringer *et al.* (2013) offers a new lens to interpret how the different strategies, already described in the literature, can be differently adopted by companies and their SCs to achieve SCR. The lens of an interpretive approach as suggested by Darby *et al.* (2019) and the time-bound adoption of strategies can be applied to SCR offering a new exciting perspective for academics and practitioners.

In fact, the adoption of different configurations of strategies to enhance SCR may be interpreted under the light of the different resilience capacities that are developed through their implementation, thus offering a new lens under which to interpret SCR. Resilience has been in fact investigated extensively over the years (Pettit *et al.*, 2013), with different approaches leading to different representations of resilience paths. Authors have described the links between disruptions and resilience through various methodologies, such as qualitative case studies (Butt, 2021; Dohale *et al.*, 2021) and quantitative methods – for example interpretive structural modeling (Ruiz-Benítez *et al.*, 2018), the Delphi method (Paul *et al.*, 2021) and structural equation modeling (Chowdhury and Quaddus, 2017; El Baz and Ruel, 2021; Liu and Lee, 2017).

However, the complexity of the configurations and interactions between SCR strategies – depending on the presence of absorptive, adaptive and restorative capacities – has been only examined from a theoretical point of view. This study aims therefore to offer a contribution in two directions: by developing the theoretical model and by providing empirical evidence on the adoption of different configurations of strategies and their link to resilience capacities. In particular, there is a lack of studies investigating the configurations of SCR strategies in relationship with the existing organization's investments in the three lines of defense (absorptive, adaptive and restorative capacities) during exceptional disruptive events, when the drivers of resilience became even more relevant than in normal times and may act differently before, during and after the pandemic. During the COVID-19 pandemic, SCs leveraged their internal resources and capabilities to develop survival mechanisms to respond to long-term and global disruptions (Birkie *et al.*, 2017; El Baz and Ruel, 2021). Thus, in this study, we decided to apply the contingent resource-based view (CRBV) perspective to interpret how SCs can achieve resilience during the recently experienced long-lasting disruptive event caused by the pandemic.

Expanding on the existing SCR studies and methodologies in the context of disruptive events, we aim to address the following research question (RQ):

RQ1. What configurations of SCR strategies and capacities to cope with the COVID-19 pandemic lead to SC resilience?

To respond to this question, we started with the definition of SCR as provided by Wieland and Durach (2021) and investigated those configurations of SCR strategies – based on the three lines of absorptive, adaptive and restorative capacities – that could lead to resilience, according to Hosseini *et al.* (2019). For this scope, we developed a fuzzy-set qualitative comparative analysis (fsQCA) to address the causal complexity of these configurations (Beynon *et al.*, 2016; Fiss, 2011; Woodside, 2014a). In fact, according to the fsQCA principle of equifinality, no single SC strategy is necessary or sufficient on its own to ensure resilience, but there is a need to explore the configurations of these strategies and capacities that strengthen or weaken resilience (Russo *et al.*, 2021).

We adopt an inductive logic to address the SCR strategy and capacity configurations that can lead to resilience, creating the foundation for a midrange theory (Russo *et al.*, 2021). Midrange theory allows theoretical insights suitable for application in a specific empirical context – in this study, the investigation of SC strategies that can ensure resilience. Conceptually, we build on the CRBV (Chowdhury *et al.*, 2019) to develop further a framework of different SCR strategies – based on the three lines of capacities – that can act in different moments of a disruptive event to achieve resilience.

A key contribution of the paper is the investigation of the concept of SCR by addressing the strategy configurations through the lens of absorptive, reactive and restorative capacities (Hosseini *et al.*, 2019; Mena *et al.*, 2022). The paper also describes different companies' profiles according to the SCR strategy and capacity configurations adopted. In addition, we enrich studies from other single countries, such as the study of French firms by El Baz and Ruel (2021), Bangladesh firms by Paul *et al.* (2021) and Chinese firms by Zheng *et al.* (2021).

2. Theoretical background

2.1 Resilience

The concept of "resilience" has been widely adopted in different disciplines. Resilience has been defined as a system's ability to recover and return to its original state after disturbances and to survive in a turbulent environment (Christopher and Peck, 2004; Dormady *et al.*, 2019; Parker and Ameen, 2018; Suryawanshi and Dutta, 2022). The present paper focuses on SCR as described by Wieland and Durach (2021) in terms of dynamic adaptation and transformation, instead of stability. SCR is linked to the need to cope with SC disruptions (Hosseini *et al.*, 2019; Chowdhury *et al.*, 2019; Mena *et al.*, 2022), that is unexpected mismatches between supply, internal processes and demand affecting operations, performance and hence profitability (Blackhurst *et al.*, 2011). Part of the literature also addresses the drivers of SCR linked to the resilience capacity concept (Biringer *et al.*, 2013; Hosseini and Barker, 2016a, 2016b). The COVID-19 pandemic, like other disruptive events (natural catastrophes, physical accidents, wars, to name a few), has shed light on the need to improve SCR further, investigating the relations between disruptions and resilience strategies to protect SC performances (Chowdhury *et al.*, 2019).

The SCR literature has also largely investigated, in different studies, how strategies may contribute to ensuring resilience and better performance (Um and Han, 2020). Soni *et al.* (2014) highlighted resilience enablers – agility, information sharing, collaboration, visibility, sustainability, risk sharing, risk-management culture, adaptive capability and structure. Collaboration in SC has been recognized as resilience enabler, underlying how firms can work jointly to plan and execute SC operations and to manage risk (Simatupang and Sridharan, 2008). More in detail, Sturm *et al.* (2021) focused on flexibility and agility to achieve SC resilience, extending the concept of collaboration. In addition, several authors have underlined the role of technological investments in achieving resilience (Balakrishnan and Ramanathan, 2021; Ghasemaghaei, 2019).

