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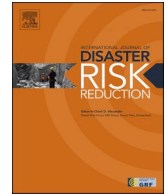
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Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies

Javid Moosavi^a, Amir M. Fathollahi-Fard^b, Maxim A. Dulebenets^{c,*}

^a School of the Built Environment, University of Technology Sydney, Sydney, Australia

^b Department of Electrical Engineering, École de Technologie Supérieure, University of Quebec, 1100 Notre-Dame St. W., Montreal, Quebec, Canada

^c Department of Civil & Environmental Engineering, Florida A&M University-Florida State University (FAMU-FSU) College of Engineering, 2035 E Paul Dirac Dr., Slinger Building, Suite 275, Tallahassee, FL, 32310, USA

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ABSTRACT

The COVID-19 pandemic has made a significant impact on various supply chains (SCs). All around the world, the COVID-19 pandemic affects different dimensions of SCs, including but not limited to finance, lead time, demand changes, and production performance. There is an urgent need to respond to this grand challenge. The catastrophic impact of the COVID-19 pandemic prompted scholars to develop innovative SC disruption management strategies and disseminate them via numerous scientific articles. However, there is still a lack of systematic literature survey studies that aim to identify promising SC disruption management strategies through the bibliometric, network, and thematic analyses. In order to address this drawback, this study presents a set of up-to-date bibliometric, network, and thematic analyses to identify the influential contributors, main research streams, and disruption management strategies related to the SC performance under the COVID-19 settings. The conducted analyses reveal that resilience and sustainability are the primary SC topics. Furthermore, the major research themes are found to be food, health-related SCs, and technology-aided tools (e.g., artificial intelligence (AI), internet of things (IoT), and blockchains). Various disruption management strategies focusing on resilience and sustainability themes are extracted from the most influential studies that were identified as a part of this work. In addition, we draw some managerial insights to ensure a resilient and sustainable supply of critical products in the event of a pandemic, such as personal protective equipment (PPE) and vaccines.

1. Introduction

The impact of coronavirus disease 2019 (COVID-19) is viewed as significant across the globe. Different public health strategies have been imposed by the relevant officials to prevent the virus spread, including social distancing, requirements on wearing masks and face coverings, transition to remote operations, temporary closure of certain businesses (e.g., shopping malls, restaurants, entertainment facilities), restrictions on public gatherings, deployment of contact tracing measures, and others [1,2]. Some governments set rather radical control measures, e.g., border closures and lockdowns, resulting in significant supply chain (SC) disruptions. Many countries impose border closures which lead to disrupted SCs across the world, mainly when there is a fear of transmitting the virus by food. In

* Corresponding author.

E-mail addresses: Seyedjavid.mousavi@uts.edu.au (J. Moosavi), amirmohammad.fathollahifard.1@ens.etsmtl.ca (A.M. Fathollahi-Fard), mdulebenets@eng.famu.fsu.edu (M.A. Dulebenets).

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Europe, some countries faced severe food supply shortages due to border closures from or to the food supplier countries like France [3]. In the US, the demand for automobiles plunged, resulting in an 80% drop in China’s automobile part export [4]. Moreover, the automobile part supply disruption affected the European car supply as well.

In the meantime, multiple lockdowns resulted in panic-buying and significant demand fluctuations. Billions of people were asked to stay at home, resulting in substantial purchase paradigm changes. People start to buy and store products that have never been held, e.g., food and toilet paper. The unexpected changes in supply and demand plus border closures created significant SC disruptions across the world [5]. These catastrophic issues prompted researchers worldwide to study the SC disruptions due to the COVID-19 pandemic more closely and develop mitigation and adaptation strategies. Indeed, hundreds of articles were published on the aspects of SC management and potential impacts associated with the COVID-19 spread [3–109].

A number of previously conducted survey studies presented bibliometric and network analyses focusing on the literature related to SC management under disruptions, including the ones caused by the COVID-19 (Montoya-Torres et al. [61]; Swanson and Santamaria [69]; Xu et al. [70]) – see Table 1. The purpose of the bibliometric analysis was to identify the most influential authors, organizations, and countries aiming to address the SC operational challenges due to various disruptions. On the other hand, the network analysis aimed to further investigate correlations between the identified influential authors to attain more insights. However, many of the previous survey studies strictly focused on the bibliometric and network analyses without considering any disruption management strategies that could be used within SCs to effectively respond to different disruptive events [61,69,70].

In the meantime, a significant amount of survey studies solely concentrated on a descriptive review of disruption management strategies without performing any supporting bibliometric and/or network analyses to gain more thorough insights into the most effective disruption management strategies (Chowdhury et al. [6]; Akintokunbo and Adim, [64]; Pujawan and Bah [66]). Cordeiro et al. [56] primarily performed a bibliometric analysis of the studies on SC management under pandemics. Alhawari et al. [52] discussed a number of disruption management strategies and presented a supplementary bibliometric analysis; however, the network analysis was not performed. Therefore, there is a lack of holistic and systematic survey studies that not solely focus on the bibliometric and network analyses of the relevant literature but also use the outcomes of bibliometric and network analyses to investigate different disruption management strategies that could be potentially used in SC management.

In order to adequately address the aforementioned gaps in the state-of-the-art, this study aims to perform a detailed bibliometric and network analysis of the literature on SC management under disruptive conditions, primarily focusing on the COVID-19 settings. The outcomes from the conducted bibliometric and network analysis will be further used to identify the most promising disruption management strategies that could be used by the relevant SC stakeholders to effectively address future pandemics and other types of disruptions. To this end, this study aims to address the following research questions:

RQ1. What are some of the most influential authors, organizations, and countries aiming to address the SC disruptions under the COVID-19 pandemic?

RQ2. What are some of the most influential articles on SCs considering the COVID-19 pandemic effects, and what are their main topics, research streams, and contributions?

RQ3. What are the strategies that can be implemented to manage a catastrophic SC disruption like the COVID-19?

Therefore, this study can be considered as the first attempt that performs a bibliometric and network analysis to identify the main literature themes with a focus on disruption mitigation and adaptation SC strategies. The rest of this paper is organized as follows: Section 2 explains how we conducted the literature search, selected the relevant studies, assessed the research streams, and conducted the analysis to answer the research questions. Then, Sections 3 and 4 conduct the bibliometric, citation, and network analyses to effectively achieve the objectives of this research. After that, Section 5 discusses the main research streams and strategies that were obtained from the analyses. Section 6 draws managerial insights for the relevant SC stakeholders and policymakers. Section 7 provides the key conclusions based on the revealed findings and indicates the future research needs.

2. Research methodology

2.1. The main research steps

A literature review method can be used in multidisciplinary sectors [9], such as supply chain management (SCM) and the assessment of COVID-19 effects on normal operations. However, there is no specific research methodology to conduct a systematic literature review in management science [10]. Here, we adopt and further refine the methods from the studies conducted by Fahimnia et al. [11] and Moosavi et al. [12] that performed a systematic literature review on SCM. It is based on three main steps, including the

Table 1
Comparison of the closely related survey studies.

Article	Bibliometric Analysis	Network Analysis	Disruption Management Strategies
Akintokunbo and Adim (2020) [64]	–	–	✓
Xu et al. (2020) [70]	✓	✓	–
Alhawari et al. (2021) [52]	✓	–	✓
Chowdhury et al. (2021) [6]	–	–	✓
Cordeiro et al. (2021) [56]	✓	–	–
Montoya-Torres et al. (2021) [61]	✓	✓	–
Pujawan and Bah (2021) [66]	–	–	✓
Swanson and Santamaria (2021) [69]	✓	✓	–

following: (1) literature search, (2) bibliometric analysis, and (3) citation analysis. Fig. 1 demonstrates the main steps of the research method that was used in this study. In the first step, the authors identified the candidate keyword(s), selected the most appropriate keywords, and conducted the database search, which is explained more in section 2.2 of the manuscript. In the second step, we performed the bibliometric analysis to identify the organizations, authors, and countries actively aiming to address the SC disruptions under the COVID-19 pandemic (research question RQ1).

Furthermore, the most repeated keywords leading to the citation analysis were identified in the second step as well. In the third step, the citation analysis along with the network analysis were conducted to specify the most influential articles as well as their relationships and indicate the primary topics, research streams, and valuable contributions (research question RQ2). Moreover, the strategies employed by the articles to manage the impact of the COVID-19 disruption were extracted as well to provide managerial insights, which can be helpful in addressing catastrophic SC disruptions that may occur in the following years.

