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The Role of Generative AI in Supply Chain Resilience: A Fuzzy AHP Approach

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Abstract

Supply chain managers rely on decision-making support to enhance resilience in the face of disruptions, emphasizing real-time monitoring and recovery actions. The COVID-19 pandemic underscores the necessity of digitalization for supply network mapping. Generative AI (Gen-AI) models offer transformative potential across various domains, facilitating proactive crisis management and resilience enhancement in supply chains. Specifically, ChatGPT's natural language capabilities streamline communication and aid in predicting disruptions. This study employs the Fuzzy AHP to investigate Gen-AI's impact on resilience drivers, integrating expert opinions and quantitative analysis. The research aims to identify key drivers influenced by Gen-AI, providing actionable insights for supply chain management strategies. Agility emerges as the most significant factor, followed by flexibility, visibility, information sharing, and collaboration. While collaboration ranks lowest, it remains vital for overall resilience. These findings support existing research, emphasizing the growing significance of agility in supply chains throughout market uncertainties. Gen-AI adoption improves agility by optimizing inventory management and response to disruptions. This research underscores the critical role of integrating Gen-AI to develop customized resilience strategies in supply chain management. By emphasizing agility, flexibility, and stakeholder cooperation, organizations can effectively leverage Gen-AI's predictive capabilities to enhance resilience and responsiveness in dynamic market environments.

Keywords
Generative Artificial Intelligence (Gen-AI), Supply Chain Management (SCM), Supply Chain Resilience (SCRes), and Fuzzy Analytical Hierarchy Process (Fuzzy AHP).

1. Introduction
As significant global disruptions like the Great Recession and the COVID-19 pandemic, supply chain resilience (SCRes) has gained widespread attention. Companies are increasingly prioritizing investments to improve their resilience, focusing on managing unforeseen disruptions and maintaining uninterrupted critical supply flows. This entails enhancing predictive capabilities and proactively managing threats to supply chains (Queiroz et al., 2022). In our current dynamic landscape, characterized by political, economic, and social challenges, the urgency to embrace cutting-edge technologies is paramount. Ongoing disruptions have resulted in inefficiencies, diminished effectiveness, customer dissatisfaction, extended delivery times, and declining revenues for businesses. It is essential for firms to recognize that unresolved issues concerning end-to-end visibility and collaboration pose significant threats to the sustainability and resilience of their supply chains (Pandey et al., 2024). The transformative impact of novel technologies is fundamentally reshaping the landscape of SCM as a whole, with a notable impact on SCRes. Digital technology encompasses a fusion of Industry 4.0, the Internet of Things, Cloud Computing, Blockchain Technology, Big Data Analytics, Artificial Intelligence, Augmented Reality and Virtual Reality, and Additive Manufacturing (Ivanov et al., 2021). Implementation of emerging technologies within the downstream supply chain has been shown to influence consumer purchasing intentions and the rate of product returns (Sanaei, 2024). In the contemporary business and technological realm, supply chains require continuous access to information to navigate various threats

and challenges. Understanding the relationships among Generative Artificial Intelligence (Gen-AI), SCRes, and supply chain performance is crucial (Belhadi et al., 2024). The Gen-AI integration in supply chain management has revolutionized modern trade. AI's transformative potential has radically changed procurement, logistics, risk management, and inventory optimization processes. By offering insights into supplier behavior and demand forecasts through predictive analytics, AI enables proactive crisis management and opportunity exploitation, enhancing SCRes and efficiency. This partnership signifies a transformative path towards enhanced productivity, flexibility, and innovation, albeit necessitating the careful management of AI's capabilities and limitations to build resilient and competitive ecosystems for the future marketplace (Shekhar et al., 2023). Gen-AI models scan global events to preemptively identify risks and automatically generate risk assessment reports, simulate scenarios, and devise proactive mitigation strategies for supply chain functions. The conversational interface of Gen-AI streamlines the risk mitigation process, ensuring rapid responses. This approach enables contextualized responses to risk events by drawing from a comprehensive library of scenarios and mitigation strategies (Deloitte, 2023).

1.1 Objectives

The exploration of Gen-AI's capabilities in SCRes is still relatively in its infancy, primarily due to the limited literature in this area. Consequently, this study endeavors to empirically investigate the impact of Gen-AI on SCRes, filling a significant void in existing academic research. Drawing from the perspective presented by Hosseini et al. (2019) on SCRes, our paper explores the core dimensions and drivers of SCRes from a qualitative lens. We examine key characteristics and components crucial for SCRes, including agility, flexibility, visibility, collaboration, and information sharing. Our objective is to investigate the influence of Gen-AI on these drivers of SCRes and to prioritize these factors systematically, identifying the pivotal drivers that contribute to the development of SCRes taxonomy.

2. Literature Review

2.1 Generative AI in SCM

Fosso Wamba et al. (2023) investigated how and why companies employ Generative AI in their Operations and Supply Chain Management (OSCM), exploring challenges and anticipated benefits. Projects were equally distributed across different stages, primarily targeting operational enhancements such as customer satisfaction and cost savings. Major challenges identified included data quality, technological issues, and organizational barriers. Furthermore, they observed variations in the adoption rates and impacts of Gen-AI across different sectors. These results contribute to the evolving literature on OSCM, AI, and Gen-AI, offering practitioners valuable insights into the potential advantages and challenges of Gen-AI integration.