Although several studies have extensively analyzed SCR strategies, there is a need to understand empirically the configurations that can answer the COVID-19 challenge.

2.2 Supply chain resilience strategies and capacities

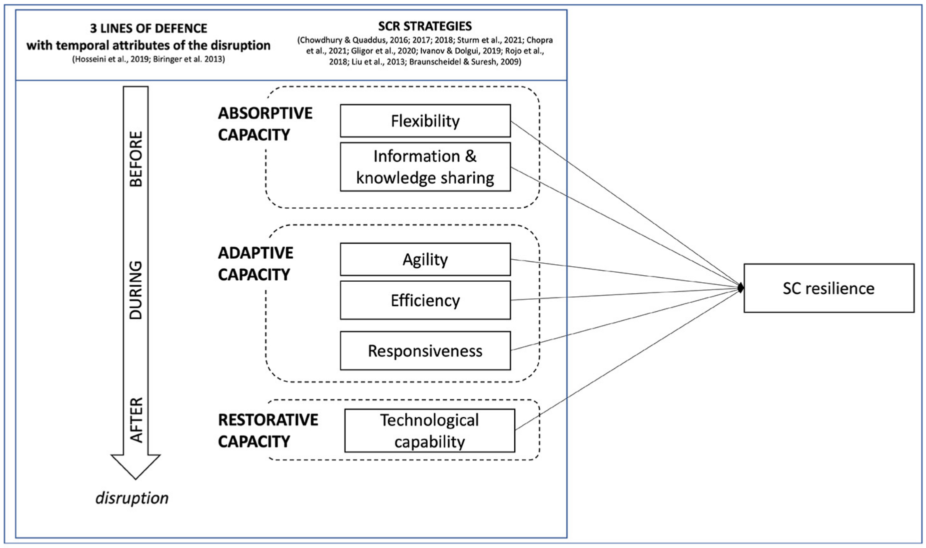
In this study, we adopted the multi-faceted definition of SCR as proposed by Wieland (2020, p. 62) in which the "engineering resilience" – defined as resistance to disturbance or speed of return to the equilibrium – co-exists with the "ecological resilience," measured as the "magnitude of disturbance" the system can absorb before it changes its structure by changing the processes and variables that control behavior. From this point of view, we adopted the categorization of SCR strategies under the lens of the three groups of capacities that Hosseini *et al.* (2019) linked to the three lines of temporal defense to respond to a disruptive event. According to Hosseini *et al.*, and Hosseini and Barker (2016a), SCR capacities can be divided into three lines of defense: absorptive, adaptive and restorative capacities. The strategies to achieve SCR (Ali *et al.*, 2023) have been carefully selected and categorized – as depicted in Figure 1 – into the three lines of defense according to the literature, particularly from the studies of Sturm *et al.* (2021), Chopra *et al.* (2021), Gligor *et al.* (2020), Ivanov and Dolgui (2019), Rojo *et al.* (2018), Chowdhury and Quaddus (2016, 2017), Liu *et al.* (2013) and Braunscheidel and Suresh (2009).

Absorptive capacity represents the capability of the SC to absorb the impacts of disruption before its occurrence. Examples of SC strategies related to the absorptive capacity are flexibility, particularly with regard to production and sourcing strategies (Rojo *et al.*, 2018), supplier segmentation, multiple-source strategies and the use of different inventory locations (Ivanov and Dolgui, 2019). Absorptive capacity is also the organization's ability to recognize the value of new information, assimilate it and apply it to commercial ends (Cohen and Levinthal, 1990). Hence, information and knowledge sharing has also been addressed as a SCR strategy related to absorptive capacity (Zheng *et al.*, 2021). An information-based capability to mitigate risk typically acts before the disruption occurs, when relationships between buyers and sellers are established and consolidated (Nguyen *et al.*, 2017). In this sense, Liu *et al.* (2013) underlined the link between absorptive capacity and knowledge sharing with SC partners typically performed before disruptive events.

Adaptive capacity represents the capability of the SC to adapt itself and attempt to overcome disruption by implementing nonstandard operating practices (Lücker *et al.*, 2018). It represents the second line of defense against disruption when absorptive capacity is inadequate to cope with it. Agility is an example of SCR strategy related to adaptive capacity as "[. . .] ability to perform operational activities together with channel partners in order to adapt or respond to marketplace changes in a rapid manner" (Liu *et al.*, 2013, p. 1453). In this sense, agility acts in conjunction with adaptive capacity and after absorptive capacity to achieve SCR performance (Hosseini and Barker, 2016a). Agility and responsiveness together serve to cope with risks, typically in the short term and in the long term (Gligor *et al.*, 2020; Braunscheidel and Suresh, 2009). Efficiency as an SCR strategy (Chopra *et al.*, 2021) is inherently linked to agility (Agarwal *et al.*, 2007), being an operational element of agility, along with quality and productivity (Ivanov *et al.*, 2014) and serves therefore as a SCR strategy related to adaptive capacity.

