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Supply chain risk management: A content analysis-based review of existing and emerging topics

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ABSTRACT

This paper presents a systematic review of the literature on Supply Chain Risk (SCR) research, focusing on content-based analysis. The study comprehensively examines the general factors associated with key themes and trends in supply chain risk management, encompassing the identification and assessment of risks, risk mitigation strategies, and the influence of emerging technologies on Supply Chain Risk Management (SCRM). The review provides an overview of current and emerging topics in SCRM, while also introducing categorization frameworks to address research gaps and provide a roadmap for future studies, thereby generating valuable insights in this field. The review highlights the significance of effective SCRM in ensuring business continuity and resilience, emphasizing the need for organizations to adopt a proactive approach to risk management. The paper concludes by identifying areas for future research, including the development of novel risk management frameworks and the integration of emerging technologies into supply chain risk management practices. Additionally, a comprehensive evaluation of each classification is presented, highlighting overlooked aspects and unexplored domains, and offering recommendations for potential next steps in SCRM research.

1. Introduction

The process of detecting, analyzing, and managing the risks associated with the global and dispersed information and communications technology structure is known as SCRM [1]. It is also the process of discovering, analyzing, and reducing threats to the integrity, reliability, and authenticity of goods and services along the supply chain [2]. A practical approach to SCRM involves identifying and assessing known and unknown risks, building a risk management framework, and implementing strategies to mitigate risks [3].

The strategies for success in SCRM include diversifying suppliers, building strong relationships with suppliers, monitoring supplier performance, and investing in technology to develop Supply Chain (SC) visibility and resilience [4]. SCRM is a critical aspect of modern business operations. Companies confront a wide range of risks as global SCs get more complicated, threatening their capacity to offer products and services to customers [5]. From natural disasters and geopolitical instability to cyber-attacks and supplier bankruptcies, the risks are many and varied. To effectively manage these risks, companies need to comprehensively understand the key matters and emerging trends in SCRM. This review will explore these issues in SCRM, providing insights and recommendations for companies looking to enhance their risk management capabilities [6].

A risk factor is "anything that increases the likelihood of developing a disorder" [7]. Risk factors include age, family history, lifestyle choices, and environmental variables. Age, a family record of particular malignancies, and exposure to specific chemicals are all risk factors for cancer [8]. The term "risk factor" is used by epidemiologists to characterize factors related to an elevated risk of illness or infection [9].

Several common risks in SCM can disrupt operations and cause significant financial losses. These risks are classified into four types: economic, environmental, political, and ethical [10]. Manufacturing risks,

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storing and shipment risks, financial risks, legal risks, quality risks, transit delays, theft, natural catastrophes, weather-related issues, and cybercrime are some critical risks associated with SCM [11].

Inadequate project management, inadequate phrasing, or alterations to the scope of work are all critical threats that might jeopardize the timetable and have severe financial consequences. To mitigate these risks, businesses can implement strategies such as diversifying suppliers, building strong relationships with suppliers, monitoring supplier performance, investing in technology to improve SC visibility and resilience, and having contingency plans [12].

Emerging technologies are predicted to considerably impact SCRM. Autonomous mobile robots, truck collaboration, and Distributed Ledger Technology (DLT) are some of the technologies expected to impact SCM in the future. However, adopting these technologies also brings new security risks that must be addressed [13].

Artificial Intelligence (AI) and advanced analytics are also key technologies that can help improve supply chain management and decision-making. Technology is essential for SCM experts to extract concrete and practical details from data, and numerous SC executives regard technology as an instrument of competitive advantage [14]. SCRM consists of identifying, evaluating, and mitigating risks in the SC [15]. The demand for SCRM has grown dramatically over the previous decade, especially in the past five years, due to the proliferation of global risks. SCRM allows government and industry to defend against known threats to SCs while building resilience to future risks [16].

The Biden-Harris administration has revealed the results of a comprehensive 100-day SC evaluation for four essential items, demonstrating various risks and vulnerabilities in US supply networks [17]. The study includes six suggestions for reinforcing critical supply networks and enhancing environmental guidelines [18]. There are several ways to approach SCRM, including determining risk categories, assessing risks, and developing mitigation strategies [19]. The review also identified several risk detection and mitigation strategies, including risk pooling, supplier diversification, and inventory management [20]. Scientists created a theoretical structure for SC resiliency established on vulnerabilities and capacities, highlighting SC risks [21]. A literature review of SCRM identified four main categories of risk: demand, supply, environmental, and operational [22].

The COVID-19 pandemic has emphasized the significance of SCRM. The pandemic has affected supply chains worldwide, leading to significant disruptions [2,5,10,11,13]. A comprehensive framework for SC-COVID-19 manifestations has been developed, considering nine factors and 58 elements. Decision-makers and researchers can use the framework, and it can be generalized to other industries [23]. The term "Risk" is used in multiple ways, denoting uncertain variables that reduce outcome predictability and the effects of those risks [24].

SCRM is described in the paper as recognizing and handling risks for the SC by an integrated strategy across SC members to lessen overall SC vulnerability [25]. Due to a growing complicated global network, which can result in delays and quality issues in SC operations, SC uncertainty is a big worry for managers. While overlooking various distinguished factors contributing to risk and uncertainty, scholarship has concentrated on particular sources of uncertainty related to in-house manufacturing processes, supply-side processes, and end-customer demand. In the present competitive economy with multiple newest challenges, enhanced comprehension of uncertainty and risk management is still a significant issue [26] due to tremendous supply and demand instability, globalization of markets, and shorter product and technology lifespan cycles. In addition, the growing use of outsourced production, distribution, and logistics creates intricate linkages in the global supply chain, boosting risk exposure [27].

Managing SCRs, a crucial aspect of SCM, is commonly understood as the probability that a hostile and unanticipated event will happen and either directly or indirectly interrupt the SC [28]. The Indian Ocean tsunami in 2004, the Fukushima Daiichi nuclear disaster in Japan in 2011, and the fire at a Philips plant in New Mexico in 2000 (that obstructed the SCs of Nokia and Ericsson, resulting in a monetary loss of 400 million Euros for Ericsson), an earthquake in Taiwan [29], recently COVID-19 and earthquake in Turkey are just a few instances of unforeseen occurrences that demonstrate the detrimental effects of disruptions on organizational performance. The kind and characteristics of unpredictable developments or the consequence of such actions are challenging or impossible to forecast [30]. To mitigate and avoid risks, scholars, and professionals agreed to manage risks [31]. Therefore, SCRM strives to create plans for identifying, evaluating, managing, and monitoring risks in SC [32]. As a result, professionals and researchers are highly interested in various aspects of SCRM.

2. Background and related research

2.1. Related works

Considering this, researchers have discovered a variety of variables that affect the connections between SCR, disruptions, resilience, and performance [33]. Although the objective versus subjective aspect of risk is still discussed, investigators agree that risk management should be viewed as a process with three phases: risk identification, estimation, and evaluation [34]. It is harder to define SCR and challenging to categorize distinct types of SCR [35].

Abbasi et al., (2023) [110] designated the home healthcare SC considering risk during COVID-19. Babu et al., (2023) [111] considered a SC risk assessment for small and medium in post-COVID-19. Vafadarnikjoo et al., (2023) [112] researched a novel grey MO binary linear programming model for risk assessment in SCM. Debnath et al., (2023) [113] investigated sustainable supplier selection in the healthcare supply chains. Deretarla et al., (2023) [114] studied the SCM for assessments of the vendor selection area. Kabir et al., (2023) [115] analyzed the risk assessment and decision-making in fuzzy systems.

To advance common cognition, scholars must know what has already been accomplished, the advantages and disadvantages of current studies, and their underlying significance [36].

Khalili-Damghani and Ghasemi (2016) [116] planned the SC model in risk and fuzzy framework simultaneously. Ghasemi et al., (2017) [117] designed the decentralized SC planning model considering risk. Ahmadi Choukolaei et al., (2021) [118] analyzed the efficient crisis management in Tehran with a risk approach. Ghasemi et al., (2022, c) [123] considered the location-routing problem in the SC based on risk. Shokouhifar et al., (2021) [119] designed the blood supply chain considering risk with the fuzzy model. Safaei et al., (2022) [120] designed a Closed-loop Supply Chain Network (CLSCN) by forecasting risk management.

Ghasemi et al., (2022,a) [121] suggested the model for blood SC focused on a risk problem robust optimization approach. Shokouhifar & Ranjbarimesan (2022) [124] managed the supply chain network (SCN) during the COVID-19 pandemic. Considering the risk. Li et al., (2023) [125] analyzed SCRM for the big data in disaster conditions. Fernando et al., (2023) [126] consider SCRM with performance in the industry 4.0 era.

Abbasi's (2023) [127] assessment of environmental impacts at risk the COVID-19. The vaccine supply chain network (VSCN), proposed by Abbasi et al. in 2023 [128], is considered environmental risk environmental risk into consideration. Ghasemi et al., (2022, b) [122] suggested a new humanitarian relief logistic network in risk situations. Kamran, et al., (2023) [129] designed the COVID-19 Vaccine Supply Chain Network (VSCN) under risk issues. Shokouhifar et al., (2023) [130] considered the SCRM in Sustainable Supply Chain (SSC).

Existing literature reviews, as shown in Table 1, promote the development of identification of possible risks in the SC process, better categorization methods and models, and, as a result, a better comprehension of the problems involved in the study of SCRM. Table 1 details the published review papers on SCRs.

Although valuable, these research investigations either had

Table 1
Published Review Papers on SCRs area between 2004 and 2022.

Author	Year	Title	Journal	Focus	Reviewed Papers	Time Period	Bibliometric View		Citations
[37]	2004	A Review of Enterprise Supply Chain Risk Management	Journal of Systems Science and Systems Engineering	Enterprise risk management practices	34 (REF)	Until 2004			133
[38]	2006	Perspectives in supply chain risk management	International Journal of Production Economics	Quantitative models for SCRM	217(REF)	Until 2006			1888
[39]	2007	Supply chain risk management and performance: A guiding framework for future development	International Journal of Operations and Production Management	Interaction between Risk and Performance in a supply chain context	47(REF)	Until 2006			708
[40]	2007	Risk and supply chain management: Creating a research agenda	The International Journal of Logistics Management	Developing a research agenda for risk and supply chain management	94 (REF)	Until 2005			605
[41]	2009	Supply Chain Risk Management: Literature Review and Future Research	Int'l Journal of Information Systems and Supply Chain Management	The types of risks, the unit of analysis, the industry sectors, and the risk management process or strategies	82	2000 – 2007			282
[27]	2009	Supply chain risks: A review and typology	The International Journal of Logistics Management	Develop a typology for SCRs	132 (REF)	Until 2008			860
[42]	2010	A review of enterprise risk management in supply chain	Kybernetes	Identification and classification of types of risks, cases, and models in SCRM	42 (REF)	Until 2010			289
[35]	2010	State of the art in supply chain risk management research: Empirical and conceptual findings and a roadmap for the implementation in practice	Logistics Research	Main principles of SCRM and evolutionary steps for its implementation	68 (REF)	Until 2008			282
[43]	2011	Identifying risk issues and research advancements in supply chain risk management	International Journal of Production Economics	Identification the major risk issues and risk mitigation techniques based on material, cash, and information flows	236	1995–2009	*		1252
[26]	2012	Supply-chain uncertainty: A review and theoretical foundation for future research	International Journal of Production Research	Developing of theoretical foundation for SCRs and SC-uncertainty	109 (REF)	Until 2010			479
[44]	2012	Researchers' perspectives on supply chain risk management	Production and Operations Management	Researcher views	133 (RES)	2009			847
[45]	2012	Supply chain risk management: A new methodology for a systematic literature review	Supply Chain Management	İnvestigating the process of knowledge creation, transfer and development from a dynamic perspective	55	1994–2010	*		835
[46]	2012	Supply Chain Risk Management Present and Future Scope	International Journal of Logistics Management	A holistic systems thinking perspective by considering seven distinctive research factors	120	2000–2010	*		533
[47]	2013	Supply chain risk management-II: A review of individual and integrated operational and financial approaches	Risk Management	Classification and analysis of operational, financial, and integrated approaches against SCRS	68 (REF)	Until 2011			45
[48]	2013	Supply Chain Risk Management: A Content Analysis Approach	International Journal of Industrial Engineering and Management (IJIEM)	Content Analysis of SCR	60	2003–2012			71

