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Emerging Paradigms in Supply Chain Resilience Under Crisis Circumstances: A Roadmap for Future Investigations

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ABSTRACT

Objective: The growing frequency and complexity of modern crises have strengthened the link between crisis management and change trend identification. Geopolitical tensions, climate change, and global pandemics have made supply chain resilience (SCR) a strategic priority. This study aims to analyze the evolution of SCR research and identify key thematic shifts and future research directions.

Methods: A bibliometric analysis of supply chain resilience studies indexed in the Scopus database from 2007 to 2025 is conducted. Co-citation analysis, keyword co-occurrence, and topic evolution mapping are applied to examine the intellectual structure and paradigm development of the field.

Results: The results reveal a shift from reactive supply chain risk management toward proactive, technology-driven resilience approaches. The COVID-19 pandemic accelerated this transition, highlighting the role of artificial intelligence (AI), blockchain, and Internet of Things (IoT) technologies. However, notable gaps remain in integrating technological solutions with strategic resilience frameworks.

Conclusion: This study emphasizes the need for a more integrated supply chain resilience approach that combines technological innovation with strategic planning. A targeted research agenda is proposed to guide future studies and support managers in building resilient supply chains capable of addressing future crises.

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1. Introduction

Supply Chain Resilience (SCR) has become a key strategic theme in the face of growing complexity and uncertainty of disruptions. SCR is the ability to identify potential threats, respond to risks effectively, and recover to ensure business operations are carried on without a break in structure or function(Ponomarov & Holcomb, 2009; Wang et al., 2023; Yuan & Li, 2022).

The last decade has been marked by the most extreme challenges to global supply chains in history, including natural disasters, geopolitical wars, and the COVID-19 pandemic, which caused widespread factory closures, shortages of vital materials, and consumer scepticism. These events have revealed major weaknesses in traditional supply chain designs, making it necessary for organizations to treat resilience as a strategic necessity rather than an afterthought (Altay et al., 2018; Ambulkar et al., 2015; Blackhurst et al., 2011; Blackhurst* et al., 2005).

However, there is a lack of studies that examine how research trends have changed depending on the type of crisis over the years in terms of technological advancements and strategic management. Moreover, previous bibliometric reviews were usually conducted for certain types of disruptions or certain time frames, and they do not provide a full picture of the development of SCR research across different crisis contexts over time.

In response to this volatile environment, "Supply Chain Resilience" (SCR) has transformed from a marginal concept into an undeniable strategic necessity. Resilience no longer merely signifies a return to the initial state after a disruption; rather, it has evolved into a dynamic capability to anticipate, absorb, adapt, and recover from disruptions while maintaining and even enhancing competitive advantage(Cheng & Shan, 2025)This paradigm shift necessitates a fundamental transition from reactive risk management towards creating systems that are inherently adaptive and intelligent. The significance of this transition is highlighted by (Nieto-Rodriguez, 2021), who stated that organizational managers have moved from spending on identifying and managing risks to building resilience against crises.

Despite the growing importance of SCR, our understanding of how its research field has evolved in response to these multifaceted crises remains incomplete. Many previous bibliometric reviews have either focused on a specific type of crisis (such as the pandemic) or a limited timeframe, failing to provide a comprehensive picture of the paradigm shifts over time. Consequently, a clear gap exists in the literature: the need for a comprehensive, data-driven map that charts the intellectual structure and technological evolution of SCR research in an era of perpetual crises.

This paper aims to fill this gap by pursuing three main objectives: (1) to conduct a systematic and comprehensive review of SCR literature using bibliometric analysis for the period of 2007 to 2025; (2) to identify and map the key technologies, strategies, and paradigm shifts that have shaped the evolution of this field; and (3) to provide a structured agenda for future research that can guide both researchers and practitioners. The primary novelty and contributions of this research are as follows:

- Presenting the First Comprehensive Temporal Map: This study is the first to cohesively analyze the evolution of SCR research over an extensive period (2007-2025) and across various types of crises (pandemics, geopolitical events, natural disasters).
- Synthesizing the Digital Paradigm: Through a deep review of recent literature, this paper synthesizes and analyzes the pivotal role of digital technologies (AI, IoT, Blockchain) in the transition from traditional risk management to proactive resilience.
- Identifying Gaps and Providing a Roadmap: By identifying critical research gaps, such as the limited attention to human-centric factors (within the industry 5.0 framework) and the challenges of technology integration, this research offers a clear and practical agenda to direct future studies.