Restorative capacity represents the capability of the SC to restore its processes and operations when the absorptive and adaptive capacities are not able to maintain an acceptable performance level (Biringer *et al.*, 2013). Despite the frequent generic association of the two concepts of "restoration" and "resilience" (Brandon-Jones *et al.*, 2014), we contextualize restorative capacity in a specific domain of resilience according to Hosseini *et al.* (2019). We argue that all the SCR strategies linked to adaptive resilience capacities must be improved and implemented further once their effectiveness is inadequate in a

Figure 1 Theoretical model



Source: Author's own creation

certain time, according to a continuous improvement principle (Hohenstein *et al.*, 2015). However, Hosseini *et al.* (2019) proposed technological capability and technology investments as key drivers to continuously improving the potentiality of previous resilience capacities. Belhadi *et al.* (2022) and Rai *et al.* (2006) underlined the role of digital capabilities and investments in fostering the effectiveness of resilience, and Liu *et al.* (2013) identified how digital investments can serve, after absorptive and adaptive capacities, to foster, for example, visibility. Similarly, Modgil *et al.* (2022) highlighted the contribution of digital investments and artificial intelligence to enhancing SCR.

2.3 Contingent resource-based view

As stated, companies and SCs need to adopt a multi-level set of SCR strategies based on absorptive, adaptive and restorative capacities to cope with disruptive events to ensure resilience, acting before the event through prevention strategies, during the event using reactive strategies and after the event to ensure continuity and to consolidate capability to protect the competitive advantage (Paul *et al.*, 2021; Sharma *et al.*, 2022). Also, Hohenstein *et al.* (2015) distinguished "ex-ante" and "ex-post" resilience approaches, and Biringer *et al.* (2013) further categorized the temporal lines of "before," "during" and "after" a disruption, highlighting the importance of addressing the combination of these strategies based on when each of them is applied.

The CRBV offers an important lens through which to interpret how SCs can achieve resilience as a key source of competitive advantage (Kwak *et al.*, 2018) by investing in key capabilities linked to SCR strategies. A resource-based view (RBV) indicates how to pursue a durable competitive advantage by investing in valuable, rare and inimitable strategic capabilities (Barney, 1991) that are critical to achieve the organization's key goals (Hitt, 2011). The CRBV makes an additional contribution to the RBV by addressing the conditions in which capabilities could be most valuable (Ling-yee, 2007). In fact, the contingency theory may highlight how SCs are influenced by specific conditions in selecting when and how to invest in these capabilities (Donaldson, 2001). The CRBV clarifies the utility of finalizing a combination of capabilities to achieve a specific goal under a specific condition, which – in the present study – is related to the SCs' capacity to cope with a disruptive event such as the COVID-19 pandemic.

3. Method

3.1 Sample and data collection

Data collection focused on the evaluation of SCR strategies – linked to the absorptive, adaptive and restorative capacities – as perceived by companies' managers in 2021.

The study participants were selected from 428 small- and medium-sized enterprises and large companies in Italy, to ensure heterogeneity of the sample. To define the potential participants of our final sample, we used the following criteria. Participants were SC management professionals, middle and senior managers, who are most likely to have relevant knowledge about information flows between SC partners as well as upstream and downstream integration and strategies, and were identified as key informants for this study.

During the initial research stages, a qualitative investigation was undertaken to pre-test a survey in the first quarter of 2021. This preliminary inquiry also pursued understanding the participants' ways of evaluating the topic of resilience and related strategies and capacity required. Based on that, half-an-hour to 1-h interviews were conducted with ten SCM managers in the Italian context. This sample size is in line with this type of pre-evaluation study and participants were selected through a convenience sampling process and were recruited among participants of a leading logistics and SC management association in Italy.

Thanks to this pre-test, interviews provided the researchers with an evaluation of the clarity, understanding and readability of existing theoretical constructs and measurement items. In doing so, the pilot survey was read by participants and revised based on their perceptions and knowledge of the SCM field. Most of the issues were related to the length and structure of the survey rather than to the content or meaning of each item. After the pre-test, data collection took place during the second quarter of 2021 through an online questionnaire in Google Forms, comprising a cover letter from the researchers explaining the research aim and a self-administered questionnaire with instructions.

A key informant approach was followed (Braunscheidel and Suresh, 2009; Dubey *et al.*, 2021); hence, we screened and selected those from respondents whose title was related to SC or its related functions. The following SC professional titles were deemed appropriate to be part of the final sample: president, general manager, SC director and SC manager. We also deleted some responses with missing information. A total of 81 completed responses were collected, with an 18.92% response rate. This is in line with the number of cases selected in recent literature using qualitative comparative analysis (QCA) (Chen and Tian, 2022; Xie *et al.*, 2021) and is consistent with the number of cases required to be managed by QCA, an approach designed for small samples. Non-respondents had similar characteristics to those of the 81 respondents, and no statistically significant differences were detected. Sample characteristics are summarized in Table 1.

3.2 Variable measurement

The questionnaire consisted of two sections. The introductory section collected respondents' roles and company characteristics, such as sector, sales and number of employees. The second section required respondents to assess their SC's resilience by evaluating the status of the activity suspension resulting from COVID-19 and whether SCR strategies have been implemented to deal with COVID-19 impacts.

Table 1 Sample characteristics

Sample characteristics (sample = 81)	No.	%
Sector		
Manufacturing	41	50.62
Transportation and storage	9	11.11
Wholesale and retail	7	8.64
Pharmaceutical	5	6.17
Other	19	23.46
Sales (in million €)		
< 2	4	4.94
< 10	6	7.41
< 43	17	20.99
≥ 43	52	64.20
NA	2	2.47
No. of employees		
< 10	1	1.23
< 50	11	13.58
< 250	20	24.69
≥ 250	49	60.49
Respondent job title		
President	2	2.47
General manager	4	4.94
SC director	18	22.22
SC manager	57	70.37

Source: Authors' own work

They were asked to measure the adoption of the following SCR strategies on a five-point Likert scale ranging from 1 (not at all) to 5 (fully adopted): flexibility (six items), information and knowledge sharing (one item), agility (two items), efficiency (five items), responsiveness (four items) and technological capability (one item).

