



# Conceptualizing Supply Chain Resilience in Exogenous Crisis Times: Toward a Holistic Definition

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## Abstract

Supply chain resilience has become increasingly crucial in today's scenario in response to major disruptions that generated huge exogenous crises. This paper investigates the current SCR-related academic literature related to SCR to develop a new holistic definition. A total amount of 214 scientific contributions the last 5 years (i.e., between 2018 and 2022) have been analyzed. Findings revealed four important issues to achieve SCR, i.e., *Key resilience attributes*, *Technology-aided visible SC*, *Sustainable and measurable SCR practices*, and *Relationship between SC partners*. Leveraging insights gleaned from these critical issues, we have meticulously crafted an updated and comprehensive definition of SCR, by considering the multi-faceted facets that contribute to its holistic understanding. In light of our emerging insights, we suggest a novel approach to fortify organizational supply chain resilience, emphasizing a more holistic perspective. Our recommendations for future research include (1) exploring the integration of emerging technologies like blockchain and artificial intelligence for real-time monitoring to enhance adaptive decision-making in post-COVID-19 supply chains, (2) investigating the strategic role of collaborative networks and information sharing among supply chain partners to enhance agility and responsiveness amidst post-pandemic uncertainties, and (3) analyzing the impact of sustainable and circular supply chain practices on resilience. Findings of the paper and the new holistic definition of SCR have several implications for both academics and managers that are listed at the end of the paper along with limitations of the study and future research avenues.

**Keywords** Supply chain resilience · Systematic literature review · COVID-19 · Supply chain disruption

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## Introduction

In the aftermath of the global pandemic and by considering the broader responses to general exogenous crises (major disruptions) such as the recent wars in Ukraine and in Gaza, it is imperative for organizations to cultivate resilience as a fundamental facet of their operational framework (Faggioni et al., 2023). Particularly crucial in this regard is the fortification of supply chain management mechanisms, as the ability to navigate disruptions in the supply chain landscape emerges as a cornerstone of sustained organizational efficacy (Novak et al. 2021).

In response to these disruptions, several organizations have grappled with the imperative challenge of enhancing the resilience of their global value and supply chains. This imperative has been underscored by the need to optimize operational processes, safeguard output quality, ensure the sustainability of overarching procedures, reconfigure supply networks, update knowledge and capabilities, and navigate the complexities of a global crisis (Ivanov & Dolgui, 2019). Although the concept of supply chain resilience (SCR) is not novel within managerial discourse or as a robust business strategy in the face of adverse contingencies (Christopher & Peck, 2004; Kähkönen & Patrucco, 2022; Sheffi & Rice, 2005), the aftermath of the recent pandemic has elevated SCR to a paramount concern for supply chain managers, propelling them toward a fervent quest for solutions aimed at fortifying the resilience of their supply chains (Bak et al., 2020; Kähkönen & Patrucco, 2022). SCR, as conceptualized over the years, is delineated as a multi-faceted construct, with diverse definitions elucidating its conceptual boundaries. Christopher and Peck (2004) posit SCR as “the ability of a system to return to its original state or move to a new, more desirable state after being disturbed” (p. 2), while Ponomarov and Halcomb (2009) define it as “the supply chain adaptation capability to prepare for unexpected events, respond to interruptions, and recover from them to maintain continuity of operations at the desired level of connection and control over the structure and function” (p. 131). Scholars collectively perceive SCR as the capacity of a supply chain to ensure continuity in operations, heighten effectiveness in absorbing disruptions, and mitigate the time-to-recovery, signifying the duration required to recuperate from a disruptive negative event (Kamalahmadi & Parast, 2016). Nevertheless, a consensus exists among researchers that prevailing definitions of SCR lack precision and may engender misconceptions among practitioners and scholars (Dickens et al., 2023; Faggioni et al., 2023; Ribeiro & Barbosa-Povoa, 2018). Consequently, scholarly inquiry advocates for renewed efforts, including comprehensive literature reviews, to elucidate the nature and characteristics of SCR, especially given the resurgence of interest in the subject, leading to a proliferation of multi-disciplinary contributions that have engendered a fragmented knowledge base on the matter (Katsaliaki et al., 2021).

To address the aforementioned concerns, this paper provides a systematic literature review of the contemporary state-of-the-art, to augment the robustness of the discourse and offer an all-encompassing definition of supply chain resilience (SCR). A systematic literature review focused on the last 5 years (2018–2022), because of the considered exogenous crisis (i.e., the pandemic) has been conducted, and because of the multi-disciplinary contributions on this matter.

Moreover, in the last year and a half, the pandemic has magnified the importance of being resilient for SCs, as it has been acknowledged as one of the most impactful disruptions of the last decades (BCI 2021). Coherently, the COVID-19 pandemic has not only led firms to a “new normal,” to which they necessarily have to adapt (e.g., the daily use of personal protective equipment—PPE), but it will also have significant disruption tails for SCs (Ivanov, 2021).

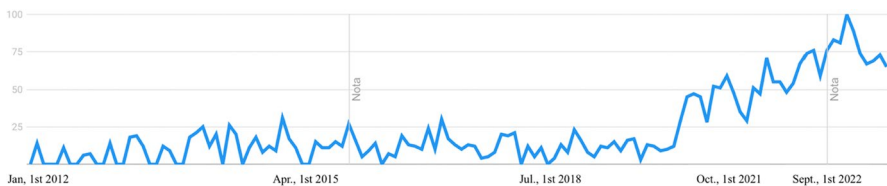
Furthermore, to better confirm the recent renewed attention around SCR both as a “buzzword” and as strong business strategy, we searched for web pages dealing with “supply chain resilience” as a term during the last decade (2012–2022), by showing how SCR popularity incredibly increase in the end of 2019: This confirms the researchers’ interest, and literature knowledge in the selected period (see Fig. 1).

As suggested by the figure above (Fig. 1), despite constant interest in the SCR over the last decade (2012–2022), a considerable spike may be found at the turn of the COVID-19 pandemic, and thus since the end of 2019, currently still increasing also because of the consequences of the pandemic and still changing variants (Pujawan & Bah 2022), thus confirming authors’ intuitions, and making valuable the effort to provide a systematic conceptualization on the matter.