2.2. Literature search and selection

Throughout the literature search, “supply chain management” and “COVID-19” were used as the main keywords. The literature search was performed on 01 June 2021. Two reputable databases were considered in this study: Scopus and Web-Of-Science. The obtained records revealed that Scopus covered all the records from Web-Of-Science. The Scopus search¹ was conducted using *Article title*, *Abstract*, and *Keywords*. A one-step search was performed, supply chain management AND COVID-19, resulting in 511 records. Then, we excluded non-articles, non-English documents, and non-journal published documents, resulting in 489 papers. The refined data set was then carefully evaluated by all the authors to exclude the out-of-scope records. The authors read the titles and abstracts and decided on the relevance of 469 of the articles. All the articles identified to be the most relevant to the theme of the present survey were further used to conduct the bibliometric, citation, and network analyses.

3. Bibliometric analysis

A bibliometric analysis is a scientometric analysis that is widely used to evaluate the scientific content of publications [12]. This method facilitates the analysis of keywords [14], geographical information [15], and various topics [16]. It has been used in both interdisciplinary and multidisciplinary research. For example, Moosavi et al. [12] employed a bibliometric analysis in an interdisciplinary domain, i.e., SCM and blockchain. Similarly, this study uses a bibliometric analysis for multidisciplinary research, i.e., the COVID-19 and SCM. In order to conduct a scientometric analysis [14–18], scholars use different software, e.g., BibExcel [18], Cite-space [19,20], and VOSviewer [21,22]. The VOSviewer software was used in this research because it is able to process the Scopus data format, and it has user-friendly settings when comparing to other software packages. The following subsections explain how we used this software to identify the main authors, organizations, countries, and keywords.

3.1. Authors and journals

The data set that was compiled as a part of this study includes 1870 authors in total, resulting in approximately four authors per publication. To identify the influential authors, we limited the minimum number of documents of an author to two publications and ten citations, resulting in ten distinguished authors. Table 2 demonstrates the top ten authors, their number of articles, and the total number of citations. It can be observed that Ivanov D., with ten articles and 726 citations, is the most influential author in the SC research under the COVID-19 settings and is far ahead of Dolgui A., with four papers and 350 citations. The identification of the most influential authors and articles by means of the citation analysis (i.e., the total number of citations) has been used widely by many studies [11,56,60,61,70]. However, the time of publication should be taken into consideration when estimating the total number of citations, as it may create some bias (i.e., the studies that were published earlier may receive more citations due to the time of publication, not due to their practical importance). Therefore, a set of additional analyses were performed in this study as well (i.e., bibliographic analysis and network analysis discussed in the following sections) to partially offset the limitations of the citation analysis and gain more insights. Throughout the conducted analysis, it was found that eight out of ten authors have published more than three articles at the moment of conducting the present literature survey. To investigate the research fields of the top contributing authors, we reviewed their Research Gate and Google Scholar profiles. Eight out of ten of the author’s research fields are related to SCs, and the other two are in the medical field of study.

Several journals have published a variety of articles on the SC operations under the COVID-19 settings. Table 3 demonstrates the top 15 journals that published most of the articles relevant to the theme of the present literature survey. Sustainability Switzerland appeared as the most active journal on the SC disruptions under the COVID-19 settings, with 39 records far ahead of the other sources. The Agricultural Systems and Recourses Conversation and Recycling were found to be popular journals as well, with nine and eight records, respectively. It can be observed that all the journals published less than ten papers, except Sustainability Switzerland with a large number of publications.

3.2. Countries

The COVID-19 caused major SC disruptions all over the world. All the countries of the world have been affected drastically. Therefore, the research communities attempted to investigate the impact of the COVID-19 and assess potential mitigation and adaptation strategies. Here, we aimed to identify the influential countries that have been contributing to this research field. We

¹ <https://www.scopus.com/search/form.uri?display=basic#basic>.

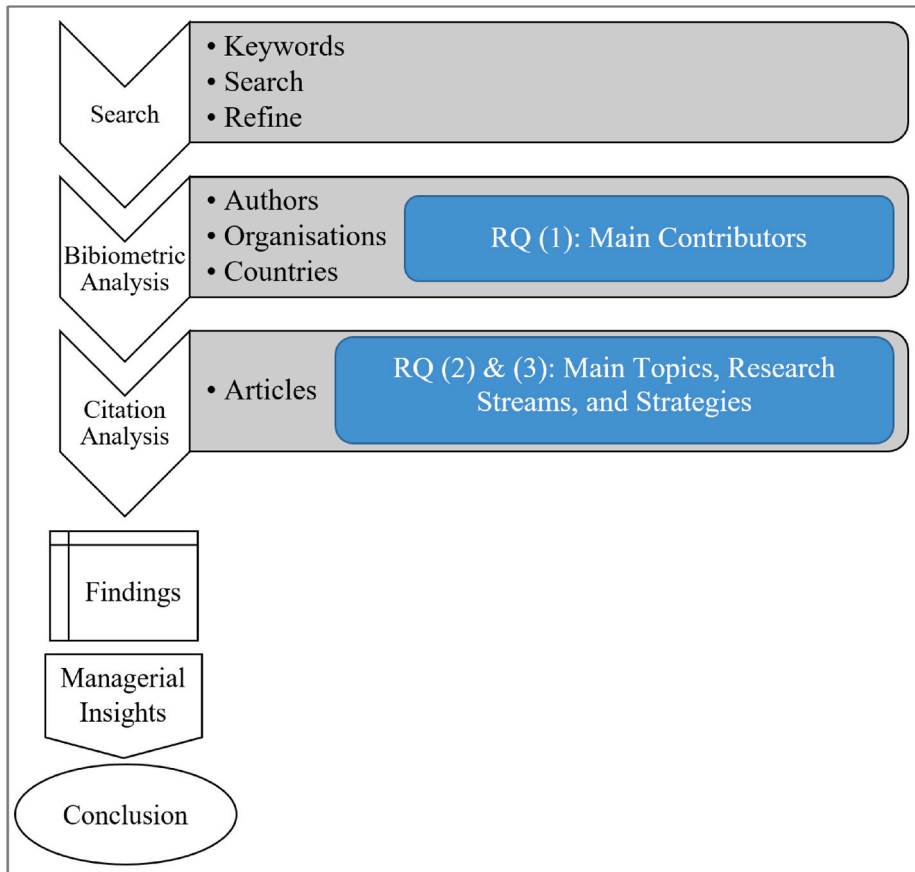


Fig. 1. Research method.

Table 2
The top 10 authors, number of articles, and citations.

Authors	No. of articles	No. of citations
Ivanov D.	10	726
Dolgui A.	4	350
Ketchen D.J.	3	48
Craighead C.W	3	48
Gunasekran A.	3	46
Sarkis J.	3	29
Paul S.K.	3	22
Ahmad I.	3	16
Laffey J.P	2	134
Rowan N.J.	2	134

selected the *country* on the software’s bibliometric analysis, resulting in 110 countries. To identify the top 15 countries, we limited the minimum number of documents of a country to five and the minimum number of citations to 90. Table 4 illustrates the highest number of publications and citations associated with the geographical regions in this field of study. The United States, with 116 articles and 654 citations, was ranked first with almost double the number of articles and citations compared to the United Kingdom and China. Germany published the most-cited papers with the highest citation rate per paper (i.e., 30 citations per paper on average). It should be noted that the number of researchers focusing on SCM under the COVID-19 settings and the population size may influence the number of publications and citations. For example, Australia with a population of 25 million may have a smaller number of researchers in the area of SCM under the COVID-19 settings compared to China and India with a population of more than one billion, which can directly affect the number of publications produced on this topic. The relative values (e.g., ratios of the number of publications to the total number of active researchers) are not provided due to the data unavailability (i.e., the actual population size of each country is available and can be easily accessed, but the number of researchers active in SCM under the COVID-19 settings is not reported).

Table 3
The top contributing journals.

Source title	No. of articles
Sustainability Switzerland	39
Agricultural Systems	9
Resources Conservation and Recycling	8
Science of The Total Environment	8
Annals of Operations Research	7
International Journal of Environmental Research and Public Health	7
International Journal of Operations and Production Management	7
IEEE Engineering Management Review	6
International Journal of Production Research	6
Operations Management Research	6
International Journal of Logistics Management	5
Journal of Humanitarian Logistics and Supply Chain Management	5
Journal of Supply Chain Management	5
Transportation Research Part E: Logistics and Transportation Review	5
International Journal of Logistics Research and Applications	4

Table 4
Geographical regions of publications.

Countries	No. of articles	No. of citations
United States	116	654
United Kingdom	58	384
China	58	345
India	55	230
Australia	30	190
Canada	25	180
Germany	24	763
France	21	448
Italy	20	167
Indonesia	18	16
Netherlands	13	84
Brazil	12	125
Taiwan	11	33
Bangladesh	11	57
Iran	11	144

Table 5
Top keywords.