A study by Yandrapalli (2023) presented that the integration of Gen-AI into supply chain management signifies the emergence of a new era of efficiency and innovation. This investigation explores its impacts on risk management, inventory optimization, procurement, and logistics. Leveraging its predictive capabilities, Gen-AI revolutionizes traditional approaches, enhancing resilience and driving proactive responses to market dynamics. Challenges include scalability, ethics, skill gaps, and complexity in data integration. Future advancements promise significant improvements, reshaping supply chain models with autonomous supply chains and enhanced transparency.

Another study by Oliveira and Pereira (Oliveira and Pereira, 2023) explored the utilization of Deep Generative Models (DGM) in supply chains, offering several contributions such as an overview of DGM models, a literature review on DGM's application in supply chains, and a discussion on future adoption. Despite the novelty, only 12 papers using DGM in supply chains were found, focusing on performance enhancement, processing non-structured data, and generating new data. The primary barrier is the scarcity of data, yet DGM's self-supervised nature becomes crucial when adequate data is available. The growing importance of supply chain visibility may drive further DGM application.

Furthermore, Wamba et al. (2023) investigated Gen-AI on OSCM in the USA and UK, considering both adopters and non-adopters, with insights from organizational learning theory. The results indicated efficiency as a significant advantage for both groups, alongside prevalent security concerns. The prevailing expectations indicate an anticipated improvement in supply chain performance. Notably, adopters perceive greater benefits, while non-adopters face amplified challenges, mitigated post-implementation. Organizational learning facilitates Gen-AI/ChatGPT diffusion and risk reduction. Adopters inclined to embrace technological innovations typically demonstrate optimistic perspectives. To conclude, while Gen-AI/ChatGPT offers benefits like efficiency improvement, challenges such as ethical use persist. Their study suggested tracks for future research and provided practitioners and policymakers with valuable insights into the dynamics of Gen-AI/ChatGPT within the realm of OSCM.

In another study, Jackson et al. (2024) discussed how artificial intelligence, specifically Gen-AI, impacts OSCM. This study examines how AI capabilities like learning, perception, prediction, and reasoning influence OSCM decision-making across various areas, using the resource-based view. Providing a practical roadmap, this research offers practitioners and researchers to apply Gen-AI in OSCM. It underscores the importance of enhancing decision-making, streamlining processes, and facilitating skill development. Additionally, it highlights Gen-AI's distinct capability to generate innovative and original content. ability to generate novel content and its integration with critical OSCM processes, showcasing their strategic role in Industry 4.0.

Rathor (2023) investigated the effect of integrating ChatGPT and Gen-AI on enhancing operational performance, sustainability, and data monetization. The project aimed to experimentally investigate the tuna fish supply chain in the United States. This research aimed to identify key operational processes from end to end, analyze methods for handling materials and data, and explore the potential application of artificial intelligence alongside ChatGPT. AI enables data-driven decision-making, contingent on accurate data flow, while ChatGPT ensures transparency and traceability. Leveraging these digital technologies allows supply chains to overcome limitations, promoting operational improvements and dynamic decision-making. This approach facilitates sustainability benefits and income generation through data monetization.

2.2 Supply Chain Resilience Drivers

Resilience research has roots in social psychology theory and is closely linked to ecological and social vulnerability, disaster recovery policies and psychology, leading to the mitigation of risks facing high levels of threats. In supply chain contexts, resilience denotes the capacity of a supply chain to promptly recover normal operations post-disruption, or even enhance performance beyond pre-disruption levels (Tortorella et al., 2022). Existing literature extensively explores the qualitative and quantitative aspects influencing SCRes. These attributes, including agility, visibility, flexibility, collaboration, and information sharing (Figure 1) have been prominent themes in various studies (Deloitte, 2023; Hosseini et al., 2019; Marinagi et al., 2023). While these elements may overlap in some studies, clearly delineate them and identify key drivers essential for developing a quantitative understanding of SCRes (Hosseini et al., 2019).

2.2.1 Agility

Researchers have characterized supply chain agility as an organization's capacity to adapt its strategies and operations within the supply chain in response to environmental shifts, opportunities, and challenges (Dubey et al., 2018). Agility in the context of supply chains pertains to promptly detecting short-term fluctuations, opportunities, and risks, and swiftly responding to them by making minor adjustments to strategies and operations, all without necessitating substantial alterations to the existing structural setup of the supply chain (Liu et al., 2023).

2.2.2 Visibility

Francis (2008) defined visibility within the supply chain as the capacity to track the identity, locations, and status of firms as they move through the entire supply chain. This includes timely updates on events, encompassing both planned occurrences and actual dates and times. Visibility in supply chain management encompasses several essential attributes, such as accessibility, accuracy, timeliness, completeness, and utility. These characteristics play a pivotal role in enhancing both operational and strategic activities within the supply chain (Kalaiarasan et al., 2023). Supply chain visibility involves gaining insight into both upstream and downstream inventories, as well as understanding supply and demand conditions along with manufacturing and purchasing schedules (Hosseini et al., 2019).

2.2.3 Flexibility

Supply chain flexibility is characterized by its ability to maintain uninterrupted product flow from suppliers to customers despite risks and uncertainties in the environment. This includes minimizing variations between demand and supply at each node and mitigating penalties or resource impacts within the supply chain with the minimum cost (Tiwari et al., 2014). Flexibility within the supply chain context denotes the capacity to adopt various approaches in order to effectively address unexpected scenarios in abnormal situations and swiftly adjust to significant shifts in the operational environment (Kamalahmadi et al., 2022).

