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Mitigating Supply Chain Vulnerabilities: A Bibliometric Analysis of Sustainable Logistics for Resilience and Risk Management with Perspectives on the Automotive Industry

Shereen Abdelaziz[1,2*], Munjiati Munawaroh[3]

[1] *Master of Management, Postgraduate Program, Universitas Muhammadiyah Yogyakarta, Yogyakarta, 55183, Indonesia*
[2] *Electrical Engineer, Ministry of Electricity and Renewable Energy, East Delta Electricity Production Company, Ismailia, 41517, Egypt*
[3] *Department of Management, Faculty of Economics and Business, Universitas Muhammadiyah Yogyakarta, Yogyakarta, 55183, Indonesia*

Abstract

In a world increasingly shaped by global disruptions—ranging from pandemics and natural disasters to geopolitical tensions—the integration of sustainable logistics practices and supply chain resilience has become a cornerstone of modern supply chain strategies. This study undertakes a bibliometric analysis of 445 Scopus-indexed documents (2002–2024) using VOSviewer and Biblioshiny, offering a systematic exploration of critical research trends, thematic clusters, and knowledge gaps within this intersection. The analysis identifies several dominant themes, including green logistics, circular economy principles, digital transformation technologies, and adaptive risk management. Findings highlight the transformative role of digital tools—such as blockchain, IoT, and AI—in enhancing supply chain transparency, predictive analytics, and operational agility. The automotive sector emerges as a focal industry, facing unique challenges of resource dependency, regulatory compliance, and the need to align sustainability with resilience frameworks. Additionally, the study underscores the growing prominence of circular economy practices, such as reverse logistics and closed-loop supply chains, in addressing environmental goals while bolstering supply chain adaptability. However, significant gaps persist, particularly in the empirical validation of sustainable logistics practices and their measurable impact on resilience outcomes across diverse regions and sectors. The study calls for the development of integrated frameworks that align environmental sustainability with technological innovation and operational efficiency, supported by longitudinal studies and cross-industry comparisons. This research contributes to academic discourse by offering actionable insights for scholars and practitioners. It establishes a foundational roadmap for integrating sustainability and resilience, emphasizing the pivotal role of digitalization and circular economy principles in shaping robust, adaptable supply chains capable of withstanding the complexities of an increasingly volatile global environment.

Keywords: Bibliometric Analysis; Resilience; Risk Management; Supply Chain Management; Sustainable Logistics

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Contact
* Corresponding author
Shereen Taha Taha Abdelaziz
Shereen.taha.psc23@mail.umy.ac.id,
eng.shereentaha77@gmail.com

Address: Department of Management, Postgraduate Program, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia.
Tel: +6282329189503

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1. Introduction

Supply chains are the backbone of the global economy, facilitating the continuous flow of goods and services across borders and industries. However, in an increasingly volatile world, modern supply chains are more susceptible than ever to disruptions, including natural disasters, geopolitical tensions, and pandemics like COVID-19 [1]. These challenges underscore the critical need for robust resilience and risk management strategies to ensure continuity and maintain a competitive edge [2,3]. In this context, sustainable logistics emerges as a transformative approach, offering environmentally and socially responsible solutions to enhance supply chain resilience and mitigate risks [4,5].

Globalization has revolutionized international competition, driving the development of complex global supply chains that require seamless coordination of goods, services, and information across national boundaries [6]. These networks involve the movement of raw materials, components, and finished products across both manufacturing and service

industries, requiring efficient management to optimize business performance [7]. These networks span multiple sectors—such as manufacturing, energy, retail, and agri-food—each with distinct challenges and risk profiles. For instance, disruptions in renewable energy markets can lead to price volatility, requiring supplier diversification and inventory management, while manufacturing industries emphasize agility and adaptability to maintain production during unforeseen events [8,9]. Similarly, cascading effects across interconnected sectors, such as energy and transportation, highlight the importance of cross-sectoral collaboration to mitigate risks [10,11].

Although globalization has enabled companies to improve efficiency and competitive positioning, it has also introduced new risks and complexities that must be managed strategically [7]. For instance, practices such as outsourcing and offshore manufacturing within global supply chains can reduce costs and increase benefits through mechanisms like tariff and trade concessions, low-cost direct labor, capital subsidies, reduced logistics costs, and proximity to markets, customers, and suppliers [12]. While these practices offer short-term benefits, they often misalign with long-term resilience goals. Aligning supply chain decisions with an organization's broader mission and long-term strategy is essential for sustaining a competitive advantage over time [13,14].

Alongside the advantages of globalization, supply chains face increased management challenges due to their inherent complexity, including material and information risks [15,16]. The increasing interdependence of supply chains makes them highly vulnerable to a wide range of disruptions—from natural disasters and political instability to economic uncertainties and technological risks [1]. Interdependencies between critical infrastructure sectors amplify these challenges, as disruptions in one area can lead to cascading effects across others, such as disruptions in transportation affecting food and medical supply chains [11]. Trust, transparent communication, and cross-sectoral partnerships are essential to enable effective stakeholder coordination and risk mitigation [17–19].

Traditional supply chain risk management techniques, such as interpretive structural modeling, fault tree, and event tree analysis, are no longer sufficient to address the complexity and unpredictability of global supply chains [4,5]. These methods must be supplemented with a more proactive and holistic approach to supply chain resilience. This approach emphasizes building adaptive capacities—such as flexibility, speed, visibility, and collaboration—so that firms can respond swiftly and effectively to unforeseen disruptions [2,3]. Adaptive supply chain resilience focuses on achieving flexibility, velocity, visibility, and collaboration, which are crucial for responding to unexpected events [20]. By fostering these dynamic capabilities, organizations can not only withstand disruptions but also recover rapidly, ensuring operational continuity [14].

Given the rising complexity of global supply chains, coupled with increasing risks from natural disasters, geopolitical tensions, and technological threats, traditional risk management techniques have proven insufficient in addressing these vulnerabilities [16,21–23]. As a result, organizations must adopt a more integrated approach, where sustainability becomes a central component of resilience-building strategies [1,24]. Sustainable logistics, which incorporates environmental, social, and economic factors, provides a holistic framework that not only mitigates risks but also enhances the adaptability and flexibility of supply chains [25]. By embedding sustainable practices—such as reducing resource dependency, optimizing energy use, and fostering collaboration across the supply network—companies can better withstand and recover from disruptions [26,27]. Therefore, sustainable logistics offers a crucial pathway toward achieving long-term supply chain resilience [28].

Supply chain resilience demands a nuanced understanding of the distinct challenges faced by various sectors, along with the implementation of tailored strategies to address these complexities effectively. The dynamics of the automotive, agri-food, energy, and retail sectors vividly illustrate the importance of cross-sectoral insights in building sustainable and resilient supply chains. For instance, the automotive sector grapples with challenges such as reliance on rare earth materials, which heightens vulnerability to supply chain disruptions [29]. Addressing these risks requires adopting circular economy solutions like recycling and remanufacturing [30]. Additionally, sustainable logistics practices, such as green supply chain management [GSCM] and digital transformation technologies like blockchain and IoT, have been shown to not only reduce environmental impact but also improve operational efficiency and adaptability within automotive supply chains. Practices such as reverse logistics and green distribution further enhance resilience by contributing to cost savings and enabling greater flexibility in responding to disruptions [31].

Similarly, the agri-food sector prioritizes ensuring food safety and meeting stringent regulatory standards. IoT-enabled cold chain systems are crucial for enhancing traceability and managing the risks associated with perishable products [32–34], In the energy sector, resilience strategies center around integrating renewable logistics to mitigate supply risks and advance decarbonization efforts [35]. These examples demonstrate how sector-specific challenges necessitate diverse and context-sensitive strategies for enhancing supply chain resilience [8,11].

Despite the growing emphasis on sustainability, sustainable logistics, and supply chain resilience, significant gaps remain in the bibliometric and literature reviews of existing studies regarding a comprehensive examination of sustainable logistics practices in conjunction with supply chain resilience. While research on both sustainable logistics and supply chain resilience has steadily grown over the past decade [36–39], most studies tend to address these topics in isolation rather than in an integrated manner. For instance, significant work has been conducted on supply chain resilience strategies [40–45], and on green and sustainable logistics [46–48], green logistics on SC

resilience [46], alongside studies focusing on emerging technologies like blockchain [49,50], IoT applications [51] and other focused on improve the sustainability and resilience of supply chains by emerging technologies [52]. However, these works often fail to systematically analyze how sustainable logistics practices actively contribute to resilience-building, particularly in industries with high vulnerability, such as automotive.

Several bibliometric analyses have explored aspects of sustainable logistics and supply chain management [53]. For instance, studies have examined the use of green technologies in sustainable supply chain management [54], resilient strategies in SSCM [55], sustainable green supply chain management [56,57], sustainable supply chains [58–60], Sustainable Supply Chain Management and circular economy [61], sustainable logistics and supply chain [62], digital innovation in supply chain resilience [63], and resilient supply chains [36,38,40,42–44,64,65]. However, these studies often focus on isolated dimensions—either sustainability or resilience—without delving into their interconnectedness. Even comprehensive bibliometric reviews, such as those by [62] on sustainable logistics, or [65] on resilient supply chain networks, tend to overlook how sustainability contributes to resilience in practice, particularly through strategic logistics approaches. Similarly, bibliometric studies focused on the automotive industry, such as [66] and [67], have explored disruption risk management and supply chain performance but fail to integrate sustainability into their resilience frameworks. Moreover, while individual bibliometric reviews have shed light on topics such as sustainability in risk management [68], supply chain collaboration [69], and the impact of COVID-19 on supply chains [70], there remains a notable absence of comprehensive bibliometric analyses that incorporate these sustainable logistics practices as a strategic approach to building resilience.

The automotive industry presents a particularly relevant context for this research, given its global interconnectivity, reliance on critical raw materials, and susceptibility to disruptions such as the COVID-19 pandemic [71]. While recent studies highlight supply chain risk mitigation strategies to manage these disruptions [72–75], they often lack a focus on the integration of sustainability into these strategies. Similarly, risk management and resilience strategies in the automotive supply chain have been explored by studies such as those by [1,76–80] as well as systematic reviews like that of [81]. However, these works do not examine the specific role of sustainable logistics in enhancing supply chain resilience.

Additionally, studies in the automotive sector have investigated technology-driven solutions, such as blockchain applications [49], machine learning and inventory management [82], cybersecurity in supply chains [83], and digital supply chain integration [84]. These studies focus on technological innovation without combining these insights with sustainability practices. Similarly, studies like [85] on Sustainable Logistics, [86] on reverse logistics, [87] on return supply chains, and [88] on circular economy practices highlight the importance of individual sustainability elements but stop short of examining their collective impact on resilience frameworks within the automotive industry. Moreover, while studies such as [89], [90] and [37] explore the relationship between sustainability and resilience, they remain largely sector-agnostic, leaving a gap in understanding how these dynamics play out in high-stakes industries like automotive. Similarly, research by [36] and [38] proposes conceptual frameworks for integrating sustainability and resilience but lacks empirical or bibliometric analysis specific to the automotive supply chain.

Thus, there is a clear lack of a comprehensive bibliometric study that examines how sustainable logistics practices contribute to supply chain resilience across multiple dimensions in the automotive industry. While existing bibliometric reviews provide valuable insights, they often remain fragmented, focusing on isolated aspects. For instance, bibliometric analyses on additive manufacturing by [91], electric vehicle supply chains by [92], and supply chain management in the automotive industry by [67] offer specialized perspectives but fail to integrate these findings into a broader resilience framework. Similarly, studies such as [93] on blockchain and IoT applications in vehicles and [66] on disruption risk management in automotive supply chains adopt a narrow focus, overlooking the holistic interplay between sustainability and resilience. Moreover, while some bibliometric analyses touch upon broader themes like resilience strategies or digital transformation [50], they often neglect the interconnection of sustainability practices with resilience-building in the automotive context. This fragmented approach leaves a significant gap in understanding how various dimensions—such as green logistics, circular economy practices, and digital innovations—can collectively enhance resilience in the automotive supply chain. No study has systematically integrated these elements into a unified framework, emphasizing the need for a comprehensive bibliometric analysis that bridges these gaps and provides actionable insights for both researchers and industry practitioners.

To address these gaps, this study conducts a comprehensive bibliometric analysis using advanced tools such as VOSviewer and Biblioshiny to systematically examine how sustainable logistics practices integrate with supply chain resilience frameworks. This approach enables a systematic mapping of existing literature, highlighting key trends, emerging themes, and research gaps. By synthesizing these findings, the study aims to provide a comprehensive understanding of how sustainable logistics practices impact resilience, guiding future research and practical applications. The analysis draws on data from major academic databases, focusing on peer-reviewed articles, conference papers, and book chapters published over the past two decades. Building on methodologies demonstrated by bibliometric studies such as those by [47] and [54], this research identifies knowledge domains, thematic clusters, and temporal trends in the literature, particularly in the automotive

industry. The bibliometric analysis focuses on co-occurrence, citation networks, and thematic evolution to uncover emerging trends and critical research gaps at the intersection of sustainability, logistics, and resilience.

This research offers several key contributions. First, it provides a holistic perspective by bridging the gap between sustainable logistics and supply chain resilience, an area where existing bibliometric studies often remain fragmented. By systematically integrating various sustainability dimensions—such as green logistics, renewable energy, and circular economy practices—this study offers a more comprehensive understanding of their collective impact on resilience frameworks. Second, it advances bibliometric methodologies by incorporating advanced tools such as VOSviewer for visualizing networks and Biblioshiny for thematic mapping, enabling a more nuanced and detailed analysis of literature trends. Third, by focusing on the automotive industry, the study addresses sector-specific challenges such as disruption risks, resource scarcity, digital transformation, and environmental compliance, providing practical insights into integrating sustainability into resilience frameworks [87,88]. Fourth, it highlights the strategic role of sustainable logistics practices—including reverse logistics, digital technology integration, and data-driven approaches—in mitigating risks and enhancing supply chain adaptability [35,82].