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Table 1 (*continued*)

Author	Year	Title	Journal	Focus	Reviewed Papers	Time Period	Bibliometric View	Citations
[49]	2014	Supply Chain Risk Management: A Review	Int. J Sup. Chain. Mgt	Definition of each SCRM component	55 (REF)	Until 2014		26
[50]	2015	Supply chain risk management: A literature review	International Journal of Production Research	Categorizing of SCRM based on risk definitions, risk types, risk factors and risk management/ mitigation strategies	224	2003–2013		1259
[30]	2015	A critical review on supply chain risk - Definition, measure, and modeling	Omega (United Kingdom)	Supply chain risk definitions, quantification measures and modeling approaches	162	Until 2014		985
[51]	2015	Quantitative models for managing supply chain risks: A review	European Journal of Operational Research	Quantitative and analytical models for SCRM	1108	1978–2015	*	501
[52]	2015	Supply chain risk classification: Discussion and proposal	International Journal of Production Research	Risk categorization based on SCOR model	33 (REF)	2000–2012		179
[36]	2016	Supply chain risk management research: avenues for further studies	International Journal of Supply Chain and Operations Resilience	The relationship of performance with SCRM	60	2000–2013		17
[53]	2016	Supply chain risk analysis with mean-variance models: a technical review	Annals of Operations Research	Analyzing stochastic SCRM	52	Until 2012		271
[54]	2016	The strategies of supply chain risk management – a synthesis and classification	International Journal of Logistics Research and Applications	Classification and analysis of SCRM strategies	86	2000–2015		100
[55]	2017	Literature Review on Disruption Recovery in the Supply Chain	International Journal of Production Research	The existing methods for SC design and planning with both disruptions and recovery	130 (REF)	Until 2017		505
[56]	2017	Supply Chain Risk Classification Schemes: A Literature Review	Operations and Supply Chain Management	Identification risk sources and classification of risks	25	2003–2015		49
[57]	2017	Integrated supply chain risk management: A systematic review	International Journal of Logistics Management	Integration SC with SCRM	67	1998–2015		90
[58]	2017	What is supply chain risk management? A review	Advanced Science Letters	General definition of SCRM	62	Until 2016		50
[59]	2017	A critical analysis of supply chain risk management content: a structured literature review	Journal of Advances in Management Research	Risk-based content classification of SCRM	343	2004–2014		103
[60]	2017	The ISO 31000 standard in supply chain risk management	Journal of Cleaner Production	Pathway to identify and prioritize which ISO 31000:2009 risk assessment tool	27	2004–2015		213
[61]	2017	Decision-making models for supply chain risk mitigation: A review	Computers and Industrial Engineering	Decision-making models for SCR mitigation	126	2015–2016	*	139
[62]	2018	Supply chain risk assessment: A content analysis-based literature review	International Journal of Logistics Systems and Management	Content analysis of SCR assessment methods	140	2002–2017		35
[32]	2018	A Review of supply chain risk management: definition, theory, and research agenda	International Journal of Physical Distribution and Logistics Management	Risk identification, assessment, treatment, and monitoring	354	2000–2016	*	412
[63]	2018	Optimization of a supply portfolio in the context of supply chain risk management: literature review	Journal of Intelligent Manufacturing	Supplier selection under SCRM	124	2003–2014		88
[64]	2018	Analysis of supply chain risk management research	Gestao e Producao	Analyzing the profile of papers published on SCRM	248	2004–2015	*	20
[28]	2019	Malicious Supply Chain Risk: A Literature Review and Future Directions	Springer Series in Supply Chain Management	Malicious SCR	47 (REF)	Until 2018		10

(*continued on next page*)

Table 1 (*continued*)

Author	Year	Title	Journal	Focus	Reviewed Papers	Time Period	Bibliometric View	Citations
[29]	2019	The Impact of Supply Chain Disruptions on Organizational Performance: A Literature Review	Springer Series in Supply Chain Management	Relationship between supply chain disruption risks and organizational performance	50	2000–2017		47
[65]	2019	Categorizing Supply Chain Risks: Review, Integrated Typology and Future Research	Springer Series in Supply Chain Management	Classification of SCRs	100	2000–2017	*	24
[66]	2019	Supply Chain Risk Management and Artificial Intelligence: State of the Art and Future Research Directions	International Journal of Production Research	Problems relevant to SCRM using approaches that fall within the AI spectrum	276	1978–2018		495
[67]	2019	Supply chain risk management: models and methods	Int. J. Management and Decision Making	Models and methods applied in SCRM	500	1997–2018	*	45
[68]	2019	The role of simulation and optimization methods in supply chain risk management: Performance and review standpoints	Simulation Modelling Practice and Theory	Analyzing the role and contribution of simulation and optimization methods for the SCRM	57	2000–2017		92
[69]	2020	Supply Chain Risk Governance: Towards a Conceptual Multi-Level Framework	Operations and Supply Chain Management	Extending existing multi-level frameworks with inter-organizational governance mechanisms	33 + 26	2002–2018		33
[70]	2020	Smarter supply chain: a literature review and practices	Journal of Data, Information and Management	SSCM's beneficial contribution to supply chain intellectualization	68	2009–2019		32
[71]	2020	A Review of the Existing and Emerging Topics in the Supply Chain Risk Management Literature	Decision Sciences	Categorizing the areas of SCRM with 11 clusters	119	2001 – 2019	*	151
[72]	2020	A Global Supply Chain Risk Management Framework: An Application of Text-mining to Identify Region-specific Supply Chain Risks	Advanced Engineering Informatics	Global SCRM framework	11,118,911	2000–2020	*	74
[73]	2020	The development of supply chain risk management over time: revisiting Ericsson	International Journal of Physical Distribution and Logistics Management	Current developments in SCRM	17 (REF)	Until 2020		49
[74]	2020	A systematic review on supply chain risk management: using the strategy-structure-process-performance framework	International Journal of Logistics Research and Applications	Strategy, structure, process, and performance in SCRM	174	2001–2017		15
[75]	2020	A Meta-Analytic Review of Supply Chain Risk Management: Assessing Buffering and Bridging Strategies and Firm Performance	Journal of Supply Chain Management	Buffering and bridging strategies to determine their effect on SCRM	26	Until 2018		93
[76]	2021	A Systematic Investigation of the Integration of Machine Learning into Supply Chain Risk Management	Logistics	Application of Machine Learning in SCRM	109	Until 2020		15
[77]	2021	Supply chain risk management: Literature review	Risks	Review the literature on risk factors in supply chain management in an uncertain and competitive business environment	455	2010 – 2019		73
[31]	2021	Mitigation Strategies in Supply Chain Risk Management: A Literature Review	Central Asia and the Caucasus	Analyze SCR mitigation	30	2004–2019		NA
[78]	2021	A systematic literature review on supply chain risk management: is healthcare management a forsaken research field?	Benchmarking	Application of SCRM in Healthcare	8 + 114 + 119	Until 2020	*	21
[79]	2022	Explain ability in supply chain operational risk management: A systematic literature review	Knowledge-Based Systems	Analysis and evaluation of methods for identifying operational risks	72	2000–2020		15

(*continued on next page*)

Table 1 (*continued*)

Author	Year	Title	Journal	Focus	Reviewed Papers	Time Period	Bibliometric View		Citations
[80]	2022	Optimization models for supply chains under risk, uncertainty, and resilience: A state-of-the-art review and future research directions	Transportation Research Part E: Logistics and Transportation Review	The quantitative models for SC resilience	3672	1996–2020	*		19

X(REF): The number of references in the reference list; X (RES): Review *via* Interview; Until (X) represents the upper bound year of the reviewed article.

quantitative models or specific industries (e.g., [30,38]. Moreover, most of these papers—save for two—only evaluated a tiny number of publications. Given the focus area of interest, [44] evaluated 31 publications, [27] examined 55 papers, and [45] investigated 55 articles. However, the SCRM field is expanding so quickly that 658 articles have been released since 2020 **(**Fig. 1**).** The studies that involved risk categories and were published between 2020 and 2023 (801) were never reviewed, as shown in Table 1**.** Additionally, as seen in Table 1**,** content-based reviews after the pandemic were addressed by [78], [72], [71], and [80], however except for [80], the authors have reviewed tiny numbers of articles, and [80] concerned on the optimization models in SCRM, not a holistically reviewed the papers. Again, none of these reviews has used bibliometric analysis. As a result, it is stated that a new SLR on SCRM is required.

Finally, we review the literature to identify potential SCRM gaps. Numerous studies have also used data-driven methodologies or extensive data analysis in SCM and risk analysis. However, they either concentrate solely on the internal operations of the SC, a single industry, or assessments based on internal numerical data gathered from test companies. In contrast, this study created a comprehensive risk classification backed by a sizable dataset that included existing literature until 2023. By classifying SCR categories, risk factors, and risk management techniques, our work also suggests a new insight into SCRM. It provides a comprehensive view since 1478 articles were included in the bibliometric analysis.

2.2. Research gap, novelty, and contribution

One contribution of this study is to offer a structure for the present stage of research, which would be helpful to us as researchers. This review presents the past and current focuses on the SCR investigation and offers a future direction.

The main contribution of this review paper is to answer the following questions:

1. What are the most studied themes related to SCCR over the years?
2. How has the research on SCR evolved over the past years?
3. Which countries have been the most active in publishing research on SCR?
4. What are the most frequently cited publications on SCR?
5. How has the emphasis on diverse types of SCR (e.g., operational, financial, managerial) changed over time?

3. Research method and scope

3.1. Research method

In this research, a content-based Systematic Literature Review (SLR) was performed. Although an SLR is often carried out manually and may be time-consuming, the SLR procedure might be performed efficiently, quickly, and evidence-based with novel information management instruments [46]. Combining in-depth qualitative methods with potent quantitative analyses is a crucial benefit of content analysis. Flexible investigations on two levels are made possible by this method: First, reveal the subject matter of text and documents, and latter, unearth the text's hidden meaning and content [62]. On the other hand, the suggested systematic artificial-intelligent-based framework may produce findings more quickly as it can quickly analyze a more extensive dataset. A data-driven approach would produce results with less human bias [81].