All measures were adapted from previous research, as reported in Table 2, and as stated previously, before launching the survey we ran a pre-test with SCM managers to assess the clarity and feasibility of the survey.

Procedural methods were applied to minimize the threat of common method bias, as both the independent and the dependent measures were obtained from the same source. First, the sample included experienced professionals with significant levels of relevant knowledge to mitigate single-source bias (Mitchell, 1985). Second, common method bias was reduced by separating the predictor and criterion variable items across the survey and by assuring participants that their responses would remain anonymous (Podsakoff *et al.*, 2003). Additionally, Harman's one-factor test was conducted to examine whether common method bias posed a threat to the data (Podsakoff *et al.*, 2003). A factor analysis performed on the variables did not yield a single-factor solution.

Table 3 presents the means, standard deviations and Cronbach alpha of the focal constructs. The correlations between the proposed independent variables were less than 0.70; thus, multicollinearity was not a threat. The shared variance between the various study variables did not exceed 50%, indicating empirically distinct constructs. Reliability was satisfactory for all scales, with alpha values ranging from 0.77 to 0.85. In aggregate, the results support construct unidimensionality.

4. Data analysis: qualitative comparative analysis

This study used fsQCA to analyze data. Since Ragin introduced QCA in 1987, the approach has evolved and been expanded to meet the needs of social sciences research (Ragin, 2009). Although QCA was initially developed for small samples (15–40 cases), recent studies have extended its application to larger samples (Kraus *et al.*, 2016; Leischnig *et al.*, 2016). Such a method helps explore the underlying combinations of causal conditions that lead to a given outcome (Ragin, 2009; Woodside, 2014b), identifying the complex complementary relationships among antecedents. Such analysis is helpful not only for the relevance of the topic but also because previous studies have mostly applied regression-based methods that can only capture net effects which are not fully explaining complex sets of relationships (Dubey *et al.*, 2021; El Baz and Ruel, 2021). Instead, applying QCA can help to uncover possible asymmetrical relationships (Woodside, 2014), thus providing more in-depth insights (Scarpi *et al.*, 2021). Furthermore, QCA allows for the exploration of how different combinations of antecedents might lead to similar outcomes. Because of the complexity of the relationships examined in this research, there could be a number of cases where the effects of X on Y are negative, even if the total effect of the X to Y relationship is positive. These cases are usually ignored, as many studies run symmetric analyses, such as structural equation models, where the focus is on how well high values of the

Table 2 SCR strategies and capacities

Resilience capacity	Variable (SCR strategy)	Item	Adapted from
ABSORPTIVE	Flexibility	Sourcing flexibility Contract flexibility Distribution flexibility Production flexibility Production diversification Volume flexibility	Chowdhury and Quaddus (2017)
	Information and knowledge sharing	Communication and information-sharing improvement	Chowdhury and Quaddus (2017)
ADAPTIVE	Agility	Response to changes in demand without overstocks or lost sales Response to real market demand	Sturm *et al.* (2021)
	Efficiency	Employee efficiency Quality control Recycled component use for product manufacturing SC risk management improvement Overall operations management improvement	Chowdhury and Quaddus (2017) El Baz and Ruel (2021)
	Responsiveness	Quick response to disruptions Adequate response to crisis Ability to handle crisis by reducing impact of loss Ability to recover from crisis at less cost	Chowdhury and Quaddus (2017)
RESTORATIVE	Technological capability	Investments in DSC technologies	Ghasemaghaei (2019)

Notes: DSC = digital supply chain; SC = supply chain
Source: Authors' own work

Table 3 Means, standard deviations, Cronbach alpha of the focal constructs

Resilience capacity, variable (SCR strategy)		Mean	SD	Max	Min	Cronbach
	Resilience	2.46	0.708	3	1	= =
ABSORPTIVE	Flexibility	2.42	0.783	5	1	0.81
	Information and knowledge sharing	3.44	1.032	5	1	= =
ADAPTIVE	Agility	2.22	0.930	5	1	0.75
	Efficiency	3.00	0.715	5	1	0.80
	Responsiveness	2.34	0.863	4	1	0.77
RESTORATIVE	Technological capability	3.27	1.190	5	1	= =

Source: Authors' own work

independent variable can predict high values of the dependent variable. Instead, QCA uses an asymmetric technique, where the causes of high levels of Y usually differ from the causes of low Y values. This analysis will help companies to relocate their current resources or strategies and highlights core and necessary resources.

To analyze our data using the QCA approach, multistep analysis was required. Before performing a configural analysis using fsQCA software, contrarian case analysis was helpful to verify the presence of contrarian cases by cross-tabulation to explore the existence of different combinations of antecedents that lead to the same output (i.e. the presence of business continuity).

4.1 Qualitative comparative analysis procedure

To conduct the analysis, this study followed the four-step procedure suggested by Fiss (2011), starting with defining the property space in which all possible configurations of the drivers of an outcome are identified. To find the most relevant drivers, we selected some of the most important SCR strategies from the extant resilience literature. The property space consists of all combinations of binary states, that is the presence or absence of the influence attributes affecting resilience.