Furthermore, the study uniquely contributes by exploring the automotive industry's high-stakes environment, characterized by global interconnectivity, vulnerability to disruptions, and stringent environmental regulations. By synthesizing fragmented insights from previous bibliometric studies, such as those on blockchain technologies [49], , IoT integration [93], additive manufacturing [91], and disruption risk management [66], this research presents an integrated framework that connects sustainability practices to resilience-building within this critical sector. The comprehensive bibliometric approach not only identifies key trends but also maps underexplored areas, offering a clear direction for future research in both academic and practical contexts.

Based on the identified gaps in the literature, the following research questions (RQs) will guide this study:

RQ1: What are the emerging trends in sustainable logistics practices that contribute to enhancing supply chain resilience, particularly within the automotive industry, as identified through bibliometric analysis?

RQ2: What are the dominant areas of research focus in integrating sustainability into supply chain resilience frameworks across different industries and specifically for the automotive supply chain?

RQ3: What are the critical gaps in the current research on the integration of sustainable logistics and supply chain resilience, with particular attention to applications within the automotive industry?

This research is significant in its ability to provide a thorough understanding of how sustainable logistics practices can be systematically implemented to enhance supply chain resilience. By offering a comprehensive overview of the literature and identifying emerging trends, this study contributes to both the theoretical development and empirical validation of sustainable logistics practices, offering valuable insights for improving supply chain resilience globally. Moreover, it emphasizes actionable recommendations for industry stakeholders, enabling them to adopt sustainable logistics strategies that align with environmental and social objectives while enhancing their ability to withstand and recover from disruptions.

The findings will serve as a foundation for future research, guiding both academic inquiry and the practical implementation of sustainable and resilient supply chain strategies. Given the increasing complexity of global supply chains and the pressing need for sustainability [60,94], this research also highlights how sustainable practices can be scaled to enhance resilience on a global level. In an era marked by increasing vulnerabilities, this research provides a roadmap for integrating sustainability and resilience into supply chain management [43,95], particularly within the automotive industry. This focus is especially critical given the sector's unique challenges and opportunities, where operational continuity and environmental compliance are pivotal for long-term success.

The article is structured into eight sections, beginning with an introduction, literature review, and methodology. The third section presents initial findings, followed by a detailed bibliometric analysis in the fourth. The fifth section focuses on cluster-based content analysis, while the sixth discusses the findings. Conclusions are presented in the seventh section, with the final section addressing limitations and future research directions, ensuring a thorough exploration of the subject.

2. Literature review

2.1 Global Supply Chain Vulnerabilities and Supply Chain Risk Management (SCRM)

In today's interconnected global economy, supply chains serve as the backbone of countless industries, enabling the seamless flow of goods and services worldwide. As globalization deepens and supply chains become more intricate, they are increasingly subject to a variety of risks—ranging from natural disasters to geopolitical tensions and technological disruptions [21,22]. The COVID-19 pandemic, in particular, revealed the fragility of global supply chains, causing unprecedented disruptions in production, distribution, and procurement networks [1]. These disruptions underscore the urgent need for effective risk management strategies that can not only mitigate these threats but also enhance supply chain resilience [1,24].

Globalization, shorter product lifecycles, and increasingly multifaceted networks of trade partners have significantly heightened the risks facing modern supply chains [96,97]. These complexities demand a high level of transparency and collaboration among supply chain participants to effectively

manage risks that can disrupt entire networks [5,98]. Geopolitical tensions, trade disputes, political instability, and the growing prevalence of digital technologies such as cyber-attacks further exacerbate these challenges, threatening the integrity and security of supply chain operations [16,23].

Recent disruptions, such as the 2010 earthquake in Haiti, and the 2011 floods in Thailand, demonstrated the severe impact of both natural and human-made disasters on global supply chains. These events caused significant economic damage, disrupting purchasing, manufacturing, and delivery processes, and revealing the vulnerabilities that exist within highly integrated supply chains [99,100]. Additionally, technological advancements, while enhancing efficiency, have also introduced new risks. Companies that rely heavily on global outsourcing, single sourcing, and just-in-time inventory strategies have found their supply chains increasingly fragile, lacking the flexibility needed to adapt to unexpected disruptions [101–105].

Supply chain vulnerability is often measured by assessing the likelihood of risk events and the severity of their potential impact [106,107]. However, traditional risk management techniques, while foundational, are insufficient for addressing the complexity of modern supply chains. Companies must now adopt comprehensive strategies that consider both upstream and downstream vulnerabilities across the entire supply chain [108–112]. These strategies should incorporate resilience-building measures, such as flexibility, agility, and proactive contingency planning, to effectively manage the risks posed by today's volatile global environment [5,113]. A comprehensive evaluation of risks across multiple dimensions is necessary to mitigate the substantial impact these disruptions have on supply chain management. Supply chains are exposed to various sources of risks, which can be categorized into operational and disruption risks, each of the risk sources is closely related to logistics risks or gives rise to logistics risks [103,114–117].

The COVID-19 pandemic further illustrated the extent of global supply chain vulnerabilities, with widespread shutdowns, labor shortages, and logistical disruptions causing a ripple effect across all levels of the supply chain [118–123]. These challenges have been exacerbated by ongoing geopolitical tensions and environmental disruptions, such as the Red Sea crisis following the Gaza War in 2023, along with weather anomalies affecting the Panama Canal, and the Suez Canal blockage by the 'Ever Given' in 2021, which continue to threaten global supply chain stability [124]. These events, combined with the growing threat of cyber-attacks and data breaches, demonstrate the urgent need for companies to adopt flexible and resilient supply chain designs that can withstand both internal and external disruptions [16,23].

Ultimately, as supply chains become more vulnerable due to globalization and technological advancements, organizations must prioritize resilience alongside traditional risk management strategies. This involves regular vulnerability assessments, contingency planning, and the development of adaptive supply chain designs that can respond to future disruptions, ensuring long-term operational continuity and competitiveness in an increasingly volatile global market [113].

2.2 Supply Chain Resilience (SCRES)

In response to the increasing complexities and challenges of global supply chains, building resilience has emerged as a strategic imperative for organizations. While traditional risk management approaches focus on identifying and mitigating risks, Supply Chain Resilience [SCRES] goes a step further, emphasizing the ability of supply chains to not only withstand but also recover from disruptions and maintain operational continuity [24,125]. Supply chains are exposed to a multitude of risks, including natural disasters, geopolitical tensions, cyber-attacks, and pandemics each with the potential to cause severe disruptions to the flow of goods and services [104,117].

Unlike traditional risk management approaches, SCRES builds proactive capabilities within supply chains, such as agility, flexibility, and collaboration, enabling organizations to adapt to unforeseen challenges more effectively [126,127]. These capabilities are critical, especially as supply chains become more intertwined globally, relying on just-in-time production, international sourcing, and lean inventory strategies, which leave little room for error maintaining continuity of operations at the desired level of connectedness and control [20,128]. For example, the COVID-19 pandemic demonstrated how a single disruption could cascade throughout the supply chain, affecting multiple stages of production and distribution, ultimately highlighting the need for adaptive resilience strategies [129].

To strengthen resilience, companies must embed SCRES within their supply chain strategies, incorporating regular vulnerability assessments, robust contingency planning, and flexible supply chain designs [113]. These measures not only mitigate immediate risks but also enhance the supply chain’s ability to recover swiftly from disruptions, ensuring long-term stability and competitiveness [1]. In an increasingly volatile global market, SCRES serves as a comprehensive approach that combines proactive risk management with the dynamic capabilities needed to sustain operations under disruptive conditions [125,126].

2.3 Sustainability a Key Factor in Supply Chain Resilience

As global supply chains face mounting vulnerabilities, sustainability has emerged as a crucial factor in enhancing supply chain resilience. Sustainability involves the integration of Environmental, Social, and Governance [ESG] principles into supply chain management practices, by embedding these principles, companies can mitigate their exposure to disruptions while also enhancing resilience, ensuring long-term stability and sustainable growth [130].

Sustainability's role in mitigating risks has gained attention in recent years. For example, a survey on SCRES found that 32% of respondents are increasing ESG due diligence with suppliers to mitigate risks [131]. Sustainable development, defined in the

Brundtland Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [132], is often associated with environmental sustainability but extends to include ecological, economic, and social components.

Research supports the positive impact of sustainability on supply chain resilience. For instance, a study by [133] reveals that sustainability is an antecedent to SCRES, meaning sustainable supply chains are better equipped to adapt to and recover from disruptions. Similarly, [134] identified a positive link between sustainable manufacturing practices and enhanced resilience. Furthermore, building social capital within supply chains—fostering collaboration and strong relationships—has been shown to contribute to resilience [135], The growing emphasis on sustainability is likely to significantly impact the future design of supply chains. Companies that fail to comply with sustainability factors may face increased risks and disruptions, particularly as regulatory requirements and consumer expectations evolve. For instance, activities such as reverse logistics for remanufacturing and recycling, alongside new government regulations, are expected to play a growing role in supply chain management [136]. As companies strive to remain profitable, there is a greater need to mitigate risks by integrating sustainability into their core operations.

Sustainable logistics practices are increasingly recognized as essential for building supply chain resilience across various sectors. These practices integrate environmental, social, and economic considerations, which not only enhance operational efficiencies but also fortify supply chains against disruptions [137]. By adopting sustainable logistics, organizations can achieve cost savings, improve brand reputation, and ensure long-term viability, thereby creating a competitive advantage. While sustainability principles like ESG offer a foundational framework, their application varies significantly across industries, requiring tailored strategies to address unique challenges.

Building supply chain resilience requires sector-specific strategies to address unique operational challenges. For example, in the healthcare sector, blockchain technology has been transformative in enhancing the traceability and security of critical medical supplies, such as vaccines during the COVID-19 pandemic [138,139]. By enabling transparent and tamper-proof tracking, blockchain mitigates risks of counterfeiting and ensures supply chain integrity during disruptions [88,140,141].

In the agri-food sector, the focus is on maintaining the quality and safety of perishable goods. Sustainable cold chain logistics, supported by IoT-enabled monitoring systems, reduce food losses and ensure compliance with safety standards during transit [142]. These innovations demonstrate how climate and perishability factors shape sectoral resilience strategies. For the automotive industry, circular economy principles are integral to resilience-building. Practices like remanufacturing and recycling end-of-life vehicles not only address environmental concerns but also enhance adaptability by reducing dependence on raw material supply chains. Additionally, the adoption of AI for predictive maintenance and advanced planning strengthens the industry's ability to manage disruptions while achieving sustainability goals [143,144].

Green logistics practices, such as reducing carbon emissions and optimizing resource use, directly contribute to supply chain resilience by minimizing environmental risks and enhancing operational efficiency [46,145]. In the context of Egyptian manufacturing firms, sustainable supply chain management [SSCM] practices have been shown to significantly enhance resilience, suggesting that integrating environmental, economic, and social sustainability practices can provide a competitive edge [37]. These sector-specific strategies not only address immediate operational challenges but also demonstrate how sustainability can serve as a unifying framework for enhancing supply chain resilience across diverse industries.

2.4 Sustainable Practices in Supply Chain Management

Sustainable supply chain management [SSCM] encompasses a broad range of activities, including internal environmental management, green purchasing, supplier collaboration, eco-design, investment recovery, social supply chain practices, and resilience practices [28].

Environmental SSCM practices include adopting environmental standards [e.g., ISO 14001 certification], supplier evaluations, and the implementation of monitoring systems for environmental performance. Social SSCM practices focus on ensuring the health, safety, and well-being of suppliers, promoting fair wages, and collaborating with local communities. Governance SSCM practices involve integrating environmental and social concerns into business operations through control mechanisms and stakeholder engagement strategies. Incorporating sustainability into supply chain resilience strategies has proven to offer a competitive advantage. Sustainable practices, such as eco-design, green logistics, and collaborative planning, not only contribute to long-term resilience but also enhance operational efficiency and reduce costs [129].

Sustainable practices in supply chain management involve a broad range of activities, including internal environment management, green purchasing, customer cooperation, supplier collaboration, eco-design, investment recovery, social supply chain practices, and resilient supply chain practices [28]. Environmental SSCM activities include adopting environmental standards and directives, such as ISO 14001 [146–149], providing environmental training and certification for suppliers [150–152], conducting environmental audits [153–155], and implementing monitoring systems for environmental performance [156,157]. Collaboration with suppliers to reduce material consumption, minimize waste, promote recycling, avoid hazardous materials, and optimize transportation, products, and processes is also crucial [150,158–161]. Social SSCM activities focus on ensuring the health, safety, and well-being of suppliers [162], promoting fair labor practices, such as

social training and fair wages [163–165], and collaborating with suppliers, local communities, and NGOs [148,160]. Governance SSCM activities involve integrating social and environmental concerns into business operations through control mechanisms and stakeholder strategies, including board oversight on non-economic impacts [166–173].

While SSCM activities form the foundation for sustainability, their effectiveness is significantly enhanced by the integration of advanced technologies, which enable real-time decision-making and risk mitigation. Technological integration plays a pivotal role in sustainable logistics. The adoption of technologies like AI, IoT, and blockchain enhances supply chain visibility and predictive analytics, which are crucial for proactive risk management and resilience [174,175]. Blockchain, in particular, has transformed the retail sector by offering preventive measures to manage risks, thereby establishing a sustainable and resilient supply chain. For instance, in the automotive sector, IoT-enabled predictive maintenance systems have improved operational efficiency, while AI-driven analytics enhance supply chain adaptability during disruptions [17]. Collaborative practices, such as information sharing and joint decision-making, further enhance supply chain resilience by improving response times and fostering innovation through shared knowledge [17]. These approaches highlight the importance of integrating technology and collaboration to build adaptable and resilient supply chains.

This integration of sustainability practices with technological and collaborative strategies provides organizations with a robust framework to enhance supply chain resilience and achieve long-term competitiveness in a volatile global market. As businesses strive to achieve long-term competitiveness, sustainability is increasingly seen as a key driver for resilience, helping firms withstand disruptions and maintain continuity in an unpredictable global environment [44,102,115].