Due to various utilizing areas of bibliometric methods, such as organization, innovation, entrepreneurship, and operations management, strategic management, there is a trend of using bibliometric and lexicographic techniques. The power of bibliometric analyses stands in their

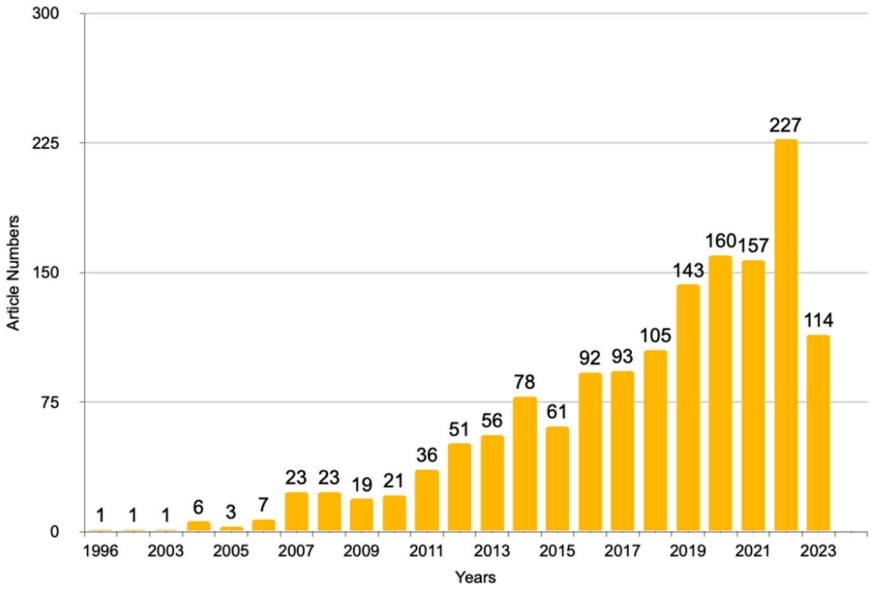

Fig. 1. The number of papers published over the years.

unobtrusiveness and objectivity, allowing for a high level of quantifiability and quantitative analysis. The outcome depicts the core subjects of research efforts with a conceptual structure based on the authors' contributions to its intellectual advancement [82]. The most prevalent bibliometric network approaches are co-citation and co-occurrence analysis. A relationship between two articles arises in co-citation when another work cites both. A core premise of co-citation is that the more two publications are mentioned, the more probable their topics are connected. Although co-citation analysis identifies leading documents, developing trends, and other intriguing outcomes, it frequently fails to accurately reflect the content of the study themes discussed in the literature. In addition, it is less trustworthy and constrained by its search approach to less referenced and the latest papers. In contrast, co-occurrence analysis employs a set of common terms rather than groups of shared citations. Co-occurrence analysis is the only bibliometric approach mapping relevant literature based on term encounters. Co-occurrence analysis tacitly believes that a set of collected keywords may reveal the root topics and that keyword co-occurrences can reveal the relationship with those themes [61]. Hence, in this review, the co-occurrence of keyword analysis was employed to detect the themes related to SCR.

3.2. Search scope

Scopus and Web of Science are two of the most used search engines accessible for discovering scholarly publications from various publishers and periodicals. We utilized the Scopus search engine to perform our literature inquiry since it is highly regarded and utilized for content mapping and co-citation analysis. Compared to the Web of Science, Scopus presents a database of documents most closely associated with the research subject [71].

On 3rd May 2023, the search term SCR in article titles, keywords, and abstracts yielded 2703 documents. We refined the articles written in English and published them in peer-reviewed international journals from review papers, conference documents, master and doctoral theses and dissertations, textbooks, or book chapters, giving us 1498. We further confined the source of these documents to journals that yielded 1478 articles. These articles were extracted as a CSV file with complete information and uploaded into VOS-Viewer software to analyze.

We profited from bibliometric analysis, a scientific analytic method to show data and information that uses mathematical and statistical tools to identify study areas and hotspots and track trends in a subject. VOS-viewer, developed by [83], is a widely used display tool for bibliometric analysis nowadays.

4. Results

4.1. Descriptive statistics

This section gave summary statistics related to the articles in SCR. Based on the 1478 articles were examined in terms of article count, as shown in Fig. 1 below.

From an observational standpoint - taking the publishing years into account - it is noteworthy to observe that the quantity of articles is rising throughout the period (2015–2023), indicating that the subject is expanding. The number of published articles was picked last year, and 801 articles were written in this area during and after COVID-19.

Because the topic's potential is open to investigation, such theoretical, empirical, numerical, political, and strategical aspects were handled by investigators across numerous disciplines. The distribution of publications on various study fields is depicted in the pie chart in Fig. 2 below. According to Fig. 2, researchers mainly focused on business and management aspects of SCR, accounting for 29% of overall study fields. The following explored areas are decision science and engineering, accounting for 17% of the total. The topic gained attention by computer scientists appearing to rank third and social scientists fourth.

SCR was investigated by scholars in the fields 4% in economics, econometrics, and finance, 3% in environmental science and mathematics, and 3% in Energy. The remaining disciplines in Fig. 2 constitute approximately %1 of all areas, while the rest that is not illustrated in Fig. 2 represents less than 1% of the total all domains.

The highly cited articles over the years in the SCR are demonstrated in Table 2 below. [84]'s article, " Building the Resilient Supply Chain," published in 2004, was referenced by 1714 other papers.

More recently, Ivanov and friend's articles ("Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak" and "The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics" have gained attention by scholars and cited by over 700 papers.

It is clear from Table 2 that the scholars are particularly interested in resilience and risk mitigation studies and have recently focused on digital solutions of SCR. Fig. 3 has mapped the top nations where writers produced the most articles.

The United States has the most published articles in this field, constituting approximately 17.5% of the total. China is the second most creative country, accounting for around 10.8% of all papers published in this field, followed by India, the United Kingdom, Germany, and Australia, with articles 183, 156, 100, and 80, respectively. Iran, Canada, Italy, France, the Netherlands, Taiwan, Hong Kong, Brazil, and

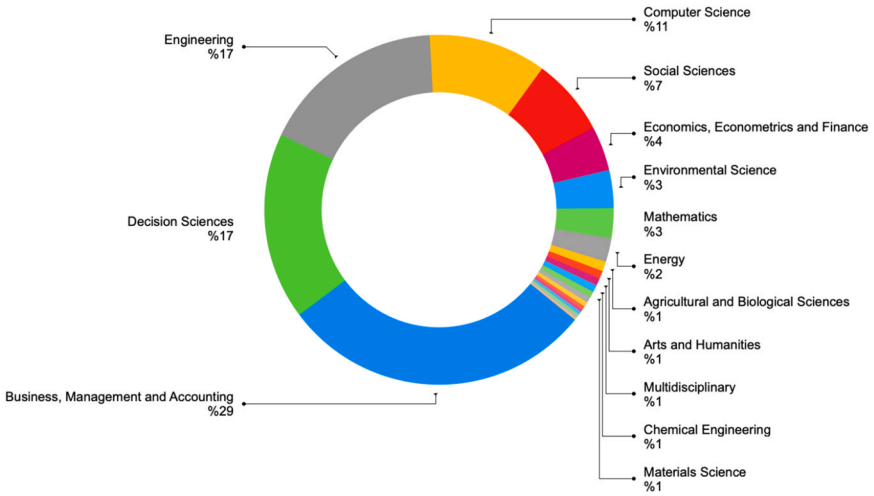

Fig. 2. The number of papers published in the scientific areas.

Table 2
The top 20 most cited articles in the SCR.

Authors	Title	Year	Cited by	Journals
[84]	Building the Resilient Supply Chain	2004	1714	Int. J. Logist. Manage.
[85]	The severity of supply chain disruptions: Design characteristics and mitigation capabilities	2007	1046	Decis. Sci.
[25]	Supply chain risk management: outlining an agenda for future research	2003	1010	Int. J. Logist. Res. Applic.
[86]	Mitigating supply chain risk through improved confidence	2004	820	Int. J. Phys. Distrib. Logist. Manage.
[87]	Global supply chain risk management strategies	2008	728	Int. J. Phys. Distrib. Logist. Manage.
[88]	Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by the COVID-19 outbreak	2020	728	Int J Prod Res
[89]	The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics	2019	718	Int J Prod Res
[90]	Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident	2004	708	Int. J. Phys. Distrib. Logist. Manage.
[43]	Identifying risk issues and research advancements in supply chain risk management	2011	645	Int J Prod Econ
[91]	Supply chain risk management: Understanding the business requirements from a practitioner perspective	2005	635	Int. J. Logist. Manage.
[92]	Supply chain resilience in the global financial crisis: An empirical study	2011	632	Supply Chain Manage.
[93]	An empirical examination of supply chain performance along several dimensions of risk	2008	577	J. Bus. Logist.
[94]	Global supply chain risk management	2008	573	J. Bus. Logist.
[95]	The power of flexibility for mitigating supply chain risks	2008	566	Int J Prod Econ
[96]	A review of the literature on the principles of enterprise and supply chain resilience: Major findings and directions for future research	2016	491	Int J Prod Econ
[97]	An empirical investigation into supply chain vulnerability	2006	478	J. Purch. Supply Manage.
[98]	Supply chain risk mitigation: Modeling the enablers	2006	475	Bus. Process Manage. J.
[99]	An empirical analysis of supply chain risk management in the German automotive industry	2011	460	Int J Prod Econ
[44]	Researchers' Perspectives on supply chain risk management	2012	434	Prod. Oper. Manage.
[100]	An empirically derived agenda of critical research issues for managing supply-chain disruptions	2005	416	Int J Prod Res

Spain contributed around 3% of the total (10,468). The nations whose number of articles is more than 30 are Iran (48), France(45), Indonesia42, Malaysia (39), Canada (37), Italy (36), Brazil (35), Vietnam (33), Japan (32), Pakistan (32), Sweden (32), Thailand (32), and Turkey (31).

Although this general visualization does not reflect the true number of articles in total because different nations co-authored some papers, further visualization is needed to uncover the most creative countries and the collaboration between them.

Jermsitiyparsert, K. contributed to the SCR area mainly with 20 articles. Wagner, S.M., Gunasekaran, A., Ghadge, A., and Sawik, T. are among the top creative authors with their contributions to the literature.

Of 159 journals, the top 25 that released articles in the SCRs are listed in Table 3. The International Journal of Production Research is the leading journal with 85 pieces, constituting approximately 7.59% of the total articles. The International Journal of Production Economics was the second most released paper in the field with 58 articles, followed by the journals Supply Chain Management (3.48%), International Journal of Logistics Management (3.21%), International Journal of Supply Chain Management (2.86%), and Sustainability Switzerland (2.86%) contributing to the area respectively.

4.2. *Bibliographic coupling analysis*

Like co-citation, bibliographic coupling is a similarity metric that establishes a connection between texts based on citation analysis. When two works cite the same third work in their bibliographies, this is known as bibliographic coupling. It is a sign that there is a chance the two works deal with the same subject matter.

If two papers both cite one or more other documents, they are said to be bibliographically connected. The more citations to other texts two given documents have, the stronger their "coupling strength" is. The idea of bibliographic coupling is shown in the image to the right. Bibliographic coupling may be helpful in a wide range of domains since it enables researchers to locate similar work that has already been done. However, if two papers are independently cited by one or more additional documents, they are said to be co-cited [115].

The classification of research articles according to the journal is too broad or vague because each scientific journal is categorized into a significant field, even though journals increasingly cover a more comprehensive range of disciplines and paradigms. The bibliographic coupling method determines how comparable the subject matter of the two publications is. Bibliographic coupling is not subjectively helpful in all domains of study since it assists investigators in locating previous relevant research.

4.2.1. *Co-authorship analysis*

The link between the primary research aims to be shown in co-authorship. It contains authors, institutions, and national collaboration networks. VOSviewer visualization analysis of collaborating networks is presented in the next section from the perspectives of authors and countries/regions.

Fig. 5 displays the co-authorship network diagram of 54 authors because it is intended to illustrate the authors whose min article number is 2 in the network diagram. The authors' relationships were divided into seven categories. The diameter of the nodes represents the number of articles written by the author, and the link between any nodes symbolizes collaborations between two authors. That implies that the two scientists joined by the line collaborated on at least one work.

Rajesh, R. has the greatest total connection strength (TCS= 24.61) and published five articles in this area, followed by the co-authors Alora, A. -Barua, M.K. with their TCS= 72.37. Ekwall, D. - Lantz, B. comes third in terms of TCS (72.17). Although Sawik, T. has the most published articles in this area, the TCS of Sawik is lower than the authors mentioned above.

The thickness of the lines represents the level of collaboration among particular two authors. Put another way, the thicker the lines, the more publications they co-authored. The level of collaboration between writers within groups is significantly greater than between authors from distinct groups. For example, Sawik, T., Ivanov, D., and Tarei P.K.-Thakkar, J.J. has more collaboration than others.