Based on above, the research questions we aim to answer by means of the review is:

*RQ1.* Which are the fundamental topics in terms of current issues and opportunities, dealing with the current literature about SCR together with the related promising strands of research requiring further investigation, useful to provide a fresh and comprehensive holistic definition of SCR, on the basis of such insights?

The insights of our literature review shed light on four pivotal dimensions crucial features of supply chain resilience (SCR), regarding the identification of key resilience attributes, the integration of technology for enhanced supply chain visibility, the adoption of sustainable and measurable SCR practices, and the exploitation of inter-organizational relationships among supply chain partners. Based on our emerging insights, we suggest the exploitation of a new approach to embrace the resilience of organizations’ supply chain, accordingly a more holistic vision, and we stimulate future research in terms of (1) the investigation of the integration of emerging technologies, such as blockchain and artificial intelligence, in enhancing real-time monitoring and adaptive decision-making within supply chains to fortify resilience in the aftermath of the COVID-19 pandemic; (2) the examination of the role of collaborative networks and information sharing among supply chain partners as a strategic avenue to bolster resilience, with a focus on fostering agility and



**Fig. 1** Popularity of “supply chain resilience” as a term among web users, between 2018 and 2022: The vertical axis shows the relative search frequency of each term included the group of selected terms, normalized within the [0, 100] range. Authors’ elaboration. Source: Google Trends

responsiveness in the face of dynamic post-pandemic uncertainties; and (3) inspiring future analysis regarding the influence of sustainable and circular supply chain practices on resilience.

## Methodology

As declared above, in the attempt to answer the proposed research questions also by capturing useful insights hidden in the recent advanced on the SCR domain, a literature review systematic approach may guarantee the identification of the fundamental contributions to scientific progress because able to identify which ones inspired subsequent research, and by shedding light on current gaps, issues and opportunities which researchers, scholars, and practitioners might focus (Tranfield et al., 2003).

According to Tranfield et al. (2003), and similarly to Sestino et al., (2020, 2022), an extensive analysis of the most relevant management literature search engines to which we had access through our Institution library system has been conducted, e.g., as for we used ScienceDirect, Emerald, EBSCO Business Source Complete, Wiley Online Library, IEEE Xplore, Taylor and Francis Online, Google Scholar, and ResearchGate, by exploring those databases by keywords, to collect the most relevant articles coherent with the proposed research questions.

The collected articles have been then managed with the help of Mendeley, a scholarly reference manager and citation generator software which is widely used (Morenikeji, 2017). For our analysis, we adopted the seven-stage approach proposed by Fan and Stevenson (2018), consisting of (1) research questions formulation; (2) keyword definition, and database mining; (3) duplicates removing; (4) analysis of article quality and relevance assessment; (5) other relevant articles capture; (6) full-text analysis; and (7) reporting. Thus, the ensure consistency and in the attempt to propose a solid review, also aimed to provide a final comprehensive holistic definition of SCR, the captured findings have been reviewed and synthesized results in a coherent and integrated manner (Bal & Nijkamp, 2001).

By considering the RQ deriving from the first stage, and proposed at the end of the “[Introduction](#)” section, we then selected a list of keywords able to query the selected database by considering a period of 5 years (2018–2022). More specifically, by following the approach proposed by Ho et al. (2015), we used broad terms in the attempt to consider all the relevant papers on the topic, thus also by capturing those one not be correctly indexed by the search engines, thus also including studies that use different or alternative nomenclatures. Thus, we used the following strings of research: “supply chain resilience” AND “supply chain” AND “resilience,” according a sample used query as TITLE-ABS (“Supply chain” or “SC”) and (“resilience” or “SCR”) AND 2018<PUBYEAR<2022 AND ( LIMIT-TO ( DOCTYPE, “ar”) OR LIMIT-TO ( DOCTYPE, “cp”) AND (LIMIT-TO (LANGUAGE, “English”).”

After a first search led us to find 2,35 articles for the selected time span (January 1st, 2018–July 1st, 2022), we made an exception to our searching protocol to also include papers found by typing “business continuity” and “business

resilience,” as these terms are often used as synonyms for SCR. This returned 2747 articles. Notably, confirming our intuitions, the amount of research on the SCR has grown steadily since 2018, currently increasing, also according to the popularity of SCR as a term among web users shown in Fig. 1.

In the third stage, all the papers have been analyzed in a first screening based on authors so as to remove all the duplicates, and to understand, on the basis of the contents included in titles and abstracts of papers, if the final selected papers were actually dealing with the topic of interest. After the screening, more than 50% of papers were excluded from the literature review because of their different scope, or because their typologies were different from journals' articles (e.g., conference papers, working papers, thesis, PhD dissertations, books, managerial literature).

Coherently with the fourth stage and the proposed methodology (Fan & Stevenson, 2018), in the attempt to address the quality of the remainder set of papers, we chose to include only peer-reviewed papers in the final set which had been published in journals with an impact factor (IF) higher than, or equal to, 2.66, as this value is considered a very good IF for the “Business, Management, and Accounting” journals' category, according to the Sci Journal (2018) ranking. This second screening resulted in a final set of 214 papers, that were consequently included in the review process to answer the RQs.

Accordingly, to the fifth stage of the literature review process, we then we checked the references of the selected articles, finding that eight new papers were eligible, in terms of scope and issue, to be included in our final set of papers, to capture other relevant studies that we might have missed in the first search. However, we noted that the papers referred to were not published in journals with an IF higher than 2.66, and so we did not include them in the final set. Additionally, a last search was conducted on Google Scholar to identify papers published in the last days before the beginning of writing, but also in this case there were no articles eligible to be included in the final set of papers, which therefore remained as 214 studies.

Subsequently, in the sixth stage, the collection of papers included in the final set were all read and analyzed by the authors, independently. An MS Excel database with multiple electronic sheets was created to summarize all the information useful for the necessary analyses. In addition to the “traditional” bibliographic information (such as author(s), year, journal, number of pages, DOI), we explored the following: If papers provided a definition of SCR, the methodology used, if there were a specific industry as a context for investigation, and if one or more of the countries being investigated were developed. Clearly, some information was extrapolated in a deductive way (e.g., country or industry, if indicated in the title), while other data were discovered in a more inductive manner (e.g., if a new definition of SCR had been provided).

