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Applications of Artificial Intelligence for Supply Chain Resiliency: A Bibliometric Analysis

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ABSTRACT
Supply chains have become more dynamic due to the current state of the economy and technological developments. These dynamic supply chains need more advanced technical solutions, such as blockchain and artificial intelligence (AI), to handle disruptions. This study aims to understand the current knowledge of supply chain resilience and artificial intelligence applications. Using bibliometric analysis, we examined the research documents of six book chapters, ten conference papers, and 58 articles from the SCOPUS database. The documents cover the years 2021–2024. The most significant and prolific writer is Modgil. In co-authorship analysis, France is the most influential country, while India is the most productive. The authors' primary areas of collaboration include India, UK, and France. Artificial intelligence, Supply chains, resilience are the most occurred keywords. Manufacturing is the most explored sector for using AI to improve supply chain resilience. AI-powered strategies including visibility, adaptability, agility, sustainability, forecasting, information processing capabilities, and decision-making drive the supply chain toward resilience.

Keywords: Artificial intelligence, supply chain resilience, supply chain disruption, bibliometric analysis.

INTRODUCTION:

The literature on artificial intelligence (AI) acknowledges it as a revolutionary analytical tool for supply chain performance optimization. AI can add value to supply chain planning, including production, inventory management, and product distribution. AI helps supply chains to become more resilient and sustainable. It transforms the supply chain from technology-driven to value-driven (Gupta et al., 2023a). Resilience is the capability of the supply chain to recover from disruptions (Wang and Pan, 2022; Hirsch et al., 2024). It is the capacity to endure disruptions without causing them to affect the supply chain's overall functioning. Supply chains had disruptions amid the COVID-19 outbreak, which increased their vulnerability. Enhancing robustness requires minimizing this supply chain's susceptibility (Yang et al., 2024). Under complex and uncertain disruptions, quick and proper business decision-making is critical (Gupta et al., 2024). The current study uses AI to deal with disruptions brought on by various events, such as war, pandemics, etc. AI-enabled strategies, which can be examined in the literature, might help address these challenges.

Though AI is not new, its many uses have only now come to light. It is relatively a novel concept to use AI to achieve supply chain resilience. Because of the highly complicated business environment, dynamism, environmental change, concepts like globalization, and more significant rivalry between businesses in the national and international arenas, enterprises and supply chains have experienced substantial changes (Ismail et al., 2024). AI facilitates tools and techniques to cope with this dynamism in the markets. AI may enhance supply chain decision-making by anticipating and preparing for possible challenges (Zheng et al., 2023). AI technology can help address problems and obstacles in sustainable supply chains (Kazancoglu et al., 2023). AI is instrumental to handle operational issues resulting from disruptions. During COVID-19, the robustness and sustainability of supply chains across many industrial sectors have been called at risk (Bechtsis et al., 2022; Cuong et al., 2023). The industries that are affected most by the disruptions are manufacturing and automobiles. A robust supply chain can be built by handling complexity, responding to changes, and evaluating various data sources (Debnath et al., 2024).

The current study aims at understanding the existing state of the AI-driven supply chain for resiliency. Uncertain events like pandemics and war may cause supply chain disruptions, which impact the whole business performance. These disruptions need to be minimized to ensure resiliency in the supply chains with the application of AI. Based on the potential gap for study of AI-powered supply chain resilience, the following research questions are framed, to understand the phenomenon better.

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- RQ1 What is the current state of literature on AI-enabled supply chain resilience?
- RQ2 What AI-enabled strategies help to enhance supply chain resilience?

REVIEW OF LITERATURE

Achieving excellent and sustainable supply chain performance requires organizations to function in a dynamic supply chain. Developing resilience against disruptive and unexpected occurrences is critical. AI improves the performance of the organizations. The influence of AI on supply chain management is far more significant than expected. The supply chain can now endure any disruptions through AI. AI-driven innovations provide substantial benefits in dynamic markets, such as a robust supply chain that improves overall performance (Belhadi et al., 2024). Several kinds of AI-powered strategies provide supply chain resiliency. One way to achieve resilience is to have end-to-end visibility throughout supply chain operations (Ghabak and Chougule, 2024; Ivanov, 2024; Wu et al., 2024). AI helps businesses make quick and appropriate decisions when facing complex and unpredictable challenges. Resilience in supply chains is achieved by data-driven decision-making (Roux et al., 2023; Wu et al., 2024). AI analyzes vast amounts of data to provide personalized answers to all parties involved. Supply chain management activities will be resilient if an agile strategy is enabled (Modgil et al., 2022b).