Second, an important phase is related to variable calibration. As our variables were not naturally dichotomous, we transformed them into fuzzy-set membership scores, calibrating measures by specifying three qualitative anchors: the threshold for full membership in a set (i.e. value 1), the threshold for full non-membership in a set (i.e. value 0) and the crossover point (i.e. value 0.5) (Ragin, 2009). The range of fsQCA variables is continuous. The values of these variables are defined as fine-scale values between 0 and 1. Values of 1 and 0 represent full

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Table 4 Fuzzy-set membership calibrations and sample descriptives

SCR capacity	Variable (SCR strategy)	Fuzzy-set calibration			Measure descriptive			
		Fully in	Crossover	Fully out	Mean	SD	Max	Min
	Resilience	4	3	1	2.46	0.708	3	1
ABSORPTIVE	Flexibility	5	2.5	1	2.42	0.783	5	1
	Information and knowledge sharing	5	3.4	1	3.44	1.032	5	1
ADAPTIVE	Agility	5	2	1	2.22	0.930	5	1
	Efficiency	5	3	1	3.00	0.715	5	1
	Responsiveness	5	2	1	2.34	0.863	4	1
RESTORATIVE	Technological capability	5	3	1	3.27	1.190	5	1

Note: SD = standard deviation
Source: Authors' own work

membership and full non-membership in the set, respectively. A value of 0.5 represents the fuzziest point of the set. All other scores in between have fuzzy partial membership. Table 4 indicates the full, full non-membership and crossover point values for each variable. For the conditions and the outcome, we coded the case data into fuzzy sets by setting the threshold of full membership at the 75th percentile, the point of maximum ambiguity at the 50th percentile and the threshold of non-membership at the 25th percentile (Fiss, 2011). Although calibration is ideally developed on a theoretical foundation, no theoretical basis was identified for the variables of this study (e.g. Xie *et al.*, 2021).

Third, consistency in set relations aims at refining a truth table (Figure 2) via two criteria, frequency and consistency (Ragin, 2009). To define the frequency cut-off, we considered only those configurations exceeding a minimum number of empirical representations. The threshold for the frequency of medium-sized samples is 1, so we considered all configurations that had at least one best-fit case; this can be higher for large-scale samples (e.g. 150 or more cases) (Ragin and Fiss, 2008; Ribeiro-Navarrete *et al.*, 2021). In addition to frequency, we considered only those configurations with a minimum raw consistency of 0.80 and a proportional reduction in inconsistency of at least 0.70 (Bell *et al.*, 2014; Fiss, 2011; Greckhamer *et al.*, 2018). To conduct this analysis and obtain the output solutions, we used fsQCA software (version 3.0). Figure 2 shows all potential combinations of our variables that have allowed companies to avoid business interruption during the pandemic.

The final step of analysis is related to the logical reduction and analysis of configurations, identifying whether not only the configurations are consistent but also representative of, and provide adequate coverage of, the cases. "Coverage" represents the relevance of the combination and reflects the share of consistent memberships as a proportion of total memberships in the outcome set (Ragin, 2000). It is comparable to the R-square value reported in correlational methods (Woodside and Baxter, 2013). While coverage should be > 0.1, the consistency is fixed as > 0.8 (Ragin, 2000).

Section 5 will illustrate the nine configurations leading to SCR.

4.2 Robustness checks

We adopted common methods to ensure the robustness of the QCA results, including adjusting the calibration threshold, changing the consistency threshold, adding or removing cases, changing the frequency threshold and adding other conditions (Zhang and Du, 2019). As suggested by Schneider and Wagemann (2012), we decreased the consistency threshold from 0.80 to 0.75, and found the nine configurations were still supported. The overall consistency decreased slightly, and the overall coverage increased slightly. Three cases were then randomly selected and removed. The solutions remained similar, indicating the research results are robust.

Figure 2 Truth table

Edit Truth Table
File Edit Sort

Technolog	Responsive	Information	Agility	Efficiency	Flexibility	Number	Resilience	Raw consist	PRI consist.	SYN consist
0	0	0	0	0	0	5	1	0.889005	0.833203	0.851882
1	1	1	1	1	1	3	1	0.891587	0.813773	0.855250
1	1	0	1	1	1	2	1	0.906143	0.855769	0.855769
1	0	0	0	0	0	2	1	0.932958	0.894270	0.894269
1	1	1	1	1	0	1	1	0.927545	0.872527	0.884187
1	1	1	0	0	0	1	1	0.899872	0.816471	0.834135
1	1	0	0	0	0	1	1	0.888621	0.816650	0.816650
1	0	1	1	1	0	1	1	0.928704	0.869318	0.869318
1	0	0	1	1	0	1	1	0.928035	0.871938	0.871937
1	0	0	1	0	0	1	1	0.920683	0.860664	0.865301
1	0	0	0	0	1	1	1	0.922812	0.869768	0.869767
0	1	1	1	1	1	1	1	0.868538	0.756164	0.756164
0	1	0	0	1	1	1	1	0.856259	0.746051	0.746051
0	1	0	0	0	1	1	1	0.882560	0.783959	0.790091
0	1	0	0	0	0	1	1	0.851078	0.753780	0.753780
0	0	1	1	0	0	1	1	0.925954	0.859574	0.869441

Note: PRI = proportional reduction in inconsistency
Source: Author's own work

5. Qualitative comparative analysis findings

Before analyzing the sufficient conditions of the fsQCA, we identified the necessary conditions. If the threshold for consistency is 0.90 for a condition to be necessary (Ragin, 2009; Schneider and Wagemann, 2012), as Table 5 shows, no variable can be considered necessary, highlighting no single condition determines and explains a high degree of resilience.

Hence, based on the steps already described in Section 3.4 where the QCA procedure has been extensively reported, the analysis provides those configurations that have a minimum raw consistency and coverage. This is in line with the final step of the QCA analysis related to the logical reduction and analysis of configurations, identifying whether not only the configurations are consistent but also representative of, and provide adequate coverage of, the cases.