4.2.2. *Co-authorship to countries*

The threshold value, in this case, was set to 5, indicating that the

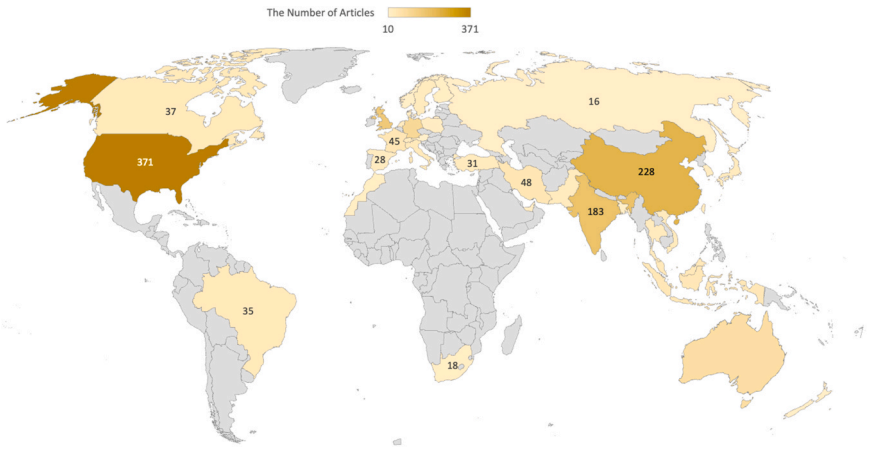

Fig. 3. *The number of papers published crossover the countries.*

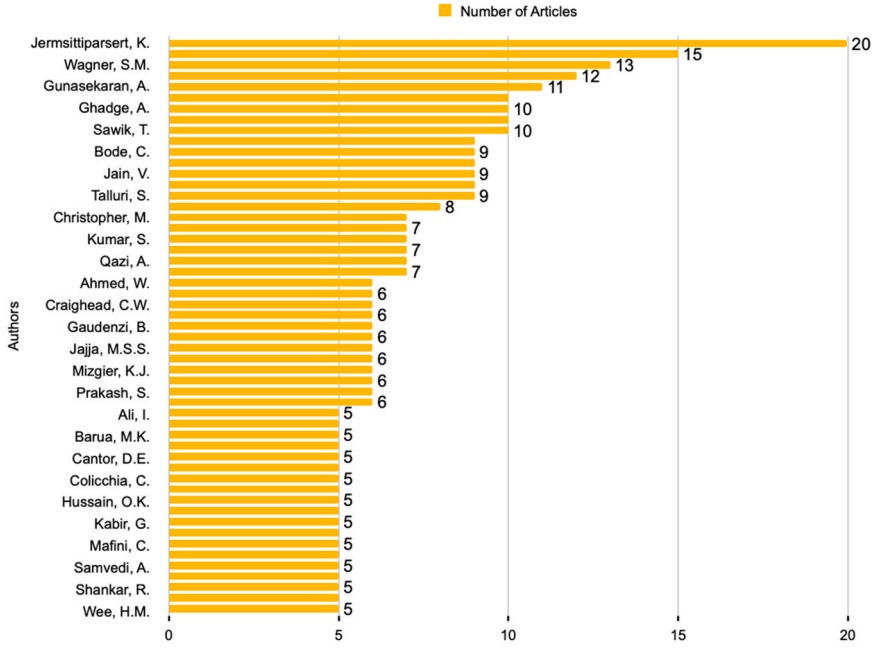

Fig. 4. The number of papers of authors.

nations in the figure have at least five articles. This condition was satisfied by 51 of the 92 countries/regions. The 51 countries were grouped into different color groupings. The item-based density mapping confirms that most leading country is the US, and China, India, the UK, and Germany are among the top five countries in terms of publishing papers in the field of SCR. Fig. 6 visualizes the co-authorship frequency among countries and depicts that the US, China, India, and the UK have high densities. The marks on the country density view are the same as those on the visible item, and a single nation has a different hue based on its density at the time. It denotes that the color of a mapping item is decided by the number of countries relating to another country.

For further analysis, the Network diagram in Fig. 7a and the time-based overlay diagram in Fig. 7b were created by VOS-Viewer software. The primary node represents the US, followed by China and India. The thickest line represents the most vigorous cooperation between China and the US. It also demonstrates that the US has the most remarkable connections to other nations. It is plausible to assume that the level of collaboration within the nations and areas influences the number of articles.

As seen in Fig. 7a, The US has a relationship with different countries in terms of publishing scientific papers. The following countries co-authored the articles published in the US: the UK, Turkey, Iran, South Korea, South Africa, Iran, and Denmark. China, Poland, Saudi Arabia, and Tunisia have co-authorship in this field. In contrast, India has an authorship- network with Jordan, New Zealand, and the United Arab Emirates. The authors from Germany mainly published articles with the researcher from mostly European countries, including Switzerland, Netherlands, Greece, Brazil, and Belgium.

However, as seen in Fig. 7b, this co-authorship has changed over the years, and recently, the authors expanded their network worldwide. For example, the researchers from Turkey collaborated in this field with the countries France, Norway, Iran, Australia, and others frequently. The scientific conferences and scholarship programs might be the reason for this shift.

4.2.3. Co-citation analysis

Co-citation analysis categorizes scientific literature into tiny publications that address specific issues. Co-citation coupling is a technique for determining the subject similarity of two publications. When two papers appear in a third document's reference list, they are regarded to

Table 3
The journals published articles in the field of SCR.

Rank	Journal	The number of Articles	The percentage of total
1	International Journal of Production Research	85	7.59%
2	International Journal of Production Economics	58	5.18%
3	Supply Chain Management	39	3.48%
4	International Journal of Logistics Management	36	3.21%
5	International Journal of Supply Chain Management	32	2.86%
6	Sustainability Switzerland	32	2.86%
7	Computers And Industrial Engineering	28	2.50%
8	Annals of Operations Research	25	2.23%
9	International Journal of Logistics Research and Applications	23	2.05%
10	International Journal of Operations and Production Management	23	2.05%
11	International Journal of Physical Distribution and Logistics Management	22	1.96%
12	Benchmarking	21	1.88%
13	International Journal of Logistics Systems and Management	20	1.79%
14	Industrial Management and Data Systems	16	1.43%
15	Decision Sciences	15	1.34%
16	Uncertain Supply Chain Management	15	1.34%
17	Journal of Business Logistics	14	1.25%
18	IEEE Transactions on Engineering Management	13	1.16%
19	Journal of Cleaner Production	13	1.16%
20	Journal of Manufacturing Technology Management	13	1.16%
21	Omega United Kingdom	13	1.16%
22	Production Planning and Control	13	1.16%
23	Transportation Research Part E Logistics and Transportation Review	13	1.16%
24	Journal of Intelligent and Fuzzy Systems	12	1.07%
25	Supply Chain Forum	12	1.07%

be co-cited. These writers have a co-citation connection. Papers A and B may be considered connected if they are both cited by paper C, even if they do not explicitly cite each other. Papers A and B have a stronger association if referenced by several other papers [101]. It comprises a co-citation network comprising cited references, cited sources, and cited authors. The node size shows the number of citations; the line connecting the two points denotes a co-citation link between them. The more publications that reference them, the stronger their association becomes. The incidence with which two texts are jointly mentioned is the co-citation occurrence.

A reference indicates that one author was affected by the published work by a different author, but it does not usually specify the intensity or direction of that effect. It is commonly considered that each reference contributes equally to the citing article. Small's (1973) study, which first presented co-citation analysis, assesses the association between co-cited papers with the premise that, more often, co-cited papers demonstrate greater co-citation strength [102]. VOSviewer graphical visualization of a co-citation network is displayed below from the authors' perspective.

The co-citation connection of 192 authors whose citation is at least 100 is depicted in Fig. 8a. The author ties are color-coded into three categories. The most central node represents Christopher, M., followed by Ivanov, D. and Tang, C.S. The more citations there are, the bigger the node. It means Christopher, M. has the most often referenced publications among these authors, followed by Ivanov, D. and Tang, C.S. As seen in Fig. 8b, the path connecting Ivanov, D. and Dolgui, A. has the thickest weight (TCS=86.46), followed by Sokolov, B. and Ivanov, D. (TCS=57.35). It denotes the strength of their co-citations. That is, Ivanov, D., and Dolgui are referenced 86.46 times they are referenced together.

4.2.4. *Co-citation of references*

Co-citation to references depicts the connection of objects by counting how many times they are referenced together. The main understanding of the study topic may be retrieved effectively and readily from the multitude of referenced references using co-citation analysis. Additionally, the significance of publications can be examined and mined. Papers having more than 100 citations of a cited reference were evaluated with VOS viewer, and 4 references are presented in Fig. 9**.** These four papers have six connections between the group and the TCS is 174.50. Tang, C.S.'s article titled "Perspectives in supply chain risk management" has the greatest TCS (104), followed by the paper titled "Managing disruption risks in supply chains" by Kleindorfer, Pl and Saad G., H., with a TCS of 90 times.

4.2.5. *Co-occurrence analysis*

Occurrences. When working with keywords, the Occurrences property specifies how many documents include a term. The definition of the occurrences property when dealing with words is determined by the counting technique selected in the VOSviewer. The occurrences property in binary counting represents the number of papers in which a phrase emerges at least once. The occurrences property in complete counting specifies a phrase's total number of occurrences in all documents.

4.2.5.1. Co-occurrence to authors' keywords. Co-occurrence to Authors' keywords is a bibliometric study that shows the frequency of keywords or phrases occurring in papers at the same time. Correlation is computed at the paper level in this study. The correlation shows the frequency with which two keywords appear together in a paper [72]. The stronger the connection between two terms, the higher their co-occurrence frequency.

The power of connection is high within members of a shared cluster but low amongst components of distinct clusters. The minimum number of keyword co-occurrences was set to 10 for analysis. The requirement was met by 78 of the 3343 keywords. VOS viewer program computed the connection degree of the co-occurrence relationship with other phrases or keywords for each of the 78 terms. The graphic was created with the highest total connection power, and 78 keywords were color-coded and grouped into ten categories. Fig. 10 depicts the network analysis diagram based on the authors' keywords. "supply chain risk management," "supply chain risk," "risk management", "supply chain," "risk mitigation,", "agility,", "supply chain disruption," and "logistics" were the most frequently appeared keywords and listed with the highest TCS.

4.2.5.2. Co-occurrence of terms in abstracts and titles. The co-occurrence of items in various documents can be determined through the analysis of relatedness. This type of analysis can be useful in identifying popular topics and trends in scientific research, leading to better monitoring and follow-up.