2.2.4 Collaboration

Effective supply chain collaboration fosters synergistic relationships among partners, promoting collective planning and facilitating timely communication. This collaboration is essential for preparing for, responding to, and recovering from disruptions while minimizing their impact. Authors frequently highlight mutual benefits and shared risks, as the cornerstone of effective collaboration (Scholten and Schilder, 2015). Every member of the supply chain is influenced by the decisions made by other members of the supply chain(Asgari Sooran et al., 2023). Supply chain collaboration encompasses various forms of relationships, which can be broadly categorized into intra and inter-firms or vertical and horizontal collaboration. During disruptions, firms engage in horizontal collaboration with relief providers, governments, and competitors, while vertical collaboration involves cooperation with suppliers and buyers (Umar and Wilson, 2021).

2.2.5 Information Sharing

This strategy proves effective in mitigating disruptions by fostering information sharing and data exchange among supply chain members. Improved coordination and communication help prevent production planning and control issues. Effective information sharing enables timely problem identification and resolution, reducing uncertainty and minimizing supply chain risks (Mehrjerdi and Shafiee, 2021). The effectiveness of a supply chain in mitigating risks depends largely on how its members cooperate, with information sharing playing a crucial role in fostering cooperation and support among supply chain partners (Li et al., 2017).

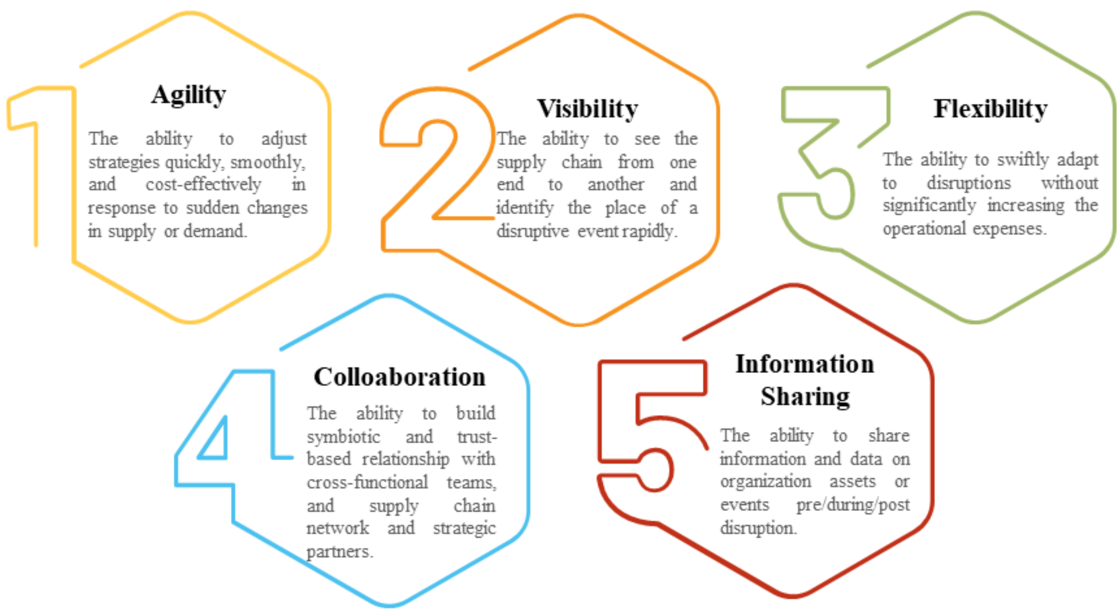

Figure 1. Supply Chain Resilience Drivers.

3. Methods

The methodology proposed in this study comprises five distinct phases, as illustrated in Figure 2. Initially, key drivers of supply chain resilience (SCRes) affected by Generative Artificial Intelligence (Gen-AI) are identified through a thorough review of existing literature and expert consultations. Secondly, the questionnaire was formed, and data was collected from experts. Thirdly, the valuable insights contributed by the chosen experts are employed to construct a pairwise comparison matrix for the identified drivers. In the next phase, the drivers are ranked in order of priority. Finally, the validation of the prioritization process is conducted through the assessment of consistency ratio.

3.1. Identification of SCRes Drivers

The study aimed to rank the most influential factors impacted by the implementation of Gen-AI on aspects related to SCRes. Therefore, the research adopts a literature review approach, enriched by expert consultations, to explore the principal factors influencing SCRes. In the initial step and through a comprehensive review of the literature, crucial drivers for SCRes were identified and the conceptual framework was developed (Figure 1).

3.2. Data Collection
Experts were engaged to provide insights and comparisons regarding the identified criteria, ensuring diverse perspectives were considered. A questionnaire containing the five key conceptual drivers, determined through considering industrial perspective and academic literature, was developed. To collect participants' input, a Fuzzy AHP survey with a linguistic scale was utilized. This method involved gathering inputs through pair-wise comparison.