Building trust with stakeholders through efficient communication and knowledge exchange across supply chain partners would help the company move toward a resilient supply chain (Ali et al., 2024; Mitra et al., 2024). Organizations will become more resilient through improving their information processing and forecasting capacities (Belhadi et al., 2024; Wu et al., 2024). Technology-driven to value-driven transformation is made feasible with AI, thus adding value to the company (Gupta et al., 2023a). Moreover, companies typically create risk management and business continuity plans to minimize disruptions (Brintrup et al., 2022; Dey et al., 2024). These risk management techniques facilitate resilient supply chain management. Collaboration throughout the supply chain may increase operational efficacy, profitability, and efficiency, contributing to resilience (Samadhiya et al., 2023; Rashid et al., 2024).

Operations are automated, and decision-making is enhanced by AI, which increases profits, lowers costs, and enhances customer service (Zhu and Vuppalapati, 2023). Artificial Intelligence (AI) has the potential to significantly improve supply chain visibility, forecasting accuracy, and decision-making support (Wu et al., 2024). AI improves adaptability and makes it possible to create a supply chain that is both robust and sustainable (Ansari and Kohl, 2022). To maintain efficiency and sustainability in supply chains, it is possible to effectively suppress chaos and address synchronization issues brought on by disruptions (Cuong et al., 2023). The supply chain's resilience is enhanced by an efficient risk mitigation strategy, robust, adaptable, agile, responsive systems, and higher communication and information exchange (Rafi-Ul-Shan et al., 2024). The supply chains' enhanced information processing quality and quicker response times help firms become more resilient (Claus and Szupories, 2022).

RESEARCH METHODOLOGY

A systematic literature review is carried out to understand the resiliency of the supply chain by applying artificial intelligence. The following keywords were used to search the documents from the SCOPUS database.

A total of 374 documents were found with the keywords "artificial intelligence" and "supply chain resilience", "supply chain resiliences", "supply chain disruption", and "supply chain disruptions". These documents included decision science, social science, business, accounting, and management. Again, the review article and conference reviews were excluded to get 168 papers. Then, 74 primary documents were shortlisted for the review. Figure 1 below explains the flow of research. Bibliometric analysis was carried out using VOS Viewer.

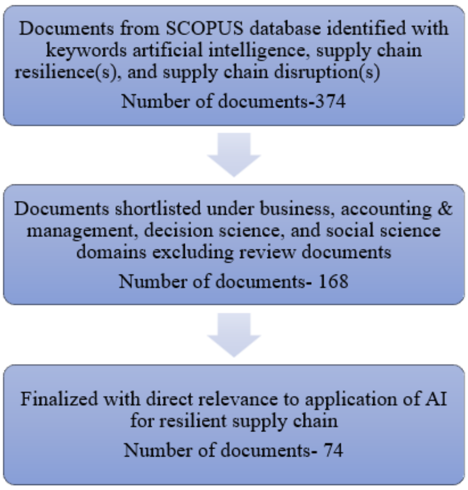

Figure 1 Flow of research

The review's key findings are documented in the following part of the article. The review records the documents by year, type, co-authorship, co-occurrence, co-citation, citation, and sector. This study puts forth AI-enabled strategies to enhance supply chain resilience.

Documenting the review

Documents by year

The shortlisted documents are from 2021 to 2024, as shown in Figure 2. The annual number of articles published is rising. After COVID-19, a novel idea using AI to manage supply chain disruption was realized. Almost every sector has seen negative consequences on business continuity during COVID-19. The disruption of the organizations' supply chains led to the use of AI. There were five research documents published in the year 2021 with reference to AI and supply chain resilience. In the year 2022, 15 documents were published which address the supply chain disruption with AI. The number of documents increased to 24 and 30 in the years 2023 and 2024 respectively.