2.5 Sustainable Supply Chain Management in the Automotive Industry

The automotive industry, as one of the most globally interconnected and resource-intensive sectors, is undergoing a transformative shift to integrate Sustainable Supply Chain Management [SSCM] practices while enhancing resilience [176]. This transition is driven by stringent environmental regulations, such as the EU Directive on End-of-Life Vehicles, and growing consumer demand for environmentally responsible and socially ethical practices [176,177]. The industry's reliance on materials such as plastics, metals, and glass, and fossil fuels, necessitates a strategic shift toward sustainability across all stages of the supply chain [178]. These interconnected challenges highlight the dual focus required on operational efficiency and environmental sustainability. Simultaneously, global disruptions like the COVID-19 pandemic have exposed vulnerabilities in supply chains, emphasizing the critical importance of resilience to ensure operational continuity and future adaptability [88,179].

Key SSCM practices implemented by the industry include eco-design, green procurement, reverse logistics, and collaboration with suppliers, which reduce emissions, conserve resources, and minimize environmental impact [180,181]. The automotive supply chain is a sophisticated, interdependent network designed to ensure the efficient production, delivery, and post-sales management of vehicles [182]. It encompasses raw material procurement, component manufacturing, assembly, logistics, distribution, and post-sales services [183,184]. By integrating sustainability into each stage, the industry systematically meets environmental, operational, and consumer demands while ensuring long-term resilience. Aligning SSCM practices with advanced technological innovations allows the automotive sector to mitigate risks, enhance operational efficiency, and maintain competitiveness in a dynamic global landscape [46,176]. As illustrated in Figure 1, SSCM practices in the automotive industry are aligned with specific resilience factors across the supply chain stages, including raw material procurement, manufacturing, assembly, logistics, and post-sales management. The figure highlights key sustainable practices and resilience solutions critical to ensuring both environmental and operational performance.

Sustainability in the automotive supply chain begins with ethical and environmentally responsible procurement of essential raw materials, such as metals, plastics, and electronics [1,176]. Sustainable sourcing emphasizes eco-friendly materials and sustainable procurement practices, reducing environmental impact [87]. For example, incorporating metrics like emissions tracking and social responsibility into procurement decisions helps embed sustainability from the outset, ensuring consistent quality and reduced carbon footprints [185]. Effective supplier collaboration, achieved through open communication and relationship management, enhances quality and reduces costs [184]. Technologies like blockchain and IoT enhance visibility and traceability by creating real-time digital records of material flows [73]. Blockchain supports ethical sourcing by verifying compliance with sustainability standards, while IoT devices monitor inventory levels and transportation conditions to optimize resource use [1,186]. Predictive analytics further facilitates demand forecasting and dynamic route planning, reducing emissions and costs while improving operational flexibility [187].

The component manufacturing stage involves transforming raw materials into intermediate automotive parts, such as engines, transmissions, and electronic systems [79]. This process demands energy-efficient manufacturing technologies and recyclable materials to minimize waste and carbon emissions [176]. However, challenges persist, including the high costs of implementing cradle-to-cradle practices and the complexities of fully recycling components to meet stringent environmental standards [66,79]. Despite these challenges, adopting advanced energy-efficient manufacturing technologies and circular economy models has enabled manufacturers to optimize material reuse, reduce emissions while meeting

compliance with environmental regulations like the EU Directive on End-of-Life Vehicles and supporting both sustainability and resilience objectives [76,176,184].

Assembly and production leverage lean manufacturing techniques such as Just-in-Time [JIT] and Total Productive Maintenance [TPM] to enhance efficiency while reducing operational waste and costs [184]. Proactive risk assessment methodologies, such as Bayesian Belief Networks, enable firms to identify and prioritize risks, developing effective mitigation strategies for disruptions [1]. For instance, these techniques allow manufacturers to anticipate potential supply chain disruptions and develop contingency plans in advance [80,188]. Throughout the manufacturing process, rigorous quality control and testing ensure that safety, performance, and regulatory compliance standards are met [66]. Despite these advancements, balancing operational efficiency with stringent regulatory requirements, such as those governing end-of-life vehicles, adds complexity to production processes [176]. Addressing these challenges requires continuous innovation and adherence to sustainability frameworks.

Logistics and distribution stages form the backbone of the supply chain, ensuring the timely delivery of components and finished vehicles [184]. Efficient transportation, inventory management, and warehousing are essential for maintaining supply chain performance [189]. Companies increasingly rely on digital technologies such as blockchain, IoT, and predictive analytics to enhance visibility and coordination across stakeholders, enabling real-time tracking, demand forecasting, and route optimization to minimize emissions and costs [1,187]. Collaboration with supply chain partners is critical, but trust issues and varying levels of operational maturity often limit its effectiveness [76]. Distribution to dealerships adopt green logistics practices by incorporating eco-friendly vehicles, telematics, and GPS tracking, reducing environmental impact while optimizing operational performance [18,46]. For example, hybrid and electric vehicles are frequently used for distribution, aligning with sustainability goals [87]. Despite these advancements, logistical challenges like high transportation costs and warehousing disruptions persist, highlighting the need for energy-efficient solutions and strategic partnerships [74,186]. The COVID-19 pandemic further underscored these vulnerabilities, as parts shortages disrupted production globally [88,179,190].

The automotive supply chain extends beyond vehicle sales to encompass post-sales and end-of-life management. Practices such as recycling, remanufacturing, green logistics and reverse logistics align with circular economy principles, reducing environmental impact by prioritizing material recycling and reuse, thus decreasing dependency on raw materials and enhancing supply chain flexibility [46,87,176], enabling the industry to address challenges like resource depletion and waste management, while also ensuring compliance with stringent environmental regulations [191,192]. Recovery management processes—such as maintenance, repair, and refurbishing—extend product lifecycles, reducing waste and ensuring compliance with environmental regulations while maintaining customer satisfaction [176]. However, inefficiencies in recycling systems and challenges in achieving full material reuse persist, requiring systematic approaches to optimization [193]. Frameworks like Integration Definition Function [IDEF0] analyze and refine business processes to optimize these practices [176]. A notable example is BMW's reverse logistics system, which enables the recycling of parts from end-of-life vehicles, significantly reducing raw material usage while aligning operations with circular economy principles [194]. This focus on resource efficiency is critical as the industry moves toward achieving global sustainability targets and aligning with the principles of the circular economy practices, such as recycling and material reuse to enhance operational efficiency [193].

Despite progress, the automotive sector faces persistent challenges in integrating sustainability and resilience into supply chain operations [11,19,88]. Core issues such as traceability and transparency, compounded by inadequate infrastructure in certain regions, frequently lead to inefficiencies, inventory obsolescence, and delays [74,186]. Geopolitical risks and global trade complexities further emphasize the need for adaptive strategies [179]. Simultaneously, the industry's shift towards automation, connectivity, electrification, and shared mobility (ACES) requires innovative business models to tackle new challenges associated with software integration, operational complexity, and the demand for advanced technology solutions [85,195]. Balancing these technological shifts with social considerations, such as labor practices and regulatory compliance, remains critical, especially in regions with weaker enforcement standards [196,197]. High implementation costs and limited technical expertise in cradle-to-cradle approaches also hinder progress in achieving comprehensive sustainability goals [176].

Key challenges also include managing stakeholder relationships, balancing customer expectations with operational realities, and addressing global competition [71,197]. These are critical for maintaining supply chain resilience [19,46,89]. Social concerns, such as labor standards and environmental compliance, further complicate operations, particularly in regions with weaker regulatory frameworks [196,197]. Additionally, issues like fluctuating demand volumes, transit time variability, and order fulfillment errors underscore the importance of agility and robust contingency planning in supply chains [74,81]. Despite these challenges, the automotive industry has significant opportunities for growth and innovation. By leveraging big data and analytics, companies can enhance visibility, improve demand forecasting, and strengthen risk management strategies [198]. Collaboration among stakeholders, including governments, industry players, and academia, is essential to foster innovation, address regulatory requirements, and enhance sustainability efforts [87].

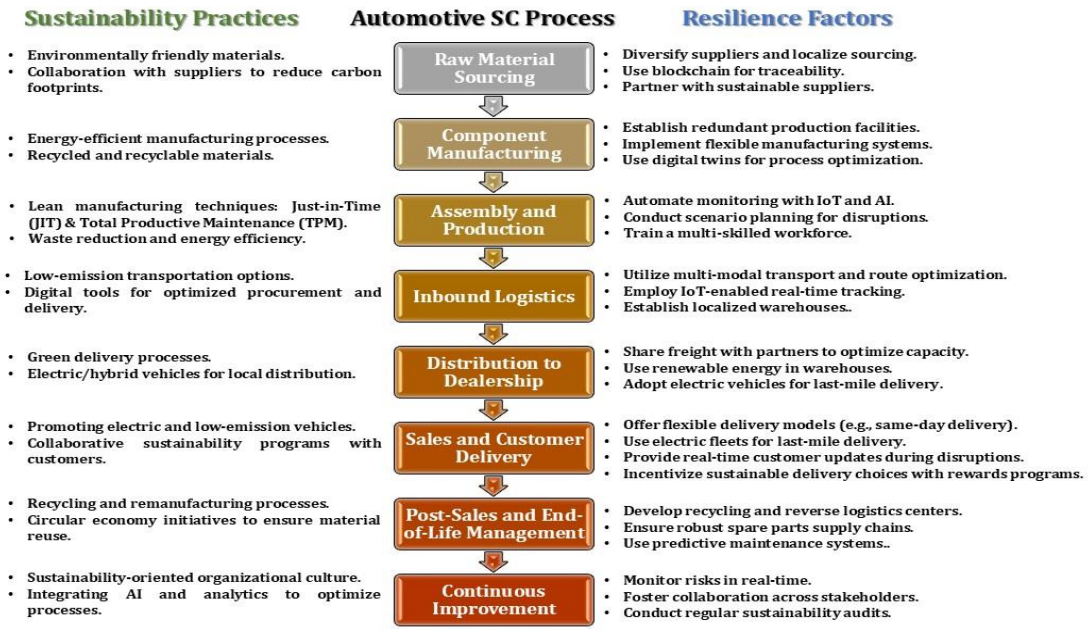

Fig. 1. Sustainable and Resilience Factors in Automotive Supply Chain Process

Geopolitical realignments and the diversification of procurement sources further reduce risks associated with global dependencies, enabling the creation of more resilient supply chains [75].

Risk mitigation strategies are central to building resilience, particularly for regions like Europe, where dependency on international suppliers increases vulnerability to global disruptions [76]. To address these challenges, the automotive industry adopts agility and redundancy strategies, including multiple sourcing, strategic partnerships, and maintaining extra inventory, to reduce risks and enhance adaptability to unforeseen events [73,75,76]. Collaborative approaches, such as supplier integration and risk-sharing contracts enabled by Multi-Criteria Decision-Making [MCDM] methods like AHP and fuzzy-TOPSIS, facilitate effective supplier selection and risk assessment, ensuring alignment among stakeholders [1,73]. Advanced digital tools such as IoT and AI further enhance supply chain visibility and support proactive decision-making by modeling potential disruptions through scenario planning and risk simulations [1,187]. Scenario planning and risk-sharing contracts help align incentives across stakeholders, providing companies with a strategic edge in addressing disruptions [72,75,199].

Emerging technologies are also playing a pivotal role in enabling the automotive sector to enhance supply chain resilience [84,200,201]. The adoption of digital transformation technologies such as blockchain, Internet of Things [IoT], and Artificial Intelligence [AI] provides real-time visibility, predictive analytics, and enhanced transparency, allowing automotive companies to respond swiftly to supply chain disruptions [202–204]. For instance, real-time tracking systems powered by IoT enable companies to reduce inefficiencies and optimize transportation routes, minimizing both costs and environmental impacts. In addition, blockchain ensures authenticity in sourcing, enhancing brand credibility [73]. Practices such as green logistics—incorporating eco-friendly vehicles, telematics, and GPS tracking—reduce environmental impact while optimizing operational performance [18,46]. These innovations reduce inefficiencies, optimize resource utilization, and improve environmental performance, positioning the automotive supply chain to be more adaptable and resilient to both market and environmental challenges [205].

Sustainability considerations are increasingly integrated into risk management and resilience frameworks across all supply chain stages. Green supply chain management [GSCM] practices, such as renewable energy utilization, eco-friendly packaging, and green transportation, not only reduce environmental footprints but also support compliance with stringent regulations [87,89,176]. Organizations leverage AI-driven analytics to align production planning with demand forecasting, reducing waste and enhancing resource efficiency [32–34,82,84,88,187,200,206,207]. Circular economy models emphasizing recycling and material reuse further enhance competitiveness and long-term resilience by fostering resource efficiency and reducing waste [30,86,88,176]. The development of sustainable practices within the automotive supply chain is not only an environmental imperative but also a competitive advantage. Advanced technologies and sustainability initiatives demonstrate how industry-specific strategies can address environmental challenges while meeting regulatory requirements and customer expectations [195]. These efforts enable the creation of robust, adaptable supply chains, which are critical for maintaining competitiveness in a rapidly evolving global market [193].

In conclusion, while the automotive supply chain faces significant challenges in achieving sustainability and resilience,

technological advancements and innovative practices provide avenues for growth. Embedding sustainability into every stage—such as adopting low-emission transportation, leveraging digital tools like blockchain and IoT, and fostering a culture of continuous improvement and trust among stakeholder—enhances operational efficiency and environmental performance [82,88]. Strategic collaboration, adaptive risk management, and investments in circular economy practices position the automotive industry to overcome disruptions and maintain competitiveness in a rapidly evolving global landscape [184]. Future research should focus on scaling these initiatives and developing comprehensive policy frameworks. For instance, tax incentives for adopting green technologies, grants for research on circular economy practices, and stricter enforcement of recycling standards could accelerate the industry's sustainable transformation.

2.6 Sustainable Logistics as a Strategy for Resilience

Logistics serves as a critical component in supply chain management [SCM], encompassing the movement of goods, information, and resources from their origins to final destinations. This function plays a vital role in ensuring the efficiency and effectiveness of supply chains, particularly in managing disruptions that can arise across various logistical activities such as transportation, warehousing, and inventory management [208]. Given the increasing complexity of global supply chains, the logistics function is especially vulnerable to external shocks. Delays, stockouts, and inefficient management of logistics can amplify vulnerabilities within supply chains, leading to operational disruptions. However, technological advancements such as autonomous vehicles, route optimization software, and warehouse automation are helping enhance supply chain resilience by improving logistical efficiency [24].