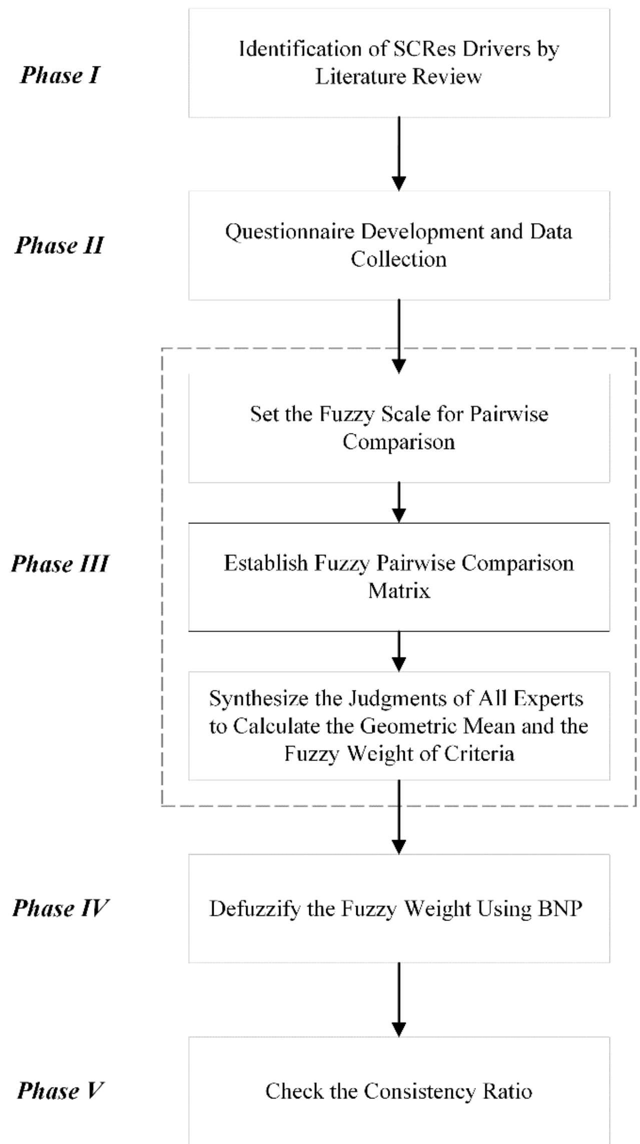

Figure 2. Research Design and Framework.

3.3 Fuzzy AHP
The Analytic Hierarchy Process (AHP) methodology, developed by Satty in 1980, offers a systematic approach to comparing criteria and alternatives in decision-making scenarios. Although AHP offers a structured approach to decision-making, it comes with certain limitations. Firstly, AHP is primarily geared towards decisions based on precise criteria, which may overlook the nuances of real-world situations. Furthermore, it struggles to handle unbalanced scales of judgment effectively, potentially leading to biased outcomes. Additionally, AHP may lack precision in ranking alternatives, as it heavily relies on subjective evaluations. Moreover, decision-makers preferences strongly

influence AHP results, introducing potential biases. Furthermore, navigating ambiguity and multiple considerations during alternative evaluation further complicates the process. Lastly, human assessments of qualitative attributes in AHP evaluations are inherently subjective and prone to imprecision, posing challenges to accurate decision-making (Gnanavelbabu and Arunagiri, 2018). This has led to the development of the Fuzzy AHP approach, which incorporates uncertainty and vagueness in expert judgments through linguistic variables. This fuzzy approach helps to reduce uncertainty in decision-making and was introduced by pioneers in the field (Zadeh, 1965).

The procedure for implementing the Fuzzy AHP approach is as follows:

Step 1 – Choosing the appropriate scale for pairwise comparison:
In our research, professionals were provided with a 5-point linguistic scale to evaluate factors. This linguistic scale served as a mechanism for converting the prioritization of factors into triangular fuzzy sets, thus facilitating a quantitative assessment of their significance as shown in both Table 1 and Figure 3. This approach allowed for the facilitation of pairwise comparisons between drivers using a scale of relative importance (ranging from 1 to 9), enhancing the comprehensibility and interpretability of the data gathered from the study.

Table 1. Fuzzy Linguistics and Triangular Fuzzy Conversion Scale.

Numeric Scale	Linguistic Scale	Triangular Fuzzy Scale	Triangular Fuzzy Reciprocal Scale
1	Equally important	(1,1,3)	(1/3,1/1,1/1)
3	Slightly important	(1,3,5)	(1/5,1/3,1)
5	Moderately important	(3,5,7)	(1/7,1/5,1/3)
7	Strongly important	(5,7,9)	(1/9,1/7,1/5)
9	Extremely important	(7,9,9)	(1/9,1/9,1/7)

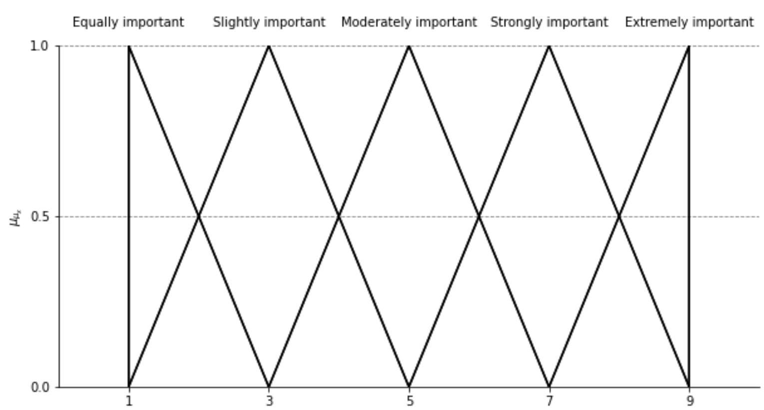

Figure 3. Fuzzy Membership Function for Criteria.

Step 2 – Establish a pairwise comparison matrix:
A pairwise comparison matrix was crafted to evaluate the relative importance of these criteria concerning the study's overarching objective. In cases involving multiple experts, preferences were averaged to reflect a collective view.

Step 3 – Calculation of fuzzy weights:
Utilizing a method adapted from Buckley (1985), the geometric mean of fuzzy comparison values for each criterion was computed. Furthermore, Fuzzy weights were assigned to each criterion, with the summation of triangular values providing a comprehensive assessment.