Based on that, the study results are reported in Table 6, following the guidelines on representing results suggested by Ragin and Fiss (2008). Black circles (●) indicate the presence of a condition; circles with a cross (⊗) indicate its absence; blank cells indicate the "do not care" condition, which means a specific condition is not considered in a solution.

Table 5 Necessity of conditions for high resilience

Condition tested	Consistency	Coverage
Flexibility	0.495593	0.825056
~Flexibility	0.647966	0.821091
Information and knowledge sharing	0.478305	0.814665
~Information and knowledge sharing	0.663390	0.826436
Agility	0.556271	0.846749
~Agility	0.605593	0.826318
Efficiency	0.572542	0.821698
~Efficiency	0.589491	0.850575
Responsiveness	0.554068	0.779633
~Responsiveness	0.589491	0.867981
Technological capability	0.655424	0.821368
~Technological capability	0.448135	0.757159

Note: ~ = absence of the variable
Source: Authors' own work

Our findings indicate that nine configurations lead to obtaining resilience. Overall consistency is 0.85 and each path configuration exceeds 0.88, which is above the recommended threshold of 0.80 (Ragin and Fiss, 2008), demonstrating the robustness of the results. Further, the overall coverage of 0.64 confirms these combinations of causal conditions account for 64% of cases.

Table 5 shows different combinations of SCR strategies are successful in achieving SC resilience. The QCA results reveal nine solutions that combine the absence and presence of the variables included in the analysis. In summary, the results provide an overall solution with a coverage of 0.64 and overall consistency of 0.85 (Ragin, 2000; Woodside and Baxter, 2013).

To rationalize and provide more clarity to the QCA results, we identified four groups under which the nine solutions could be allocated, using the lens and the criteria of six SCR strategies linked to the three lines of defense that absorptive, adaptive and restorative capacities that can differently lead to SCR (Hosseini *et al.*, 2019), as reported in Table 7.

In the first group (absence of capacities and no investment in SCR strategies), there is Solution 1, a combination of the absence of SCR strategies.

In the second group (presence of strategies linked to all three capacities), there are Solutions 6 and 8, which show a combination of different SCR strategies related to all three capacities. Solution 6 combines the absence of flexibility and the presence of information and knowledge sharing in terms of absorptive capacity, the presence of all the SCR strategies linked to adaptive capacity (agility, efficiency, responsiveness) and restorative capacity. Solution 8 combines the presence of flexibility in terms of absorptive capacity, the presence of all SCR strategies linked to adaptive capacity (agility, efficiency, responsiveness) and restorative capacity.

In the third group (presence of restorative capacity in conjunction with adaptive capacity), there are Solutions 2, 4 and 5. Solution 2 combines the absence of information and knowledge sharing in terms of absorptive capacity, the absence of all the SCR strategies linked to adaptive capacity (agility, efficiency, responsiveness) and the presence of restorative

Table 6 Sufficient configurations leading to SCR

Variables	Sol.1	Sol.2	Sol.3	Sol.4	Sol.5	Sol.6	Sol.7	Sol.8	Sol.9
Flexibility	⊗		●	⊗	⊗	⊗	●	●	⊗
Information and knowledge sharing	⊗	⊗	⊗	⊗		●	●		●
Agility	⊗	⊗	⊗	●	⊗	●	●	●	●
Efficiency	⊗	⊗			⊗	●	●	●	⊗
Responsiveness		⊗	●	⊗	●		●	●	⊗
Technological capability		●	⊗	●	●	●		●	⊗
Consistency	0.88	0.93	0.84	0.92	0.89	0.93	0.88	0.88	0.93
Raw coverage	0.42	0.31	0.21	0.27	0.28	0.29	0.29	0.32	0.20
Unique coverage	0.07	0.006	0.01	0.008	0.005	0.02	0.01	0.03	0.01
Solution coverage	0.64								
Solution consistency	0.85								

Notes: Sol. = solution. Black circles (●) indicate the presence of a condition; circles with a cross (⊗) indicate its absence; blank cells indicate the "do not care" condition, which means a specific condition is not considered in a solution
Source: Authors' own work

Table 7 Groups of SCR strategies configurations leading to SCR

		Group 1	Group 2		Group 3			Group 4		
		Absence of capacities and no investments in SCR strategies	Presence of strategies linked to all three capacities		Presence of restorative capacity and max. one strategy related to adaptive capacities			Presence of strategies linked to absorptive and adaptive capacities		
SCR capacity	**Variable (SCR strategy)**	**Sol. 1**	**Sol. 6**	**Sol. 8**	**Sol. 2**	**Sol. 4**	**Sol. 5**	**Sol. 3**	**Sol. 7**	**Sol. 9**
ABSORPTIVE	Flexibility	⊗	⊗	●		⊗	⊗	●	●	⊗
	Information and knowledge sharing	⊗	●		⊗	⊗		⊗	●	●
ADAPTIVE	Agility	⊗	●	●	⊗	●	⊗	⊗	●	●
	Efficiency	⊗	●	●	⊗		⊗		●	⊗
	Responsiveness			●	⊗	⊗	●	●	●	⊗
RESTORATIVE	Technological capability		●	●	●	●	●	⊗		⊗
Consistency		0.88	0.93	0.88	0.93	0.92	0.89	0.84	0.88	0.93
Raw coverage		0.42	0.29	0.32	0.31	0.27	0.28	0.21	0.29	0.20
Unique coverage		0.070	0.020	0.030	0.006	0.008	0.005	0.010	0.010	0.010
Solution coverage	0.64									
Solution consistency	0.85									

Notes: Sol. = solution. Black circles (●) indicate the presence of a condition; circles with a cross (⊗) indicate its absence; blank cells indicate the "do not care" condition, which means a specific condition is not considered in a solution
Source: Authors' own work

capacity. Solution 4 reflects a combination of the absence of all the SCR strategies related to the absorptive capacity, the presence of agility and the absence of responsiveness in terms of adaptive capacity and the presence of restorative capacity. Solution 5 reflects a combination of the absence of flexibility in terms of absorptive capacity, the absence of agility and efficiency with regard to adaptive capacity and the presence of restorative capacity.