The interplay between logistics and supply chain management [SCM] has long been debated, with logistics traditionally viewed as an operational function focused on procurement, movement, and storage of goods, while SCM integrates broader strategic goals including coordination and cooperation between supply chain partners [209]. The Supply Chain Operations Reference [SCOR] model supports this distinction by linking logistics activities to strategic SCM objectives, optimizing communication, and enhancing the overall performance of supply chain networks [210]. This integration of logistics with SCM enables companies to manage procurement, production, and distribution more efficiently, which is essential in maintaining competitive advantages within highly complex global supply chains [211].

As the globalization of supply chains continues, logistical complexities have grown, prompting many organizations to outsource logistics functions to specialized logistics service providers [LSPs] [212–214]. LSPs now hold a critical position in supply chains, especially during disruptions, where their ability to effectively manage logistics can mitigate the negative impact of disruptions and maintain operational continuity. For instance, during the COVID-19 pandemic, the vulnerabilities of globalized supply chains were exposed, as shortages of essential goods, including food and medical supplies, underscored the importance of superior logistical capabilities in maintaining supply chain resilience [215,216]. These disruptions revealed the need for supply chains to adopt more resilient logistical systems to cope with increasing uncertainties and the inherent risks of global operations [217–220].

To address these vulnerabilities in global supply chains, the adoption of sustainable logistics practices, supported by advanced technologies and sector-specific strategies, are emerging as critical solutions for mitigating risks and building more resilient supply chains [25–27]. Sustainable logistics integrates environmental, social, and economic considerations into logistics operations, aiming to minimize environmental impact while maintaining operational efficiency and robustness [26]. By adopting practices such as optimizing transportation networks, utilizing renewable energy sources, and implementing energy-efficient technologies, companies can significantly reduce their carbon footprint while also addressing regulatory pressures and mitigating risks associated with resource scarcity [221]. These practices not only contribute to environmental sustainability but also lead to cost savings and operational efficiency, supporting long-term supply chain resilience [26,27]. For example, during the COVID-19 pandemic, healthcare logistics systems relied on IoT-enabled cold chain networks to ensure the safe and efficient delivery of vaccines, showcasing the critical role of sustainable practices in managing global crises [222].

Sustainable logistics encompasses a broad range of practices integrating environmental, social, and governance [ESG] dimensions into supply chain management. Often framed within the Triple Bottom Line [TBL] approach, sustainable logistics balances the needs of people, the planet, and profits. Sustainable logistics aims to optimize logistics operations by reducing adverse environmental impacts while promoting social responsibility and maintaining profitability, ensuring efficiency and equity across the supply chain [223].

Key practices in sustainable logistics include supplier development programs [224], fair labor practices [225,226], ethical sourcing [227], and collaborative planning and forecasting [209,228]. Other important strategies include supply source diversification [229], supplier integration especially in automative industry [230], near-shoring and on-shoring [108,231], and investment in supply chain transparency [232].

Additionally, lean logistics [233], risk management and contingency planning [234], and just-in-time [JIT] logistics [235], particularly in industries such as automative industry [236], are essential for increasing flexibility and responsiveness. Advanced inventory management systems [237,238], flexible logistics networks [239], and the use of green technologies [240] further enhance sustainability. Further the integration of circular economy principles [241], particularly in automative sector [242], sustainable packaging solutions [243], optimizing

warehouse and eco-friendly infrastructure [244] are also crucial, alongside the utilization of renewable energy sources and energy-efficient logistics [245].

The social dimension of sustainable logistics is equally critical in enhancing supply chain resilience. Practices such as promoting fair labor standards, ensuring ethical sourcing, and engaging with local communities foster collaboration and trust among supply chain partners [115]. This collaborative approach is essential for risk management, as it strengthens relationships across the supply chain and facilitates coordinated responses to crises. Companies that adopt sustainable logistics practices are also better equipped to comply with increasingly stringent environmental and social regulations, reducing legal risks and maintaining a positive market reputation [26,27].

Additionally, the integration of advanced technologies, including AI and IoT, supports real-time decision-making and operational efficiency, enhancing the adaptability of supply chains in sectors like retail and automotive [18]. These approaches demonstrate how sustainability and resilience strategies can be combined to create robust, future-ready supply chains. By integrating of digital transformation technologies [DTT], such as blockchain, the Internet of Things [IoT], and advanced analytics, companies can strengthen sustainable logistics by increasing transparency, improving decision-making, and enabling real-time monitoring of supply chain activities [246,247]. These technologies allow companies to manage resources more effectively, reduce inefficiencies, and respond to disruptions with greater agility [247].

The automotive industry provides a compelling example of leveraging these technologies to enhance supply chain visibility and risk management. By predicting disruptions and responding quickly enabling [29]. The sector has optimized transportation routes, reduced energy consumption, and adopted autonomous vehicle technology, significantly improving operational efficiency and resilience [26,31]. For instance, the implementation of circular economy principles such as recycling, reusing, and remanufacturing materials, has reduced dependence on raw materials and enhanced supply chain stability during resource shortages and price fluctuations [221,242]. Reverse logistics further exemplifies sustainability within the automotive sector, enabling companies to recover and reuse parts. This approach not only enhances environmental sustainability but also contributes to cost efficiency and resilience [248]. In addition, Green Supply Chain Management [GSCM] practices adopted by the automotive sector, including green procurement and green manufacturing, have demonstrated measurable benefits in improving environmental performance and overall supply chain efficiency [31]. These practices support both environmental goals and operational resilience by lowering material costs and reducing waste [26,27]. As demonstrated by the automotive sector, the integration of sustainable logistics practices and digital transformation technologies is not merely a response to immediate challenges but a strategic approach that supports long-term resilience and adaptability. These technologies and practices collectively serve as a model for other industries seeking to enhance the sustainability and resilience of their global supply chains.

Sustainable logistics practices are increasingly tailored to meet the needs of specific industries. In the retail sector, green logistics initiatives, such as urban consolidation centers and AI-powered route optimization, have enabled companies like Amazon to enhance delivery efficiency while minimizing environmental impact [249,250]. These strategies demonstrate how sustainability can coexist with operational flexibility in high-demand industries. Similarly, in the energy sector, the integration of renewable energy sources into logistics networks has proven effective in diversifying supply and mitigating resource risks. Facilities powered by wind and solar energy not only reduce carbon emissions but also enhance resilience by decreasing reliance on non-renewable energy sources [35,251]. Meanwhile, the agri-food sector emphasizes the dual goals of ensuring food safety and maintaining supply chain efficiency. Technologies like IoT sensors and blockchain improve traceability, allowing firms to adapt to disruptions while meeting strict safety regulations. These advancements highlight the critical role of digital tools in managing perishable goods logistics [142]. In addition, ethical supply chain practices, such as sustainable procurement and transparent sourcing, are essential for building resilience by increasing transparency and reducing societal and environmental risks [252,253]. Sustainable sourcing practices not only improve brand reputation but also contribute to economic viability by ensuring business continuity amidst disruptions [174].

Recent studies emphasize the importance of adopting a multi-objective approach in sustainable logistics network modeling, which integrates economic, environmental, and social factors. By doing so, companies can optimize their logistics networks to achieve a balance between cost efficiency, environmental responsibility, and social sustainability [28,246]. For instance, the application of life cycle assessment [LCA] in logistics networks helps evaluate the environmental impact of logistics activities, while social performance metrics ensure that supply chain practices meet societal expectations [246]. This holistic approach to sustainable logistics supports the development of resilient and adaptable supply chains that can better withstand external shocks and disruptions [28].

In conclusion, embedding sustainability into logistics operations is not merely a risk mitigation strategy but a comprehensive approach to achieving long-term resilience and competitive advantage. As global supply chains face mounting vulnerabilities, the convergence of sustainability and digital transformation in logistics offers a powerful response to the challenges posed by today's complex supply chains [26,27]. By adopting sustainable logistics practices, companies can better navigate future disruptions and maintain operational continuity in an increasingly volatile global market.

3. Methodology

This study employs a bibliometric methodology to systematically investigate the research landscape of Sustainable Logistics and its role in enhancing Supply Chain Resilience, with insights into the Automotive Industry. Bibliometric analysis is a well-established quantitative approach that allows for the structured examination of academic literature, uncovering patterns, trends, and networks within a field [254]. This method is particularly suited for analyzing evolving domains like sustainable logistics and supply chain resilience, as it enables a comprehensive assessment of publication metrics, author networks, and thematic clusters [255].

2.1 Data Collection

The data for this study were sourced from Scopus, the largest abstract and citation database of peer-reviewed literature, known for its extensive coverage and indexing of high-quality journals across multiple disciplines, including logistics, supply chain management, sustainability, and automotive engineering. While databases like Web of Science also provide robust research collections, Scopus was selected over other databases due to its robust indexing capabilities and its alignment with the study's objectives to map global research output in sustainable logistics and resilience [256]. This choice ensures that the data is reliable and sufficiently representative of the research landscape in sustainable logistics and supply chain resilience.

To ensure a broad and thorough analysis, data was collected from Scopus using the following search criteria [sustainable AND logistics] AND [Resilience] OR [Resilient AND supply AND chain] OR [supply AND chain AND resilience] OR [automotive AND supply AND chain]]. This search strategy encompasses multiple variations of keywords related to sustainability, resilience, and the automotive supply chain, ensuring an inclusive dataset that captures the range of relevant studies within this field.

The analysis period spans from 2002 to October 2024, totaling 22 years. The decision to start from 2002 is grounded in significant academic and practical developments in sustainable logistics and supply chain resilience, particularly within the automotive industry. Notably, the first relevant publication retrieved from Scopus, titled *"Case studies of greening the automotive supply chain through technology and operations"* by [257], highlights early efforts to integrate sustainable practices specifically within automotive supply chains. This publication is significant because it reflects the initial academic interest in exploring how sustainability and resilience could be embedded in supply chain operations, a theme that has since become foundational within the field.

This period represents a pivotal moment where supply chain resilience and sustainable logistics emerged as distinct and critical themes, driven by a growing recognition of global vulnerabilities and environmental responsibilities [107,115,258]. Early foundational works, such as [115] exploration of resilience and [258] framework for green supply chain management, underscore the shift toward resilience and sustainability in supply chains during the early 2000s. This aligns with the broader movement toward sustainable practices, as influenced by concepts like the "triple bottom line" [259], which gained traction in business and supply chain management literature by the early 2000s. By starting from this point, the study provides a comprehensive longitudinal analysis that tracks the evolution of these concepts from their inception to their current state, offering valuable insights into the development and trajectory of sustainable logistics and supply chain resilience over time.

The initial search yielded 448 documents from the Scopus database. After excluding documents published outside the time frame of 2002 to October 2024, a final dataset of 445 documents was obtained from the screening process as illustrated in Figure 2. The selected dataset was then exported in both RIS and CSV formats for further processing. The RIS and CSV formats were chosen for their compatibility with bibliometric software, enabling seamless data import into tools such as VOSviewer and Biblioshiny for detailed analysis. To ensure a comprehensive and unbiased analysis, no additional exclusion criteria were applied. Retaining the entire dataset within the defined period prevents selection bias and provides a holistic view of the field. This approach allows for the inclusion of both foundational studies and emerging research, capturing lesser-known studies and newly developing themes, which contributes to a nuanced understanding of sustainable logistics and resilience [260].

2.2 Bibliometric Analysis

The bibliometric analysis was conducted using both VOSviewer and Biblioshiny, two widely recognized tools for creating and visualizing bibliometric networks. VOSviewer was selected for its robust capability to handle large datasets and visualize complex relationships, such as co-authorship networks, citation patterns, and keyword co-occurrences [261]. Biblioshiny, an R-based interface, complemented this analysis by offering advanced options for thematic mapping and trend analysis, enhancing the depth and clarity of the bibliometric review [254].

In this study, VOSviewer facilitated the identification and mapping of research clusters and thematic trends within the dataset, while Biblioshiny provided additional insights into temporal patterns and thematic evolution. A total of 3,331 unique keywords were initially identified in the dataset. To concentrate on the most relevant terms, a threshold was applied to include only keywords with at least three co-occurrences, resulting in 335 keywords meeting this criterion. To further ensure focus on pertinent topics, non-relevant keywords were excluded, refining the final set to 330 key items. These keywords were then organized into thematic clusters using VOSviewer's clustering algorithms, which created color-coded visualizations. Each cluster represents a distinct area of research

focus within sustainability, supply chains, logistics, resilience, and the automotive industry. This structured approach enabled a comprehensive exploration of the research landscape, offering valuable insights into the thematic structure of the field and highlighting emerging areas, particularly within the automotive industry. By integrating the capabilities of VOSviewer and Biblioshiny, this study provides a detailed and nuanced understanding of the interplay between sustainability and resilience in supply chain management.

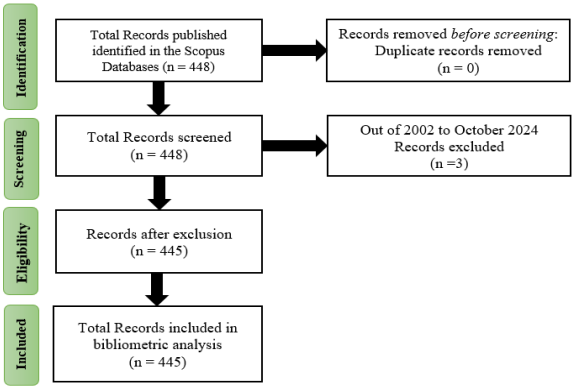

Fig. 2 Steps in Identification and Screening of Sources.

3. Research results

3.1 Scopus Search Results Analysis

The Scopus dataset used in this study includes a diverse range of document types and subject areas, illustrating the breadth of academic interest in Sustainable Logistics and Supply Chain Resilience, particular in automotive industry. The dataset shows that most publications are in English [438, 98.4%] and with less than half are available as open access [187, 42%]. The results of document types revealed that [264, 59.3%] are research articles [92, 20.7%] are conference papers, [36, 8.1 %] are book chapters, [30, 6.7 %] are conference review [16, 3.6%] are review papers, and [5, 1.1%] are books.