Finally, at the seventh and last stage of our literature review activity, we reported a descriptive and thematic analysis (Braun & Clarke, 2006), according an integrated and coherent manner (Bal & Nijkamp, 2001). The adopted seven-stages methodology process is shown in the figure below (Fig. 2).

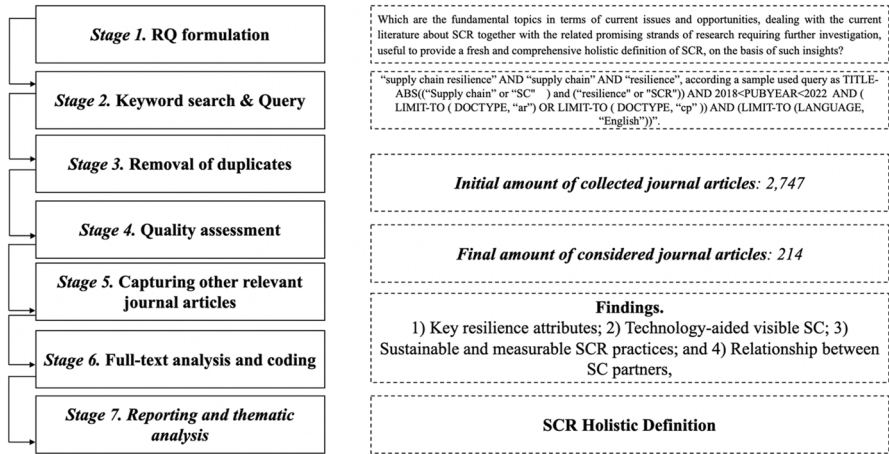


Fig. 2 The proposed systematic literature review–based research approach

## Findings

### Descriptive Analysis

First of all, our literature review significantly confirmed a renewed attention toward SCR, consistently with a significant increase in scholarly interest in the SCR thematic during the relevant time span (2018–2022; see Fig. 3). In fact, while only 28 (out of 214) articles were published in 2018, representing the 14% of the total, in 2019 and

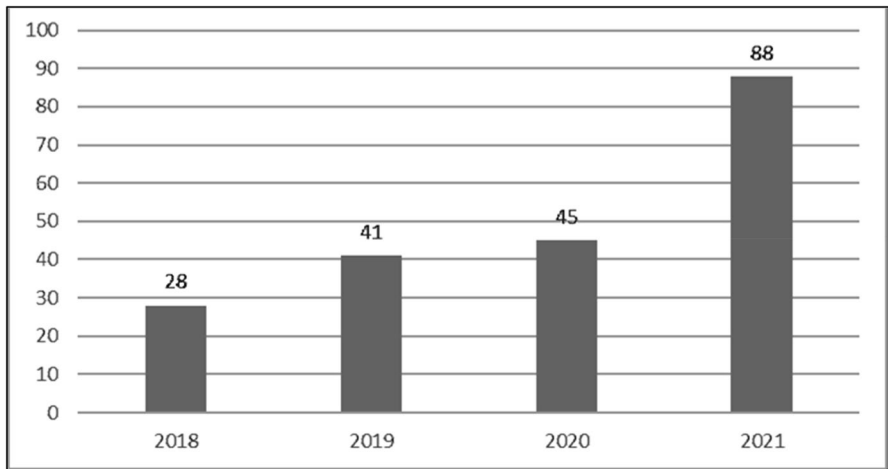
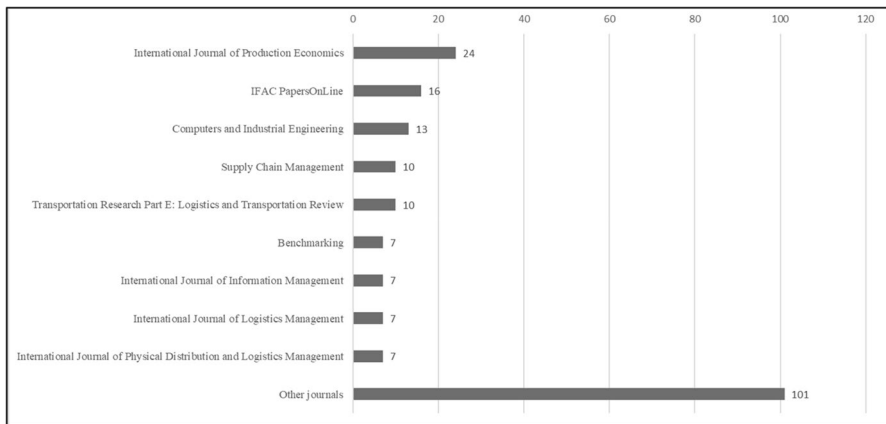


Fig. 3 Bar chart about SCR-related journal articles (2018–2022). *Note.* Despite the findings are built on the basis of the full period (2018–2022), the contributions related to the 2022 are only referred to the first semester, and thus not shown in the bar chart above

2020, 41 and 45, respectively, were published in high-quality journals. Given that getting published in a top peer-reviewed journal requires quite a long time (perhaps several months, or sometimes 1 or 2 years), we treated 2018, 2019, and 2020 articles as pre-COVID-19 papers, while only articles published in 2021 were considered post-COVID-19 publications. In our unanimous view, 2021 has been “the year of SCR,” with 88 papers published on this topic (43.5% of the final set). This is the first interesting insight in relation to our second RQ, as the significant imbalance in the number of publications (2021 accounted for more articles—88—than the sum of papers published in 2019 and 2020—86) is initial evidence per se of a change in the importance of, and interest in, this theme from scholars. In such analysis, 2022 has not be considered because the analysis stops at July 1st, 2022. However, in presenting the most relevant findings, the most valuable contributions produced in the period January 1st, 2022–July 1st, 2022, have been considered as well.

As shown in Fig. 4, about half of the selected articles for review were published in nine different journals, with the highest number of articles published in the *International Journal of Production Economics*. The other half of papers were published in 56 other journals, with a maximum of six articles in a few journals like the *European Journal of Operational Research* and a minimum of one paper in many other journals (e.g., *Computers in Industry*, *European Management Journal*).