Keywords	Occurrence	Keywords	Occurrence	Keywords	Occurrence	Keywords	Occurrence
Resilience	35	Disruption	5	Digital Twin	3	Lean	3
Sustainability	26	PPE	5	Procurement	3	Lockdown	3
Supply Chain	16	Sustainable	5	Big Data	3	Pandemic	3
Resilience		Development				Preparedness	
Food Security	13	Agility	5	SC Dynamic	3	Artificial Intelligence	3
Food SC	12	Personal Protective Equipment	5	Data Analytics	3	E-Commerce	3
Blockchain	11	Shocks	5	Food Safety	3	Humanitarian Logistics	3
Risk Management	10	Circular Economy	5	SC Vulnerability	3	Infection Control	3
SC Risk Management	10	Simulation	4	Food Industry	3	Disruptions	3
Public Health	10	Viability	4	Governance	3	Operations Management	3
SC Disruption	9	Industry 4.0	4	3D Printing	3	Decision Making	3
Crisis Management	8	Logistics	4	Additive Manufacturing	3	Disaster Management	3
Manufacturing	7	Adaptation	4	Disaster Response	3	Mitigation	3
Food Waste	6	Technology	4	Food SCs	3	SC Performance	3
Waste Management	6	SC Risk	4	Plastic Waste	3		
Traceability	6	Agriculture	4	Risk Assessment	3		
China	6	Critical Care	4	Small-Scale Fisheries	3		
Ripple Effect	5	Health Policy	4	SC Disruptions	3		
Consumer Behavior Crises	5	Open Innovation	4	IoT	3		

3.3. Keywords

The keyword analysis is one of the primary analyses of bibliometric research. Keywords are expected to reflect the topic of a document [23]. Also, they could indicate the main research streams [24]. Farooq et al. [25] and Moosavi et al. [109] used the keyword analysis to identify the leading principles in the COVID-19 context. We selected the *Co-occurrence* analysis in the VOSviewer software that could provide the most popular keywords among the collected articles on the SC disruptions under the COVID-19 settings. The software provides three units of analysis, i.e., *all keywords*, *author keywords*, and *index keywords*. We selected the author keywords that eliminate the unrelated words. The search resulted in more than 1400 keywords. The minimum number of occurrences of a keyword was set to three to reveal the top 100 keywords. We excluded the searched keywords, i.e., *supply chain* and *COVID-19*. Also, the combinations of the word “*supply chain*” with other terms, i.e., *supply chain management*, *supply chains*, and *supply chain operations*, were excluded from the results. Similarly, the terms associated with the virus name, i.e., *coronavirus*, *COVID*, *sars-cov-2*, *COVID-19*, were eliminated.

Moreover, some out-of-scope words were not considered in the analysis, e.g., pandemic, COVID pandemic, outbreak, and epidemic outbreaks. Table 5 indicates the top keywords revealed, whereas Fig. 2 demonstrates the density network for the top keywords. The denser the keyword’s area and colure, the higher the keyword repetition, and the closer located keywords, the more related the topics. In the meantime, the bluer the colure, the less repeated the keyword; the redder the colure, the higher the keyword occurrence. Based on the conducted network analysis, *resilience* and *sustainability* were found to have the highest occurrence compared to other keywords. Moreover, close relationships between the following keywords were identified: (1) *public health* and *risk management*; (2) *traceability* and *blockchain*; (3) *disruption* and *supply chain disruptions* and *supply chain risk management*; (4) *sustainable development* and *circular economy* and *food security*; (5) *waste management* and *food waste* and *food supply chains*; and (6) *crisis management* and *personal protective equipment*.

Based on the conducted keyword analysis, along with resilience and sustainability, the following keywords had a fairly high occurrence as well (i.e., the occurrence of 10 times and more): *supply chain resilience*, *food security*, *food SC*, *blockchain*, *risk management*, *SC risk management*, and *public health*. After identifying the most popular keywords, we used a labeling method to label the clusters by reading and considering the dominant topic (for more information, see Moosavi et al. [12]). The keyword network analysis revealed a total of five keyword network clusters, i.e., resilience, sustainability, technology, food, and health. Table 6 demonstrates the keyword network clusters in detail. Based on the conducted analysis, resilience, food, and technology clusters were found to have the largest number of keywords.

In addition, a thematic analysis was performed to identify the primary research streams and topics aiming to adequately answer research question RQ2. We counted and grouped all the related top 40 keywords in one of the considered themes to support the bibliometric analysis results and draw some insights for further analysis (for more information, see Moosavi et al. [12]). The results from the conducted keyword thematic analysis are presented in Fig. 3. The outcomes from the thematic analysis confirm significant

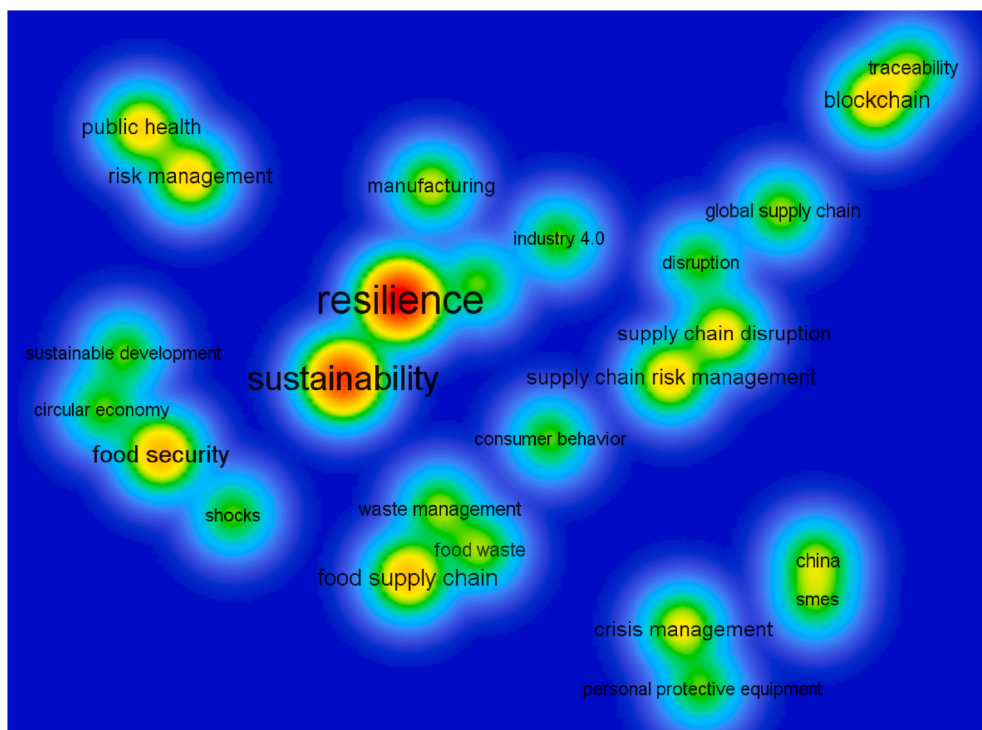


Fig. 2. The most occurred keywords.

Table 6
Keyword network clusters.

Resilience	Sustainability	Technology	Food	Health
Adaptation	Circular Economy	Artificial Intelligence	Agriculture	Global Health
Agility	Consumer Behavior	Big Data	Food Industry	Governance
China	Decision Making	Blockchain	Food Safety	Health Policy
Crisis Management	E-Commerce	Data Analytics	Food SC	Public Health
Critical Care	Plastic Waste	Global SC	Food Security	
Digital Twin	Sustainability	IoT	Food Waste	
Disaster Response	Sustainable Development	Logistic	Lockdown	
Disruption	Waste Management	Manufacturing	Procurement	
Industry 4.0		PPE	SC Performance	
Infection Control		Traceability	Shocks	
Lean			Small Scale Fisheries	
Pandemic Preparedness				
Ripple Effect				
Risk Assessment				
SC Disruption				
SC Dynamics				
SC Resilience				
SC Risk				
SC Risk Management				
SC Vulnerability				
Simulation				
SMEs				

attention of the authors to the resilience theme (a total of 33% of the identified top keywords), technology theme (a total of 21% of the identified top keywords), and sustainability theme (a total of 19% of the identified top keywords). The following section of the manuscript will use the keyword network and theme analysis results to employ the citation and network analyses in order to identify the most reputable articles, main topics, and SC disruption strategies.