3.4 Defuzzification

In the fourth phase of the study, to establish a coherent sequence, the defuzzification process was done with the use of the Best Non-Fuzzy Performance value (BNP).

$$BNP_i = \frac{[(uX_i - lX_i) + (mX_i - lX_i)]}{3} + lX_i \qquad Eq. 1$$

3.5 Consistency Ratio

Finally, in the last phase, survey responses yielded prioritized weights for identified criteria, with a thorough evaluation ensuring consistency across judgments. To ensure the reliability of comparisons, the consistency test employs a "consistency ratio" (C.R.), determined by:

$$C.I. = \frac{\lambda_{max} - n}{n - 1}, C.R. = \frac{C.I.}{R.I.} \qquad Eq. 2$$

where R.I. is a random index dependent on n. In assessing consistency, if C.R.≤ 0.10, it is deemed sufficiently consistent, and if C.I. = 0, it signifies full consistency. Notably, the threshold of C.R. = 0.10 indicates that the consistency index represents ten percent of the average consistency index of randomly generated matrices. If the resulting C.R. value is 0.1 or higher, it indicates the need to revisit and revise the pairwise comparison matrix.

4. Results

In phase I, this study marks a pioneering effort in examining and prioritizing the impact of Generative Artificial Intelligence (Gen-AI) on five fundamental drivers of supply chain resilience (SCRes). This study examines five key conceptual drivers: Agility, Visibility, Flexibility, Collaboration, and Information sharing to develop the Fuzzy AHP model.

Starting with data collection in phase II, the questionnaire was distributed to over 300 professionals specializing in Gen-AI or supply chain management via email and LinkedIn. From the responses received, totaling 20 experts, 11 questionnaires were completed while 9 were incomplete. These responses served as the basis for conducting pair-wise comparisons among the drivers of SCRes, considering the influence of Gen-AI, with the assistance of the fuzzy AHP methodology. Nine academic participants were predominantly active researchers in Gen-AI and supply chain management, mainly serving as university professors with an average of 18.44 years of work experience. Moreover, there were two highly experienced practitioners involved in our study, with 23 years and 15 years of work experience respectively. Both groups of professionals (both academics and practitioners) have a proper and deep knowledge and understanding in Gen-AI and sustainable supply chain management. Detailed information and profiles of the respondents can be found in Table 2.

Table 2. Respondents' profiles.

No.	Academic/Practitioner	Education	Position	Type of Organization/ Department	Experience (years)
1	Academic	Doctorate	Assistant Professor of Practice	Supply Chain Management and Analytics	10
2	Academic	Doctorate	Assistant Professor	University	11
3	Academic	Doctorate	Faculty	Logistics	14
4	Academic	Doctorate	Professor	University	15
5	Academic	Doctorate	Senior Lecturer	University	55
6	Academic	Doctorate	Full Professor	Higher Education Institute	18
7	Academic	Doctorate	Assistant Professor	New Jersey Institute of Technology	8
8	Academic	Doctorate	Professor	Business School	30
9	Academic	Doctorate	Researcher	University	5
10	Practitioner	Doctorate	CEO (Chief Innovation Officer)		15
11	Practitioner	Bachelor	Senior Project Manager	IT Consulting / Project Management, Supply Chain Management, Artificial Intelligence	23

In phase III, the pairwise comparison matrix for drivers was constructed utilizing the scale provided in Table 1 by synthesizing the judgments of experts. The pairwise comparison matrix is provided in Table 3. To determine the fuzzy weights of drivers, the geometric mean was used. The results are derived from the pairwise comparison matrix and are presented in Table 4.

Table 3. Pairwise Comparison Matrix of the SCRes Drivers based on Gen-AI's Impact.

Factor	**Agility**	**Visibility**	**Flexibility**	**Collaboration**	**Information Sharing**
Agility	(1,1,1)	(1.33,1.79,2.87)	(0.71,1.02,2.06)	(0.93,1.36,2.52)	(0.68,0.86,1.46)
Visibility	(0.43,0.56,0.75)	(1,1,1)	(0.8,1.12,1.88)	(1.17,1.56,3.39)	(0.76,1.02,1.82)
Flexibility	(0.72,0.98,1.16)	(0.65,0.89,1.13)	(1,1,1)	(1.31,1.82,3.10)	(1.38,1.87,3.24)
Collaboration	(0.49,0.74,0.98)	(0.49,0.64,0.77)	(0.39,0.55,0.76)	(1,1,1)	(0.6,0.67,1.56)
Information Sharing	(0.84,1.16,1.47)	(0.74,0.98,1.18)	(0.38,0.54,0.72)	(1.17,1.49,1.67)	(1,1,1)

Table 4. Geometric Mean and Fuzzy Weights of the SCRes Drivers based on Gen-AI's Impact.

Factor	**Geometric Mean**	**Fuzzy Weights**
Agility	(0.9009,1.1646,1.8493)	(0.125,0.2287,0.4634)
Visibility	(0.7892,1.0001,1.5423)	(0.1095,0.1964,0.3865)
Flexibility	(0.9683,1.2441,1.6735)	(0.1344,0.2443,0.4193)
Collaboration	(0.5609,0.7043,0.9787)	(0.0779,0.1383,0.2452)
Information Sharing	(0.7714,0.9799,1.1606)	(0.1071,0.1924,0.2908)

The defuzzification process was done in phase IV with the use of BNP (Eq. 1) and the result is presented in Figure 4 and the final ranking of the criteria is presented in Table 5.