In Tables 1 and 2, we summarized papers that investigated specific geographical context(s) and industry(ies). Before continuing, it is important to highlight a methodological note. Since some papers are conceptual and/or theoretical in nature (both “pure” conceptual papers and literature reviews) or proposing a simulation/mathematical model (see below) as research approach, not all of the 214 papers analyzed have a geographical context(s) or industry(ies) to which the study refers, or the authors did not specify these details in the papers. Therefore, we coded all the papers that did not include these details as “N/A.” Regarding papers that adopted



**Fig. 4** Bar chart about SCR-related journals: The graph presents those journals welcoming at least seven articles on the matter (2018–2022). *Note.* Despite the findings are built on the basis of the full period (2018–2022), the contributions related to the 2022 are only referred to the first semester, and thus not shown in the bar chart above

**Table 1** Number of selected journal articles, grouped by *industry*

Code	Number of selected journal articles	% of journal articles included in the final set (214)
Single industry	52	24.30
Multiple industries	54	25.23
N/A (industry)	108	50.47
<b>Total</b>	<b>214</b>	<b>100</b>

**Table 2** Number of selected journal articles, grouped by *countries*

Code	Number of selected journal articles	% of journal articles included in the final set (214)
Single country	74	34.58%
Multiple countries	24	11.21%
N/A (country)	116	54.21%
<b>Total</b>	<b>214</b>	<b>100</b>

a single-industry approach, most of the studies investigated industries such as the automotive (e.g., as for in Kaviani et al., 2020) and food (e.g., as for in Alikhani et al., 2021). These were also the principal sectors for authors that studied multiple industries, with a noticeable increase in the pharmaceutical, medical equipment, and healthcare industries in studies published in 2021. This was evidently influenced by the advent of the COVID-19 pandemic (e.g., Rahman et al., 2021). Excluding papers that did not refer explicitly to one or more specific industries, we noted a near-perfect balance between papers investigating single and multiple industries (52 vs. 54, respectively). Regarding the geographical context of investigation (single country vs. multiple countries), we observed that a clear majority of papers focused on single countries (74), while only few papers conducted research in two or more countries simultaneously (24). Moreover, by considering the selected papers, the context of investigation was related to both developed countries (and specifically mostly conducted in North America and European countries, e.g., Germany, UK, France, Spain, Italy, Norway; e.g., as in Dickens et al., 2023; Schätter et al., 2019) and to developing countries (especially China, India, Iran, Taiwan, and some African and South-African regions; e.g., as in Raut et al., 2021; Wang et al., 2021).

Moreover, additionally to the country and industry of investigation, we also coded the research methodologies adopted by the papers included in our final set. We divided papers into three major categories, specifically, conceptual papers (which also include perspective and opinion studies, e.g., Verboeket & Krikke, 2019), review papers (both systematic and non-systematic, e.g., Chowdhury et al., 2021), empirical and other papers (also simply known as “empirical papers,” e.g., Ali et al., 2021; Mandal & Dubey, 2021; Roßmann et al., 2018). The latter was split in two sub-categories, namely, qualitative papers and quantitative papers. In the quantitative papers category, we included not only papers which adopted “traditional” empirical techniques of data analysis (e.g., exploratory and confirmatory



factor analysis, structural equation modeling), but also studies based on simulations, experiments, mathematical, stochastic, and algorithmic models (e.g., Behzadi et al., 2020; Salama & McGarvey, 2023; Snoeck et al., 2019). Qualitative papers, on the other hand, mostly adopted research methods such as the Delphi method, single and/or multiple case study(ies) analysis, focus groups, and in-depth semi-structured interviews (e.g., Ferreira et al., 2021; Nandi et al. 2020; see Table 3).

The category of empirical and other papers contained the overwhelming majority of the set of papers considered, with a strong difference in number between qualitative (27) and quantitative (126) journal articles. Review papers (31) included both traditional and systematic literature reviews on SCR, with the main objectives of illustrating gaps in the literature and providing avenues for future research (e.g., Al Naimi et al., 2022; Bak et al. 2020). Finally, conceptual papers (23) were mainly focused on providing conceptual and interpretative frameworks to understand one or more specific aspects, resources, and tools that a SC can use to achieve resilience (e.g., Beninger & Francis, 2022). These included, for example, the benefits of blockchain technology adoption to mitigate risk, the enhancement of supply chain visibility, and trust between partners, strengthening resilience in single nodes of the chain or in the overall network (e.g., Min, 2019).

Finally, considering our RQ, we explored all 214 final selected journal articles, to look for definitions of SCR, as the formulation of a new and more comprehensive definition is the primary objective of this paper. Out of the 214 articles, we found only two papers that formulated a new definition of SCR (Ribeiro & Barbosa-Povoa, 2018; Wieland & Durach, 2021), that is, less than 1% of our entire set, confirming that SCR literature needs more efforts by scholars to conceptualize and to define this concept, especially holistically. Wieland and Durach (2021, p. 2) defined SCR as “the capacity of a supply chain to persist, adapt, or transform in the face of change”; on the other hand, Ribeiro and Barbosa-Povoa (2018) stated that “a resilient supply chain should be able to prepare, respond and recover from disturbances and afterwards maintain a positive steady state operation in an acceptable cost and time” (p. 116). As stated previously, although these are acceptable definitions, we believe that they are still rather vague and unable to capture the complexity and multi-dimensional aspects of a concept like resilience. Therefore, in the remainder of this study, we will analyze all the SCR’s most important elements to provide a new definition that can be as holistic and comprehensive as possible, given these elements.

**Table 3** Number of selected journal articles, grouped by adopted research design

Code	Number of selected journal articles	% of journal articles included in the final set (202)
Conceptual papers	23	11.38
Review papers	31	15.34
Empirical and other papers		
-Qualitative	27	12.62
-Quantitative	126	58.88
<b>Total</b>	<b>214</b>	<b>100</b>

## Thematic Analysis: Toward a New SCR Conceptualization and a Holistic Definition

Given the novelty of the scenario created by the COVID-19 pandemic, we decided to adopt an inductive approach to the thematic analysis of our set of papers (Armstrong, 1979; Braun & Clarke, 2006). With this method, we have uncovered all the elements considered most important by SCR literature to achieve resilience in the last four years (our time span, which ranged from 2018 to 2021).