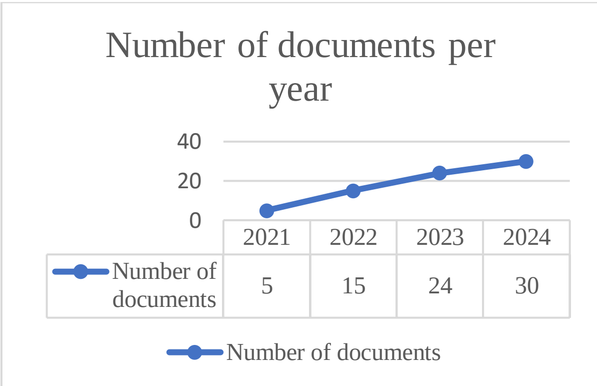

Figure 2 Number of documents per year

Documents by type

The documents comprise 58 journal articles, ten conference papers, and six book chapters for the review. The following Figure 3 shows the documents by type. The review articles and conference reviews were excluded from the study. The documents are relevant to implementing artificial intelligence in the supply chain.

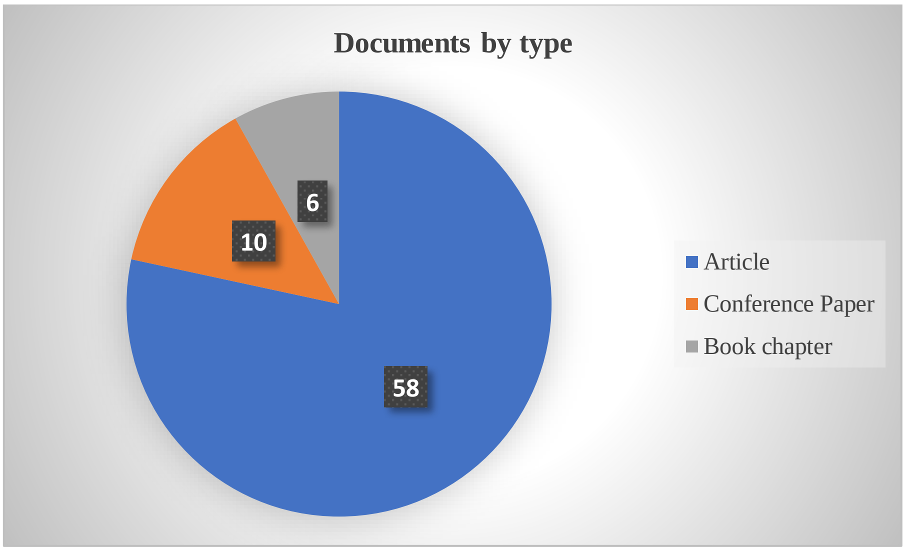

Figure 3 Documents by type

Documents by co-authorship

Co-authorship analysis for authors

Using the VOS viewer software, the documents were analyzed by co-authorship for authors. The 74 documents reviewed comprise 255 authors. Of 255 authors, 22 have written at least two papers and received at least two citations. The network visualization illustrates the connections among the 12 authors. There are four clusters presented in different colours in the network diagram, each with three items.

Author	Documents	Total link strength
Modgil, S	5	7
Gupta, S	4	7
Belhadi, A	3	4
Dwivedi, Y	2	4
Kumar, A	2	4
Bryde, D	2	3
Dubey, R	2	3
Kamble,S	2	3
Singh, R	2	2
Kazancoglu, Y	2	2
Fosso Wamba, S	2	1
Ivanov, D	2	0

Table 1.1 Document-wise co-authorship analysis for authors

Author	Citations	Total link strength
Modgil, S	344	7
Belhadi, A	244	4
Bryde, D	194	3
Dubey, R	194	3
Gupta, S	181	7
Singh, R	177	2
Ivanov, D	153	0
Kamble,S	148	3
Dwivedi, Y	108	4
Fosso Wamba, S	98	1
Kazancoglu, Y	92	2
Kumar, A	72	4

Table 1.2 Citation-wise co-authorship analysis for authors

From Table 1.1 above, author Modgil has five documents since 2021, which makes him the most productive author. Author Gupta and Belhadi has four and three documents respectively which makes them the productive authors. Also, Modgil has the highest number of citations, followed by Belhadi, which makes them the most influential authors in this field as shown in Table 1.2. In the network visualization Figure 4, the thickness of the line shows the link strength, which means how the authors have collaborated to publish the documents. Gupta and Modgil have the highest link strength, which means both have collaborated the most with other authors.