4. Citation and network analyses

4.1. Citation analysis

The citation analysis was conducted as a part of this study to answer research questions RQ2 and RQ3 (i.e., identify the most influential articles on SCs considering the COVID-19 pandemic effects, and their main topics, research streams, and contributions; identify the most promising strategies that could be used to effectively respond to a catastrophic SC disruption like the COVID-19). The citation analysis is recognized as a well-developed method for systematic literature reviews and has been used widely by many studies [11,56,60,61,70]. Such an analysis could be performed not only for a single year but also for up to a 10-year time period [60]. However, as indicated earlier, the time of publication should be taken into consideration when conducting the citation analysis, as it may create some bias (i.e., the studies that were published earlier may receive more citations due to the time of publication, not due to their practical importance; a particular SC disruption management strategy can be effective despite having fewer citations due to the time of publication). In this study, the citation analysis was conducted after two years since the beginning of the COVID-19 outbreak. However, a set of additional analyses were performed in this study as well (i.e., bibliographic analysis, network analysis) to partially offset the limitations of the citation analysis and gain more insights.

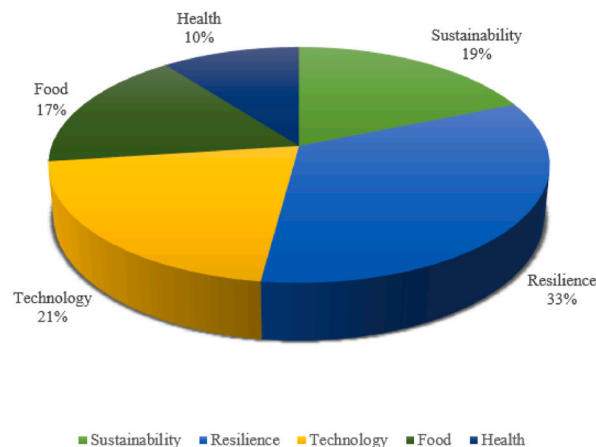


Fig. 3. Keyword themes with dominant research streams.

We employed the citation analysis by the VOSviewer software to identify the most influential articles. As mentioned in section 2.2, the data set search was performed on 01 June 2021. Then, we thoroughly read and analyzed the articles to identify the dominant research streams as well as the suggested strategies for SC management under the COVID-19 settings. The results from the conducted citation analysis are reported for highly-cited studies in Table 7. In particular, the following information is provided for each study: (1) article; (2) total number of citations; (3) methodology used; and (4) research theme. Based on the conducted analysis, it was found that approximately 70% of the articles' research streams are resilience-oriented, and the rest are related to either sustainability or a combination of resilience and sustainability (see Fig. 4). Furthermore, it can be observed that the majority of highly-cited studies are qualitative in nature. Only a few studies adopted a quantitative methodology (e.g., simulation models, game theory, and fuzzy systems). Such a pattern can be justified by potential difficulties in quantitative modeling of the COVID-19 effects on SC operations.

A set of additional insights were retrieved from the reviewed articles, including the following (see Table 8): (a) considered COVID-19 impacts on SCs; (b) disruption management strategies proposed; and (c) planning dimensions considered. It can be observed that the previous studies modeled different types of COVID-19 effects on SC operations, such as demand spike, PPE shortage, ripple effect, supply disruption, shortage of vital products, changes in purchasing behavior, SC network failures, perishable food losses, and decline in the Gross Domestic Product (GDP). Furthermore, a large variety of SC disruption management strategies were identified as a result of the conducted analysis (e.g., diversifying and localizing supply and demand, information sharing, online delivery, modeling unknown disruptions, intertwined supply network, computerized risk assessment, additive manufacturing, bespoke manufacturing, and optimization of the facility opening time), which will be discussed in more detail in section 5.2 of the manuscript. As for the planning dimensions considered, disruption preparedness and disruption response were found to be the most common planning dimensions addressed by the most influential studies.

4.2. Network analysis

Supply chain scholars have recently started performing network analyses to evaluate the logical correlation of articles [12,44]. Accordingly, we conducted the network analysis to advance the investigation of the highly-cited studies. Fig. 5 demonstrates the network of highly co-cited articles. The term "co-citation" refers to the two articles that were both referenced in another article [70]. The bigger the size of the article's frame, the more co-cited the article is, and the closer located the articles, the more related they are [21]. The network analysis outcome is aligned with the citation analysis results and highlights the significant dominance of the resilience research stream comparing to the sustainability research stream. The most influential articles identified as a result of the network analysis also discuss different disruption strategies. The following section of the manuscript focuses more on the analysis results with a primary emphasis on the major research streams identified and potential mitigation and adaptation strategies proposed.

5. Main research streams and strategies

This section discusses the main research streams that were identified as a result of the conducted literature review and investigates how the reviewed articles address the resilience and sustainability issues. More importantly, we aim to reveal the strategies that can be used in the following years to manage catastrophic SC disruptions based on the lessons learned from the COVID-19 pandemic. Accordingly, the second part of this section explores various alternatives that were proposed by the reviewed studies to manage the COVID-19 impact on SCs.

Table 7
Analysis of highly-cited articles on supply chain management under the COVID-19 settings.

Article	Citations	Methodology	Research Theme
Ivanov [26]	318	Simulation	Resilience
Ivanov and Dolgui [27]	187	Game theory	Resilience
Rowan and Laffey [28]	115	Qualitative	Sustainability
Queiroz et al. [29]	97	Qualitative	Sustainability & Resilience
Govindan et al. [30]	86	Fuzzy System	Resilience
Sharma et al. [68]	74	Qualitative	Sustainability
Ivanov and Dolgui [32]	63	Qualitative	Resilience
Yuen et al. [33]	61	Qualitative	Resilience
Remko [34]	57	Qualitative	Resilience
Iyengar et al. [35]	54	Qualitative	Resilience
Aldaco et al. [36]	47	Material Flow & Life Cycle Analysis	Sustainability
Golan et al. [8]	47	Simulation	Resilience
Ivanov and Das [37]	43	Qualitative	Resilience
Ibn-Mohammed et al. [38]	42	Qualitative	Sustainability
Gordon et al. [39]	41	Qualitative	Resilience
Pulighe and Lupia [3]	36	Qualitative	Sustainability
Akseer et al. [40]	34	Qualitative	Resilience
Liu et al. [41]	32	Qualitative	Resilience
Lu et al. [42]	30	Qualitative	Resilience
Goh et al. [43]	30	Qualitative	Sustainability & Resilience

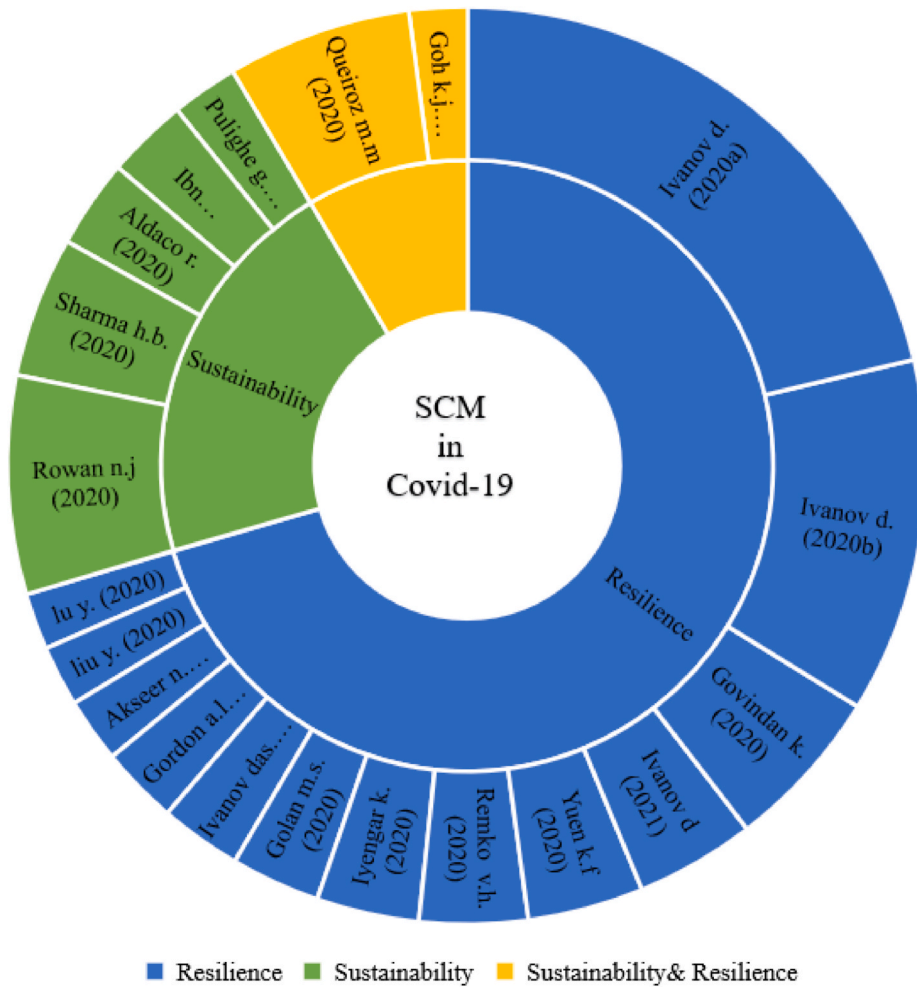


Fig. 4. Research streams of the top articles.