The dataset's distribution across subject areas as illustrated in Figure 3, highlights the interdisciplinary nature of research in Sustainable Logistics and Supply Chain Resilience, with particular relevance to the automotive sector. Engineering dominates [164], reflecting the sector's reliance on technical advancements for resilient systems. Computer Science follows closely [127], underscoring the role of digital innovations in optimizing supply chain operations. Business, Management, and Accounting [125], along with Environmental Science [118], showcase the need for sustainable practices integrated into corporate strategies and ecological considerations. Social Sciences add depth [115], addressing policy and societal impacts, while Decision Sciences [86] and Energy [62] provide critical insights into risk management and energy efficiency considerations. This broad disciplinary spread provides a robust base for thematic and network analysis, capturing the complexity of sustainability and resilience challenges within diverse contexts, including the automotive supply chain.

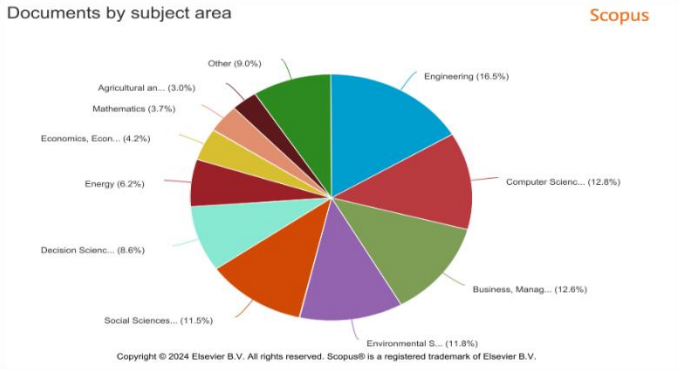

Fig. 3 Published Documents by Subject Area. [Scopus Database]

Fig. **4** illustrates the thematic landscape in sustainable logistics and supply chain resilience, with prominent terms such as sustainability, resilience, supply chain management, and risk management, which collectively highlight the field's core focus areas, with significant attention to the automotive industry. The frequent appearance of terms like reverse logistics, and circular economy underscores the specific application of sustainable logistics principles within industry contexts, particularly in automotive supply chains. Notably, terms like COVID-19, machine learning, blockchain, and digitalization reflect niche areas addressing contemporary challenges and technological advancements. This visualization supports RQ1 by revealing how sustainability is embedded within logistics practices, emphasizing the role of circular economy principles, technological innovations and waste reduction strategies in achieving resilience. Additionally, the strong focus on risk management, supply chain resilience, digitalization, and COVID-19-related impacts directly relates to RQ2, showcasing the prevalent strategies aimed at enhancing resilience against vulnerabilities. Together, these insights contribute to a deeper understanding of how sustainability and resilience practices are integrated into supply chains, particularly within the automotive sector. This thematic overview provides a foundation for further, more targeted analyses in subsequent sections, as it clarifies the current research focus and lays out an agenda for advancing knowledge in sustainable logistics with specific applications in the automotive supply chain.

Fig. 4. Thematic Keywords of Scopus Database. [Biblioshiny Software]

3.1.1 Publication per Year

The analysis of publication trends over time highlights a substantial increase in research focused on Sustainable Logistics and Supply Chain Resilience, particularly in the past five years. As illustrated in Figure 5, from 2002 to 2016, research activity in this field was minimal, indicating its nascent stages. However, starting around 2018, there was a notable surge in publications, reflecting a heightened scholarly interest in addressing the complexities of global supply chains. This upward trend accelerated sharply from 2020 onwards, likely influenced by recent global disruptions emphasizing supply chain vulnerabilities and the importance of resilience. The peak observed in 2023-2024, underscores the increasing recognition of sustainability's role in bolstering supply chain resilience amidst global disruptions. This surge aligns with rising environmental concerns and the need for resilient supply chains, driven by both academic inquiry and industry demand.

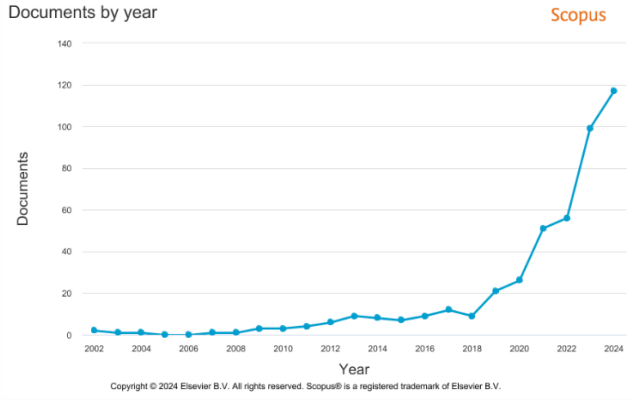

Fig. 5 Published Documents per Year.[Scopus Database].

3.1.2 Institutional Contributions and Thematic Keywords

Fig. **6** presents an interconnected framework of academic sources [SO], institutional affiliations [AU_UN], and research themes [DE], offering a comprehensive overview of the research landscape in sustainable logistics and supply chain resilience. Leading journals such as *Sustainability [Switzerland]*, *International Journal of Production Research*, and *Logistics* play pivotal roles, addressing themes like sustainability, circular economy, resilience, and supply chain management. *Sustainability [Switzerland]* emphasizes environmental stewardship and climate adaptation in logistics, while *International Journal of Production Research* bridges advanced technologies like Industry 4.0 and blockchain with operational efficiency. Institutions such as the University of Tehran lead with research on sustainability and emissions reduction, Politecnico di Milano focuses on digitalization and technological integration such as blockchain and IoT, and Dalhousie University highlights resilience in sector-specific contexts, including humanitarian logistics and the automotive industry. The geographical diversity of contributors, spanning Asia, Europe, and North America, underscores the global commitment to advancing sustainability and resilience, blending localized solutions with international frameworks.

The keywords in the visualization, such as sustainability, resilience, circular economy, and automotive industry, underscore the evolving thematic focus of the field. The overlap between sustainability and resilience highlights a growing emphasis on balancing environmental stewardship with operational efficiency to mitigate disruptions. Technological advancements, evident through terms like digitalization and Industry 4.0, reflect the critical role of predictive analytics, real-time tracking, and blockchain technologies in improving supply chain adaptability. Sector-specific terms such as automotive industry and reverse logistics point to targeted strategies addressing challenges like resource dependency and regulatory compliance, particularly through circular economy practices like recycling and remanufacturing. Cross-linkages between journals, institutions, and themes reveal a multidisciplinary effort to address global vulnerabilities, particularly in high-stakes industries like automotive. This visualization highlights the collaborative and transformative potential of sustainable practices and advanced technologies in building resilient and adaptable supply chains, positioning the field to address emerging challenges effectively, particularly in sectors like the automotive industry, where tailored strategies and advanced technologies play a transformative role.

3.1.3 Documentation by Country

illustrates the global scientific contributions to Sustainable Logistics and Supply Chain Resilience, revealing a strong, diverse commitment across regions. The United States and India lead with 55 publications each, underscoring their significant investment in advancing sustainable logistics and resilience strategies. China follows closely with 51 publications, reflecting its rapidly growing influence in the field. The United Kingdom and Germany contribute 41 and 31 publications, respectively, highlighting Europe's active engagement in addressing supply chain vulnerabilities.

Further contributions come from countries like Australia [21], Italy [21], and France [19], which underscore the worldwide

recognition of the need for resilient and sustainable supply chains. Countries with emerging roles, such as Iran, Canada, and Malaysia, each with 16 publications, and other contributors like Turkey and Indonesia, show that research efforts extend well beyond traditional powerhouses, encompassing both developed and emerging economies. This geographic distribution of research underscores the collaborative, global nature of efforts to enhance supply chain resilience, particularly in high-impact sectors like the automotive industry. The distribution of publications from these diverse regions shows the global research landscape in sustainable logistics, highlighting how various countries contribute to shared resilience and risk management strategies.

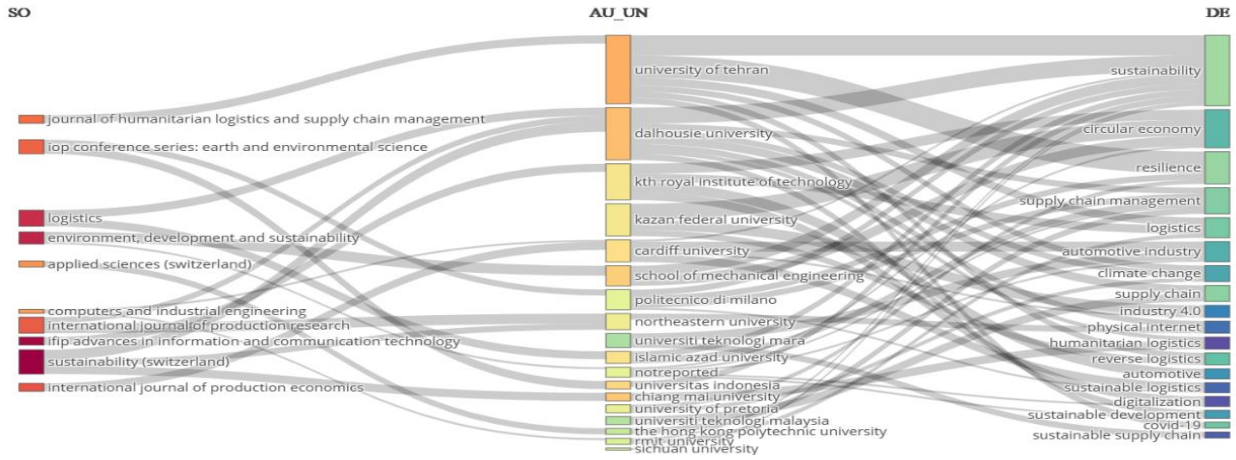

Fig. 6. Sankey diagram of Sources - Affiliations – Keywords of Scopus Database.[Biblioshiny Software]

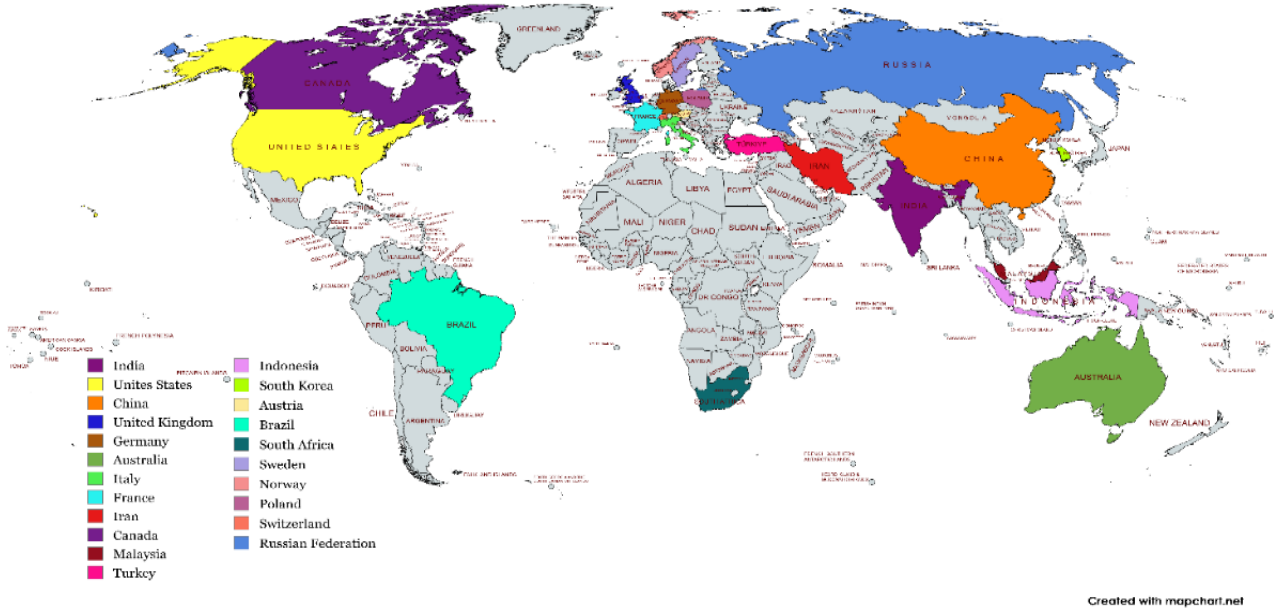

Fig. 7. Most Countries that have Publications in Sustainable Logistics and Resilience.[Scopus Database]

3.1.4 Author Documents

Table 1 highlights the 10 most-cited publications in the field of Sustainable Logistics and Supply Chain Resilience, reflecting diverse research priorities and evolving trends. The most-cited work, "Impact of supply chain management practices on sustainability" by [262], explores how sustainability practices enhance supply chain performance. This study serves as a cornerstone for understanding the integration of sustainability into supply chain resilience, particularly its operational and environmental dimensions. Several papers emphasize the automotive sector, showcasing

its critical role in advancing sustainability. "Remanufacturing for the automotive aftermarket-strategic factors: literature review and future research needs" by [143] identifies remanufacturing as a strategic component of circular supply chains. Similarly, "Green operations initiatives in the automotive industry" by [144] benchmarks environmental practices within the industry, highlighting the sector's growing commitment to green logistics and resilience frameworks. These works directly address challenges unique to the automotive supply chain, shedding light on emerging industry-specific trends relevant to RQ1 and RQ3.