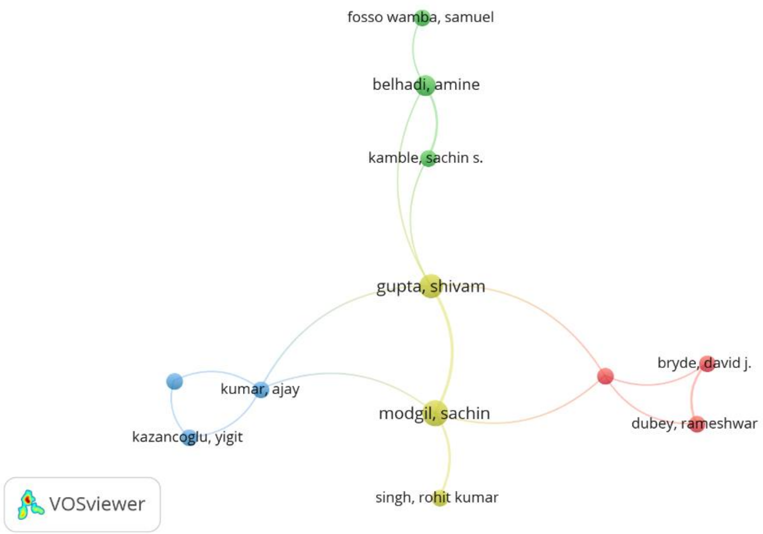

Figure 3 Network Visualization of co-authorship analysis for authors

Co-authorship analysis for countries

The VOS viewer software is used for the co-authorship analysis for 35 countries. Eight countries meet the requirements with at least five national publications and two citations per work. Seven of these eight countries are linked. The network visualization Figure 5 shows 3 clusters with items 3,2 and 2 each.

Country	Documents	Total link strength
India	21	19
United Kingdom	20	21
France	16	23
United States	10	4
Morocco	8	12
China	7	4
Italy	5	1
Germany	5	0

Country	Citations	Total link strength
France	780	23
United Kingdom	699	21
India	645	19
Morocco	291	12
China	202	4
United States	168	4
Germany	154	0
Italy	70	1

Table 2.1 Document-wise co-authorship analysis for countries Table 2.1 Citation-wise co-authorship analysis for countries

France is the center of collaboration with the highest link strength, followed by the UK and India. From Table 2.1, India has highest number of documents published which makes it the most productive country followed by UK and France. Also, from Table 2.2, documents from France have the highest number of citations which makes it the most influential country for publications in AI-enabled supply chain resilience. UK and India are also influential countries with highest number of citations. Thus, France, India, and UK are the most productive and influential countries with higher collaborations with other countries.

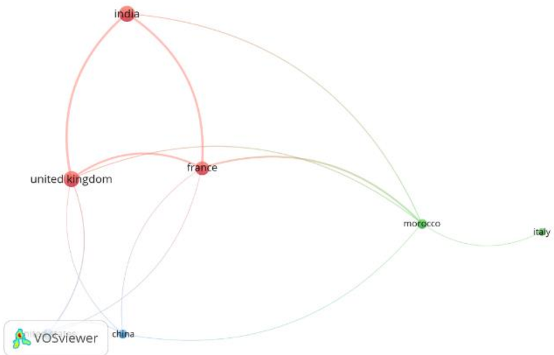

Figure 5 Network visualization of co-authorship analysis for countries

Documents by co-occurrence of keywords

For every keyword, the co-occurrence analysis is performed with VOS Viewer. Three occurrences are the minimum required to obtain the visualization network. With the threshold set at three, 43 keywords were extracted from 74 documents out of 557. Five clusters indicated with different colors in the visualization network hold 10, 10, 10, 8, and 5 elements each. The following Table 3 shows that artificial intelligence, and supply chains are the two most occurred keywords in the documents. Supply chain resilience is also the most frequently used keyword followed by supply chain management and Covid-19.