### SCR Elements and Main Findings from the Literature Review

Scholars have studied SCR from many viewpoints, but, in general, SCR today is still viewed as it was in its original formulation, that is, as the ability to overcome a negative shock (disruption), and recover as fast as possible from the damage that this shock has caused to part or the entire supply chain (e.g., Christopher & Peck, 2004; Sheffi & Rice, 2005). Over the years, to better understand this complex concept, authors have begun focusing on elements that characterize SCR, and have created conceptual and quantitative models to understand and test resilience (e.g., Fattahi et al., 2020; Snoeck et al., 2019; Taleizadeh et al., 2021). They have interviewed experts and practitioners to obtain their opinions on SCR (e.g., Belhadi et al., 2021; Modgil et al., 2021), while reviewing relevant literature in this field (e.g., Chowdhury et al., 2021; Pujawan & Bah 2022).

Despite these valuable efforts, almost all authors admit that we are still far from figuring out what resilience really is, as it is characterized by so many elements. Therefore, it is really difficult to take them all into account when studying SCR, also given that the latter is strictly related to the context and industry being investigated (e.g., Alikhani et al., 2021; Stone & Rahimifard, 2018).

As a result, we noted that SCR is considered by practically all authors to be a multi-faceted concept, in which an important role is played by several business elements. In this regard, the most recurrent elements in literature are “flexibility” (e.g., Chunsheng et al., 2019), “agility” (e.g., Bernus et al., 2020), “visibility” (e.g., Doetzer, 2020), “collaboration” (e.g., Da Silva Poberschnigg et al., 2020), “responsiveness” (e.g., Shekarian et al., 2020), “trust between network’s partners” (e.g., Giannoccaro & Iftikhar, 2019; Hou et al., 2018), “the potential aid provided by advanced digital technologies” (e.g., Autio et al., 2021; Lai et al., 2021; Modgil et al., 2021), “socio-ecological and financial sustainability” (e.g., Kaur et al., 2020; Nayeri et al., 2021), “organizational ambidexterity” (e.g., Makhashen et al. 2020; Wang et al., 2021), “vulnerability and robustness” (e.g., El Baz & Ruel, 2021; Ferreira et al., 2021; Sharma et al., 2021), and “adaptability and reconfigurability” (Ivanov & Dolgui, 2021; Zidi et al., 2021). All these elements have been discussed by scholars as isolated concepts (e.g., Iborra et al., 2020) and/or as a strategic set of capabilities to achieve SCR (e.g., Shekarian et al., 2020), sometimes as antecedents (Aslam et al. 2020; Scholten et al., 2019), and sometimes as drivers (Hosseini et al., 2019; Yang et al., 2021) of SCR. Nevertheless, to the best of our knowledge, no research has studied SCR’s elements all together in detail, and this is what will be presented in the remainder of this study—a new SCR definition that comprises the contribution of all these elements to achieve resilience in a SC.

Given the large number of these SCR elements, and the above-mentioned issues related to SCR's complexity, we believe that to categorize them into "logical" clusters that consider their "real" significance is a good way to better understand the value that these elements could add to SC to achieve higher levels of resilience. With this categorization, we have aimed to offer to scholars and practitioners a new, more comprehensive, and holistic definition of SCR. Our categorization proposal is shown in Table 4, and it is composed by four clusters. In the remainder of this subparagraph, we briefly describe each of these categories.

### Key Resilience Attributes

We named the term "key resilience attributes" to group together all the SCR elements that are dynamic in nature, and that are essential capabilities for a SC to be resilient, according to extant literature. The first capability is "flexibility," in terms of the "company's ability to adjust following a disruption" (Liu & Lee, 2018, p. 7), and "to adapt to the changing environment" (Al-Omouh et al., 2020, p. 282). Flexibility is often studied together with "agility" and "responsiveness," as some authors consider flexibility to be an antecedent of these two capabilities (Shekarian et al., 2020).

Actually, there are authors who consider agility and flexibility to be subsumed in responsiveness (e.g., Chen et al., 2019), while others consider agility as a stand-alone concept, describing it as the capability to respond to market changes in a timely manner (Mohammed et al., 2019). Furthermore, Shekarian et al. (2020) demonstrated that flexibility and agility have a positive effect on responsiveness, but agility has a stronger impact on responsiveness than flexibility, where responsiveness is considered to be the sum of flexibility and agility, in other words, the "ability of a supply chain to respond purposefully and within an appropriate time-frame to customer requests or changes in the marketplace" (Shekarian et al., 2020, p. 3). Finally, flexibility, agility, and responsiveness are considered to be at the core of redundancy strategies of SC, as to be able to respond rapidly and effectively to changes in the business environment is essential to reduce the impact of disruptions (Albertzeth et al., 2020; Duong & Chong, 2020; Gaur et al., 2020).

Two more important resilience attributes for SCR are "ambidexterity" and "adaptability." The first one refers to the ability to achieve "multiple seemingly contrasting objectives at the same time (i.e., resilience and efficiency). This means that organizations in pursuit of higher resilience cannot relinquish efficiency and vice versa" (Aslam et al., 2020, p. 1186). On the other hand, adaptability is "the ability to modify supply chain design in order to accommodate structural changes in the market and adjust the supply network according to strategies, technologies and products" (Aslam et al., 2020, p. 1188). According to many researchers, both capabilities lead to SCR and to a superior and sustainable competitive advantage (Ali & Gölgeci, 2019; Vanpoucke & Ellis 2019). Strictly related to the previous abilities is the SC "reconfigurability": Such key is considered an essential ability to mitigate the ripple effect after a disruption occurs and it can be defined as "a network designed in a cost-efficient, responsive, sustainable and resilient manner (...) to survive in a changing environment by redesigning the supply chain structures" (Dolgui & Ivanov, 2020, p. 2).