This study was designed to meet the following three objectives: (1) to conduct a systematic and coherent review of the SCR literature through a wide bibliometric review until 2004; (2) to identify and depict the key technologies, strategies, and methods that have been used to enhance SCR in the context of various crises; and (3) to reveal potential emerging trends and suggestions for future research that may help scholars and practitioners to improve the design of resilience management for complex and multi-type crises.

The remainder of this paper is organized as follows: Section 2 involves the research methodology. Related results and discussions are presented in Section 3. Finally, conclusion and future research directions are described in Section 4.

2. Research Methodology

Bibliometric is a more accurate and consistent approach as stated by (Aria & Cuccurullo, 2017). Bibliometrics analysis is a quantitative method and from it, scholars can gain knowledge of the specific research topics and trends in an area of study (Pang & Zhang, 2019). This approach employs statistical techniques to categorize and synthesize information extracted from examined literature sources, thereby revealing emergent patterns, research trajectories, and collaborative networks relevant to the subject under investigation. The bibliometric methodology facilitates the examination of extensive datasets, allowing scholars to construct a comprehensive intellectual landscape of the academic knowledge pertaining to their research focus.

More specifically, a number of reviews and bibliometrics articles have been written on the concept of resilience to date; however, the present article has a specific focus. In reviewing the significant papers, as well as conducting a keyword analysis, it attempts to determine the present trends and a wide range of keyword strategies have been used to conduct a thorough literature search.

For retrieving pertinent studies, we explored multiple academic databases, including Semantic Scholar, Scopus, and Web of Science. After preliminary analysis, Scopus was selected as the primary data source due to its more comprehensive coverage of the relevant literature. Various keyword combinations were formulated to capture all possible papers related to Supply Chain Resilience Under Crisis Circumstances. We recognized that terminology in this rapidly evolving field varies considerably, with researchers often using different terms to describe similar or overlapping concepts. Therefore, our search strategy was designed to be inclusive of this terminological diversity. To ensure the quality of the research, the process of selecting and screening articles was carried out based on the PRISMA guidelines.

In this article, we applied Bibliometric tool within Biblioshiny library in R-Studio, and VOS Viewer for visualization purposes(Aria & Cuccurullo, 2017). The SCOPUS database was used to gather data and the research strategy entailed the use of keywords from the author's names, titles, and abstracts.

The following search string was thus formulated:

*AUTHKEY (("Supply chain" AND "*Resilience*" AND "War") OR TITLE-ABS-KEY ("Supply chain" AND "Resilience" AND "Crisis") OR TITLE-ABS-KEY ("Supply chain" AND "Resilience" AND "Disaster") OR TITLE-ABS-KEY ("Supply chain" AND "Resilience" AND "Pandemic") OR TITLE-ABS-KEY ("Supply chain" AND "Resilience" AND "Geopolitical Conflicts"))*

The query was conducted on the SCOPUS database on the 28th of November 2024, and repeated on the 8th of December to also capture articles that were published recently and produced the first set of 1144 articles. From this sample, 900 papers were excluded by just reading the titles and having a look at the publication journal, and it seemed like they did not have anything to do with the supply chain context. Then 60 papers were excluded by experts' criteria. The experts' criteria for article selection include high-citation articles in the last two years, the biggest papers across the duration of the study and, the initial papers that were identified, this was done to gain a better understanding of the crisis evolution trajectory and to detect emerging trends.