5.1. Primary research themes

5.1.1. Resilience

The COVID-19 pandemic attracts significant attention of scholars, practitioners, and policymakers, aiming to improve the SC resilience. Resilience is viewed as a major attribute of transportation networks and associated SCs [45–48]. Scholars have been working on different aspects of the SC resilience more than at any time. The most-cited article Ivanov [26] aimed to predict the impact of a pandemic outbreak on the SC performance. The paper studied the SC with the lens of resilience, how long a disruption could sustain, and how long it could take for the SC to recover. It was found that certain important factors, such as facility opening/closing time, disruption propagation time, and lead time, significantly impacted the SC resilience. Furthermore, Ivanov and Das [37] modeled the ripple effect of an epidemic disruption on an SC. The study considered the production and distribution disruptions and a demand decline. Finally, various recovery plans were assessed.

Ivanov and Dolgui [27] aimed to assess various angles of the SC resilience and viability. The SC viability was defined as the system’s ability to survive in a changing environment. The study discussed how viability could address the resilience downsides. For example, the resilience system is closed, and the structure is static, but the viability is open, dynamic, and balancing through the disruption. Also, the analysis in the realm of resilience is disruption-driven and triggered by events. On the other hand, the viability analyses are behavioral-driven and can be used in analyzing changing customer behaviors during pandemics and lockdowns. Govindan et al. [30] indicated that the demand for critical care drastically increases during pandemic outbreaks, and proper demand management of hospitalization could mitigate the impact of the pandemic. The study proposed a method to optimize the hospitalization and critical care supply by prioritizing patients. Remko [34] divided the COVID-19 SC risks into control, demand, and supply risks and suggested various solutions to enhance the SC resilience. Golan et al. [8] focused on resilience modeling and quantification. The authors observed that specific scenarios had been developed to test SC models and optimize efficiency as well as reduce the associated costs, but the pandemic argued the trade-off leanness with resilience.

Liu et al. [41] demonstrated the resilience strategies of Asian countries (i.e., China, South Korea, Singapore) for managing the

Table 8
Classification of highly-cited articles based of the supply chain impacts, disruption management strategies, and planning dimensions considered.

Article	COVID-19 Impacts on Supply Chains	Disruption Management Strategy	Planning Dimension
Ivanov [26]	Decline of Financial and Service Level	Optimizing Facility Opening/Closing Time	Prepare + Respond
Ivanov and Dolgui [27]	Ripple Effect	Intertwined Supply Network	Prepare
Rowan and Laffey [28]	Demand Spike + PPE Shortage	Communication + Bespoke Manufacturing + Reuse	Respond
Queiroz et al. [29]	Ripple Effect	Diversifying Sources + Situational (Flexible) Response	Prepare and Recover
Govindan et al. [30]	Demand Spike	Prioritizing Demand	Respond
Sharma et al. [68]	Demand Spike + Waste Spike	Local SC	Respond + Recover
Ivanov and Dolgui [32]	Supply + Demand Dsruction	Computerized Modelling	Prepare + Respond + Recover
Yuen et al. [33]	Demand Spike	Regulating Purchase + Online Delivery	Response
Remko [34]	Supply + Demand Disruption	Diversifying Sources + Information Sharing	Prepare + Respond
Iyengar et al. [35]	Ventilator Shortage	Increasing Production + Additive Manufacturing	Respond
Aldaco et al. [36]	Supply Disruption + Shopping Behavior Changes	Government Regulation	Prepare + Respond
Golan et al. [8]	SC Collapse + Supply Network Failure	Modeling Unknown Disruption	Respond
Ivanov and Das [37]	Demand Decline + Production & Market Disruption + SC Collapse	Situational (Flexible) Response	Prepare + Respond
Ibn-Mohammed et al. [38]	Demand Spike + Shortage of Vital Products + Human Resources Disruption	Local Manufacturing	Respond
Gordon et al. [39]	Demand Spike	Diversifying Demand	Respond
Pulighe and Lupia [3]	Perishable Food Losses	Distributing Manufacturing	Prepare + Respond
Akseer et al. [40]	Food Shortage	Government Support	Respond + Recover
Liu et al. [41]	Demand Plunge + GDP Decline	Diversifying Sourcing	Respond + Recover
Lu et al. [42]	Demand Spike	Government Support	Respond
Goh et al. [43]	Financial Loss + Service Level Decline	Multiple Sourcing + Reuse	Prepare + Respond

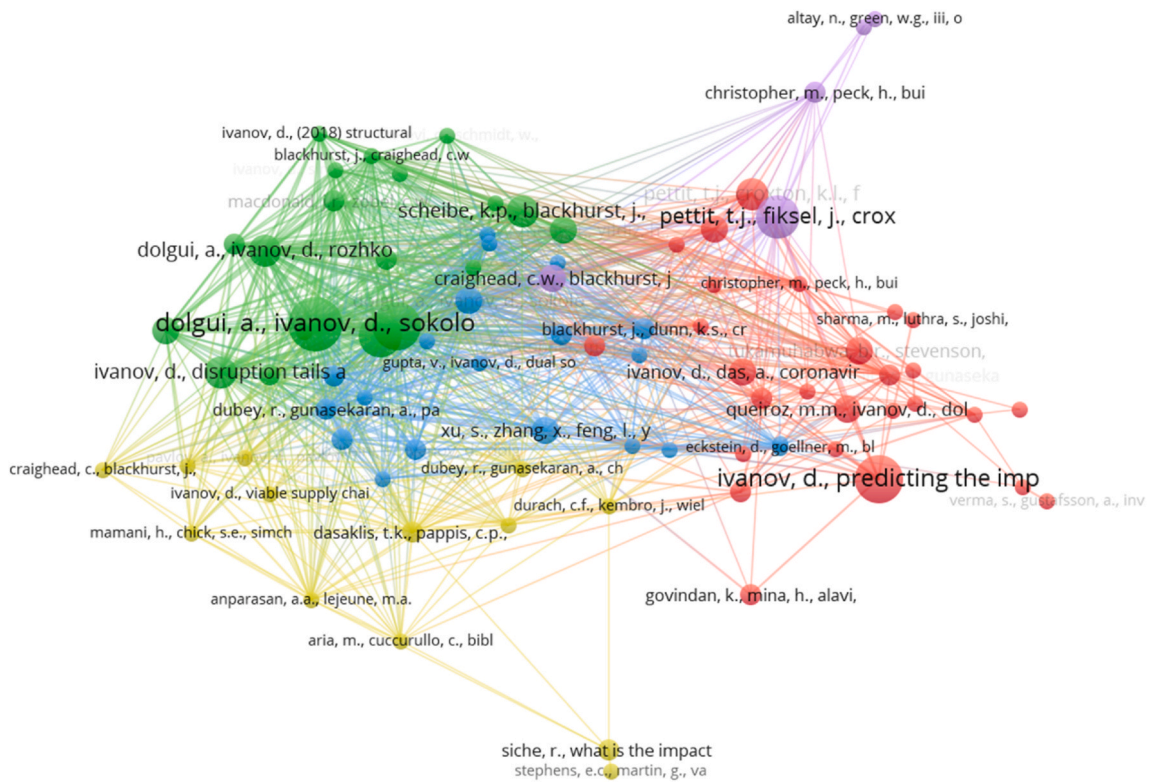


Fig. 5. Network of the highly co-cited articles.

pandemic and the country's interconnectivity of SCs. For instance, electronic, automobile, and food SCs of these countries are significantly bounded to each other, and a disruption propagates extensively. As an example, a disruption of a Chinese supplier caused a shutdown of the Hyundai car factory in South Korea. Lu et al. [42] focused only on China and the impact on small and medium-sized enterprises (SMEs). The study illustrated that most SME companies could not return to normal operations because the workers could not return to work, customer demand decreases, disrupted SCs, and shortage of materials to protect employees against the infection. Furthermore, the study indicated that Chinese SMEs are suffering from the pandemic's impact on their cash flow. Some government intervention strategies were proposed (more details are provided in section 5.2 of the manuscript). Akseer et al. [40] primarily focused on the pandemic's financial impact on low-income families. It was indicated that 80% of the world's food is consumed in Asia and Africa, where less developed countries have more potential undernutrition issues and children. Food SC disruptions increased the food price and decreased food availability, resulting in undernourishment. The impacts of the COVID-19 on food SCs and agriculture were also discussed in other research efforts [54,65,71,96,98].