The condition was set to analyze the relevancy of terms in abstracts and titles of articles so that a term appeared at least 10 times in all articles. Of the 25,751 terms, 761 satisfied the condition. 60% (457) were selected for the terms' relevancy score calculation as a default value. VOSviewer created five clusters with the colors red, green, blue, yellow, and purple that are shown in the network diagram in Fig. 11. From 457 items, some phrases irrelevant to the contents of articles, such as "future direction, "future study", "current study," "proposal," "research gap," and others, were excluded from the list, and for the remained 391 items, VOSviewer provides a time-based visualization of terms called the Overlay Diagram, as depicted in Fig. 12**.**

Each cluster has different terms or phrases related to a similar theme. Although all phrases in each cluster have been given as an Appendix, the

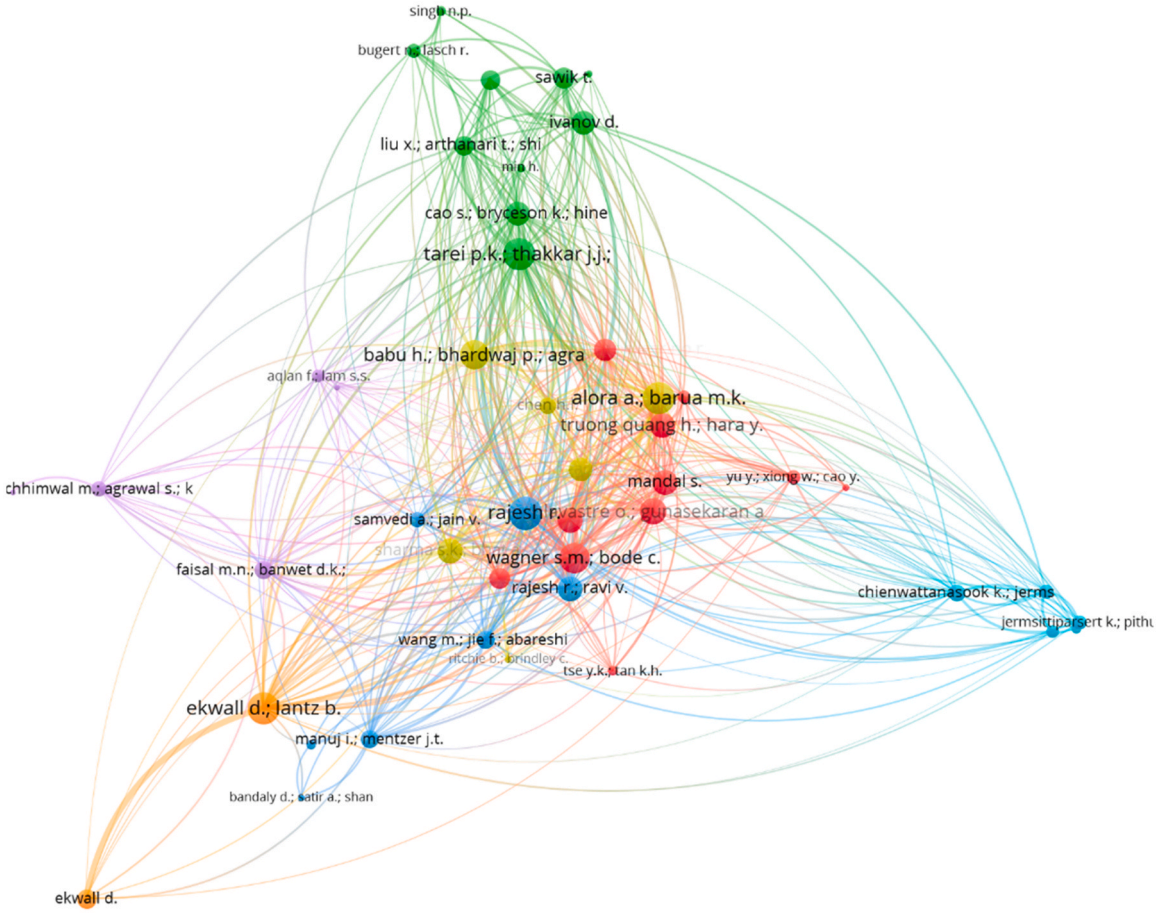

Fig. 5. The network diagram of co-authorship to authors.

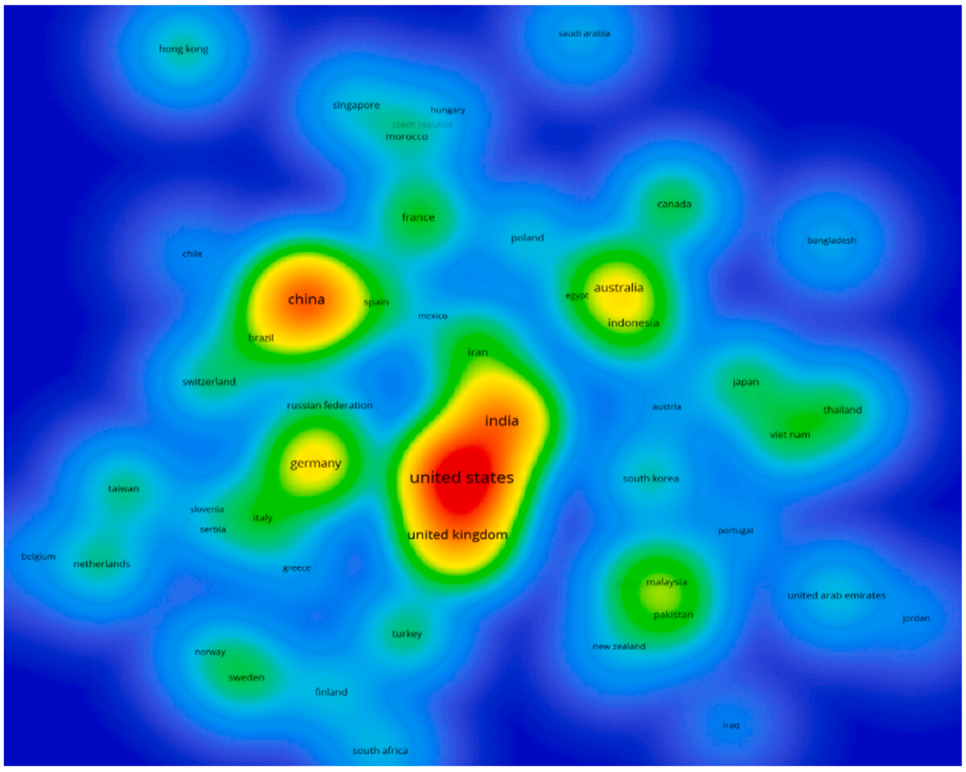

Fig. 6. Density mapping of Bibliographic coupling to the countries.

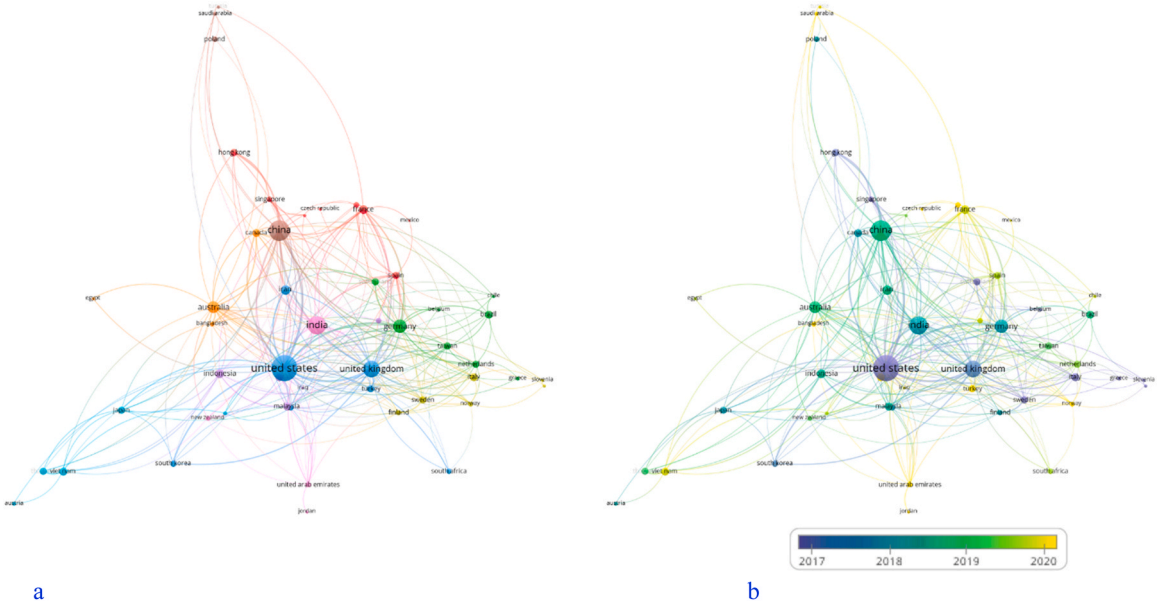

Fig. 7. Co-authorship to the countries: a: Network Analysis Diagram, b: Overlay Diagram.

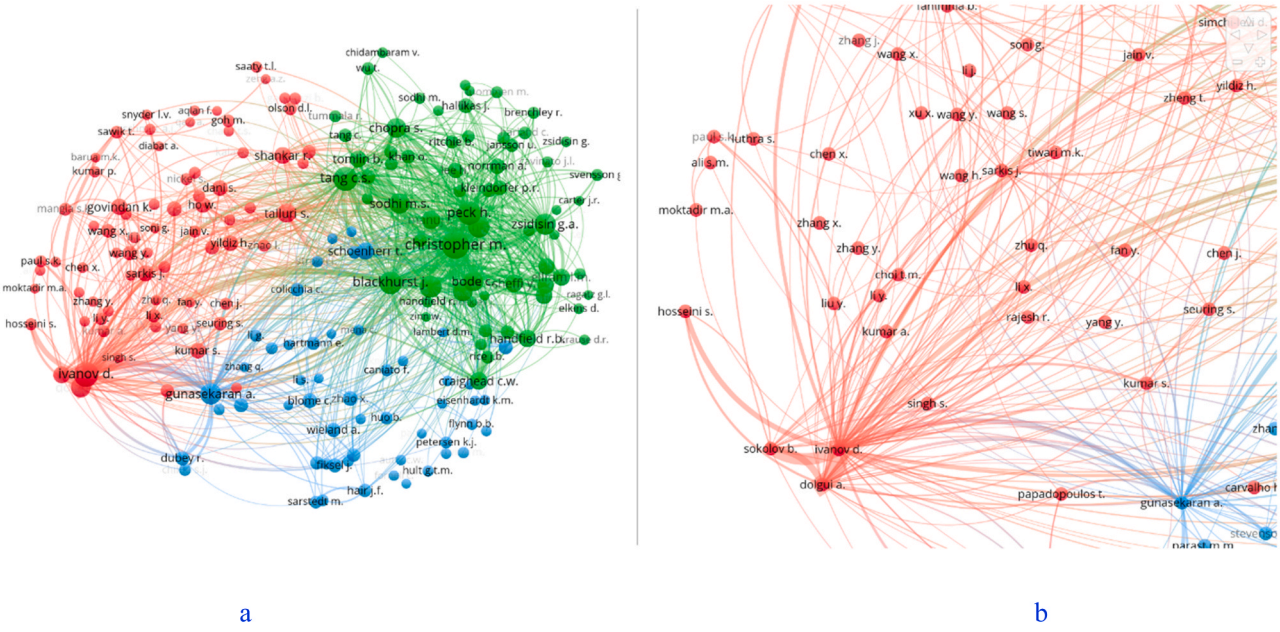

Fig. 8. Network diagram of co-citation to the authors: a: General view, b: Zoomed view.

most frequently appeared terms are the following:

In the **Red Cluster**, the most frequently appeared terms are chain risk, relationship, issue, chain management, role, practitioner, knowledge, addition, supply chain performance, flexibility, support, chain manager, supply chain resilience, integration, dimension, topic, sample, manufacturing firm, conceptual framework, competitive advantage, supply chain integration, foundation, structural equation modeling, information sharing, innovation, business environment, policymaker, risk management practice, buyer, SMEs among 125 items.

The **Blue Cluster** has 102 terms, and frequently appeared terms in abstracts and titles are the following: risk assessment, decision making, set, decision maker, probability, loss, criterium, failure, AHP, priority, procedure, analytic hierarchy process, risk identification, competition, alternative, supply chain risk assessment, success, risk analysis, risk event, automotive industry, variety, supply chain partner, similarity, demand risk, operational risk, preference, risk evaluation, failure mode, opinion, risk management process, Indonesia, dependence, stability, risk source, environmental risk, financial risk.

Contains 85 phrases, cost, problem, demand, covid, pandemic, scenario, increase, supply chain network, capacity, disruption risk, price, function, algorithm, disaster, simulation, parameter, selection, retailer, profit, trade, reliability, distribution, inventory, quantity, contract, constraint, availability, delay, supplier selection, account, experiment, amount, propagation, optimization, comparison, raw material, portfolio are the most prevalent in abstract and title terms that clustered in the **Green Group**.