3. Results and Discussion

This section presents a systematic review of the literature on supply chain resilience research in the context of crisis situations over the period 2007-2023. We present our findings under several headings: Bibliometric performance indicators: In this part, we examine the overall characteristics of the articles included in the review. Thematic evolution patterns: In this part, we discuss how the themes of supply chain resilience and crisis management have evolved over time. Research methodology trends: In this part, we review the methods used to investigate supply chain resilience during crises. Crisis typology analysis: In this part, we examine how various crisis types have been studied in the supply chain resilience literature. Industrial sector applications: In this part, we explore how supply chain resilience concepts have been applied in specific industrial sectors.

Table 1. A Review of Supply Chain and Resiliency in Crisis

Reference	Study Objective	Approach									
		Conceptual framework	Quantitative				Qualitative		Crisis Type	Industry Context
			Mathematical and Economic Modeling	Simulation and Computational Modeling	Structural Equation Modeling	Big Data and Advanced Analytics	Interviews and Field Studies	Case Studies		
Dynes et al. (2007)	To estimate the macroeconomic costs of firm-level information system disruptions within supply chains		✓				✓		Cyber Disruptions	General
Falasca et al. (2008)	Assessing supply chain resilience to disasters			✓					General	General
Jüttner and Maklan (2011)	To conceptualize supply chain resilience (SCRES) and identify its empirical relationship with supply chain vulnerability (SCV) and supply chain risk management (SCRM).						✓		Global Financial Crisis	General

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			Mathematical and Economic Modeling	Simulation and Computational Modeling	Structural Equation Modeling	Big Data and Advanced Analytics	Interviews and Field Studies	Case Studies		
Papadopoulos et al. (2017)	The role of Big Data in explaining disaster resilience in supply chains					✓			Natural Disaster (Earthquake)	General
Altay et al. (2018)	Examine the effects of supply chain agility (SCAG) and supply chain resilience (SCRES) on humanitarian supply chain performance under the moderating effect of organizational culture.				✓				Humanitarian crises	General
Ivanov (2020)	Analyze the impacts of epidemic outbreaks on global supply chains			✓					COVID-19 Pandemic	General
Hobbs (2020)	Provide an early assessment of the COVID-19 pandemic's implications for food supply chains, including resilience to demand-side and supply-side shocks.	✓							COVID-19 Pandemic	Food
Ivanov and Dolgui (2021)	A Digital Supply Chain (SC) Twin			✓		✓			COVID-19 Pandemic	General

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			Mathematical and Economic Modeling	Simulation and Computational Modeling	Structural Equation Modeling	Big Data and Advanced Analytics	Interviews and Field Studies	Case Studies		
Ivanov (2021)	To explore how digital supply chain technologies can enhance resilience by achieving end-to-end visibility.						✓	✓	COVID-19 Pandemic	General
Choudhary et al. (2021)	Analyze supply chain resilience (SCRes) during the COVID-19 pandemic using a network perspective and assess the effects of network characteristics on SCRes.		✓						COVID-19 Pandemic	Electronics
Pattanayak et al. (2023)	Investigate the role of blockchain technology (BCT) in enhancing supply chain resilience (SCRes) during disruptions.						✓		COVID-19 Pandemic	General
Belhadi et al. (2024)	Investigate the impact of AI-driven innovations on supply chain resilience (SCRes) and performance (SCP) under supply chain dynamism.	✓			✓				General	General

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Reference	Study Objective	Approach								Crisis Type	Industry Context
		Conceptual framework	Quantitative				Qualitative				
			Mathematical and Economic Modeling	Simulation and Computational Modeling	Structural Equation Modeling	Big Data and Advanced Analytics	Interviews and Field Studies	Case Studies			
Queiroz et al. (2024)	To investigate the role of supply chain agility and flexibility in enhancing resilience and performance during severe resource scarcity				✓	✓				COVID-19 Pandemic	General
Rahbari et al. (2024)	Disruptions in the wheat supply chain, and the impact on supply chain performance and costs.		✓							Russia-Ukraine War, COVID-19 Pandemic	Food
Yiran Chen et al. (2025)	How digitalization (internal factor) and supply chain network position (external factor) influence operational resilience	✓								COVID-19 Pandemic	General
Ali et al. (2025)	Explore the role of leadership styles in mitigating the negative impact of geopolitical shocks on Supply Chain Agility (SCA).				✓	✓				Geopolitical Shocks	General