El Baz and Ruel [78] investigated the role of SC risk management in mitigation of the COVID-19 effects. Based on the analysis of the data collected from 470 French firms, it was found that the SC risk management practices could significantly foster SC resilience. Queiroz et al. [80] pointed out that resource configuration and SC disruption orientation could enhance SC resilience under the COVID-19 settings. Modgil et al. [83] underlined that artificial intelligence techniques could be instrumental in developing business continuity capabilities. The study discussed how different companies use artificial intelligence for enhancing risk management, visibility, sourcing, and distribution capabilities. Nayal et al. [98] also explored the potential of artificial intelligence on SC operations under the COVID-19 settings mostly focusing on the agricultural industry. Naghshineh and Carvalho [92] indicated that the adoption of additive manufacturing could positively affect SC resilience and would be essential for business continuity. However, some of the present adoption barriers for additive manufacturing could result in SC vulnerability and undesirable consequences. Aldrighetti et al. [100] aimed to investigate the costs associated with disruptions and resilience in SC network design models. It was found that the existing studies generally rely on network decentralization and location diversification to support the SC resilience.

5.1.2. Sustainability

As discussed earlier, the COVID-19 pandemic substantially influenced sustainability in different aspects. The most-cited article of Rowan and Laffey [28], which could be fitted under the sustainability dimension, investigated the PPE sanitizing and reusing the critical care equipment to cope with the critical care equipment shortage. Moreover, the bespoke manufacturing strategies were also suggested (more details will be provided in the following sections of the manuscript). Likewise, Goh et al. [43] considered reusing N95 masks and some intensive care unit (ICU) equipment. On the other hand, Sharma et al. [31] analyzed waste management. In particular, biomedical, plastic, and food waste management patterns were investigated during and after the pandemic. The study highlighted that the pandemic changed purchasing behavior, waste composition and quantity. Household food waste may reduce because people tend to use food more efficiently and buy non-perishable items during lockdowns. However, disrupted SCs increase food waste. For instance, managing the inventory levels of perishable food products in stores, trucks, and warehouses is challenging due to the movement restriction and facility closing orders [49].

Similarly, Aldaco et al. [36] indicated that household food losses and waste have changed during the pandemic. Also, the study pointed out that greenhouse emissions due to food waste management increased by approximately 10%. Contrarily, Ibn-Mohammed et al. [38] indicated that the pandemic decreased CO₂ emissions (mainly from cars, power plants, and other sources based on fuel combustion), improved air quality, and reduced noise pollution. The study emphasized the importance of the circular economy and its implications on local manufacturing, medical equipment remanufacturing, and the built environment. Some articles can be matched with all or two of the resilience, sustainability, and technology categories. For example, Queiroz et al. [29] conducted a literature review and proposed a framework spanning various perspectives, e.g., sustainability, resilience, and digitalization. The developed framework has some commonalities with the theme of the present study. Similarly, Pulighe and Lupia [3] discussed that urban agriculture could satisfy resilience and sustainability objectives simultaneously by shortening food SCs. Goh et al. [43] also considered both sustainability and resilience strategies. The authors proposed a set of resilience strategies, such as multiple sourcing, and some sustainability methods, such as reusing the available equipment.

Baral et al. [76] presented a model for survivability of sustainable SCs during the COVID-19 pandemic. SC performance measurement under uncertain conditions, SC positioning, SC administration, and SC cooperation were found to be some of the major constructs. Chen et al. [91] conducted a risk factor analysis for business continuity management in the service industry under the COVID-19 conditions. The outcomes from the study showed that the enterprise operation and production during the pandemic could substantially differ among various sub-sectors of the service industry. An epidemic prevention and control strategy following governmental and investment regulations was proposed to ensure sustainable business development. Kumari et al. [96] underlined that the COVID-19 lockdowns and social distancing restrictions made selling behavior uncertain and complex. The objective of the study was to provide a theoretical framework that describes the stakeholder behavior under severely disrupted SC conditions. Majumdar et al. [97] focused on prioritizing risk mitigation strategies for sustainable clothing SCs. Development of SC agility, adoption of green policies, green sourcing and flexible capacities, trust development, collaboration and coordination, and introduction of economic incentives were found to be the dominant risk mitigation strategies. Several other studies discussed potential risks that could be caused by the COVID-19 on sustainable SC operations [71–75,77,81,82,85,87,89,93,94,102–106].

On the other side, some of the articles cannot be fully fitted under the research themes of the present study. For instance, Yuen et al. [33] explored how panic-buying leads to shortages and SC disruptions. It was indicated that panic-buying happens because of psychological factors such as individuals' perception to scarcity of products, anxiety, and negative emotions. These factors can be managed by assuring that there is a sufficient quantity of products in stocks. Empty shelves and long queues signal the scarcity that can

be reduced by fast replenishment and incentivizing online delivery. Furthermore, Gordon et al. [39] discussed home care delivery and how it could contribute to hospitalization and critical care SCs. The study highlighted that supplying PPE, oxygen, and subcutaneous fluids for home care is critical and requires advance planning.

5.2. Strategies

This section of the manuscript investigates the strategies that were employed or proposed by the influential papers. All the collected articles were thoroughly studied to determine practical approaches for managing significant SC disruptions under the COVID-19 settings. Multiple strategies have been extracted, as indicated in Fig. 6. The identified approaches could be categorized into three primary classifications: (1) production, (2) SC modification/redesign, and (3) government intervention. The following sections discuss circumstances under which the studies proposed particular strategies and what approach could be suitable for desirable objectives.

5.2.1. Production

Ivanov [26] indicated that the timing of the closing and opening of the facilities in different echelons could have major impacts on the SC performance rather than disruption duration and propagation speed. This proposition could be useful for policymakers to prepare a pandemic response plan. It is difficult (or even impossible in many cases) to control the disruption duration or propagation speed, but managing the facility operating time is feasible. Therefore, policymakers and SC managers can use facility opening/closing time as a major factor to manage the impact of a long-duration SC disruption, like pandemic outbreaks. Ivanov and Dolgui [27] proposed a novel decision-making tool, i.e., an intertwined supply network, a system of interconnected SCs to secure the provision of society and demands with products and services. The authors discussed that the intertwined supply chain networks could mitigate or prevent the effects of significant disruptions on SC performance.

Rowan and Laffey [28] suggested three solutions for operating SCs under disruptive settings: (1) improving communication lines by introducing web pages; (2) use of mobile phone apps to improve the stock management; and (3) bespoke manufacturing of PPEs (such as customized 3D printing). Govindan et al. [30] proposed a data analysis model to prioritize the most vulnerable patients, i.e., diabetes and individuals with high blood pressure, for the limited intensive care, medium-needed cases for hospitalization, and normal infected cases for home care. One of the primary solutions for resilience was ramping up production. Iyengar et al. [35] suggested open-source ventilator manufacturing, where companies that don't make ventilators can support the ventilator manufacturing

Supply Chain Management in the Context of COVID-19		
Research Theme	Resilience	Sustainability
Strategies	Production	Urban Agriculture Vertical Planting Rooftop Planting
	Supply Chain Modification	Distributing Manufacturing System Diversifying Sourcing Diversifying Demand Equipment Reuse
	Government Intervention	Family Cash Support Subsidies Tax cuts

Fig. 6. Research themes and strategies.

companies (i.e., Ford and Dyson companies). Also, 3D printing was recommended in making ventilators. Pulighe and Lupia [3] proposed fresh food planting in apartments, rooftop greenhouses, and vertical farming. By doing so, households could produce perishable goods at their place which significantly shortens the perishable food supply and mitigates the impact of movement restrictions and lockdowns.

Singh et al. [71] developed a simulation model to assess the COVID-19 effects on food SC distribution systems. The study pointed out that there were difficulties in matching supply and demand due to increasing number of the COVID-19 cases. The proposed model could be used for managing product distribution to ensure that varying demand would be satisfied. Butt [85] investigated potential strategies that could be used by SC stakeholders to reduce the impacts of the COVID-19. A number of semi-structured interviews were conducted as a part of the study. The results showed that buying firms are moving towards agile production with enhanced outbound material visibility and temporary closure of certain production facilities in order to adequately respond to the COVID-19 challenges. Distribution centers, on the other hand, modify their inventory policies and analyze alternative outbound routes. Naghshineh and Carvalho [92] discussed the concept of additive manufacturing and how it could facilitate business continuity under unforeseen circumstances (e.g., the COVID-19 pandemic). The study highlighted that the adoption of additive manufacturing technology is expected to substantially improve SC flexibility by changing production schedules, fulfilling customer orders, and addressing demand fluctuations.