Technology-driven strategies are another recurring theme in these influential studies. For instance, "Big Data Analytics as a mediator in Lean, Agile, Resilient, and Green [LARG] practices" by [263] demonstrates how digital technologies bridge sustainability and resilience by enabling data-driven optimization of supply chain operations. Similarly, "Robust network design for sustainable-resilient reverse logistics" by [264] focuses on utilizing big data to optimize reverse logistics networks, particularly for end-of-life vehicles, further reinforcing the importance of technological innovation in advancing sustainable practices. The pandemic has also shaped recent research directions. Papers such as "Green Closed-Loop Supply Chain Network Design During the Coronavirus (COVID-19) Pandemic: a Case Study in the Iranian Automotive Industry" by [265] and "Agriculture supply chain risks and COVID-19: mitigation strategies and implications for practitioners" by [142] illustrate adaptive strategies for maintaining resilience under crisis conditions. These studies emphasize the need for robust frameworks capable of withstanding disruptions, contributing to RQ2 by addressing how sustainability frameworks are integrated into resilience strategies

Table 1. Top 10 Most Cited Papers in Scopus Database

Document Title	Authors	Year	Source	Citations
Impact of supply chain management practices on sustainability	Govindan, K., Azevedo, S.G., Carvalho, H., Cruz-Machado, V.	2014	Journal of Cleaner Production , 85, pp. 212–225	264
Remanufacturing for the automotive aftermarket-strategic factors: literature review and future research needs	Subramoniam, R., Huisingh, D., Chinnam, R.B.	2009	Journal of Cleaner Production, 17[13], pp. 1163–1174	234
Green operations initiatives in the automotive industry: An environmental reports analysis and benchmarking study	Nunes, B., Bennett, D.	2010	Benchmarking, 17[3], pp. 396–420	189
Assessing the impact of cost optimization based on infrastructure modelling on CO2 emissions	Harris, I., Naim, M., Palmer, A., Potter, A., Mumford, C.	2011	International Journal of Production Economics, 131[1], pp. 313–321	169
Agriculture supply chain risks and COVID-19: mitigation strategies and implications for the practitioners	Sharma, R., Shishodia, A., Kamble, S., Gunasekaran, A., Belhadi, A.	2024	International Journal of Logistics Research and Applications, 27[11], pp. 2351–2377	166
Big Data Analytics as a mediator in Lean, Agile, Resilient, and Green [LARG] practices effects on sustainable supply chains	Raut, R.D., Mangla, S.K., Narwane, V.S., Dora, M., Liu, M.	2021	Transportation Research Part E: Logistics and Transportation Review, 145, 102170	165
Green Closed-Loop Supply Chain Network Design During the Coronavirus (COVID-19) Pandemic: A Case Study in the Iranian Automotive Industry	Abbasi, S., Daneshmand-Mehr, M., Ghane Kanafi, A.	2023	Environmental Modeling and Assessment, 28[1], pp. 69–103	141
Optimization of network redundancy and contingency planning in sustainable and resilient supply chain resource management under conditions of structural dynamics	Pavlov, A., Ivanov, D., Pavlov, D., Slinko, A.	2019	Annals of Operations Research	133
Linking capabilities to green operations strategies: The moderating role of corporate environmental proactivity	Liu, Y., Zhu, Q., Seuring, S.	2017	International Journal of Production Economics, 187, pp. 182–195	115
Robust network design for sustainable-resilient reverse logistics network using big data: A case study of end-of-life vehicles	Govindan, K., Gholizadeh, H.	2021	Transportation Research Part E: Logistics and Transportation Review, 149, 102279	109

In addition to technological and industry-specific focuses, broader strategic approaches are also evident. "Optimization of network redundancy and contingency planning in sustainable and resilient supply chain resource management" by [266] underscores the strategic importance of network design in enhancing resilience. Lastly, Papers such as "Assessing the impact of cost optimization based on infrastructure modelling on CO^2 emissions" by [267] and "Linking capabilities to green

operations strategies: The moderating role of corporate environmental proactivity" by [268] further contribute to understanding the balance between economic efficiency and sustainability in supply chain resilience. These papers highlight the significant academic contributions to the evolving field of Sustainable Logistics and Supply Chain Resilience. Emerging trends such as the integration of advanced technologies, green operations, and adaptive strategies for crisis management emphasize the dynamic evolution of the field, directly addressing themes in RQ1. The cross-industry applications, spanning automotive, agri-food, and broader supply chain systems, provide valuable insights into how sustainability practices are being embedded into resilience frameworks, showcasing diverse approaches to operationalizing sustainability across sectors as emphasized in RQ2. Moreover, the challenges and innovative practices specific to the automotive industry, including remanufacturing, green logistics, and closed-loop supply chains, highlight critical gaps and untapped opportunities, offering a clear pathway for further exploration and innovation aligned with RQ3. These findings collectively illustrate the interdisciplinary and sector-specific dimensions of the research landscape.

3.2 Bibliometric Results Analysis

The bibliometric analysis, conducted through both Biblioshiny and VOSviewer, provides a structured overview of key terms, concepts, and thematic structures central to sustainable logistics and supply chain resilience, with a specific focus on the automotive sector. The initial trend topic analysis reveals the most frequently occurring and emergent keywords in recent years, highlighting shifts and evolving priorities within the research landscape. This is followed by a VOSviewer clustering analysis, which organizes 330 items into eight distinct clusters, visually distinguished by different colors, to map the interconnected domains of the field comprehensively. The thematic map then categorizes these topics according to their centrality and density, distinguishing core research areas from specialized or emerging themes. Finally, the thematic evolution diagram traces the development of these themes over different time periods, illustrating how the field has responded to new challenges and advancements. Together, these analyses provide a holistic view of the domain, by identifying trends, areas of focus, and gaps, thereby setting a foundation for further exploration in sustainable logistics and supply chain resilience.

3.2.1 Concurrent Occurrence of Keywords

The Trend Topics visualization (Fig. **8**) reveals a rich evolution in sustainable logistics and supply chain resilience research, with a notable increase in focus areas since 2018. Key terms such as "sustainable development," "resilience," and "sustainable supply chains" reflect an intensifying commitment to embedding sustainability within adaptable supply chain frameworks. This trend points to a growing ambition to design resilient supply chains that meet both environmental and social imperatives, addressing RQ1 by identifying sustainability as a dominant emerging theme. A targeted approach to industry-specific applications emerges through terms like "automotive industry," "automobile manufacture," and "reverse logistics," underscoring the application of sustainable principles in high-impact sectors like automotive manufacturing. This shift suggests that sustainability research is broadening to address unique sector demands, highlighting dominant research areas across industries. Such a tailored focus supports RQ2, indicating that resilient supply chains must adapt to each sector's operational realities.

The rise in terms like "data analytics," "decision making," and "risk management" signals a deepening integration of technology within sustainable logistics, illustrating a shift toward data-driven methodologies that enhance supply chain resilience. The field is increasingly embedding advanced analytics and risk management, suggesting that technological innovation plays a crucial role in building responsive, adaptable logistics networks—further supporting RQ1 by identifying technology as a key driver. Environmental priorities also resonate strongly, with "environmental impact," "carbon dioxide," and "climate change" emphasizing the need for climate-conscious supply chain frameworks. This focus reflects sustainable logistics' response to global environmental challenges, promoting a balance between economic efficiency and environmental responsibility, which directly speaks to RQ2 by highlighting major areas of research aligned with climate goals.

Finally, the emergence of terms like "circular economy" and "energy efficiency" marks a transformative shift toward closed-loop, resource-efficient supply chains, reinforcing the circular economy as an essential framework in advancing sustainability practices. Overall, the Trend Topics visualization captures the field’s dynamic progression toward integrating sustainability, resilience, and technological innovation across various industries. This evolving focus reflects a concerted effort to create supply chains that fulfill economic and environmental goals, providing a comprehensive foundation for addressing RQ1 on emerging trends and RQ2 on sector-specific research areas.

The VOSviewer network visualization (Figure 9) reveals eight distinct clusters, each representing thematic areas within the domain of sustainable logistics and supply chain resilience. These clusters, detailed in Table 2, provide a comprehensive understanding of the field’s research trajectory while addressing emerging trends, dominant research areas, and research gaps across automotive sector supply chain. This analysis offers valuable insights into the research landscape, contributing to the study's objectives and addressing RQ1 [emerging trends], RQ2 [dominant research areas], and RQ3 [gaps with specific focus on automotive applications]. Cluster 1, Climate Change and Adaptive Management, emphasizes the intersection of climate change and adaptive management strategies within supply chains. Keywords such as “climate change,” “adaptive

management," and "resilience" emphasize the importance of building logistics systems that can withstand climate-related disruptions. Terms like "disaster management," "vulnerability," and "ecosystem resilience" reveal the growing importance of building logistics systems that can withstand environmental disruptions. Adaptive management strategies are particularly critical in sectors such as agri-food and healthcare, where real-time monitoring and disaster response frameworks address vulnerabilities related to perishability and emergency supply continuity, respectively. While this cluster aligns with RQ1 by showcasing the trend of embedding climate resilience into supply chains, it also addresses RQ2 by identifying key factors such as risk perception and disaster management that influence the successful integration of sustainability into resilience strategies. However, there remains a gap (RQ3] in exploring how these adaptive strategies are applied in high-impact industries such as automotive manufacturing, particularly in designing supply chains capable of mitigating climate risks while maintaining operational efficiency.

Cluster 2, Sustainable Logistics and Environmental Management, focuses on embedding sustainability principles into logistics operations. Terms like "green logistics," "circular economy," and "sustainable supply chains" reflect the growing focus on reducing environmental impact through sustainable practices. Sector-specific applications, as highlighted by "automotive industry" and "humanitarian logistics," reflect the varying demands of tailoring sustainability initiatives to industry needs. The integration of circular economy practices, such as recycling and remanufacturing, demonstrates how sectors like automotive and retail adapt sustainability principles to unique operational needs. These sectoral approaches showcase the scalability of green logistics while addressing specific challenges like waste reduction and resource optimization. This cluster directly answers RQ1 by identifying the adoption of circular economy and green logistics practices as key trends. For RQ2, it highlights dominant areas such as environmental sustainability and sustainable packaging, which are critical elements for integrating resilience into resilience frameworks across industries. Despite these advances, a critical gap (RQ3) exists in understanding the scalability of these practices within the automotive supply chain, particularly regarding end-of-life vehicle recycling and sustainable packaging solutions.

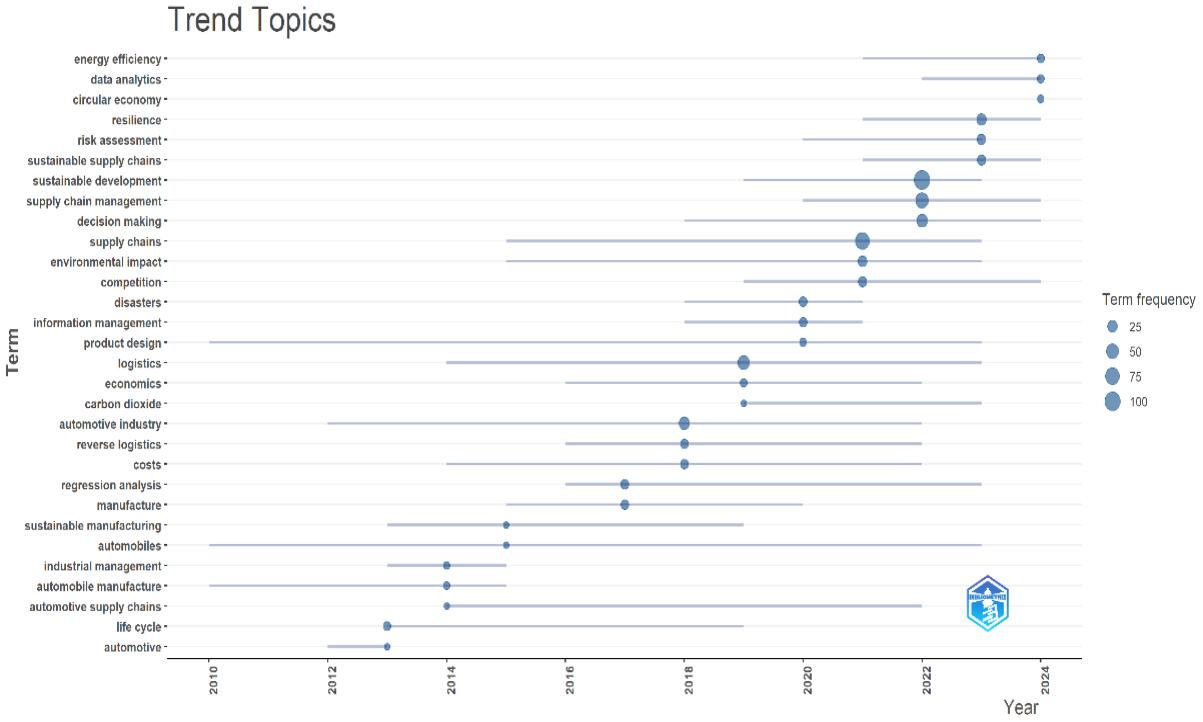

Fig. 8. Trend Topics Keywords of Scopus Database. [Biblioshiny Software]

Table 2 Sustainable Logistics and Resilience Research Clusters [2002 - October 2024] using VOSviewer Software

Cluster	Color	Items	Constructs
Cluster 1 [Climate Change and Adaptive Management]	Red	87	"Climate change", "Climate change adaptation, "Resilience", "Adaptive management", "Vulnerability", "Socioeconomic conditions", "Disaster management", "Risk perception", "Sustainable development goals", "Sustainable agriculture", "Food security", "Stakeholder", "Disaster prevention", "Ecosystem resilience", "Urban development", "Natural disaster", "Pandemics", "Economic development".
Cluster 2 [Sustainable Logistics and Environmental Management]	Green	42	"Automotive industry", "Automobile industry, "Circular economy", "Digitalization", "Disruptions", "Environmental impact", "Environmental performance", Environmental policy", "Environmental sustainability", "Green logistics", "Humanitarian logistics", "Industry 5.0", "Logistic management", "Sustainable development", "Logistics", "Sustainable logistics", "Sustainable packaging", "Sustainable supply chain management", "Sustainable supply chains", "Third-party logistics", "Outsourcing", "Supplier selection".
Cluster 3 [Transportation and Environmental Efficiency in Sustainable Logistics]	Dark Blue	37	"Air quality", "Automobiles", "City logistics", "Cost reduction", "Customer satisfaction", "Economic and social effects", "Energy efficiency", "Fleet operations", "Freight transportation", "Gas emissions", "Greenhouse gases", "Traffic congestion", "Logistics system", "Multi-objective optimization", "Performance assessment", "Sustainability and resilience", "Transportation and sustainability", "Transportation planning", "Vehicle routing".
Cluster 4 [Digitalization and Technological Innovation in Supply Chain Management]	Yellow	34	"Automotive supply chains", "Blockchain technology", "Cyber-physical systems", "Data analytics", "Digital twin", "Green supply chain", "Industry 4.0", "Information management", "Internet of Things [IoT]", "Logistics network", "Physical internet", "Supply chain network", "Supply chain practices" "Digitalization", "E-commerce", "COVID-19", "Machine learning", "Artificial intelligence", "Forecasting".
Cluster 5 [Reverse Logistics and Optimization]	Purple	34	"Big data", "Closed-loop supply chain", "Decision making", "End-of-life vehicles", "Emission control", "Network design", "Robust optimization", "Remanufacturing", "Reverse logistics", "Reverse logistics network design", "Recycling", "Waste management", "Carbon", "Cost benefit analysis", "Uncertainty analysis".
Cluster 6 [Advanced Manufacturing and Decision Support Systems]	Light Blue	33	"Artificial intelligence", "Automobile manufacture", "Business continuity", "Carbon footprint", "Decision support systems", "Digital transformation", "Environmental regulations", Environmental technology", "Inventory control", "Inventory management", "Predictive analytics", "Supply chain visibility, "Robustness", "Sustainable manufacturing", "Technology".
Cluster 7 [Supply Chain Resilience and Risk Management]	Orange	32	"Value chains", "Business performance", "Covid-19 pandemic", "Disaster resiliencies", "Global supply chain", "Green economy", "Green supply chain management", "Innovation, "Resource allocation", "Social aspects", "Risk assessment", "Risk management", "Supply chain resilience", "Supply chain risk management", "Supply chain risks", "Technology adoption".
Cluster 8 [Technological and Sustainability Approaches]	Brown	31	"Benchmarking", "Carbon dioxide emissions", "Decision support systems", "E-commerce", "Efficiency", "Food supply chain", "Forecasting", "Global warming", "Information sharing", "Machine learning", "Planning", "Simulation", "Strategic approach", "Supply chain sustainability", "Digital supply chain".