Table 3. Co-occurrence analysis of keywords

Keywords	Occurrences	Total link strength
Artificial intelligence	50	186
Supply chains	28	156
Resilience	16	62
Supply chain resilience	16	60
Supply chain management	15	68
Covid-19	14	47
Decision making	12	75
Supply chain resiliences	10	51
Machine learning	10	52
Sustainability	9	49

The size of a node in a visualization network represents the frequency of the keyword, and the links show how frequently they occur together. The network Figure 6 below demonstrates that the most popular keyword with highest node size is artificial intelligence, followed by supply chains, resilience, and supply chain resiliences.

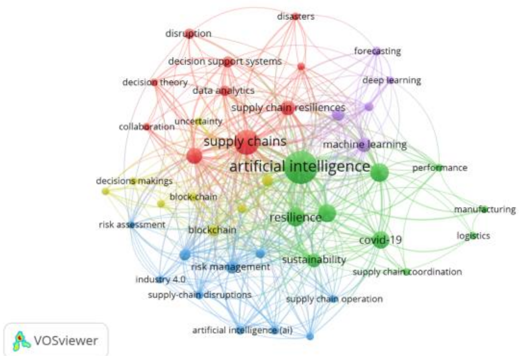

Figure 4 Network visualization of co-occurrence of keywords

Documents by citation

Citation analysis of documents

The citation analysis of 74 documents is carried out. 56 documents are cited by other articles, from which ten documents are connected, as shown in Figure 7. The study shows 4 clusters with 4,3,2 and 1 item.

Table 4 Citation analysis of documents

Documents	Citations	Link

Modgil (2022a)	167	3
Ivanov (2024)	119	0
Dubey (2021)	113	5
Modgil (2022b)	102	2
Belhadi (2022)	96	0
Dubey (2022)	81	0
Behl (2022)	79	0
Akhtar (2023)	33	1
Merhi (2024)	15	1
Riahi (2023)	2	3

From Table 4, Modgil (2022a) is the most cited document, followed by Ivanov (2024) and Dubey (2021). Modgil's (2022a) document titled "AI technologies and their impact on supply chain resilience during COVID-19" is the most influential document that discusses the impact of AI on supply chain resilience during COVID-19. Dubey (2021) facilitates AI in supply chain analytics during the pandemic. Most of the documents on AI-driven resilience were published after the COVID-19 pandemic.

Figure 5 Network visualization of citation analysis of documents

Documents by co-citation

Co-citation analysis for cited sources

For cited sources with at least 15 citations, the co-citation analysis is 56 out of 2036. Four clusters are in the network diagram Figure 8, with 16, 15, 13, and 12 items.

Table 5 Co-citation analysis for cited sources

Source	Citations	Total link strength
International Journal of Production Research	282	12148
International Journal of Production Economics	203	9692
Annals of Operations Research	134	6828
Journal of Business Research	60	3502
Journal of Operations Management	58	3193
The International Journal of Logistics Management	56	3114
Supply Chain Management: An International Journal	55	2819
Industrial Marketing Management	45	2590
Technological Forecasting and Social Change	44	2572

According to the data in Table 5, the most referenced journal is "The International Journal of Production Research," which is followed by "Annals of Operations Research" and "The International Journal of Production Economics." The most critical journals in technology, supply chain management, and core production are shown in the table. These primary journals may publish future research articles on "AI-driven supply chain."

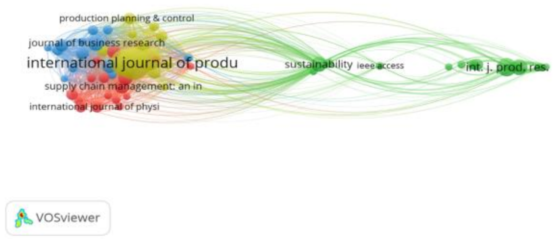

Figure 6 Network Visualization of co-citation analysis for cited sources

Documents by sector

The documents that have been reviewed examine how AI is being used to improve supply chain resilience across a range of sectors, including manufacturing, automotive, e-commerce, pharmaceuticals, and agriculture. The number of studies across several industries is displayed in Table 6 below. Since the manufacturing sector was affected most by the COVID-19 pandemic, it has received the most attention on AI-enabled resilient supply chains. Automotive sector also had the impact of pandemic which receives moderate attention for the AI-driven operations in supply chains.