**Table 4** Categorization of the most studied SCR elements by scholars

Category/cluster	SCR elements	Rationale for inclusion in the category	Sample reference(s)
<i>Key resilience attributes</i>	<ul style="list-style-type: none"> <li>- Flexibility</li> <li>- Agility</li> <li>- Responsiveness</li> <li>- Ambidexterity</li> <li>- Adaptability</li> <li>- Reconfigurability</li> <li>- Robustness</li> <li>- Vulnerability</li> </ul>	<p>These elements are widely recognized by scholars as crucial elements of SCR, and can be seen as dynamic capabilities that a firm or a SC must have to be resilient (e.g., Aslam et al., 2020; Hosseini et al., 2019; Shekarian et al., 2020). In fact, their dynamism qualifies them as dynamic capabilities within the meaning given to these capabilities by Teece et al. (1997, p. 516) “the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments”</p>	<ul style="list-style-type: none"> <li>- Hosseini et al. (2019);</li> <li>- Shekarian et al. (2020);</li> <li>- Aslam et al. (2020)</li> </ul>
<i>Technology-aided visible SC</i>	<ul style="list-style-type: none"> <li>- Visibility</li> <li>- Advanced digital technologies for SCR</li> </ul>	<p>As “Supply chain visibility engages with the internal and external sharing of essential information in a supply chain and enables resilient relationships between supply chain actors” (Doetzer, 2020, p. 1), a SC cannot have complete end-to-end visibility of the network players without using advanced digital technologies to predict and record in real-time what happens along the chain</p>	<ul style="list-style-type: none"> <li>- Doetzer (2020);</li> <li>- Finkenstadt and Handfield (2021);</li> <li>- Liu and Lee (2018)</li> <li>- Srai and Lorentz (2019)</li> </ul>

**Table 4** (continued)

Category/cluster	SCR elements	Rationale for inclusion in the category	Sample reference(s)
<i>Sustainable and measurable SCR practices</i>	<ul style="list-style-type: none"> <li>- Socio-ecological sustainability</li> <li>- Financial sustainability</li> </ul>	<p>To be effectively resilient, a SC must be sustainable both from the socio-ecological and financial sides. Scholars report that there cannot be a “fully” resilient SC if financial (e.g., Behzadi et al., 2020), social, and ecological factors (e.g., job creation and fixation of emissions’ limit—Das, 2018; Rahimi et al., 2019) are neglected and not measured to understand their sustainability</p>	<ul style="list-style-type: none"> <li>- Das (2018);</li> <li>- Rahimi et al. (2019);</li> <li>- Behzadi et al. (2020)</li> </ul>
<i>Relationships between SC partners</i>	<ul style="list-style-type: none"> <li>- Trust</li> <li>- Collaboration</li> </ul>	<p>SC visibility is a necessary, but not sufficient, condition to guarantee resilience to a SC. It has been proved that an essential role is also played by trust and collaboration between network partners, both at the upstream and downstream levels. In the global supply chain, several elements affect collaboration and trust between SC actors, such as different organizational cultures and local government legislation (Giannoccaro &amp; Iftikhar, 2019; Hou et al., 2018; Mwesumo et al. (2021))<sup>555</sup>;</p>	<ul style="list-style-type: none"> <li>- Hou et al. (2018)</li> <li>- Giannoccaro and Iftikhar (2019)</li> <li>- Mwesumo et al. (2021)</li> </ul>

To conclude, SC “robustness” conversely is related to the “firm’s ability to maintain its planned performance following a disruption (or a series of disruptions) impacts” (El Baz & Ruel, 2021, p. 11). In this respect, it is considered to be different from resilience, which concerns the “ability to recover the performance after having absorbed the disruption effects” (El Baz & Ruel, p. 12). On the other hand, SC vulnerability is often considered the inverse of robustness, and therefore it is characterized by the degree to which a SC can be damaged from a disruption (Gu et al., 2021).

### Technology-Aided Visible SC

In this second category, we included the concept of SC “visibility” and the advanced digital technologies that allow SC actors to have higher visibility along the chain nodes (e.g., as in Srail & Lorentz, 2019). SC visibility refers to the exchange and the sharing of information between the actors of the SC network, thus comprising an internal and external dimension, in order to enable stronger relationships between actors, and to push them to be more transparent and visible (Doetzer, 2020). Achieving a real-time and end-to-end visibility is considered a valuable and strategic goal by actors, even though it is often unclear as to *how* to do it, since research has shown that firms and SC often have several difficulties in obtaining that result (Colicchia et al., 2019). Since end-to-end and real-time visibility are difficult goals to achieve, especially for globally dispersed supply chains, the role of advanced digital technologies is of primary importance in order to have fully complete visibility (Autio et al., 2021; Helo & Hao, 2022). During our review, we observed a particular interest of scholars in blockchain technology (BT) to achieve this goal (Gupta et al., 2020; Lai et al., 2021; Lohmer et al., 2020). To exemplify this, Teodorescu and Korchagina (2021) asserted that the use of BT in modern SCs increases not only end-to-end and real-time visibility, but also the propensity to initiate innovation between the actors of a network. In another study, Lohmer et al. (2020) found that in blockchain-coordinated supply chains, the use of this technology can effectively mitigate the risk of ripple effect (i.e., when a disruption that affected specific nodes of the chain also spreads its effect to the rest of the network). Along with BT, other advanced digital technologies related to Industry 4.0 have been studied by researchers to understand their effect on SCR (Autio et al. 2021; Helo & Hao, 2022). For example, additive manufacturing (AM) is considered a powerful tool to enhance resilience, as it increases risk mitigation, sustainability, and innovation along the chain (Verboeket & Krikke, 2019). Another important example is the use of artificial intelligence (AI), which is seen as a facilitator of SCR given its positive “holistic impact” (Helo & Hao, 2022, p. 2) on SC because it comprises all the most recent digital technologies, such as machine learning, that can increase end-to-end and real-time visibility and better predict future disruptions with its algorithms, along with other advanced digital technologies, such as IoT, robotics, and big data analytics (Chowdhury et al., 2021). As a result, advanced digital technology can be used both to predict and absorb shocks and to recover after a disruption occurs. Finally, Niemimaa et al. (2019) remarked on the importance of having tech-savvy employees able to understand and use these technologies, as tech-oriented companies have sometimes underestimated the real degree of knowledge of its employees about technologies in which top management is planning to invest.

## Sustainable and Measurable SCR Practices

Within this category, we assembled all the practice that make a SC sustainable both from the socio-ecological and the financial point of view. Sustainability is an essential feature that all modern SCs need to possess to be truly resilient, in light of the economic and social role that they have played in society. In this regard, a sustainable supply chain design (SSCD) is seen as a proxy for value creation and resilience (Sabogal-De La Pava et al., 2021). Several studies have been conducted in these two sub-fields of study. By way of illustration, Goodarzian et al. (2021) developed a new integrated simulation–optimization model that is useful in understanding how SSCD can maximize social factors, such as job creation and the economic development of certain regions, while simultaneously diminishing costs and financial pressure on the SC as much as possible. Sabogal-De La Pava et al. (2021) developed another numerical model for SSCD that positively impacted on the financial statement, creating value, and increasing the most important financial indicators, such as the EVA.