Cluster 3, Transportation and Environmental Efficiency in Sustainable Logistics, sheds light on transportation-related sustainability issues. Keywords such as "freight transportation," "greenhouse gases," and "energy efficiency" point to the need for greener, more efficient logistics systems. The dual focus on "customer satisfaction" and "cost reduction" reveals the challenge of balancing economic efficiency with environmental goals. This cluster reveals an emerging trend (RQ1) where transportation strategies are increasingly aligned with environmental and economic objectives to achieve greener and more efficient logistics systems. This cluster addresses RQ2 by identifying logistics system optimization and carbon footprint reduction as dominant areas of research, underlining the necessity of integrating transportation efficiency into sustainability frameworks. Nevertheless, a gap exists (RQ3] in exploring how transportation strategies are adapted specifically within the automotive industry, particularly concerning vehicle emissions and logistical complexities.

Cluster 4, Digitalization and Technological Innovation in Supply Chain Management, underscores the transformative impact of technology on supply chain resilience. Keywords such as "blockchain technology," "artificial intelligence," "digital twin," and "Internet of Things [IoT]" highlight the strategic role of digitalization in enhancing resilience. Terms like "digital twin"

and “real-time monitoring” highlight the role of predictive analytics and advanced logistics networks. Terms like “logistics network,” “real-time monitoring,” and “supply chain practices” illustrate how technology enables predictive analytics, real-time monitoring, and efficient decision-making in advanced logistics networks. The transformative potential of digital tools, such as blockchain for traceability and IoT for monitoring, highlights their sector-specific applications. For example, healthcare relies on these technologies for vaccine tracking, while agri-food uses them to maintain food quality during transportation. These applications emphasize the importance of digitalization in sectoral resilience strategies. This cluster reflects the emergence of digitalization as a dominant trend (RQ1) in building agile and adaptive supply chains. Critical factors such as “forecasting” and “cyber-physical systems” demonstrate how technological tools enhance resilience and sustainability through strategic planning and advanced analytics, addressing RQ2. However, the extent to which these technologies are integrated into the automotive supply chain to address specific challenges—such as inventory management and real-time disruption response—remains underexplored (RQ3).

Cluster 5, Reverse Logistics and Optimization, revolves around closed-loop supply chains and waste reduction. Keywords such as “remanufacturing,” “recycling,” “reverse logistics,” and “carbon” illustrate how circular economy principles are being operationalized to achieve sustainability. The presence of terms like “big data” and “network design” highlights the role of advanced analytics in optimizing reverse logistics processes. Reverse logistics frameworks in industries such as automotive and retail focus on optimizing resource recovery and waste reduction. Practices like remanufacturing and AI-driven redistribution are tailored to meet the specific needs of these sectors, reflecting the operational versatility of circular economy principles. This cluster identifies a trend (RQ1) toward adopting circular economy practices to minimize waste and dependency on raw materials. Factors like “waste management” and “decision-making” underscore the role of adapting reverse logistics in achieving both environmental and economic objectives, and enhancing supply chain sustainability. For RQ2, it identifies key practices such as recycling and robust optimization as critical for integrating sustainability into resilient supply chains. However, there is limited exploration (RQ3) of how reverse logistics frameworks can address the unique challenges of the automotive industry, particularly for managing end-of-life vehicles and integrating recycled materials into manufacturing processes.

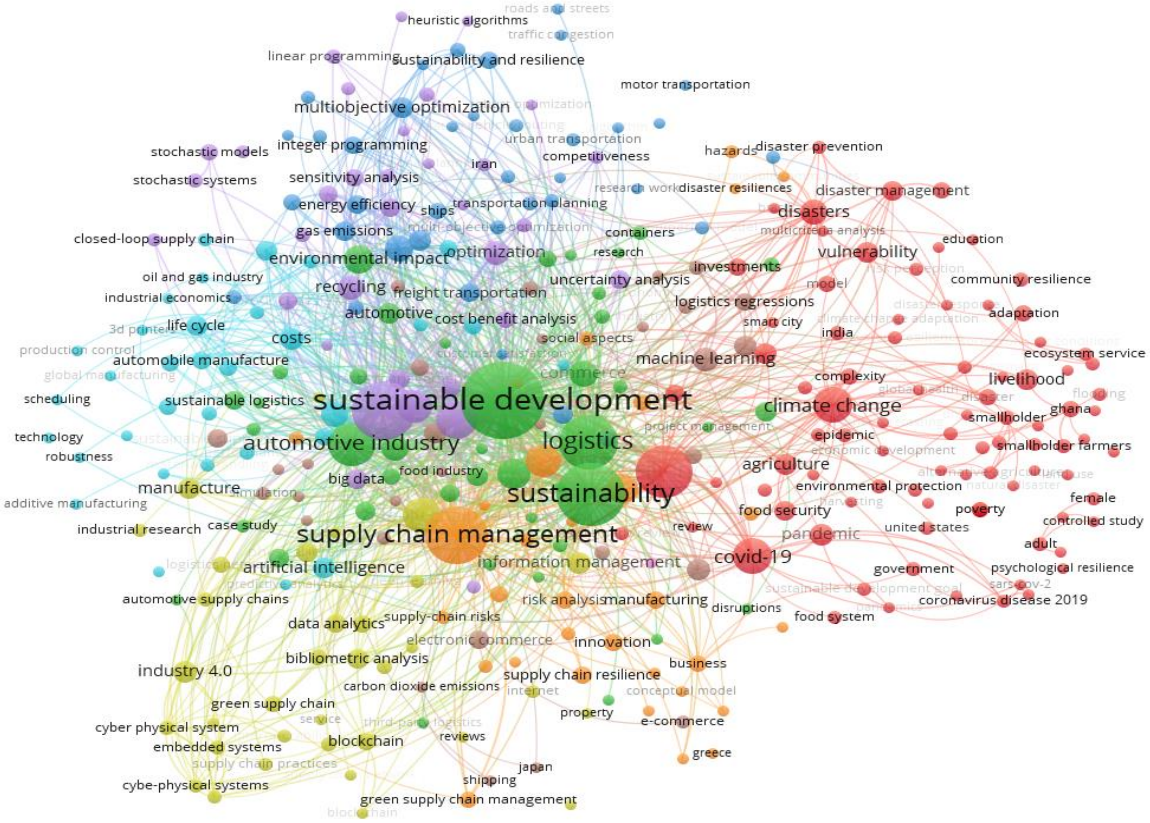

Fig. 9 Network Visualization Map of the Keywords using VOSviewer Software [2002- October 2024].

Cluster 6, Advanced Manufacturing and Decision Support Systems, highlights the intersection of manufacturing technologies and decision-making frameworks. Keywords such as "additive manufacturing," "decision support systems," [188] and "sustainable manufacturing" signal the increasing reliance on advanced tools in logistics operations to enhance supply chain resilience. Terms like "predictive analytics," "inventory control," and "supply chain visibility" emphasize the role of technology and data-driven strategies in ensuring operational efficiency and responsiveness. This cluster points to a growing trend (RQ1) where advanced manufacturing technologies contribute to sustainability. Key factors like "carbon footprint" and "robustness" show how decision support systems enable strategic integration of sustainability (RQ1). However, a critical gap (RQ3) exists in understanding how these technologies are implemented across industries, particularly in the automotive sector, which requires advanced tools to manage its complex global supply chain networks.

Cluster 7, Supply Chain Resilience and Risk Management, focuses on resiliency strategies to manage risks and disruptions in achieving sustainability. Keywords like "supply chain resilience," "risk management," and "disaster resiliencies" highlight the importance of proactive risk mitigation in achieving sustainability. The presence of terms like "resource allocation" and "social aspects" reflects a comprehensive approach for building resilient supply chains that incorporates both operational and social dimensions. This cluster identifies risk management into sustainability frameworks as a key emerging trend (RQ1) in sustainable logistics. Factors like "innovation" and "green economy" illustrate the importance of resource allocation and sustainability in enhancing resilient logistics systems (RQ1). However, there is insufficient research (RQ3) on how resilience strategies are tailored to the specific risk profiles of industries like automotive manufacturing, which faces unique challenges such as supply disruptions and high environmental challenges, necessitating customized solutions.

Cluster 8, Technological and Sustainability Approaches, integrates technological advancements with environmental goals. Keywords like "machine learning," "carbon dioxide emissions," "digital supply chain," and "e-commerce" illustrate the fusion of innovation and sustainability. The inclusion of "food supply chain" suggests that sector-specific applications are beginning to gain traction. This cluster identifies technology as a central trend (RQ1) and highlights "efficiency" and "strategic planning" as critical factors for integrating sustainability into supply chains, by aligning environmental goals with operational objectives (RQ1). However, the application of these technologies to the automotive supply chain, particularly in addressing emissions reduction and resource optimization, remains an area requiring further exploration (RQ3).

While the analysis has identified distinct clusters such as circular economy, climate adaptation, digitalization, and disaster management, a noticeable gap in the literature remains regarding the explicit correlation between sustainable logistics and supply chain resilience. Although both concepts have been explored independently, this gap directly addresses RQ3, suggesting a need for further empirical studies to demonstrate how sustainable logistics improves resilience across industries. Given its complex global supply chains and heightened vulnerability to disruptions, the automotive industry presents an ideal case for studying how digital transformation tools and sustainable practices like reverse logistics and green logistics can be integrated to bolster resilience.

3.2.2 Thematic Analysis and Evolution of Sustainable Logistics and Supply Chain Research

The thematic map in Figure 10, highlights the intricate connections within sustainable logistics, capturing the interplay between foundational, emerging, and niche themes, providing significant insights into answering the research questions. Core elements like sustainable development, reverse logistics, and circular economy dominate the basic themes quadrant, emphasizing their fundamental role in shaping sustainability in supply chains. These themes underline the necessity of closed-loop systems and environmentally conscious practices, aligning with RQ1 by revealing the critical emerging trends in sustainable logistics aimed at enhancing resilience and reducing vulnerabilities. Additionally, the inclusion of supply chain resilience and logistics in the same quadrant further supports the pivotal role of foundational practices in addressing sustainability challenges.

In the motor themes quadrant, themes such as supply chain management and decision support systems are highlighted, showcasing their centrality and advanced development within the field. The focus on decision-making processes and management reflects the growing importance of integrating technology and data analytics in creating adaptive, resilient supply chains. This directly aligns with RQ2, as it demonstrates how supply chain management frameworks integrate sustainability principles and digital tools to respond to industry-specific challenges, particularly in high-impact sectors like automotive.

Niche themes such as sustainability and resilience in the automotive industry point toward focused research areas addressing carbon dioxide emissions and transportation. These findings directly address RQ3 by identifying gaps in industry-specific applications, especially the integration of sustainability within the automotive supply chain, which remains a critical area for future exploration. Emerging themes such as machine learning, logistic regression, and optimization, located in the lower quadrants, signal untapped potential in leveraging predictive technologies to enhance supply chain operations, addressing inefficiencies and strengthening resilience frameworks.

The thematic evolution (Figure 11) provides a chronological depiction of the key themes that have defined the development of sustainable logistics and supply chain research. Initially,

between 2002 and 2004, the field was dominated by the overarching theme of "sustainable development," reflecting the early focus on embedding sustainability principles within broader economic and environmental practices. This foundational theme set the stage for subsequent research and transitioned into more specific applications in "logistics" and "supply chains" during the period from 2007 to 2011. These themes represent the initial steps in integrating sustainable practices into operational and transportation systems. The years 2012 to 2016 marked a significant diversification of themes. Core themes like "sustainable supply chains," "information management," and "resilience" emerged, showcasing the increasing complexity of supply chain research. During this phase, the field started addressing how sustainability could enhance supply chain efficiency and resilience to disruptions. Furthermore, the emergence of "regression analysis" highlighted the adoption of quantitative approaches to analyze supply chain dynamics. This period reflects a critical turning point where sustainability evolved from a conceptual framework to a practical component of supply chain operations. From 2017 to 2021, the thematic evolution reveals a growing emphasis on advanced and interdisciplinary themes such as "COVID-19," "decision support systems," and "disaster management." These themes underscore the impact of global disruptions and the need for resilience-focused research, particularly in response to crises like the pandemic. Additionally, the inclusion of themes like "human" and "economic and social effects" demonstrates a shift toward assessing the broader implications of supply chain practices, encompassing social and economic dimensions.