Table 6 Sector-wise documents

Sector	Documents
Manufacturing	Yamin et al. (2024); Rosunee and Unmar (2024); Wecken et al. (2023); Leoni et al. (2022); Rashid et al. (2024); Roux et al. (2023); Belhadi et al. (2022); Merhi and Harfouche (2024); Dey et al. (2024); Ansari and Kohl (2022); Bhatti and Bauirzhanovna (2023); Javed et al. (2024); Babazadeh et al. (2024); Dubey et al. (2021); Zhang H. (2021)
Automotive	Gabellini et al. (2023); Kazancoglu et al. (2023); Gabellini et al. (2024)
E-commerce	Modgil et al. (2022b); Hejazi et al. (2022)
Healthcare	Samadhiya et al. (2023); Adhikari et al. (2023)
Agriculture	Effah et al. (2024); Nayal et al. (2022)
Pharmaceutical	Khan et al (2023); Nguyen et al. (2023)
Electronics	Gopal et al. (2022)
Chemical	Mitra et al. (2024)
Service	Behl et al. (2022)
FMCG	Hirsch et al. (2024)
Food	Bechtsis et al. (2022)
Handicraft	Yadav and Tripathi (2024)
Fashion	Rafi-Ul-Shan et al. (2024)
Different/mixed	Ali et al. (2024); Sadeghi et al. (2024); Belhadi et al. (2024); Jauhar et al. (2024); Claus and Szupories (2022); Nandi et al. (2023); Wang and Pan (2022); Modgil et al. (2022b); Gupta et al. (2023a)

The use of AI in the manufacturing supply chain appears to be the most beneficial for improving supply chain resilience. The application of AI for resilience in different industries is a relatively new idea that has to be investigated. There is a more significant opportunity for AI-driven supply chain resilience in other fields, such as e-commerce and pharmaceuticals.

Documents by strategies of AI-driven resilient supply chain

Disruptions in the supply chain might adversely affect the organization's overall performance. Several possible causes of the disruptions include war, pandemics, and other events. A robust supply chain tolerating these disruptions can provide a competitive edge. Supply chains must be made more resilient through AI to deal with the disruptions. Achieving resilience in the supply chain can be facilitated by implementing AI-driven strategies. The below Table 7 specifies the AI-enabled strategies that influence resilience in supply chain.

Table 7 AI-driven strategies

AI-enabled strategies	Documents

Enhancing information processing capabilities	Belhadi et al. (2024); Claus and Szupories (2022); Hirsch et al. (2024), Cuong et al. (2023); Nguyen et al. (2023); Debnath et al. (2024)
Smart-data driven decision-making	Roux et al. (2023); Gupta et al. (2024); Hirsch et al. (2024); Wu et al. (2024); Mitra et al. (2024); Zhu and Vuppalapati (2023)
Effective collaboration among supply chain partners	Samadhiya et al. (2023); Rashid et al. (2024); Pimenidis et al. (2021); Hendriksen C (2023); Adhikari et al. (2023); Singh and Prabhu (2023)
Transparency	Singh et al. (2024); Modgil et al. (2022b); Ismail et al. (2024); Singh and Prabhu (2023)
Knowledge sharing among partners	Ali et al. (2024); Hirsch et al. (2024); Nguyen et al. (2023); Rafi-Ul-Shan et al. (2024); Zheng et al., 2023
Risk management	Brintrup et al. (2022); Dey et al. (2024); Rafi-Ul-Shan et al. (2024); Singh and Prabhu (2023); Nayal et al. (2022)
Sustainability, Viability	Bechtsis et al. (2022), Cuong et al. (2023); Zaoui et al. (2023); Ansari and Kohl (2022)
Effective communication	Ali et al. (2024); Mitra et al. (2024); Rafi-Ul-Shan et al. (2024)
Visibility across supply chain operations	Ghabak and Chougule (2024); Ivanov (2024); Wu et al. (2024)
Adaptability, Flexibility	Samadhiya et al. (2023); Rashid et al. (2024); Ansari and Kohl (2022)
Facilitating agile strategies	Modgil et al. (2022b); Dey et al. (2024); Rafi-Ul-Shan et al. (2024)
Improving supplier selection	Khan et al (2023); Brintrup et al. (2022); Gabellini et al. (2023)
Inventory optimization	Brintrup et al. (2022); Bhatti and Bauirzhanovna (2023)
Forecasting capability	Wu et al. (2024)
Improving customer service	Zhu and Vuppalapati (2023)
Enhance operational performance	Hejazi et al. (2022)
Value driven transformation	Gupta et al., (2023a)
Cost-competitive resilience	Bechtsis et al. (2022)
Personalized solutions to all stakeholders	Modgil et al. (2022b)