The comprehensive review table presents a systematic and complete analysis of the supply chain resilience research during crises for the period 2007-2025. Several significant paradigm shifts have been identified in this stream of literature. The first observation is that the current studies (2020-2024) are mainly focused on the COVID-19 disruptions and are also incorporating emerging technologies such as blockchain (Pattanayak et al., 2023), artificial intelligence (Belhadi et al., 2024), and digital twins (Ivanov & Dolgui, 2021). Methodologically, the field has shifted from applying isolated quantitative or qualitative methods to integrated mixed-method analyses, which combine mathematical modelling with big data analytics and case studies.

Moreover, the conceptual framework has greatly expanded to include not only traditional resilience but also its interconnected dimensions, such as supply chain vulnerability (SCV), supply chain risk management (SCRM), and supply chain agility (SCA). The scope of research has also diversified to cover different types of crises, including pandemics but also geopolitical shocks (Ali et al., 2023), resource scarcity(Queiroz et al., 2024), and industry-specific disruptions like those in wheat supply chains (Rahbari et al., 2024).

Organizational culture (Altay et al., 2018) and leadership styles (Ali et al., 2025) have been identified as critical success factors in the development of resilient supply chains, thus shifting the focus to human and organizational factors in addition to technological solutions. This evolution indicates the growth of the field towards more holistic, technology-enabled, and context-specific approaches to supply chain resilience in a volatile global environment.

Table 2. A Comparative Framework of Previous Studies and the Proposed Research Direction

Article/Research Paper	Core Problem	Core Approach/Solution	Difference & Advantage of Your Work
Faggioni et al. (2024)	The fragility of supply chains during crises and the need for a more integrated response.	A combined engineering and social approach, emphasizing proactive/reactive actions and digitalization.	**Difference:** A conceptual paper outlining a combined approach. **Advantage:** Your work provides the quantitative evidence showing the *evolution* towards such integrated approaches. Your roadmap offers a more specialized guide for *how* to build new frameworks based on emerging technologies, moving from concept to actionable research paths.
Ivanov (2021)	Managing disruption risks in the complex Industry 4.0 era using methods beyond traditional, reactive approaches.	Proposes the "Digital Supply Chain Twin" as a conceptual and simulation-based tool for proactive risk management and resilience testing.	**Difference**: A focused conceptual paper on a single technological solution. **Advantage:** Your work provides the data-driven, macro-level context, showing how and why research on tools like Digital Twins became a dominant paradigm post-2020. Your roadmap identifies the broader research gaps beyond any single technology.
Belhadi et al. (2024)	The lack of empirical evidence validating the impact of AI-driven innovations on supply chain resilience and performance.	An empirical study using Structural Equation Modeling (SEM) to confirm that AI innovations positively impact resilience, especially in dynamic environments.	**Difference:** A specific empirical study testing a single hypothesis. **Advantage:** Your bibliometric analysis provides the "big picture," quantitatively demonstrating that AI is a major emerging research theme. Your work justifies the need for *more* such empirical studies and situates this finding within a larger technological shift.
Pattanayak et al. (2023)	Understanding how new technologies like Blockchain can be	A conceptual paper that frames Blockchain Technology (BCT) as a dynamic capability that	**Difference:** A conceptual study focused on one technology through a specific theoretical lens. **Advantage:** Your work maps the