The terms include crisis, India, power, interdependency, modeling, standard, monitoring, map, input, regulation, growth, ism, safety, construction, discipline, consumer, party, society, health, food, internet, transparency, information, technology, energy, hierarchy, operator,

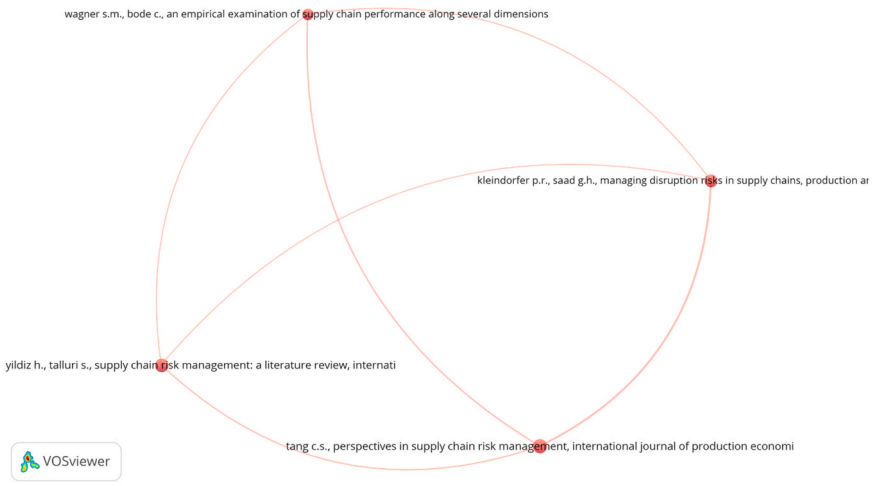

Fig. 9. Network diagram of co-citation to the references.

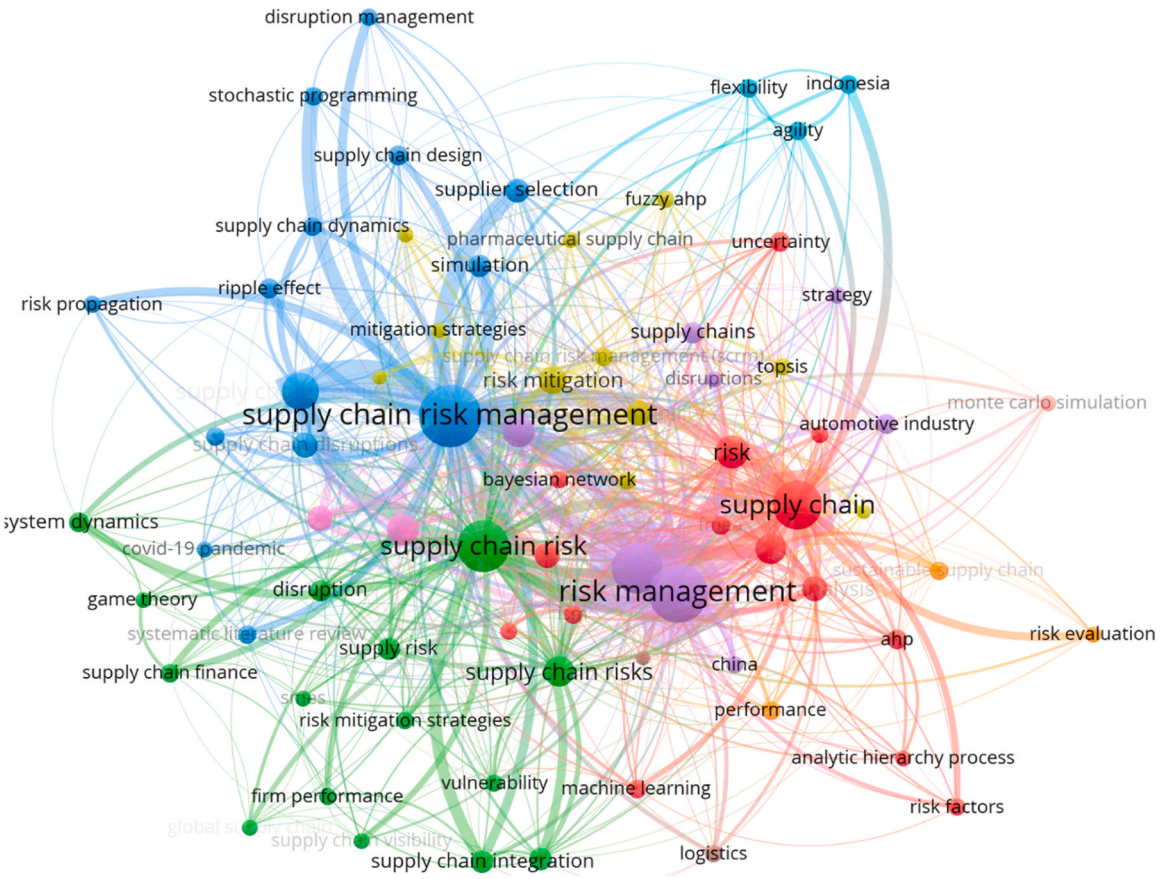

Fig. 10. Network diagram of co-occurrences to authors' keywords.

access, emergence, validation, food industry, blockchain, conflict, nation, blockchain technology, interrelationship, comparative analysis, integrated approach, pathway, distributor, traceability, utility, barrier, training, interpretive structural modeling, law, date, interruption, quality risk, risk, perception, statistical analysis, interpretive structural modeling, water, construction industry, social medium, IoT are most frequently occurred terms in the **Yellow Cluster.**.

Good, location, classification, reference, pattern, facility, frequency, creation, transport, likelihood, secondary data, content, frame, Europe, Africa, and a large number are the terms clustered in the **Purple Group**.

As seen in the overlay diagram in Fig. 12, scholars have recently integrated disasters or outbreaks such as COVID-19 into their research. The zoomed sections of the overlay diagram placed in the upper and below pictures are illustrated on the right side of Fig. 12 whichindicates that scholars mainly concentrated on giving a solution as a response to unpredictable emergencies.

5. Conceptual framework

Based on the clusters that consist of most occurred terms in abstracts and titles of articles in the SC literature, we construct a conceptual

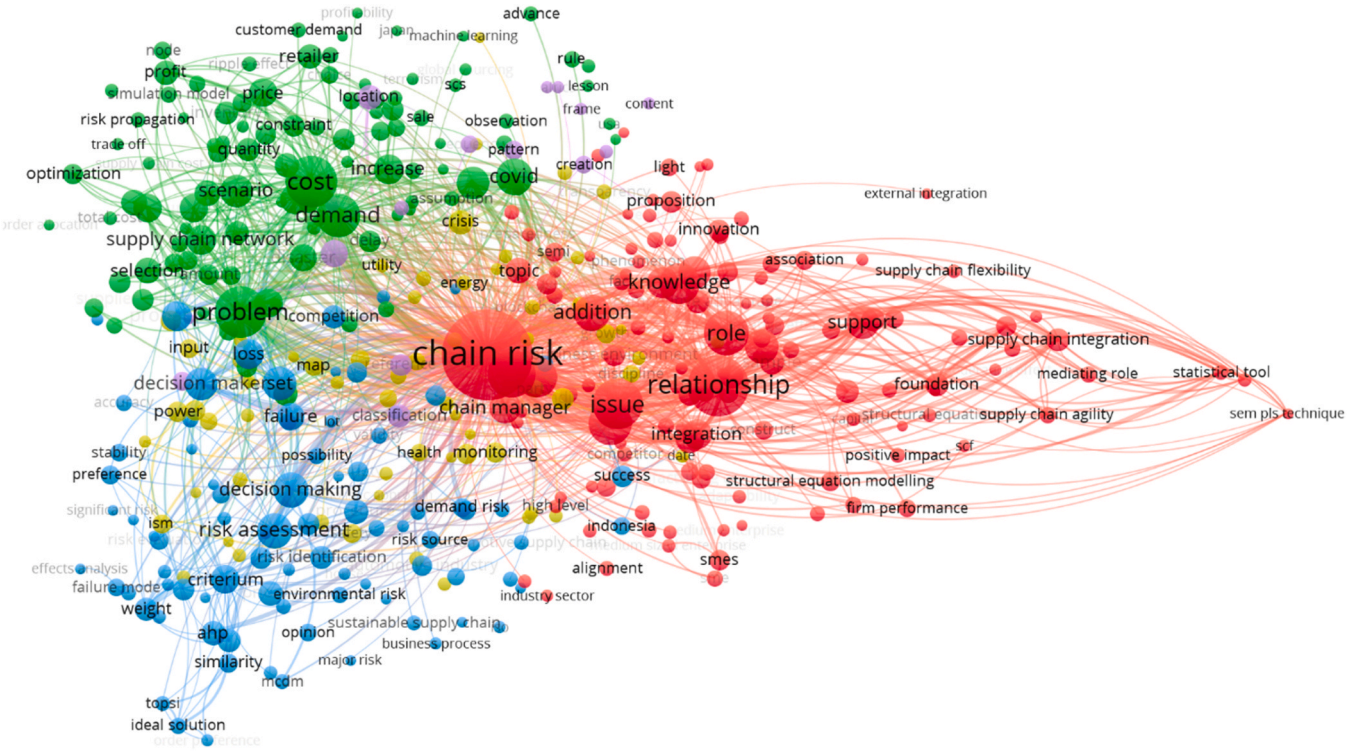

Fig. 11. Network diagram of terms' occurrences.

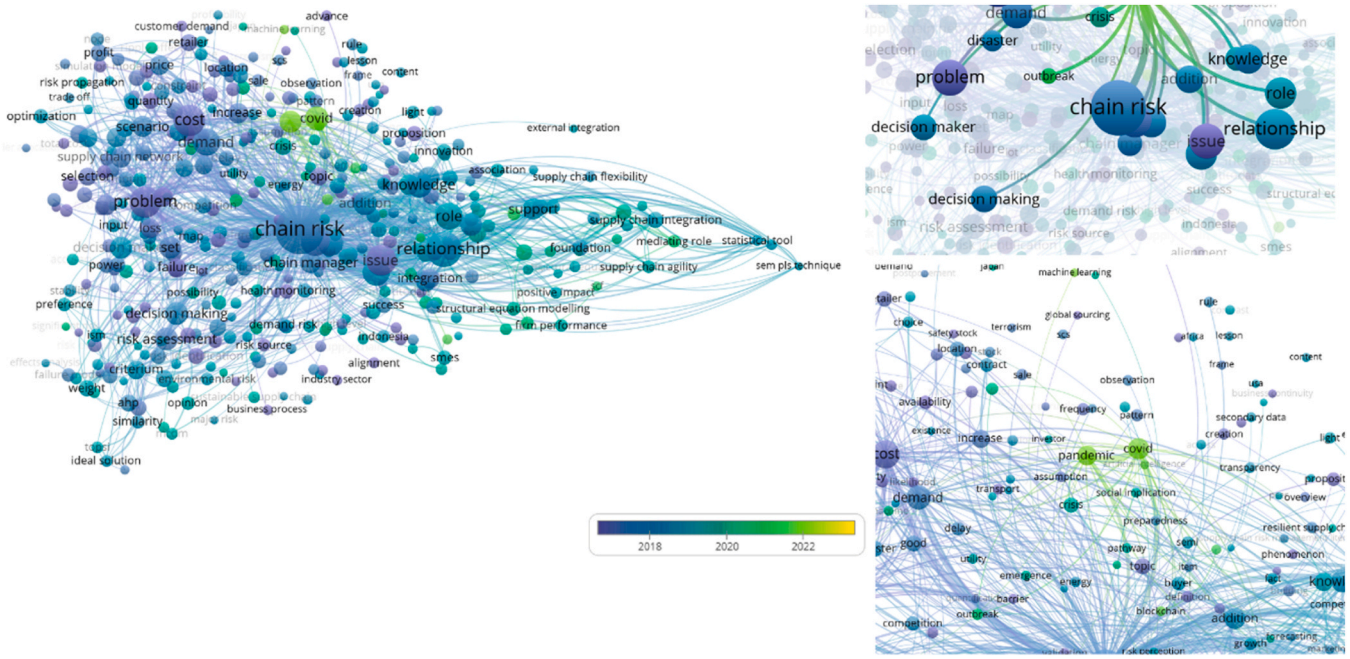

Fig. 12. Overlay Diagram of terms' occurrences.

model for dealing with risks in firms' SCM. The conceptual framework is based on five main dimensions, as illustrated in Fig. 13. To mitigate SCRs, the firms should be at a maturity level of the following dimensions: the firm's competitiveness level, operational responsiveness level, decision-making capability level, monitoring capability level, and standardization for sustainability.