In another study, Kaur et al. (2020) undertook a simulation with a new model to understand if sustainability may affect not only financial indicators, but also operations, such as procurement, asserting that their model could be used in data-driven supply chains to mitigate risk and enhance sustainability. Finally, Reefke and Sundaram (2018) stated that as “SC decisions can have significant, and often unforeseen, sustainability related impacts” (Reefke & Sundaram, 2018, p. 56), it is crucial to be “focusing on SC to push sustainability initiatives thus increases the potential for wide- ranging positive impacts and adoption” (Reefke & Sundaram, 2018, p. 57). To this end, the authors adopted a Delphi methodology to understand the main factors which can affect the decision-making of SC managers regarding sustainability. They found that, among other things, factors like documentation of the impacts of SC, an efficient ICT system to increase sharing and updates, and performance measurement are vital to reach the goal of socio-ecological and financial sustainability. The performance measurement factor relates to the second sub-theme of this category, that is, the search for new metrics that can measure not only sustainability, but also SCR, as these metrics are currently under-investigated (Behzadi et al., 2020). In this regard, out of the 214 analyzed papers, only three studies had the precise objective of identifying SCR metrics (Behzadi et al., 2020; Baghersad and Zobel 2022; Zidi et al., 2021). This is indicative of the fact that, even if measuring SCR is widely considered a priority for SC research, scant efforts have been made in that direction. In reviewing existing SCR metrics (i.e., time-to-recovery—TTR, recovery level—RL, and lost performance during recovery—LPR), Behzadi et al. (2020) noted that they referred to a single aspect of resilience and to different moments in time, as “TTR considers the time of recovery process, RL considers the long-term performance, and LPR considers the short- term performance in the recovery period” (Behzadi et al., 2020, p. 148).

However, as SCR is a multi-dimensional and multi-faceted concept, analyzing them separately prevents authors from fully understanding their contribution to the measurement of the “real” value of resilience. To overcome this issue, authors proposed a new SCR metric, namely the net present value of the loss of performance, that “combines the key aspects of resilience that each of the TTR, RL, and LPR

metrics address separately by considering time-dependent weights on the lost performance in each period” (Behzadi et al., 2020, p. 150), and this is arguably the first concrete attempt to address SCR in its entirety from the metric viewpoint. A second valuable work in this domain is the one by Baghersad and Zobel (2022), in which the authors provided three metrics to measure SCR, namely, the initial loss due to the disruption, the maximum loss, and the total loss over time. The authors found that, despite their undoubted importance for measuring SCR, the metrics are affected and conditioned by organizational slack and the organizational and geographical scope of the specific SC; thus, they are difficult to generalize (Rodriguez et al., 2023). Finally, Zidi et al. (2021) explicitly refer to the last major disruption that global SCs have faced, namely COVID-19, as evidence of the importance of the reconfigurability of a SC to be effectively flexible and agile, and thus resilient, in time of disruptive changes brought by the pandemic. In their paper, the authors analyzed and tested six principal reconfigurability indicators (i.e., modularity, integrability, convertibility, diagnosability, scalability, and customization) to come to a single, comprehensive “reconfigurability” index, which is positively affected by the six original indicators and that can cause SCs to be more resilient in a world shocked by the COVID-19 pandemic effects (Govindan et al., 2023).

### Relationships Between SC Partners

The last category is dedicated to two main aspects of relationships between SC partners, specifically collaboration and trust. Mwesiumo et al. (2021) stated that collaboration between SC partners is essential to mitigate potential risk for the whole network, finding that the propensity to collaborate with other SC actors grows when the level of perceived supply risk rises. Interestingly, authors remarked that even though previous theory has tended to consider the propensity to collaboration strictly related to “signals” provided by other actors (e.g., the low performance of a supplier may lead a buying firm to perceive a potential risk) because of the high level of transaction costs of coordination, their findings prove that this hypothesis is not supported, and that the search for a collaborative relationship is preferred by partners regardless of those “signals.” In another study, Da Silva Poberschnigg et al. (2020) investigated how cross-functional integration might support the development of some of the SCR capabilities, with a particular emphasis on collaboration, that they defined as “the capability of dealing with formal and informal integration factors to integrate the internal functions and the supply chain members, which may provide visibility, agility and adaptability toward supply chain resilience” (Da Silva Poberschnigg et al., 2020, p. 798) Furthermore, evidence of the importance of collaboration for SCR is also provided by Al-Omoush et al. (2020), who stated that collaborative knowledge creation plays a significant role in enhancing proactiveness and operational agility, thus contributing significantly to the creation of a resilient SC. With regard to trust, Hou et al. (2018) found in their simulation paper that trust between SC partners is an essential element for the increase of SCR both for random and targeted disruptions, but also that the interdependence structure of the network has a significant moderating effect on the relationship between trust, resilience, and SC performance. This is also confirmed in the study conducted by Giannoccaro and Ifikhar (2019), as they



found that, even though an average SC network's level of resilience increases with higher levels of trust, a crucial role is played by the interdependence structure of the SC, as the effect is almost neglected for SCs with a dependent structure. Furthermore, they found that trust increases the adaptive capacity of the network, since it also improves collaboration aimed to resilience (Govindan et al., 2023).

### **Conceptualizing a New Holistic Definition of SCR**

Based on our literature review, findings shed light on four fundamental topics useful to build a new holistic definition of SCR in terms of (1) key resilience attributes, (2) technology-aided visible SC, (3) sustainable and measurable SCR practices, and (4) relationships between SC partners.

Thus, on the basis of the emerging findings and its related categorization, we propose a new definition of SCR as follows:

“SCR is the supply chain dynamic capability of being prepared to cope with unexpected disruptions, and to quickly recover previous performance securing business continuity so as to maintain the competitive advantage status, or to gain a new and better one. This is achieved by proactively: leveraging key resilience attributes; ensuring real-time, end-to-end network visibility through the usage of advanced digital technologies; measuring the socio-ecological and financial sustainability of activities; and facilitating trusting and collaborative relationships among all the actors along the chain.”