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Article/Research Paper	Core Problem	Core Approach/Solution	Difference & Advantage of Your Work
	framed to build dynamic capabilities for enhancing supply chain resilience.	enhances resilience by improving transparency, traceability, and trust.	quantitative rise of "Blockchain" as a keyword, validating its importance, while also identifying practical research gaps (e.g., interoperability, governance) that conceptual papers often do not address.
Ali et al. (2025)	The under-researched role of human factors, specifically leadership, in fostering resilience during geopolitical shocks.	An empirical study demonstrating how leadership styles can mitigate the negative impact of geopolitical shocks on supply chain agility.	**Difference:** A focused empirical study on a non-technological factor. **Advantage:** Your network visualization objectively identifies "human factors" as a smaller, less-connected research cluster, providing data-driven evidence that this is a critical but under-explored area. Your roadmap champions the need for more such research.
Y. Chen et al. (2025)	The need for evidence-based policy recommendations for governments to build resilience without resorting to costly and inefficient relocalization.	A policy-focused review using economic modeling. It advocates for agility, adaptability, and alignment, providing actionable recommendations for governments.	**Difference:** A policy report for governments, not an academic review. **Advantage:** While the OECD report outlines what policies are needed, your paper provides the academic foundation and research agenda for how to achieve them. Your roadmap identifies the specific research questions that need to be answered to support these policy goals.

Supply Chain Resilience (SCR), as a field of study, has undergone a significant evolution in response to the increasing complexity and uncertainty in the global business environment(scolar). Initial approaches, rooted in traditional risk management, were primarily focused on reactive strategies to cope with disruptions. With the introduction of new perspectives and the transition beyond the initial concepts of resilience, new approaches have been examined in the literature. This section of the paper, focusing on the period between 2020 and 2025, examines this evolution, particularly the wave of digital transformation that has acted as the main driver of modern resilience. The Digital Transformation Wave (2020–2025): A Driver for Modern Resilience is mentioned in the following:

3.1 Artificial Intelligence (AI) and Predictive Analytics

With its ability to analyze vast amounts of data, Artificial Intelligence allows companies to move from reactive crisis management toward predictive risk prevention. The applications of AI in this domain are highly diverse.(Riad et al., 2024)

3.2 Blockchain for Transparency and Trust

One of the biggest challenges in global supply chains is the lack of transparency and trust among business partners. Blockchain technology offers a solution to this problem by providing a distributed, immutable, and transparent ledger.(Mensah & Merkuryev, 2014)

3.3 Internet of Things (IoT) and Real-Time Visibility

If Artificial Intelligence is the brain of the digital supply chain, the Internet of Things (IoT) is its nervous system. IoT devices and sensors provide unprecedented visibility across the entire supply chain by collecting real-time data from the physical world. (Alquraish, 2025)

3.4 Summary and Research Gaps

The recent literature review indicates a rapid and multidimensional evolution in the field of supply chain resilience. The field has shifted from reactive risk management to proactive resilience and is now in the midst of a profound digital transformation. However, several significant research gaps remain that require the attention of researchers in the future:

- **Technology Integration Challenges:** Most research has focused on the potential of a single technology (such as AI or blockchain). There is a pressing need for studies that address the challenges of **integrating** these technologies with each other and with legacy systems.
- **Socio-technical Frameworks:** An excessive focus on technological solutions has led to the neglect of human and organizational factors. Future research should develop integrated **socio-technical frameworks** that consider the interaction between technology, processes, organizational culture, and human skills.
- **Measuring Digital Resilience:** With the emergence of new technological capabilities, there is a need to develop new models and metrics for **measuring** and evaluating the level of resilience in digital supply chains.
- **Synergy and Trade-off between Resilience and Sustainability:** The relationship between resilience strategies (which may require redundancy and higher costs) and sustainability goals (which emphasize efficiency and waste reduction) is complex and requires further research to find an optimal balance.

4. Descriptive analysis and bibliographic coupling

The articles were reviewed for 18 years, and the trend analysis was done based on publication patterns over time. The last 5 years, which are from 2019-2024, are approximately 90% of the publications during the entire period (1,932 out of 2,144 total articles). As can be seen from the analysis in Figure (1), the growth rate of publications was fairly slow before 2019, but from 2019 to 2024, the article publication rate increased exponentially, with the highest number of publications in 2024 at 540. We can see a strong growth surge from 2019 onwards, all due to the COVID-19 pandemic, which clearly shows the vulnerability of supply chain resilience.