The information processing capability of AI can give solutions to real-time problems in the industry. AI analyses the supply chain's patterns, behaviors, and preferences to provide solutions to the decision-makers. AI processes a large amount of data to predict situations that might affect the supply chain. A prediction-led prescription will help retain the organizations' supply chain buoyancy. AI can give personalized solutions at all levels of management for better decision-making. Intelligent, data-driven decision-making will enable the supply chain to be more resilient. Effective stakeholder communication facilitates the solution of supply chain-related problems. AI-enabled effective communication improves coordination, which strengthens problem-solving abilities. Numerous studies have identified effective communication as a vital strategy for handling disruptions. Partners that share knowledge are less likely to be in jeopardy of supply chain crises. AI makes it easier for the partners to share knowledge. With AI capabilities, partnerships throughout the supply chain may collaborate more effectively, enhancing the robustness of the supply chain. Transparent business operations view a candid picture of the performance, which helps retain the stakeholders' beliefs that are important in times of disruption.

AI-driven cost-competitive strategies of supply chain offer an edge over the competitors. AI facilitates visibility across the supply chain, which reduces the harm caused by uncertain events. Risk management in the supply chain is possible with AI capabilities. Supply chain functions like inventory management, transportation, warehousing, and demand planning can be optimized with AI applications. AI plays a vital role in demand forecasting, which significantly affects disruptions. Agility in the supply chain will build resilient operations for a sustainable supply chain. AI-powered strategies will facilitate agility in the supply chain. Organizations' supply chains should adapt to the situation to cope with disruptions. Flexibility in the operations will help to enhance supply chain resilience. AI empowers the supply chain to excellence in terms of operational performance. An excellent supply chain will provide better customer service, increasing the business's value. AI-powered services will drive value transformation, enhancing the company's sustainability. AI-enabled strategies help ensure the viability and sustainability of supply chains.

Implications and Future Research

Current research makes AI-driven supply chain resilience strategies feasible, which is essential for business performance in today's dynamic marketplaces. The study thoroughly reviews the literature on AI-enabled supply chains to handle disruptions that negatively impact the supply chain, such as pandemics, natural disasters, conflicts, etc. The study has implications for both academia and business. The study provides strategies that help companies in improving sustainability. Academicians might continue their studies by using the research better to grasp the state of the field's study. The research offers network visualization, which gives a candid picture of essential topics, authors, sources, and their connections with each other. It helps other researchers to understand the potential areas for research.

The research that has been done on the use of AI in supply chain resilience is just at the preliminary stage. Further investigations based on empirical data are possible. Most research focuses on the manufacturing sector, but there is still a need to investigate AI applications in other areas. It is possible to identify the difficulties with implementing AI in the supply chains of various sectors. Sector-by-sector variations in the approach could yield more comprehensive analysis and outcomes. Future studies may examine how AI-driven strategies affect overall efficacy.

CONCLUSION

Recent digitalization and dynamic markets have led businesses towards more advanced technology. AI has empowered these businesses to attain resiliency. The study reviews the literature to understand the level of research done. There aren't many published research studies on AI-enabled resilient supply chains. Using AI to improve supply chain resilience is relatively a new idea that emerged following COVID-19. The most cited paper addresses supply chain resilience using AI during COVID-19. This evaluation emphasizes artificial intelligence and supply chain resilience. Various sectors have incorporated AI into supply chains to address disruptions. AI-powered strategies like visibility, agility, transparency, value transformation, and information processing capabilities enable the supply chains to be more resilient and withstand disruptions like pandemics, natural calamities, war etc.

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