In the last phase, to check the validation of the study, the calculation of the consistency ratio is done, and it equals 0.0967. Since the obtained value is less than 0.1, this indicates that the decision-maker's judgments are relatively consistent and reliable, providing a solid foundation for making informed decisions based on the analysis.

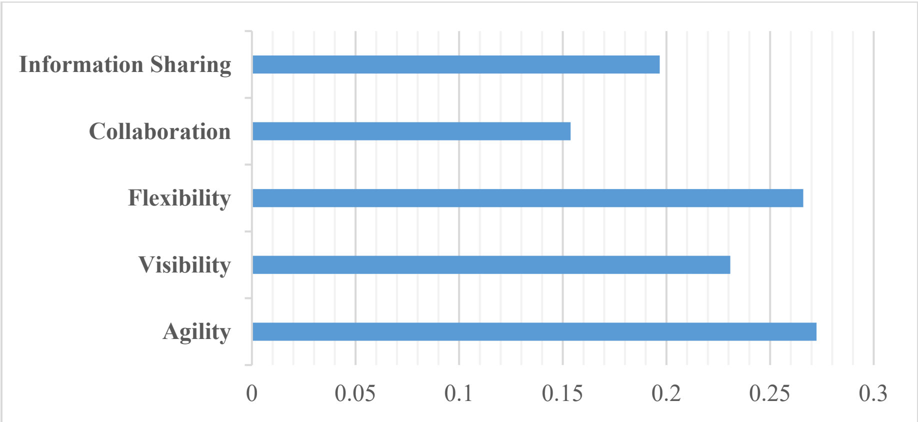

Figure 4. BNP Values.

Table 5. BNPs and Ranking of the SCRes Drivers based on Gen-AI's Impact.

Factor	BNP	Ranking
Agility	0.2724	1
Visibility	0.2308	3
Flexibility	0.2660	2
Collaboration	0.1538	5
Information Sharing	0.1968	4

5. Discussion

Among the five primary examined drivers, each holds significance in the Generative Artificial Intelligence (Gen-AI) impact on Supply Chain Resilience (SCRes), as displayed by their non-trivial weights. While there exist slight variations in their respective magnitudes, these drivers collectively play pivotal roles in fostering resilience within this context. Table 5 presents the findings regarding the primary criteria, highlighting the drivers with the highest weights, signifying their crucial significance and relative impacts. The ranking order of these primary drivers affected by Gen-AI adoption is as follows: Agility (0.2724), Flexibility (0.2660), Visibility (0.2308), Information Sharing (0.1968), and Collaboration (0.1538). This hierarchy underscores the pronounced impact of Gen-AI on supply chain Agility, followed by Flexibility, Visibility, and Information Sharing, while Collaboration emerges as the least influential driver in the context of Gen-AI adoption. Despite Collaboration occupying a lower position in terms of impact, its significance should not be dismissed. Rather, it necessitates attention to ensure comprehensive resilience facilitated by Gen-AI.

The findings of this study are consistent with prior research (Kar et al., 2023; Prasad Agrawal, 2023; Yandrapalli, 2023). The transformative potential of GenAI-driven optimization has the capacity to navigate intricate challenges (simplifies complex challenges), improving sustainable growth, innovation, and resilience in today's data-driven business world (Kar et al., 2023; Prasad Agrawal, 2023; Yandrapalli, 2023). The need for agility in supply chains has surged due to increased interdependence in logistics and market unpredictability. Simultaneously, the adoption of artificial intelligence has risen as a strategic response to these challenges. Businesses are recognizing the resilience and strategic advantage AI offers in various supply chain components like transportation, production, procurement, marketing, and sales. Gen-AI specifically aids in agility by predicting consumer behavior, market trends, and demand, allowing businesses to optimize inventory levels swiftly and respond to market shifts effectively. This adaptability ensures that inventory management remains responsive to changing market conditions, thereby enhancing overall supply chain agility (Kar et al., 2023; Yandrapalli, 2023).

Gen-AI and language models have been deployed across the supply chain to enhance agility and resilience, aiming to secure a competitive edge. In supply chain operations, the integration of Gen-AI models like ChatGPT holds potential for streamlining customer interactions. However, there are concerns regarding the possibility of biased or unethical responses, which could undermine demand forecasting and customer satisfaction. These errors, particularly across different demographic groups, may pose challenges in supply chain and logistics management, affecting the handling of customer inquiries and response generation (Kar et al., 2023; Yandrapalli, 2023).

Gen-AI holds significant potential across various sectors, including retail, manufacturing, logistics and transportation, marketing, healthcare, and finance. However, it faces several challenges related to ethics, technology, regulations, and the economy, often due to a lack of Human-Centered Artificial Intelligence (HCAI). To facilitate the successful integration of Gen-AI, prioritizing attributes such as empathy, transparency, ethics, and AI literacy is imperative. Furthermore, Gen-AI encounters challenges such as the requirement for substantial training data, data diversity, and fragmentation. High costs and infrastructure, particularly for Small and Medium Enterprises (SMEs), further complicate its deployment. Integrating data from varied sources is hindered by inconsistent formats, and privacy concerns arise from extensive data collection. Additionally, Gen-AI models may struggle with unforeseen events, necessitating real-time data integration for better decision-making and resilience (Sai et al., 2024).

5.1 Practical and Managerial Implications

This research analyzes how Gen-AI influences SCRes drivers, offering valuable insights for researchers and practitioners. It lays the groundwork for future studies to establish technical standards and practical applications in the supply chain management domain. Additionally, it highlights the positive impacts of Gen-AI-enabled supply chains on resilience and emphasizes the need for further exploration into the practical implications of implementing this technology.