5.2.2. Supply chain redesign

Relocating SC sectors, e.g., localizing, near-shoring, and diversifying suppliers and other SC tiers, are the primary sustainability and resilience strategies. These strategies also have been studied to cope with the COVID-19 impacts. For example, Sharma et al. [31] suggested that localizing SCs could be beneficial to counter food shortages and waste in the next probable pandemic disruption. Similarly, Remko [34] indicated the need to balance global sourcing with near-shoring, along with local and multiple sourcing. Also, Ivanov and Das [37] proposed a semi-active local supply and market. For instance, a total of 10–20% of the overall supply and market volume could be localized and then scaled up to 70–80% in the occurrence of a global crisis. Similarly, Ibn-Mohammed et al. [38] suggested local manufacturing and remanufacturing of medical accessories, whereas Lu et al. [42] recommended relocating strategic manufacturing operations out of China. Instead of diversifying the supply, Gordon et al. [39] diversified the demand. The study suggested demand prioritization of critical care and developed a model to identify the most needed cases to allocate limited resources. The most vulnerable patients were assigned to critical care, whereas less vulnerable patients were assigned to home care. Liu et al. [41] discussed SC transparency and proposed developing different predictive models to cope with the SC disruptions.

Maemunah and Cuaca [93] underlined that information technology, business strategy, and SC agility could strengthen SC performance under the COVID-19 pandemic settings. The results were confirmed by means of structural equation modeling based on the data collected from the medical device industry in Indonesia. Yu et al. [94] aimed to investigate the role of big data analytics on SCM in the healthcare industry. A total of 105 senior executives participated in the survey that was conducted as a part of the study. It was found that big data analytics could substantially impact three dimensions of healthcare SCs, including hospital-patient integration, inter-functional integration, and hospital-supplier integration. Furthermore, data-driven SCs have an enhanced operational flexibility that could assist with addressing disruptions imposed by the COVID-19. Majumdar et al. [97] conducted a study aiming to prioritize risk mitigation strategies for sustainable clothing SCs. A total of twelve types of risks and thirteen mitigation strategies were evaluated. The development of agility in SCs was found to be the most important strategy for risk mitigation. Multiple green sourcing, flexible capacities, adaptation of green practices, coordination, and collaboration were found to be promising strategies as well.

Butt [104] investigated possible countermeasures that could be used to alleviate the negative externalities caused by the COVID-19 in the manufacturing industry. The research was performed by means of 36 semi-structured interviews with various manufacturing firms. A number of promising countermeasures were identified, including automation of certain manufacturing processes, transferring knowledge to suppliers, understanding demand disruption impacts, and workforce diversity management. Kovács and Falagara Sigala [101] analyzed the lessons learned from the COVID-19 impacts on humanitarian SCs that could be potentially used to manage future SC disruptions. Several important strategies were discussed for SCM under the COVID-19, including avoidance of sourcing from risky locations, personnel training, structural SC flexibility, collaboration, innovation, and standardization. Ivanov [102] discussed four major strategies that could be potentially used to ensure SC viability under the pandemic effects, including scalability, intertwining, repurposing, and substitution. The study proposed a generalized model that could be used to assess the impacts of the aforementioned adaptation strategies and draw some important managerial insights.

5.2.3. Government intervention

Governments and policymakers have a critical role in managing a pandemic and its consequences [51,52]. For example, Yuan et al. [50] highlighted that the government and its public guidance could directly influence how the risk of a pandemic is perceived by individuals. Rigorous regulations and sanctions for incompliance with those regulations might be introduced by the governmental authorities to prevent the spread of the COVID-19 virus across different communities. Furthermore, Harring et al. [51] indicated that the trust between citizens and their governmental agencies is essential in order to alleviate the negative impacts of the COVID-19 on society (including transportation networks and SCs). People should trust the recommendations they receive from the governmental authorities and follow these recommendations. Moreover, the government must also trust its citizens in order to effectively transform the governmental recommendations into collective actions executed by the public. The study also underlined that the governmental authorities should be careful with the introduction of sanctions for incompliance with regulations as it may negatively impact or even completely ruin the trust.

Akseer et al. [40] suggested the government intervention to address the food affordability issues for low-income families by cash

support and tax cuts during the COVID-19 pandemic. Also, it was highlighted to be critical to ensure the accessibility to nutritious food, clean water, and sanitation to reduce the pandemic impact on maternal and children's health. Likewise, Lu et al. [42] discussed that the government financial support, e.g., tax cuts, employment payments, and operating subsidies, could be used to solve the SMEs' cash flow issues. Aldaco et al. [36] underlined the need for effective regulations to maintain sustainability under the pandemic settings.

In summary, based on the systematic review of the relevant literature that was conducted as a part of this study, SC resilience and sustainability were identified to be the main research streams among the collected studies. To enhance resilience, various strategies were recommended by the most-cited articles (see Fig. 6). More specifically, increasing production, additive manufacturing, and bespoke manufacturing were recommended to ensure production resilience. On the other hand, diversifying supply and demand, localizing supply and demand, information sharing, online delivery, modeling unknown disruptions, intertwined supply network, computerized risk assessment, and optimization of the facility opening time were found to be effective means for resilient SC redesign. As for the governmental intervention, introduction of purchase limitations and development of appropriate governmental regulations were recognized as resilient options (see Fig. 6).

Furthermore, a variety of strategies were proposed to effectively meet the sustainability goals for the SCs experiencing disruptions (see Fig. 6). In particular, urban agriculture, vertical planting, and rooftop planting could be used to facilitate production sustainability. On the other hand, equipment reuse, diversification of the supply, diversification of the demand, and deployment of distributed manufacturing systems could be effective means of sustainable SC redesign in order to respond to the disruptions caused by a pandemic. Finally, the government financial support in the form of family cash support, subsidies, and tax cuts plays an important role for meeting the sustainability goals as well (see Fig. 6).

As a part of this study, the identified disruption management strategies were divided into the following categories (see Fig. 7): (1) disruption preparedness; (2) disruption response; and (3) disruption recovery. This classification scheme for disruption management strategies is based on the scheme proposed by Chowdhury et al. [6]. Disruption preparedness refers to the activities that could be conducted before the occurrence of a given disruptive event in order to ensure an effective response. Disruption response refers to the activities that could be executed to enable SC operations after the occurrence of a given disruptive event. Disruption recovery refers to the activities that could be executed after the occurrence of a given disruptive event aiming to return to normal conditions that were common before the disruption affected a given SC. Moreover, based on the conducted literature review, a diagram for disruption causes and effects was developed considering the lessons learned from the COVID-19 pandemic (see Fig. 8). In particular, a variety of causes were identified that could potentially influence demand and supply within a given SC network. These causes could lead to certain undesirable effects that have to be addressed by the SC stakeholders to support SC operations and ensure business continuity.

6. Managerial insights

The COVID-19 pandemic significantly disrupted SCs across the world and attracted the attention of managers and policymakers to improve the SC resilience and sustainability [52], especially for SCs handling critical products. Many studies analyzed various strategies to cope with the COVID-19 impact on SCs. This study performed a comprehensive analysis to identify important topics and vital strategies to cope with the SC disruptions due to the COVID-19 pandemic. In this section, we draw managerial insights based on the findings of the reviewed literature. The present investigation revealed that resilience, sustainability, technology, food, and health-related SCs are the most important topics [54,59,62]. Also, the best practices relevant to those topics were identified as well. Therefore, the following insights can be adopted from the analysis results to manage the COVID situation and future SC disruptions.