In the fourth group (presence of strategies linked to absorptive and adaptive capacities, without strategies linked to restorative capacity), there are Solutions 3, 7 and 9. Solution 3 combines the presence of flexibility and the absence of information and knowledge sharing in terms of the absorptive capacity, the presence of responsiveness and the absence of agility linked to adaptive capacity and the absence of restorative capacity. Solution 7 combines the presence of all the strategies related to absorptive capacity and adaptive capacity, and the absence of restorative capacity. Finally, Solution 8 combines the absence of flexibility and the presence of information and knowledge sharing in terms of absorptive capacity, the presence of agility and the absence of efficiency and responsiveness linked to adaptive capacity and the absence of restorative capacity.

5.1 Linking the four groups of configurations to supply chain resilience performances

The nine solutions emerging from our fsQCA allowed us to define four companies groups, based on different SCR strategies (Wieland, 2021) and capacity combinations (Hosseini *et al.*, 2019) developed before, during and/or in response to the pandemic event. We now explain the differences among these four groups, and we will link each one more tangibly to the achieved SCR performance:

1 *Passive companies*: SCs achieving resilience in the absence of all absorptive, adaptive and restorative capacities and with no investments in SCR strategies. As documented in the risk management and resilience literature, several factors can lead to this situation. Some sectors and their SCs have not been affected by the COVID-19 pandemic or have shown smaller effects than others – for example agriculture, mining and quarrying, utilities and ICT as these are less likely to be affected by lockdowns and other restrictions. Other sectors received public and government support and were only partially affected by the consequences of pandemic-related disruptions (Anayi *et al.*, 2021). These SCs do not just include those that did not invest in resilience strategies before and during the pandemic; this profile possibly also comprises companies that did not suffer any potential impact and did not need to adopt managerial approaches to disruptions, following a kind of "laissez-faire" approach.

2 *Proactive, reactive and technology-driven companies*: companies achieving SCR through a mix of SCR strategies, leveraging all capacities (absorptive, adaptive and restorative), highlighting the presence of investments before and during the pandemic. This leads us to associate this companies' profile with the "proactive" and "reactive" definitions proposed by Hohenstein *et al.* (2015). These companies, and their SCs, used the three defense lines of resilience capacities by exploiting different strategy combinations. Pre-disaster (proactive) strategies relying on the absorptive capacity alone were insufficient for dealing with the COVID-19 pandemic, forcing firms to adopt post-disaster (reactive) strategies, being highly prompt to react during the pandemic and having in general a strong technological vocation. In particular, the presence of absorptive and adaptive capacities, supported by the booster of technological capacities, suggests the presence of strong and well-established relationships among SC partners, in line with the evidence of Chowdhury *et al.* (2019), who analyzed the impacts of resilient complex networks on relational practices.

3 *Reactive companies, driven by technological capabilities*: companies presenting a strong orientation toward technological capacities as a key enabler to quickly implement digitally driven reactions (Hohenstein *et al.*, 2015) but taking a (limited) adaptive approach, expressed by either agility or responsiveness. According to Pavlou and El Sawy (2006), IT capabilities can represent a key driver to achieve competitive advantage reactively in turbulent times, and in the COVID-19 era, they have become even more effective at enhancing resilience (Modgil *et al.*, 2022).

4 *Proactive but partially unplugged companies*: companies pursuing SCR through a mix of two to five ex-ante strategies based on absorptive and adaptive capacities, without investments in technological capabilities as restorative drivers for resilience. In two solutions, these companies, and their SCs, invested in information and knowledge sharing without using technological capabilities. This suggests the presence of a positive influence of "knowledge combination" (internal and external) (Zheng *et al.*, 2021, p. 85) in relationship with flexibility and absorptive capacity. These capacities can be also linked to the cooperation and communication between SC partners to achieve resilience, according to Wieland and Wallenburg (2013), but our results add to how these relational competencies are achieved: without the use of the technological capability. Hence, one solution of this group presents responsiveness and flexibility as key SCR strategies, without the use of the restorative technological capability. These solutions do not indicate digital technology is absent; rather, they indicate these companies are not part of technology-driven or digital-driven SCs, distancing from two of the suggested resilience research paths suggested by Ivanov (2021).

6. Discussion

The results described offer an original view and a complex picture of how companies and their SCs have combined SCR strategies, and related capacities, to achieve SCR and to cope with disruptive events. These emerging possible configurations appear new with respect to the existing studies, and reveal several complex patterns the SC adopt to achieve SCR since heterogenous and diverse solutions can lead to achieve the same outcome, that is SCR. The emerging profiles stem from a classification of companies with similar characteristics: the presence and absence of the six SCR strategies are further categorized according to the lens of absorptive, adaptive and restorative capacities. SCR can be achieved not only through different patterns of strategy implementation but also by relying on a combination of different capacities depending on when these SCR strategies need to be implemented: before the pandemic (through absorptive capacities), in conjunction with the pandemic (through adaptive capacities), and/or fostering technological investments [through information technology (IT)-based restorative capacities). In fact, our results show SCR is pursued not only through different SCR strategy combinations but also with different temporal alignments of internal organizational capacities, strategic investments and external variables related to disruptive events, as suggested by CRBV theory.