This study offers a comprehensive framework for assessing the impact of implementing Gen-AI on SCRes, providing practical guidance for practitioners and managers seeking to enhance resilience within and across organizations. Prioritizing key criteria, it facilitates the development of customized resilience strategies to navigate competitive markets effectively. Additionally, it equips practitioners and managers with the tools necessary to evaluate and improve their resilience performance. Furthermore, the prioritization of drivers provides a structured approach for optimizing the utilization of Gen-AI, aiding organizations in selecting the most suitable strategies. The study's findings offer actionable insights for practitioners and decision-makers to design effective processes for enhancing Gen-AI adoption and bolstering SCRes.

Identifying agility and flexibility as essential factors in implementing Gen-AI for resilience strategies highlights the importance of integrated systems. Such systems foster enhanced collaboration and information sharing among supply chain stakeholders, thereby enhancing preparedness for unforeseen events. Stakeholder cooperation is crucial for fortifying resilience across the entire chain. Moreover, leveraging Gen-AI's predictive capabilities enables supply chains to respond swiftly to changes in consumer behavior, market trends, and demand, ensuring resilience against disruptions. Minimizing operation times further enhances responsiveness, enabling efficient meeting of demands within limited timeframes. Moreover, managers need to prioritize investments in both AI literacy and infrastructure while fostering a culture of empathy and transparency to effectively integrate Gen-AI across diverse sectors and navigate the challenges of ethics, regulations, and data fragmentation.

6. Conclusion

The global disruptions caused by the COVID-19 pandemic have significantly affected both supply and demand dynamics. In response, companies are increasingly adopting Generative AI (Gen-AI) implementation to strengthen resilience. This strategic approach aims to reinforce supply chains, ensuring they have the resilience needed to withstand and thrive during such disruptions. The paper utilized a literature review to identify key conceptual drivers. Our research provides valuable insights that contribute to ongoing discussions regarding supply chain resilience (SCRes) and Gen-AI, particularly from a conceptual drivers' standpoint. By applying the conceptual driver's framework, we aim to enrich theoretical understanding by bridging concepts from operations management and information systems. Our findings underscore five key domains where Gen-AI stands to bolster SCRes: agility, visibility, flexibility, collaboration, and information sharing. These areas represent pivotal opportunities for leveraging Gen-AI to fortify supply chain operations against disruptions. Subsequently, data collected through a questionnaire administered to experts underwent prioritization using the fuzzy Analytic Hierarchy Process (Fuzzy AHP). This approach yielded relative weights for various factors influencing SCRes due to Gen-AI. Multicriteria decision-making techniques, such as Fuzzy AHP, were deemed optimal for addressing such complex issues. The study's findings underscore agility and flexibility as the most influential drivers impacted by Gen-AI. Additionally, the research suggests that all five drivers exert varying degrees of influence on achieving resilience.

References

Asgari Sooran, M., Tayebi, H., and Ebrahimnejad, S., A joint economic lot-size model with collaboration of supply chain members, *Journal of Modelling in Management*, vol. 18, no. 5, pp. 1333-1363, 2023.

Belhadi, A., Mani, V., Kamble, S. S., Khan, S. A. R., and Verma, S., Artificial intelligence-driven innovation for enhancing supply chain resilience and performance under the effect of supply chain dynamism: an empirical investigation, *Annals of Operations Research*, vol. 333, no. 2, pp. 627-652, 2024.

Deloitte, *Generative AI in supply chain resilience*. https://www2.deloitte.com/us/en/blog/business-operations-room-blog/2023/generative-ai-in-supply-chain-resilience.html, 2023.

Dubey, R., Altay, N., Gunasekaran, A., Blome, C., Papadopoulos, T., and Childe, S. J., Supply chain agility, adaptability and alignment: empirical evidence from the Indian auto components industry, *International Journal of Operations and Production Management*, vol. 38, no. 1, pp. 129-148, 2018.

Fosso Wamba, S., Guthrie, C., Queiroz, M. M., and Minner, S., ChatGPT and generative artificial intelligence: an exploratory study of key benefits and challenges in operations and supply chain management. *International Journal of Production Research*, 1-21, 2023.

Francis, V., Supply chain visibility: lost in translation? *Supply chain management: An international journal*, vol. 13, no. 3, pp.180-184, 2008.

Gnanavelbabu, A., and Arunagiri, P., Ranking of MUDA using AHP and Fuzzy AHP algorithm, *Materials Today: Proceedings*, vol. 5, pp. 13406-13412, 2018.

Hosseini, S., Ivanov, D., and Dolgui, A., Review of quantitative methods for supply chain resilience analysis, *Transportation research part E: logistics and transportation review*, vol. 125, pp. 285-307, 2019.

Ivanov, D., Blackhurst, J., and Das, A., Supply chain resilience and its interplay with digital technologies: Making innovations work in emergency situations, *International journal of physical distribution and logistics management*, vol. 51, no. 2, pp. 97-103, 2021.

Jackson, I., Ivanov, D., Dolgui, A., and Namdar, J., Generative artificial intelligence in supply chain and operations management: a capability-based framework for analysis and implementation, *International Journal of Production Research*, 1-26, 2024.

Kalaiarasan, R., Agrawal, T. K., Olhager, J., Wiktorsson, M., and Hauge, J. B., Supply chain visibility for improving inbound logistics: a design science approach, *International Journal of Production Research*, vol. 61, no. 15, pp. 5228-5243, 2023.