- Resilience and sustainability were found to be the most critical themes. Resilience and sustainability should be considered as important attributes of each SC (not as auxiliary attributes). Therefore, SC managers should have a plan to improve resilience and sustainability of their SCs, so these SCs could effectively respond to the changing environment under the pandemic settings. Lack of resilient and sustainable SCs could magnify the effects of a pandemic and cause additional negative consequences.
- Various innovative technologies, such as digital twin [54], blockchain [12], artificial intelligence (AI) [63], and internet of things (IoT) [67], are valuable tools that could be used in managing SCs in the occurrence of SC catastrophic disruptions, like the COVID-19 pandemic [57,58]. For example, digital twins can be used to simulate response strategies and SC operations under disruptive conditions [59–62]. Similarly, AI can be used to evaluate the effectiveness of different strategies and develop response plans by implementing optimization algorithms. Furthermore, blockchain and IoT can enhance the transparency and traceability of SCs, which is critical for the SC resilience and sustainability. The IoT can collect the data from different SC components and store the data on a blockchain-based platform to enhance the information sharing endorsed by the studies reviewed and strengthen resilience.
- Persuading sustainability and resilience simultaneously is challenging, and developing strategies that could be able to address both objectives at the same time is critical [57,58]. The analysis performed as a part of this study indicates that shortening SCs, e.g., near-shoring and local manufacturing, could simultaneously improve sustainability and resilience [68]. Furthermore, new production methods, such as additive manufacturing or rooftop planting, could contribute to resilience by manufacturing the products in the designated customer locations and sustainability by reducing CO₂ emissions associated with the product manufacturing and delivery processes [65].
- Developing a strategic plan to cope with a catastrophic SC disruption is vital. Some companies develop their plans by focusing mainly on either preparation or response phases, which may not be always the most effective approach. Consideration of preparation, response, and recovery phases in a strategic action plan altogether can more effectively mitigate the COVID-19 effects on SC operations. Therefore, SC stakeholders have to dedicate adequate attention to the planning of preparation, response, and recovery

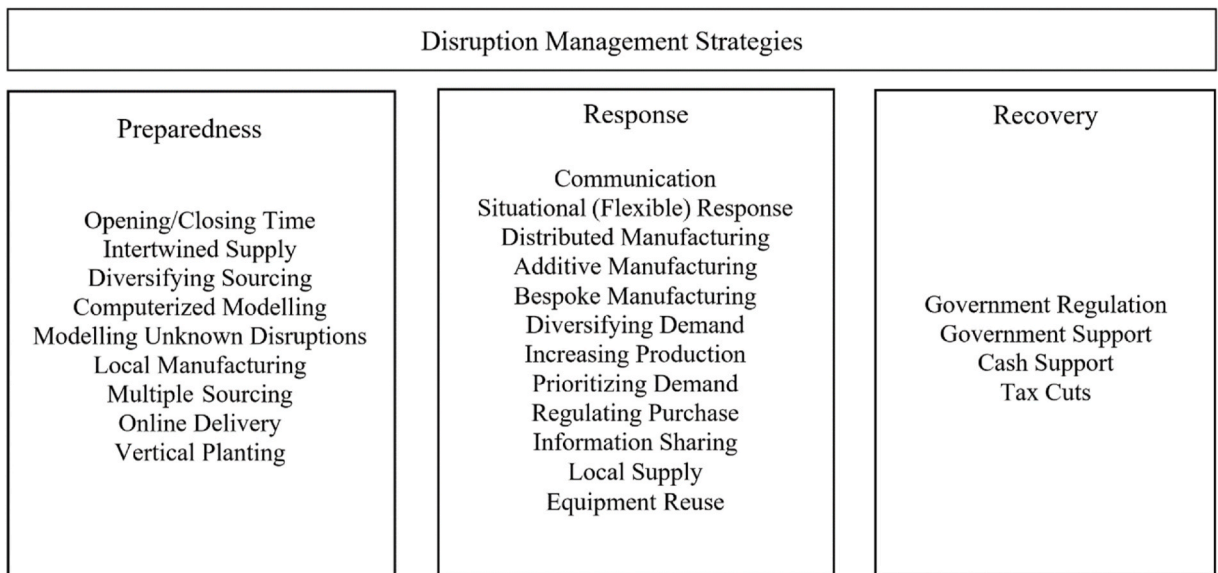


Fig. 7. Classification of the identified disruption management strategies.

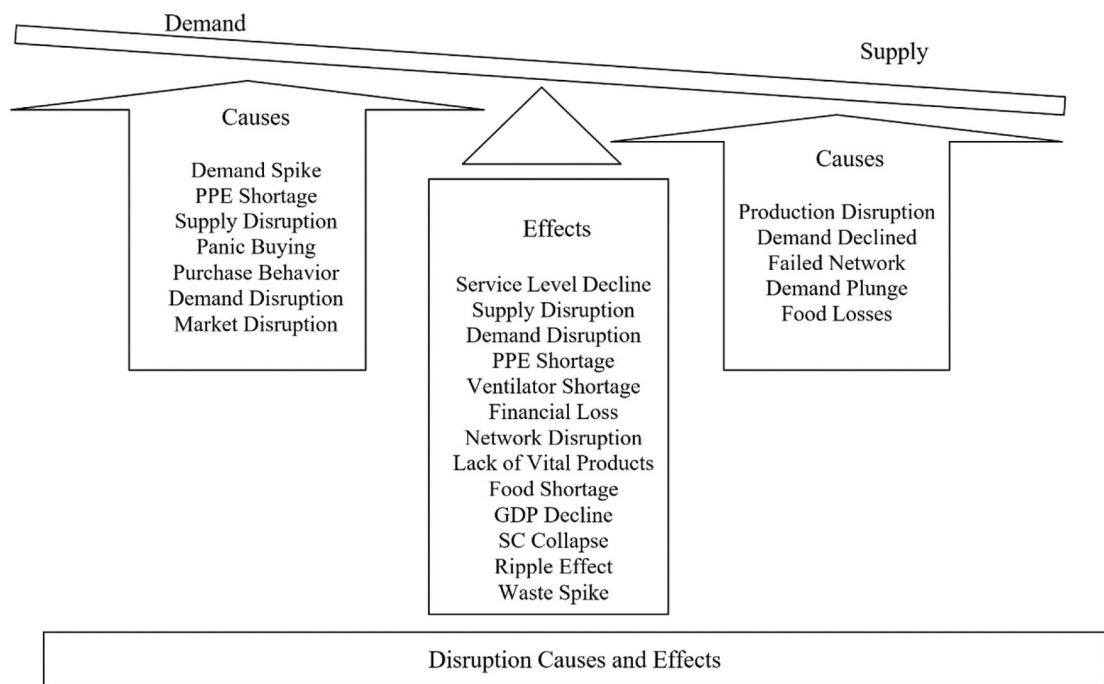


Fig. 8. Diagram for disruption causes and effects.

activities in order to better address major SC disruptions (e.g., natural hazards, man-made hazards, pandemics) in the following years.

To summarize the key managerial insights revealed as a result of the conducted literature survey and supporting analyses, developing digital technologies could help managers and policymakers to be prepared for future SC disruptions [12,57–60]. In addition, local manufacturing and near-shore supply could be a valuable strategy to ensure resilient and sustainable product flow through SCs, especially for vital products, such as PPE and vaccines [52–54].

7. Conclusion

The COVID-19 pandemic caused significant disruptions within supply chains (SCs) all over the world. This challenging issue attracted the attention of many SC scholars, aiming to conduct different investigations and assess the SC performance in the occurrence of such a significant disruption. However, the literature reviews on this topic were mostly published at the early stage of the pandemic. There is still a lack of systematic literature survey studies that aim to identify promising SC disruption management strategies through the bibliometric, network, and thematic analyses. In order to fill this gap in the state-of-the-art, this study conducted an up-to-date comprehensive bibliometric and network analyses to identify the most influential authors, countries, and studies. As a result of the conducted analyses, the primary topics, research streams, and recommended approaches to manage significant SC disruptions, like the COVID-19 pandemic, were identified. The most contributed countries on this topic were found to be the US, far ahead of the UK, China, India, and Australia. The most repeated keywords were found to be *resilience* and *sustainability*. The keyword network analysis also revealed that resilience and sustainability were the main topics of clusters. Food and technology were identified as important clusters as well. The citation analysis results confirmed the bibliometric outcomes. Resilience and sustainability became the primary research streams of the literature. The most-cited publications proposed several strategies to manage the COVID-19 impact, which were thoroughly investigated as a part of this study as well.

This study can be viewed as one of the first attempts that used the outcomes from the conducted bibliometric and network analyses to identify the most promising disruption management strategies, which could be implemented by the relevant SC stakeholders to effectively address future pandemics and other types of disruptions. The identified disruption management approaches could be categorized into three primary classifications: (1) production, (2) SC modification/redesign, and (3) government intervention. The proposed strategies were mostly driven by increasing production, diversification of sourcing and demand, localization of SCs, and various government subsidies for families and companies (e.g., family cash support, tax cuts, monthly subsidy payments). Pursuing resilience and sustainability objectives simultaneously and developing strategies to address both objectives could be challenging. However, as a result of the conducted survey, it was found that shortening SCs (e.g., near-shoring and local manufacturing) could be used to effectively achieve resilience and sustainability objectives simultaneously.

Regarding the future research needs, throughout the conducted literature survey, it was found that some of the identified aspects within the collected studies were discussed less than the others and could be further investigated in the future studies. For example, technology was revealed as a cluster but less considered by the most-cited articles. So, using technology to manage the SC disruptions or investigating technology-driven strategies could be an interesting future research direction. Furthermore, the future research could concentrate more on uncertainty modeling approaches in various SC operations under the COVID-19 settings (e.g., evaluation of different approaches for modeling uncertainty in supply, demand, delivery times, manufacturing times, etc.). Promising uncertainty modeling approaches would be critical for an effective design of robust SCs during the COVID-19 pandemic and other major disruptive events.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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