In this sense, our RQ is answered by returning to the literature a fresh and holistic definition of SCR: Indeed, this definition may now be more holistic and complete than others proposed by scholars in previous studies, as it comprises all the elements of SCR on which authors have focused their research in the last years. It is also less “broad” and vague in addressing what SCR actually means in practice.

## **Conclusion**

### **Theoretical and Managerial Implications**

Consistently with the recent calls for research on SCR from a theoretical viewpoint, in this paper we proposed a new definition of SCR that can be useful for academics and practitioners in more effectively facing super disruptions like COVID-19. In addition, we provided a brief overview of how scholars' approach to SCR has changed with the advent of COVID-19 in order to understand, from a theoretical point of view, if our definition might be in line with the direction that research is taking in this domain (Katsaliaki et al., 2021; Govindan et al., 2023). By systematically reviewing extant literature on SCR published in the last 4 years, we came to categorize all the most relevant elements that are considered most important by research for SCR. We believe that the proposed thematic categories and the resulting new definition of SCR may help academics and practitioners to have a more holistic and comprehensive view of

this multi-faceted concept. In fact, with the four main categories we found in terms of namely key resilience attributes, technology-aided visible SCs, sustainable and measurable SCR practices, and relationships between SC partners, we answered to the observations of many researchers and journals who called for a more holistic and comprehensive approach to SCR, that is currently lacking in literature. With the approach we have proposed, we also emphasized the fact that SCR is not only about effective strategic planning and network designing, but also about developing dynamic capabilities and tools useful for being resilient before, during, and after instantaneous and super disruptions, by absorbing shocks and ensuring high service levels (Chowdhury & Quaddus, 2017). This is a first major contribution of our study. A second important contribution is the comparison between studies published before and after COVID-19 to understand if, and how, scholars changed their approach to SCR after the advent of the pandemic, and to compare the appropriateness of our definition to the current general trends in SCR research. We found that, from a theoretical point of view, the development of what we have called key resilience attributes, the adoption of technologies to enhance visibility, the financial and the socio-ecological sustainability and measurability, and the importance of creating trusting and collaborative relationships between SC partners, are all in line with current research orientation. Therefore, our definition is very suitable for the current market scenario. From the managerial perspective, findings of our study are consistent with several practitioner-oriented papers that have been recently published. For instance, Faggioni et al. (2023) found that there is still a significant lack of knowledge about the importance of institutionalizing SCR into the SC routine, that requires to correctly identify the conceptual roots of the thematic (i.e., a holistic definition) and to reconsider SCR as a set of core dynamic capabilities (i.e., key resilience attributes). This is also supported by the study of Novak et al. (2021), that warned practitioners about the fact that equilibrium does not exist in supply chains, as they continuously evolve. In addition, this changing nature is inevitably supported, influenced, and (sometimes) driven by the technological advancements, as recalled recently by Lai et al. (2021). Moreover, our study is in line with those that consider the sustainability of SCR practices as crucial in order to enhance and sustain performance over time (i.e., gaining a new and better competitive advantage when a disruption occurs) such as the study of Negri et al. (2021).

Despite these contributions to both academia and management, we are aware of the fact that other studies (e.g., Chowdhury et al., 2021) have already explored the state-of-the-art of SCR in the post-COVID-19 era, but this has been a precise methodological choice by us, as our main research objective was to come to a new and more holistic definition, instead of reviewing post-COVID-19 literature more in detail, and we want to use our brief overview as a benchmark to understand the appropriateness of our SCR definition.

## Research Limitations

To some extent, the absence of a confrontation with practitioners is a first limitation of our study, even if it is generally not required for review papers, as we may have missed some ideas and cues to derive an even more complete and holistic

definition of SCR. Furthermore, we have only considered articles written in English and published in journals by the mid of 2022. Moreover, in the attempt to confer more robustness to our findings, we only selected journal articles published in highly ranked journals: Thus, some interesting insights hidden in different research output (e.g., as for book chapters, conference proceeding) may not have been considered. Finally, the considered time span was limited only to 4 years in order to understand whether 2021 has been a turning point for SCR when compared with the years immediately before. Nevertheless, arguably it would have been possible to discover more insights by expanding the time range.

### **Future Research Avenues**

Our study may be used as basis for future research, as findings revealed the presence of some under-researched areas which require further theoretical and empirical investigation.

One valuable research avenue suggested by our findings is what type of SC network is the most suitable in pandemic times like the current one, considering the interdependencies of SC nodes and the relationships between SC, as interdependence has been found to have a significant moderating role on trust and collaboration elements of SCR, and this is one of main categories we reported in our study. Moreover, another important research trajectory is represented by the role of advanced digital technologies in enforcing resilience by enhancing end-to-end and real-time visibility. Thus, future study may investigate to what extent can technologies be used to support supply, manufacturing, and demand sides of the SC. Similarly, future research may also focus on investigating in which ways firms with limited financial resources and dimensions (i.e., as for SMEs) may use technologies to be prepared for super disruptions like COVID-19.

Furthermore, financial and socio-ecological sustainability is also a critical area that needs to be addressed by scholars: To illustrate, it remains unclear as to which sustainability practices are the most effective in mitigating risks of super disruptions, and how they can contribute to the wealth and wellness of SC and societies. Thus, future research may explore possible connection between waste management, the circular economy, and other sustainability practices, and the resilience of SC in times of pandemic, also by revealing how these practices may impact on the financial sustainability of firms.

Finally, on the basis of our proposed SCR definition, to the best of authors' knowledge, the concept of SCR measurability is introduced as a fundamental issue. Indeed, based on our analysis, the concept of SCR measurability, despite its complexity, needs to be represented and measured by some synthetic metrics, and efforts by scholars in this direction are still few. As a result, we strongly believe that scholars should investigate and develop new dynamic resilience indicators. With regard to key resilience attributes, there is a need to deepen the impact of these capabilities all together, and how they can be optimally managed to achieve the highest degree of resilience possible. From a strategic management viewpoint, topics such as reshoring and nearshoring also need to be addressed by future research, as the geographical

dispersion (Rodriguez et al., 2023), and the development of SCs' footprint strategies have been strongly associated with SC vulnerability in times of COVID-19, given the impact of lockdowns in terms of restrictions and duration.

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## Declarations

**Conflict of Interest** The authors declare no competing interests.

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