6.1 Implications for theory

This study contributes to the development of a new stream of research, that addresses the combination of SCR strategies under the lens of CRBV. In particular, this study contributes by identifying a set of equifinal SCR strategies with different patterns of implementation, relying on a combination of different capacities depending on when these SCR strategies need to be implemented: before the disruptive events (through absorptive capacities), in conjunction with them (through adaptive capacities), and/or after the disruptive events, fostering technological investments (through IT-based restorative capacities) (Hosseini *et al.*, 2019). This study also enriches the research addressing the consecutives phases of SCR investments, such as that of Mena *et al.* (2022), which distinguished between robustness and responsiveness, and that of Hohenstein *et al.* (2015), which defined the consecutive phases of readiness, responsiveness, recovery and growth. In our results, five solutions describe cases of companies that invest in absorptive capacities, representing an *ex ante* readiness. However, in no solution has absorptive capacity alone been developed to reach resilience but only in conjunction with different paths of investments. Seven solutions describe cases of companies that invest in adaptive capacities that comprehend and further develop the Hohenstein *et al.*'s (2015) definition of responsiveness. In five solutions, technological capability plays a key role in assuring recovery and accelerating the effectiveness of adaptive capacities, as shown by Modgil *et al.* (2022). However, there are also cases that are not technology-driven, for which the *ex ante* investments in relations are not linked to IT investments during the recovery phase.

From this perspective, the study moves an additional step closer to the adoption of the CRBV as a key lens through which to address this temporal alignment between the SCR strategies, their temporal patterns of implementation, relying on a combination of different capacities to cope with a disruptive event, such as the recent COVID-19 pandemic (Aragòn-Correa and Sharma, 2003; Brandon-Jones *et al.*, 2014; Chowdhury *et al.*, 2019). The use of QCA in the field of CRBV offers a contribution with respect to the studies that applied fsQCA using the RBV theoretical lens (Berger *et al.*, 2018). Most studies have aimed to map linear relationships between the characteristics of resources, capacities and outcome variables (Berger *et al.*, 2018), but few studies have depicted the complex set of SCR strategy and related capacities configurations in the different phases of a disruptive event. Turbulent times require more attention to investigating how to achieve resilience, as Pavlou and El Sawy (2006) highlighted.

6.2 Implications for practice

The COVID-19 pandemic has been a global, complex and durable disruptive event (Ivanov, 2020), requiring investigation of not only the complex and nuanced configurations of adopted SCR strategies but also investments in different timelines. The recent events in Ukraine and the "energy/raw materials war" already represent a new scenario in which managers should carefully select the adoption of proactive or reactive SCR strategies.

The different configurations the study identified offer decision makers a multifaced understanding of the importance of investing in the right SCR strategies at the right time, according to a specific SC's attitudes and capacities. It means managers do not need to pursue all SCR strategies and linear relationships between SCR strategies cannot be representative. The findings empirically showing that companies and their SCs reached SCR with different configurations of capacities and defense lines confirm the recent literature on SCR defined from two perspectives (Wieland, 2021; Wieland and Durach, 2021), not only from the engineering perspective as a fail-safe design, but also from an ecological perspective as adaptability e transformability. Hence, not only those companies and SCs "able to recover its original shape after a deformation," behaving as closed, engineerable systems, have been resilient, but also those companies and SCs that have responded in a different way to the pandemic, with diverse defense lines, behaving as open, social ecological systems. The foundation of the CRBV theory allows managers to understand the relevance of the temporal investments in capacities that – differently configured – can achieve SCR. SCs may have particular characteristics and/or their companies may have different risk-taking profiles (Hock-Doepgen *et al.*, 2021) that can dramatically reduce/increase exposure to disruption and hence vulnerabilities. This may be the case with passive companies that do not act but are resilient. Conversely, companies, and their SCs, that invested *ex ante* and then presented a proactive responsiveness and a digital-driven capacity confirmed any recipe can explain everything. This study could encourage decision makers to carefully select the configuration of SCR strategies before the disruptive events, and to cope with them, where possible and in the most effective way.

6.3 Limitations and future research

Although this study contributes to filling an existing gap in the field of SCR, the research has some limitations that provide opportunities for future research. The temporal perspective in the adoption of SCR strategies and capacities can be extended considering the post-pandemic period. The conditional and mediation effects among SCR strategies can be further empirically investigated, in different countries and larger samples. Future studies can also further explore the temporal adoption of SCR strategies and capacities, and relations between companies' demographic characteristics, impacts suffered and SCR strategies and capacities adopted. Furthermore, the panel of the selected SCR strategies and capacities – that this study has robustly grounded in the literature – could be further extended, including more strategies that have been addressed in the literature in conjunction with SCR.

7. Conclusions

This study addresses the configurations of SCR strategies adopted by a sample of SCs during the COVID-19 pandemic, under the three perspectives of absorptive, reactive and restorative capacities. Based on the CRBV, the study identified four different profiles depending on when and how SCs implemented their SCR strategies. FsQCA allowed us to address different strategy and capacity configurations, highlighting a nuanced view of the pathways to achieve SCR. Our results contribute to fill a gap in the literature related to the comprehensive analysis of several approaches to achieve SCR. We empirically addressed four consistent companies' profiles based on when and how they invested in SCR strategies and capacities, revealing no single recipe is sufficient or necessary for ensuring SCR.

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Further reading

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