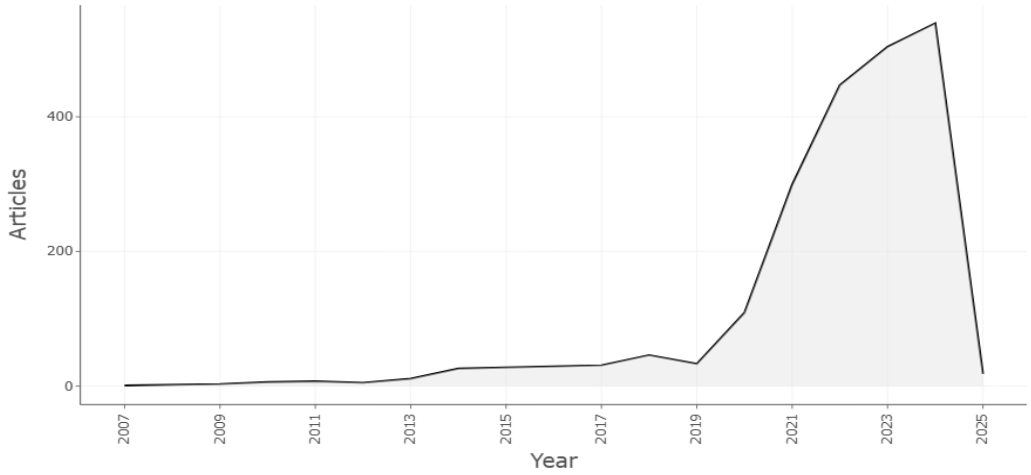

Figure 1. Annual Scientific Production

The citation trend presented in Figure (2) shows that citation patterns were non-linear before 2019. From 2019, in conjunction with the COVID-19 pandemic, citation trends picked up, with the year 2020 having the greatest number of citations. When examining the published articles, citation spikes are seen to occur with major global disruptions. In

2008, the housing and financial crisis in the US which affected raw material supply and company supply chains was a key citation driver. Likewise, in 2011 Japanese flood crisis that disrupted automotive parts supply created a brief rise in citations.