Kamalahmadi, M., Shekarian, M., and Mellat Parast, M., The impact of flexibility and redundancy on improving supply chain resilience to disruptions, *International Journal of Production Research*, vol. 60, no. 6, pp. 1992-2020, 2022.

Kar, A. K., Varsha, P. S., and Rajan, S., Unravelling the impact of generative artificial intelligence (GAI) in industrial applications: A review of scientific and grey literature, *Global Journal of Flexible Systems Management*, vol. 24, no. 4, 659-689, 2023.

Li, H., Pedrielli, G., Lee, L. H., and Chew, E. P., Enhancement of supply chain resilience through inter-echelon information sharing, *Flexible Services and Manufacturing Journal*, vol. 29, pp. 260-285, 2017.

Liu, J., Wu, J., and Gong, Y., Maritime supply chain resilience: From concept to practice, *Computers and Industrial Engineering*, vol. 182, 109366, 2023.

Marinagi, C., Reklitis, P., Trivellas, P., and Sakas, D.,The impact of industry 4.0 technologies on key performance indicators for a resilient supply chain 4.0, *Sustainability*, vol. 15, no. 6, 5185, 2023.

Mehrjerdi, Y. Z., and Shafiee, M., A resilient and sustainable closed-loop supply chain using multiple sourcing and information sharing strategies, *Journal of Cleaner Production*, vol. 289, 125141, 2021.

Oliveira, E. e., and Pereira, T., A New Generation? A Discussion on Deep Generative Models in Supply Chains., *Advances in Production Management Systems. Production Management Systems for Responsible Manufacturing, Service, and Logistics Futures, APMS 2023*, Cham, 2023.

Pandey, A. K., Daultani, Y., and Pratap, S., Blockchain technology enabled critical success factors for supply chain resilience and sustainability, *Business Strategy and the Environment*, *vol. 33, no.* 2, pp. 1533-1554, 2024.

Prasad Agrawal, K., Organizational Sustainability of Generative AI-Driven Optimization Intelligence, *Journal of Computer Information Systems*, 1-15, 2023.

Queiroz, M. M., Wamba, S. F., Jabbour, C. J. C., and Machado, M. C., Supply chain resilience in the UK during the coronavirus pandemic: A resource orchestration perspective, *International Journal of Production Economics*, vol. 245, 108405, 2022.

Rathor, K., Impact of using Artificial Intelligence-Based Chatgpt Technology for Achieving Sustainable Supply Chain Management Practices in Selected Industries, *International Journal of Computer Trends and Technology*, vol. 71, no. 3, pp. 34-40, 2023.

Sai, S., Sai, R., and Chamola, V., Generative AI for Industry 5.0: Analyzing the impact of ChatGPT, DALLE, and Other Models, *IEEE Open Journal of the Communications Society*, 2024.

Sanaei, F., How customers' satisfaction change with the use of AR shopping application: A conceptuall model, *arXiv preprint arXiv:2401.10953*, 2024.

Scholten, K., and Schilder, S., The role of collaboration in supply chain resilience, *Supply Chain Management: An International Journal*, vol. 20, no. 4 , pp. 471-484, 2015.

Shekhar, A., Prabhat, P., Yandrapalli, V., Umar, S., Abdul, F., and Wakjira, W. D., Generative AI in Supply Chain Management, 2023.

Tiwari, A. K., Tiwari, A., and Samuel, C., Measuring procurement flexibility in disastrous environment, *International Journal of Procurement Management*, vol. 7, no. 5, pp. 543-562, 2014.

Tortorella, G., Fogliatto, F. S., Gao, S., and Chan, T.-K, Contributions of Industry 4.0 to supply chain resilience, *The international journal of logistics management*, *v*ol. 33, no. 2, pp. 547-566, 2022.

Umar, M., and Wilson, M., Supply chain resilience: Unleashing the power of collaboration in disaster management, *Sustainability*, vol.13, pp. 1–20, 2021.

Wamba, S. F., Queiroz, M. M., Jabbour, C. J. C., and Shi, C. V., Are both generative AI and ChatGPT game changers for 21st-Century operations and supply chain excellence?, *International Journal of Production Economics*, vol. 265, 109015, 2023.
Yandrapalli, V., Revolutionizing Supply Chains Using Power of Generative AI, *International Journal of Research Publication and Reviews*, vol. 4, no. 12, pp. 1556-1562, 2023.
Zadeh, L. A., Fuzzy sets. *Information and Control*, vol. 8, no. 3, pp. 338-353, 1965.

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Dr. Thomas Patrick O'Neal is an entrepreneur in the business of helping entrepreneurs. Tom is a Professor in the Department of Industrial Engineering and Management Systems at the University of Central Florida (UCF). He founded the UCF Business Incubation Program (UCFBIP) and the Florida Economic Gardening Institute (FEGI), now known as GrowFL. He was part of UCF's Office of Research and Commercialization team working to help UCF become a leading metropolitan research university. Tom's areas of interest include all things Entrepreneurship, Technology Transfer, Business Incubation, Lean Startup, Venture scale up and support for second stage companies. He founded the UCF Center for Innovation and Entrepreneurship. He has served as Chairman of the Board for the National Business Incubator Association and the National Entrepreneur Center. Other board memberships include the UCF Research Foundation, GrowFL, the Tampa Bay Tech council and the Orlando Chamber of Commerce. He is a certified I-Corps Instructor and was one of the original 16 I-Corps sites for the National Science Foundation.