5.1. *Firm's competitiveness level*

In the following subsections, these dimensions are explained. Due to globalization, offshore, and outsourcing growth, the consciousness of risks within SCs has increased as more stakeholders are engaged. Because of the inherent linkages, which can result in problems on both the supply and demand sides, globalization encourages risks in SCs [36]. Many organizations overlook critical risks in their SCs, leading to significant problems. Recent events have highlighted the vulnerabilities

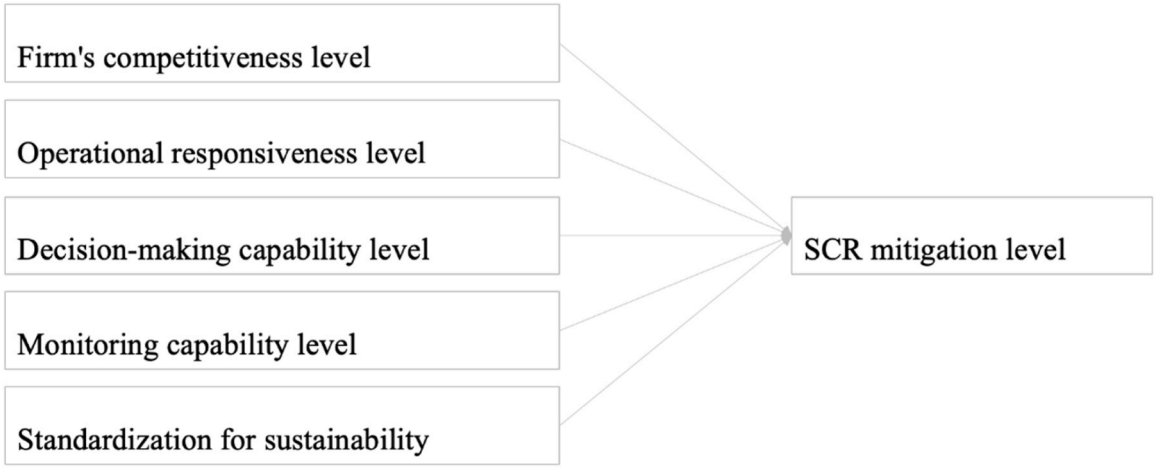

Fig. 13. Conceptual Model for Mitigation SCRs.

present in today's complex SCs. Despite this, a systematic and structured approach to conceptualizing vulnerabilities and SCRs has only recently emerged [25]. Scientists and managers use vulnerability and disruption to characterize a risk-affected supply chain.

Vulnerability is an encounter with disruptions caused by SCRs that impair the capacity to satisfy the demands of the end customer market [66]. Due to their limited resources, Small and Medium-Sized Enterprises (SMEs) are more vulnerable to SC disruptions, severely affecting their financial performance, competitive advantage, and survival. However, the lack of knowledge and the absence of a theoretical foundation limit the development of SCRM practice in SMEs, especially for policymakers, SC professionals, and practitioners.

It was argued that organizations' main reasons for using risk management strategies are increased global rivalry, technological development, and the constant pursuit of competitive advantage. Similarly, more risks were present in the SCRM and performance chain context, and new strategies were required to manage them. The need to provide acceptable performance measurements and metrics to assess, inform, and guide operational and strategic choices underlies these advancements in SCRM [39]. That means SC resilience and agility are a foundation for competitive advantage, as they provide flexibility, responsiveness, and adaptability in an uncertain business environment.

Resilience refers to an organization's ability to swiftly return to an original working condition following a disruption, i.e., the ability to ''bounce back from hardship''. This behavior is analogous to an elastic material under extreme pressure. The phrase will be considered equivalent to agile at the same time, to express the essential word of flexibility represented by resilient [35].

Agility is one of the most successful paths to design a resilient SC since it evaluates the ability to respond swiftly to changing situations. Agility effectively changes operating states to respond to external uncertainty or market volatility. A corporation may adapt quickly to market shifts and anticipated SC disruptions by planning for agility, a risk management technique [29].

SC managers and account executives are two managers tmainly influenced by the developments. Both roles are growing in strategic relevance and are becoming more engaged in the development of inter-organizational value and relationship management. The responsibilities of SC managers are changing from functional to tactical. Their primary concerns, including operational tasks such as contract generation, negotiating, complying with contracts, expediting, planning, and scheduling, have evolved dramatically over the last decade, frequently through diverse standardization and automation. Still, SC experts have also been increasingly engaged in strategic decision-making in complete life cycle management, most notably proactively extending into the design process and adopting collaborative innovation approaches in solving issues and risk mitigation inside the SC [103].

Research into the antecedents of SC resilience has shown that factors such as trust, information sharing, and culture play a vital role in building a resilient SC. Furthermore, it has been suggested that SC agility is an enabler of resilience and can significantly impact firm performance.

Organizational culture is vital for successful SCM. Employee attitudes toward information sharing, cooperation, and risk-taking are influenced by organizational culture. Trust and interpersonal interactions in the workplace enhance company culture. In the lack of excellent corporate culture, achieving objectives might be challenging [104]. An awareness of the underlying corporate cultural features, strategic goals, and behavioral habits is required to design SC information infrastructures effectively. According to Roh etal., (2008) [105], the organizational culture of a chief or primary firm impacts suppliers and distributors in the same SC. The integration of external partners and the alignment of the SCRM practice with the business strategy are critical enablers to enhance SC performance.

5.2. *Operational responsiveness level*

The COVID-19 outbreak has wreaked havoc on the global SC network. As a result, the cost of goods has increased, demand has fluctuated, and SCs have been put under immense strain. The pandemic has increased demand for certain products, such as personal protective equipment, while other products have experienced a decrease in order. It has resulted in a raw material shortage, further exacerbating the problem. The disruption risk has also increased, with many SC members needing help maintaining their operations due to delays and availability constraints. To diminish the influence of the pandemic, SC practitioners have implemented various strategies such as postponement, safety stock, and order allocation. However, these strategies require a trade-off between cost and reliability, as increasing safety stock or postponing production can increase the total cost of the SC.

The pandemic has reminded the importance of preparedness for such disasters. SC practitioners and investors have had lessons from the outbreak to optimize their SC network and improve their profitability in the long term. Many scholars focus on the critical areas of SCM affected by the pandemic, such as SC design, inventory management, demand uncertainty, and SC cost.

SC disruption is commonly operationalized through self-reported impact on six cross-functional metrics: prices, operational efficiency, quality, responsiveness, reliability, and sales. This measure should continue to be used, as it provides a parsimonious and holistic measure of results.

The frequency of recurrence has been quantified on a rating system

that spans zero to regular, although temporal assessments might be more objective. Safety inventory is a crucial buffering approach, and future research should use more objective criteria to allow for cross-study comparability. Most research projects are conducted from the standpoint of the focus company, but a more nuanced measure of the SC network perspective is essential. SC resilience is a necessary construct, but there is no agreement on how to define it. Longitudinal studies are necessary to understand how SCRM evolves and how firms learn and adapt in response to disruptions [75].

In this context, firms' SC partners must acquire competencies to protect their operations in case of an interruption.

The risks that cause problems companies experience due to poor coordination or contract with vendors. Hence, the researcher proposed new contract designs that ensure risk and revenue sharing with vendors. The pricing strategy is one of the critical factors that play in contracting. For example, due to credit risk, many companies become disadvantaged. Some studies, therefore, utilized game theory or the Stackelberg game. Game theory has been employed in advanced food and agricultural research, such as examining various coordination techniques between farmers and retailers under production and demand uncertainty [106].

On the other hand, others have proposed dynamic modeling to better control inventory and production. [63] discovered a few methods for this purpose, including missing the target MtT, mean-variance, exponential function utility, and value at risk.

Value-at-Risk (VAR) originating from the financial services business is a statistical measure of risk. It was initially designed to analyze the risk of an economic portfolio, and it is increasingly used to examine different hazards that a company faces. VAR's power to give a uniform gauge for assessing and controlling risks throughout the company is one of its primary capabilities. It estimates the maximum amount a business may anticipate losing on an investment over a particular time at a given confidence level in dollars or any currency [37].

The review article by [35] explores different mathematical models used in SCRM. It discusses the application of Value-at-Risk (VaR) and Conditional-Value-at-Risk (CVaR) to single-echelon and multi-echelon inventory management problems. The study examines research investigating risk analysis payment delays and various SC contracts, such as SC discount contracts, wholesale pricing contracts, and returns policies. The article also highlights the issue of information asymmetry in SCM and how it has become a hot topic in the last decade, with various studies exploring the ideal contractual structure under information asymmetry.

When each SC partner places their order separately in a situation where consumer demand follows an AR (1) process, it has been demonstrated that this locally optimum ordering choice would produce the ''bullwhip'' effect, which creates operational inefficiencies. On the other hand, when consumer demand is a predictable and decreasing function of the retail cost, each SC partner gives their ordering choice by maximizing their profit for the case; it turns out that these locally optimal choices lead to lower overall earnings for the whole SC. Recently, there has been a surge in curiosity in SC contract analysis to increase efficiency in operations or SC coordination. Usually, supply contract concepts assume an SC with a single manufacturer (supplier) and one retailer (buyer) who must meet consumer demand [38].

Heuristic, Multi-Objective (MO), Multi-Integer-linear Programing (MILP), Multi-Integer-Programing (MIP), Linear Programing (LP), Lagrangian Relaxation (LR), Genetic Algorithm (GA), probabilistic and stochastic programming, and Monte Carlo Simulation are primarily employed in mathematical methods.

Suryawanshi and Dutta (2022) [80] demonstrated that the scholars who used techniques in SCRM are in this way: 44% for MILP and MINLP, 18% for LR, 10% for MCDM, 8% for Analytical, 8% for Simulation, in the literature.

In the literature, various risk mitigation strategies exist for SCM, including postponement and flexibility. Product development, production, and logistical postponement are all examples of postponement techniques, while flexibility strategies contain flexible pricing, supply, and contractual strategy. Possible responses include resource flexibility systems and run-out reaction activities. Finally, a stochastic multi-objective mixed integer programming approach has been proposed to establish optimal workflows for a multinational corporation doing business in several countries [47].

5.3. Decision-making capability level

SCR assessment involves the identification of potential risk sources and competition among alternative SC partners. Choosing suppliers is crucial to a company's ability to control SCRs. The critical issue of today's managers is locating ideal suppliers who will provide the right items at the correct spot at the right price and at the right time. The product must also be supplied in the proper quantity, with the appropriate information, and, most importantly, with a minor interruption.

Therefore, when choosing suppliers, businesses should consider all facets of a candidate's performance, including price, product quality, quantity, and service, and associated risks, including uncertainty, vulnerability, and potential supply disruption [63].

In the automotive industry, SCRM is a critical issue due to the variety of components and suppliers involved. Failure in any part of the SC system can result in significant losses for the entire industry. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Failure Modes and Effects Analysis (FMEA), Multi-Criteria Decision Making (MCDM), and Monte Carlo simulation are quantitative methods for sustainable SC ranking and criticality analysis in the automotive and pharmaceutical industries.

Identifying and quantifying critical risks and involving all stakeholders in the decision-making process is essential for the stability and success of the SC system. The accuracy and validity of the risk analysis are pressing issues that need to be addressed to find the ideal solution for sustainable SCM.