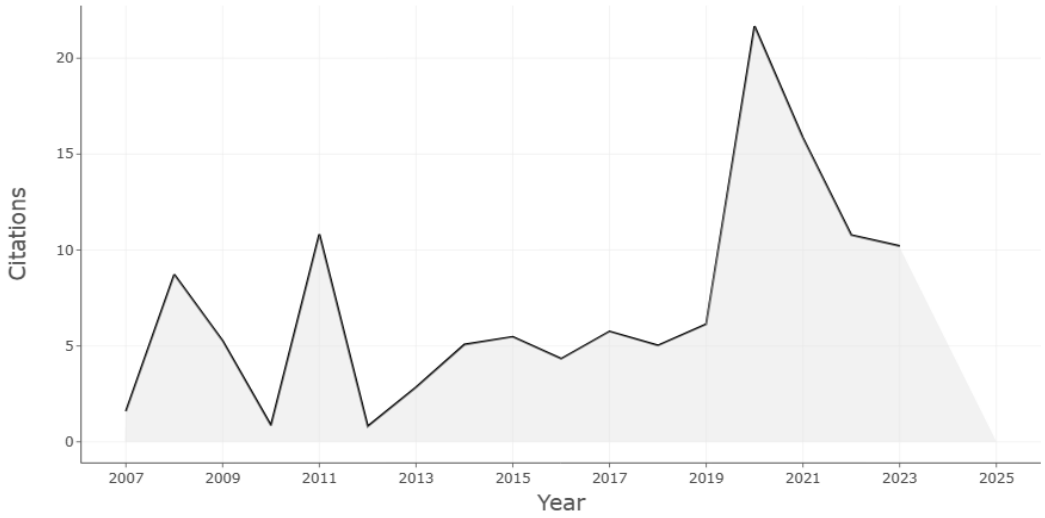

Figure 2. Average Citation Per Year

The research trend analysis in Figure (3), we observe research trend analysis over time, with crises like the Fukushima earthquake in Japan influencing trend patterns through 2020. In the period 2020-2022 (COVID-19 pandemic and its impacts), we witness keywords such as covid-19, covid-19 pandemic, coronavirus, and resilience. During this period, the global COVID-19 pandemic caused extensive supply chain disruptions, bringing attention to crisis resilience to its peak. Additionally, we observe *digitalization* and *industry 5.0* in recent years, indicating a shift in new studies towards digital transformation aimed at creating *sustainable and flexible supply chains* that can resist crises while simultaneously minimizing environmental impacts.

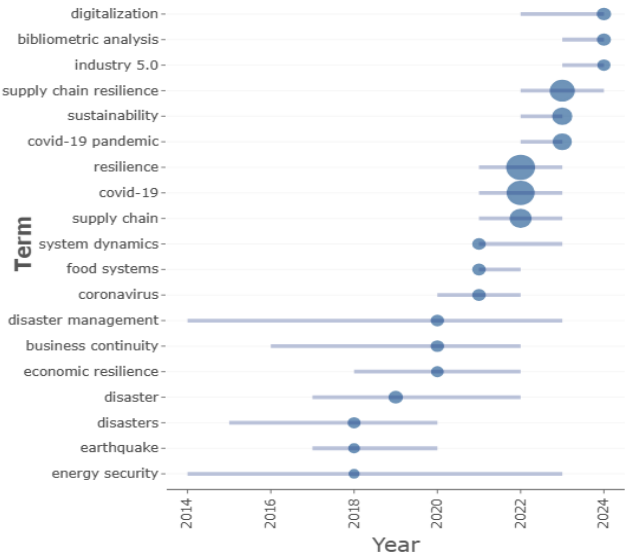

Figure 3. Trend Topics

In Figure (4), using VOSVIEWER software, we can examine the clustering analysis. The current figure reveals 3 distinct clusters, with keyword selection focusing on terms repeated more than 20 times to reduce low-impact words and provide a comprehensive network perspective. In this network, "*Supply chains*" serves as a central node connected to sub-topics such as "*Global supply chain*", "*Supply chain disruption*", "*Supply chain resilience*", and "*supply chain resilience*". Additionally, other frequently used related keywords include "*Risk management*", "*Uncertainty analysis*", "*Artificial intelligence*", "*Climate change*", "*Disasters*", and "*Human factors*".