Sustainable supplier selection.

5.4. Monitoring capability level

Crises can arise from multiple factors, such as natural disasters, conflicts, or technological interruptions. On the other hand, data falsification, supply chain fraud, counterfeit manufacturing, digital security threats, intellectual property theft, and contract violations are examples of how malicious risks can manifest. According to the report, 33% of fish samples had erroneous labels, and SC fraud has been called the "single most exposed area" of fraud. Counterfeit manufacturing has also become a significant issue in the automotive SC [28]. These are inevitable and can have far-reaching effects on society, the economy, and the environment.

Logistics and SCM play an essential role in the food industry to ensure the supply of safe, healthy, and nutritious food. Due to the perishable nature of agri-food, there is a high risk of damage from the farmer to the consumer. The agri-food SC is also unique and is classified into two categories: fresh agri-food and non-perishable agri-food. The transportation of food is also critical to maintaining food safety and quality, as controlling the temperature will reduce microbial growth in food. The Food and Agriculture Organization (FAO) has established guidelines for risk classification of food and food businesses to improve food safety by enhancing food inspection systems. However, risk cannot be eliminated but mitigated through a proactive approach [107].

Collaborative disruption risk management is essential to reduce risks, improve disruptions, and achieve responsiveness and high customer service. Because they provide capabilities like information sharing, customer sensitivity, and process integration, Information and Communication Technology (ICT) tools are essential for achieving collaborative perception [108].

Greater adaptability to cost fluctuation might be attained through more intelligent cost-control approaches and collaborative risk

management along the entire supply chain; consumer feedback should permeate the SC through more profound customer experiences, and the global SC should be intelligently incorporated and optimized.

In particular, intelligent manufacturing may be a crucial strategy for implementing more competent SCM. Manufacturing, engineering, the usage of materials, the SC, and life cycle management were all entirely redesigned by Industry 4.0 [70].

Big data analytics, machine learning, drones, the Internet of Things, advanced robotics, the sharing economy, cloud computing, 3D printing, and blockchain are just a few of the nine cutting-edge technologies it incorporates and heavily uses SSCM [70].

However, digital security is a problem that must be addressed in the "Digital Dimension" to attain supply chain intelligence. The digitization process's governance will determine the future direction of supply chains. As a result, the risks covered by SSCM are heavily focused on events involving Information Technology (IT) and data security. Digital security has lately concentrated on safeguarding corporate information, resolving network issues, and coordinating and integrating operational technology. Another significant cyber problem for the supply chain community is the slight growth in the number of gateways handled by cloud-based and Internet of Things (IoT) systems [70].

Conventional IT lacks real-time adaptation and concentrates on dyadic settings of cooperation, and supply chain process reconfiguration can be rigid and expensive to maintain. Adopting multi-agent modeling, a branch of AI, may be a practical tool for making decisions in supply chains. These agents might communicate and work together inside and across enterprises, enabling the automatic real-time correction of SC operations [108].

As a rapidly growing nation, India depends on its power and energy sectors for growth and development.

In such a scenario, interdependency between various sectors becomes crucial, and modeling the same can help in standardizing the monitoring of the system.

The role of blockchain technology, regulatory discipline, and safety measures ensure transparency and traceability in the SC, with specific reference to the food industry.

5.5. Standardization for Sustainability

The Takata airbag recall, the Volkswagen emissions scandal, and the horsemeat scandal are just a few instances that illustrate the dangers of malicious behavior in SCs. Each time, the businesses engaged in dishonest behavior that negatively impacted every link in the SC.

The success of any business depends mainly on its SCM. With the increasing complexity of global trade, SCRs have become a significant concern for companies worldwide.

Classification is another critical factor in mitigating SCRs. By classifying suppliers based on their level of risk, companies can prioritize their risk management efforts. This can be done by analyzing the supplier's financial stability, reputation, and compliance with regulations.

Reference patterns are another useful tool in risk management. By analyzing historical data, companies can identify patterns in supplier performance, transportation delays, and other risk factors. This information can be used to develop proactive measures to prevent future disruptions.

Regular inspections can help identify potential risks and prevent disruptions before they occur.

The creation of a robust transport network is also critical in mitigating SCRs. Companies should have multiple transportation options, including air, sea, and land transport, to ensure that they can quickly adapt to changing market conditions and disruptions.

6. Conclusions, limitations, and direction for future implications

6.1. Finding and discussing

This paper examined the recent state of investigations on SCM. The review aimed to present the current state of SCRM studies, identify holes in the literature, and underline emergent areas requiring more investigation. In an unpredictable and competitive corporate climate, the review investigates several risk concerns in SCM. It provides a thorough and organized examination of the SCRM literature to offer a complete grasp of the subject. The scope of the evaluation includes risk identification, assessment, mitigation, and monitoring. It also emphasizes the need for SC partners to cooperate and exchange information to successfully manage risks. The review concludes by identifying rising topics including the use of technology, big data analytics, and blockchain in SCRM.

This paper identifies three categories of risk sources in SCs: environmental, network-related, and organizational, and highlights risk drivers and risk-mitigating strategies, including avoidance, control, cooperation, and flexibility. According to them, SCRM involves comprehending risk assessment, recognizing the SC's risk theme, identifying risk drivers, and managing risks in the SC. Developing AI risk management models can improve SC competence in the new dynamic and business environment.

Further investigations are necessary to fully understand risk and its SCM. There is a need to explore how organizations manage SCRs, including the processes and techniques used to define and analyze SCRs, how firms benchmark their SCR processes, and how companies evaluate their SCR profile and develop risk contingencies. In conclusion, managing SCR should be an essential activity for most organizations, and to understand this, a three-pronged research agenda is vital involving the study of risk, in-depth empirical research, and the creation of solid and well-founded risk management systems that include risk management tools and approaches from different academic areas.

Integrating Machine Learning (ML) into SCRM has provided numerous benefits, including increased flexibility and response time, higher reliability and precision, and integration of new data sources. However, there needs to be more research in practical use cases and guidance for companies on integrating ML into SCRM. The integration of ML also necessitates innovative assessment principles and changes to the qualification requirements for SCR managers. While ML can improve decision-making and mitigate potential biases, it also requires high initial investments and legal issues regarding data collection and usage for risk management. More detailed use cases and empirical studies are needed to better understand ML's positive effect on SCRM [76].

According to Cunha et al., (2019) [109], The majority of businesses lack an established SCRM and mitigation framework. Some research defines sustainability risks and develops a realistic management model for SCRs connected to sustainability. The distribution of risk in public-private collaborations is also discussed. The articles are focused on recognizing the social hazards that firms face. The two most common repercussions in the sample of articles are reputational harm and financial losses. The framework understands that stakeholders will respond if a social risk scenario exists in an organization's SC, resulting in implications for the enterprise. According to the concept, controlling a company's social risks can begin with determining its stakeholders and the process that results from already outlined social hazards. In conclusion, this study contributed to the current literature by proposing a conceptual frame highlighting the SCRM's vital role in enhancing SC performance. The framework provides a theoretical foundation for policymakers, SC professionals, and practitioners to develop and implement effective SCRM strategies to build a resilient and agile SC.

In conclusion, effective SCRM is crucial for firms to maintain competitiveness and achieve long-term success in today's globalized and complex business environment. The literature has highlighted various

factors that impact the level of SCRs, such as globalization, operational responsiveness, decision-making capability, and monitoring capability. It has also emphasized the importance of developing resilient and agile SCs through trust, information sharing, and culture. However, there are still limitations in the literature, such as the lack of a theoretical foundation for SCRM practice in SMEs and the absence of a consensus on how to define SC resilience. Future research should focus on developing standardized guidelines for sustainable SCM, exploring emerging technologies' impact on risk management and transport logistics, and investigating the feasibility and effectiveness of using drones to mitigate SCRs. Overall, the key is for companies to prioritize risk management and proactively assess and mitigate potential disruptions to maintain stable and efficient SCs.

6.2. Limitations and future implications

The limitation is that due to the VOSviewer nature, we could not change plural terms into the singular form, nor did we standardize identical phrases like 'resilient,' 'resiliency,' and resilience,' which could bring about a decreased value of the phrases that convey the actual study term and thus affect the reliability of network clustering [61].

The study has some research limitations and social implications. Furthermore, the study is limited to SMEs, and future research could explore the impact of SCRM on large companies.

The existing literature on SCRM has been reviewed in several studies. Future research in this area could focus on emerging topics such as the impact of new technologies on SCRM, the role of social and environmental risks, and the integration of risk management into SC sustainability efforts. Additionally, there is a need for more empirical research to validate existing frameworks and models and to explore the effectiveness of different risk management strategies in different contexts.

The possible future investigations can be summarized as follows:

6.2.1. Firm's competitiveness level

- Developing a systematic and structured approach to conceptualizing vulnerabilities and SCRs in SMEs for policymakers, SC professionals, and practitioners.
- Creating new strategies to operate and control the risks present in the SCRM and performance chain context.
- Providing acceptable performance measurements and metrics to assess, inform, and guide operational and strategic choices in SCRM.
- Focusing on research to recognize the importance of trust, information sharing, and culture in building a resilient SC.
- Establishing methods to improve the organizational culture for successful SCM.
- Identifying and producing achievable goals to improve organizational culture and employee attitudes towards information sharing, cooperation, and risk-taking.
- Examining the effect of SC managers and account executives on inter-organizational value and relationship management.
- Investigating how external partners' integration and aligning the SCRM practice with business strategy can boost SC performance.
- Exploring the impact of agility as an enabler of resilience on firm performance.
- Enhancing the resilience and agility of SC through collaborative innovation approaches in solving issues and risk mitigation.

6.2.2. Operational responsiveness level

- Developing new strategies that trade-off between cost and reliability to meet the disruption risk due to pandemics like COVID-19.
- Quantifying recurrence frequency using temporal assessments to achieve more objective criteria for cross-study comparability.
- Measuring SC resilience from a more nuanced SC network perspective to better understand how firms learn and adapt in response to disruptions.
- Developing new contract designs that ensure risk and revenue sharing with vendors to protect companies in case of interruptions.
- Using game theory to examine various coordination techniques between farmers and retailers under production and demand uncertainty.
- Exploring how an ideal contractual structure can solve information asymmetry in SCM.

6.2.3. Decision-making capability

- Developing ideal solutions for sustainable SCM and accurately and validly addressing pressing issues related to risk analysis.
- Identifying and quantifying critical risks and involving all stakeholders in the decision-making process for the stability and success of the SC system.
- Collaborative disruption risk management using information and communication technology (ICT) tools to reduce risks, improve disruptions, and achieve responsiveness and high customer service.
- Implementing intelligent manufacturing is a crucial strategy for more competent SCM.
- Exploring the role of multi-agent modeling, a branch of AI, as a practical tool for making decisions in SCs.
- Modeling the interdependency between various sectors, especially in rapidly growing nations like India, and standardizing the monitoring of the system.
- Enhancing blockchain technology, regulatory discipline, and safety measures to ensure transparency and traceability in the SC system, especially with specific reference to the food industry.

6.2.4. Standardization for Sustainability

- Developing standardized global guidelines for sustainable SCM practices that can be universally implemented to mitigate SCRs caused by malicious behavior and ensure transparency in every link of the SC.
- Investigating the impact of cultural and regional differences on the effectiveness of risk management strategies in SCM for different regions, such as Africa and Europe.
- Exploring the use of artificial intelligence (AI) and machine learning algorithms to classify suppliers based on risk factors, improve the accuracy of risk management efforts, and prioritize proactive measures to prevent future disruptions.
- Investigating the impact of emerging technologies like blockchain, IoT, and cloud computing on risk management and transport logistics in SCM and developing innovative solutions to mitigate potential risks.
- Studying the feasibility and effectiveness of using drones as a sustainable and cost-effective mode of transportation to mitigate SCRs caused by transportation delays and geopolitical tensions.

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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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