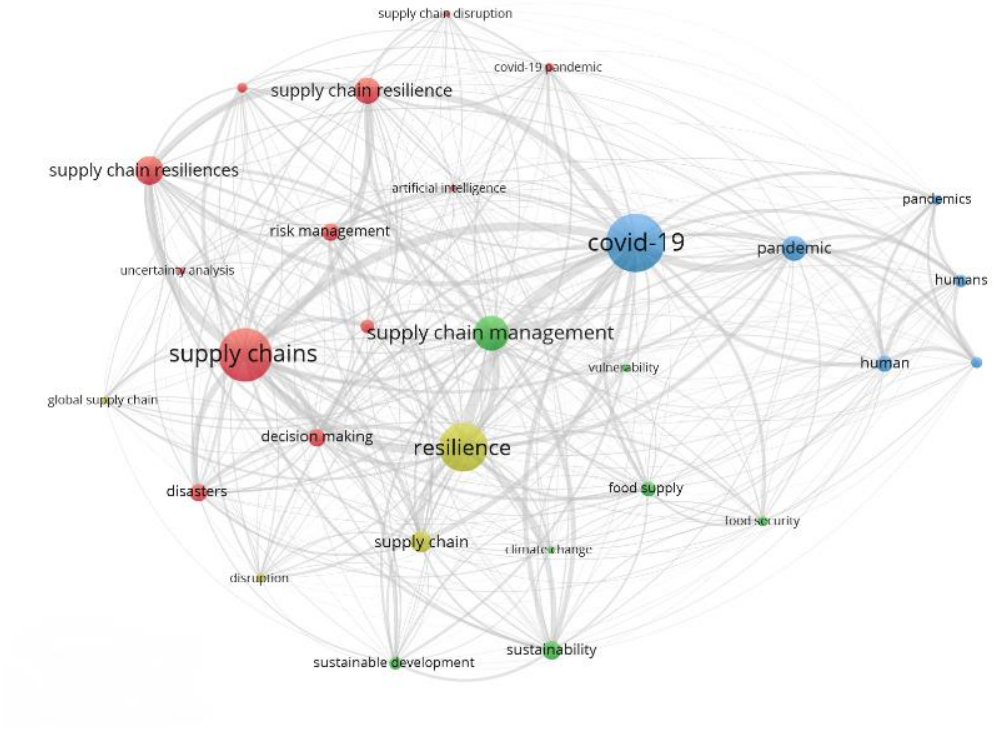

Figure 4. Network Visualization

5. Conclusion and Future Research Directions

This broad bibliometric analysis of 1,144 articles over 18 years reveals a growing trajectory of supply chain resilience research, especially in the wake of major global crises. Our findings show a noticeable shift from the traditional risk management approaches to the new technology-driven resilience approaches after the COVID-19 pandemic. The enhancement of AI, blockchain, IoT, and Industry 4.0 technologies is a clear shift in the way that supply chains are created to manage multidimensional disruptions. Nevertheless, there are still numerous research gaps that emerge during this study, including the absence of design thinking in the literature and the absence of integrated frameworks that would link technological innovation with strategic resilience management.

As global supply chains face increasing complexity and interconnected risks such as pandemics, geopolitical wars and climate change, future research needs to go beyond technological fixes to more holistic approaches that integrate technological capability and strategic flexibility. This paper offers a clear and systematic way forward for researchers and practitioners to tackle these issues, while also indicating the priority of cross-disciplinary cooperation to address the rising complexity of modern supply networks while ensuring resilience, sustainability, and operational effectiveness.

Considering the contemporary trends and the number of crises that are ongoing in the world such as the Syrian war, the current conflict in Ukraine, and the possible appearance of new pandemic diseases it seems that in the future, research will be focused extensively on supply chain resilience in the context of crises.

In reviewing articles and analyzing publication trends it is suggested that future work should investigate the role of digitization and digital transformation, the Internet of Things (IoT), artificial intelligence (AI), and blockchain in enhancing the resilience of supply chains in the face of crises. Moreover, paying attention to the design of resilient and sustainable supply chains may help to create sustainable and environmentally friendly resilient supply chain networks.

Another potentially interesting direction for future research might be the implementation of Design Thinking in supply chain resilience management. Studying how innovations in various areas can improve resilience can help to reveal novel approaches to rapid and effective responses to crises. Exploring the new business models and transforming the industrial strategies to improve supply chain resilience are also possible directions for future research.

5.1 The roadmap of the Future

Based on the identified findings and gaps, we propose a structured agenda for future research. The most important topics for researchers are outlined below. The aim of this agenda is to guide researchers toward critical questions, the answers to which can help build more resilient, sustainable, and intelligent supply chains in the future.

5.5.1 Future Research Directions:

1. "Sustainable Supply Chain Resilience under Climate and Health Crises: A Dual Threat Approach"
2. "Faster Crisis Identification for Improving Supply Chain Sustainability (*Using Local Social Networks*)"
3. "Optimal Resource Allocation in Multi-layered Crisis Conditions (*Using Decision-Support Models*)"
4. "Enhancing Supply Chain Resilience to Improve Food Security (*Using Blockchain Technology*)"
5. "Predicting the Impact of Geopolitical Decisions on Supply Chain Resilience (*Internal Crises and International Crises)"*

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