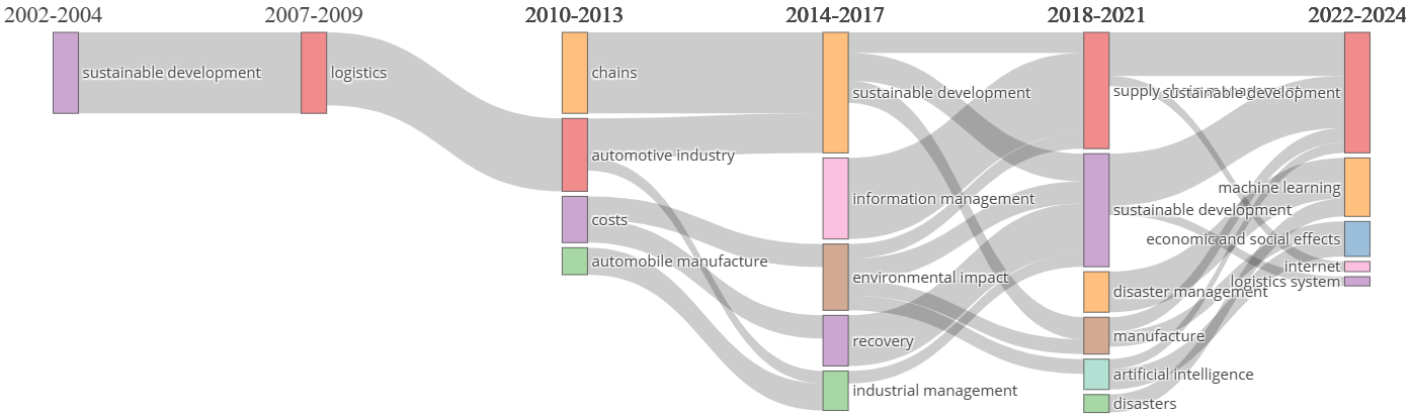

Fig. 10 Thematic Map of Scopus Database (2002 - October 2024) Biblioshiny Software.

In the most recent period, 2022 to 2024, the field has expanded further, with themes such as "machine learning," "artificial intelligence," and "internet" becoming central to sustainable logistics research. These themes indicate a growing reliance on technological advancements to address sustainability challenges. The evolution also shows a resurgence of foundational themes like "sustainable development" and "logistics systems," which suggests an ongoing commitment to integrating traditional sustainability goals with cutting-edge innovations. Overall, the thematic evolution highlights the dynamic progression of the field from foundational concepts to advanced, technology-driven approaches. It answers RQ1 by identifying emerging trends like artificial intelligence and economic analysis in supply chain research. RQ2 is addressed by showcasing the dominance of resilience and disaster management as central areas of focus. Finally, RQ3 is illuminated through the identification of gaps, such as the need for further exploration of social and human dimensions within the context of technological integration. This analysis demonstrates the field's adaptability and the importance of continuously evolving to meet contemporary challenges.

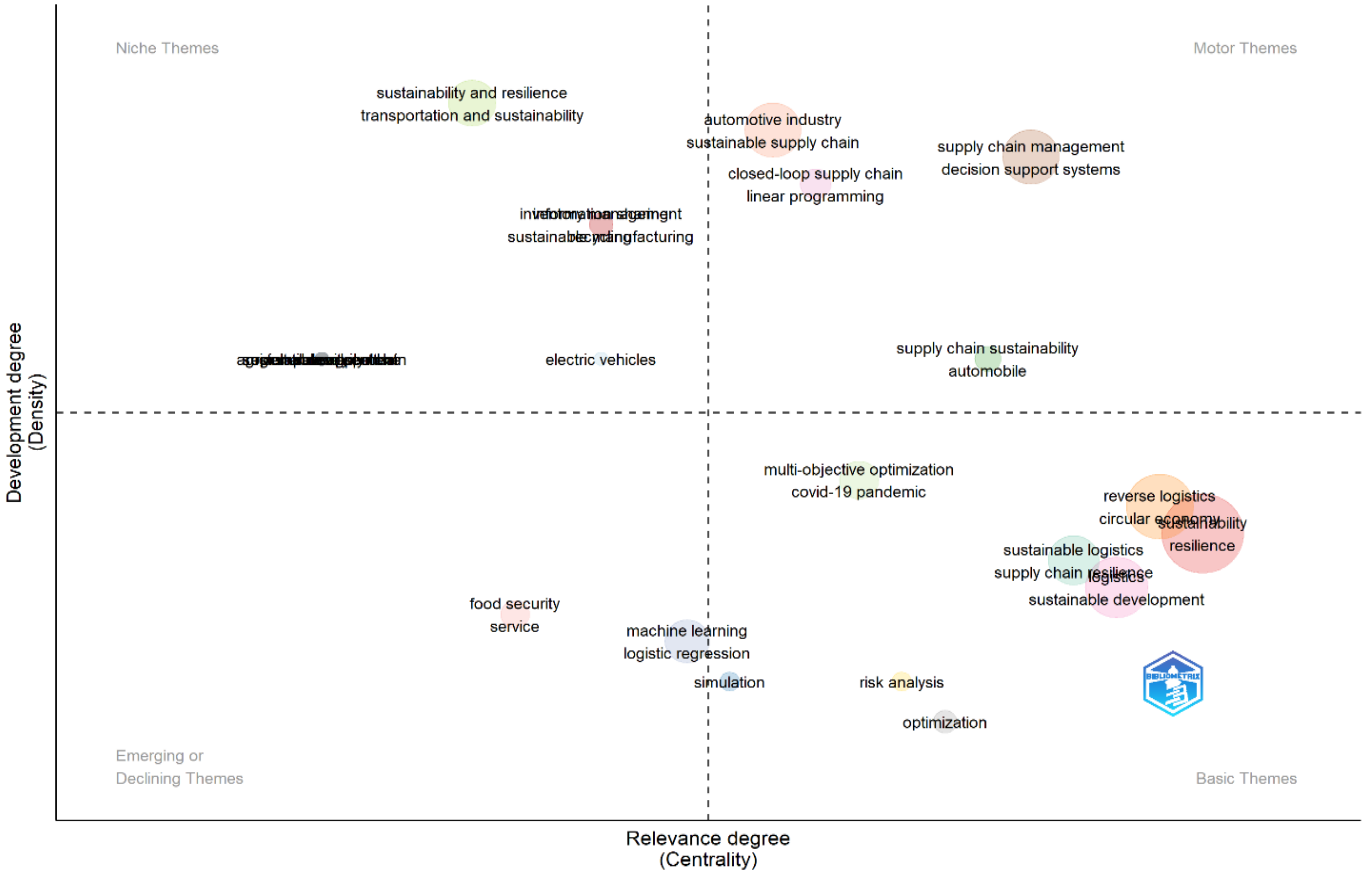

Fig. 11 Thematic Evolution of Scopus Database (2002 - October 2024). Biblioshiny Software.

3.2.3 The Role of Sustainable Logistics in the Automotive Industry Supply Chains Resilience

The automotive industry operates one of the most globally interconnected and complex supply chains, exposing it to vulnerabilities such as climate-induced disruptions, geopolitical risks, and stringent regulatory pressures [230,248,269–272]. The resilience of supply chains has garnered increasing attention due to global disruptions such as the COVID-19 pandemic, geopolitical tensions, and climate-related challenges [220]. Sustainability and resilience are now seen as interconnected goals, where the adoption of green practices and digital technologies has become pivotal for achieving long-term supply chain stability and flexibility [52]. These challenges are compounded by reliance on lean manufacturing models, particularly just-in-time [JIT] systems, which amplify risks during global crises [236,245,273–276]. Sustainable logistics practices, as highlighted in the bibliometric analysis and clusters, have emerged as critical strategies for mitigating these vulnerabilities while enhancing resilience. Using bibliometric analysis, the study explores how sustainable logistics practices contribute to building resilience, particularly in automotive supply chains.

Figure 12 derived from VOSviewer clusters, provides a detailed visualization of the relationships between sustainable logistics practices, resilience, and the automotive industry. Central constructs such as "automotive industry," "sustainable logistics," "reverse logistics," "green logistics," and "digitalization" highlight their prominence in research and practice. These themes are connected to critical constructs like "supply chain resilience," "risk management," "circular economy," and "climate change," underscoring the integration of sustainability and resilience principles into automotive supply chains. Furthermore, the trend topics analysis identifies the emergence of terms such as "green logistics" and "reverse logistics" post-2018, reflecting the industry's response to global challenges, including the COVID-19 pandemic, regulatory shifts, and resource scarcities. The thematic evolution reveals how the focus has shifted from broad sustainability goals to targeted applications like "end-of-life vehicle management" and "predictive analytics," emphasizing the growing importance of sustainability-driven resilience strategies.

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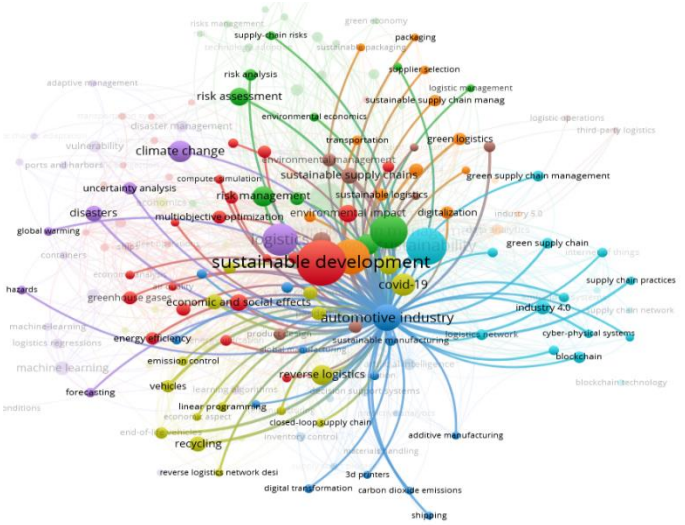

Fig. 12 Automotive Industry Supply Chain Visualization. [VOSviewer Software].

Figure 12 further illustrates the interconnected nature of sustainable logistics practices and their critical role in enhancing resilience within the automotive supply chain. Key processes such as raw material sourcing, component manufacturing, and end-of-life management directly benefit from sustainability-driven strategies. These strategies are operationalized across these processes are operationalized through specific sustainable logistics practices that address vulnerabilities and bolster supply chain adaptability. For instance, renewable energy sources, closed-loop systems, and carbon-neutral logistics practices have been shown to reduce vulnerability to disruptions significantly [35,38,153]. The Iranian automotive industry's green closed-loop supply chain adoption during the COVID-19 pandemic showcased how sustainability-driven resilience strategies can protect against systemic shocks [265].

Raw Material Sourcing emerges as a critical process where blockchain technology ensures traceability and ethical sourcing, reducing vulnerabilities linked to geopolitical risks [225]. This directly addresses RQ1 by showcasing emerging trends in digital transparency and practices like digital transformation and circular economy principles that enable automotive companies to navigate disruptions effectively. Component Manufacturing leverages circular economy practices to decrease reliance on virgin resources, fostering production flexibility. This aligns with RQ2 by emphasizing dominant sustainability research areas like green logistics and supply chain risk management, which integrate sustainability into resilience frameworks. In addition, Inbound and Outbound Logistics benefit from green logistics practices such as low-emission transportation and optimized route planning, improving cost efficiency and minimizing environmental impacts [112,229]. These strategies address both RQ1 and RQ2, illustrating how sustainability enhances resilience in transportation and logistics. Furthermore, End-of-Life Management is facilitated by reverse logistics frameworks, as highlighted by nodes like "recycling" and "remanufacturing" in the visualization. These frameworks tackle challenges associated with end-of-life vehicles [ELVs], fostering resource recovery and ensuring supply chain continuity during global disruptions [264]. This directly supports RQ3 by identifying gaps and opportunities in scaling these practices, particularly in addressing economic and infrastructural barriers. The clustering of terms such as "automotive industry," "reverse logistics," and "sustainable development" within Figure 12 underscores the integration of these practices into broader sustainability and resilience frameworks. This interconnectedness highlights how sustainable logistics strategies address critical challenges and opportunities for further research and practice, linking them to the broader context of the automotive industry's global supply chains.

The bibliometric analysis identifies key sustainable logistics practices such as reverse logistics, green logistics, and digital transformation technologies that contribute to enhancing resilience in automotive supply chains. Cluster 2 [Sustainable Logistics and Environmental Management] illustrates that emerging trends such as green logistics and circular economy principles enable automotive companies to mitigate the effects of disruptions, including global crises like the COVID-19 pandemic, by ensuring resource optimization and reducing emissions [242]. Moreover, reverse logistics, as identified in Cluster 5 (Reverse Logistics and Optimization], incorporates circular economy principles to enable manufacturers to recycle and remanufacture end-of-life vehicles [ELVs], thereby reducing dependence on volatile raw material markets. The European Union′s End-of-Life Vehicle Directive [Directive 2000/53/EC of September 2000] exemplifies how regulatory frameworks incentivize circular economy adoption, aligning environmental goals with supply chain resilience. These practices reduce dependency on raw materials, mitigate supply chain disruptions, and promote environmental sustainability. Studies such as [31,143] demonstrate that reverse logistics frameworks not only meet environmental objectives but also allow companies to recover materials and reintegrate them into

production processes, ensuring resource continuity during disruptions. For instance, Volkswagen's lithium battery recycling initiative demonstrates how circular economy practices can create resource loops, enhance operational continuity, and mitigate risks associated with raw material shortages [277]. These strategies address RQ1 by showcasing emerging trends that integrate sustainability into resilience frameworks.

Green logistics, emphasized in Cluster 3 [Transportation and Environmental Efficiency], represents another critical pillar for enhancing resilience. Practices such as low-emission transportation, optimized routing, and the electrification of logistics fleets minimize environmental impacts while improving cost efficiency and adaptability. For instance, [29,251] document how hybrid and electric vehicles in logistics minimize exposure to fuel price volatility while ensuring compliance with emission regulations. Companies like Tesla and Volvo exemplify how green logistics aligns sustainability goals with operational resilience, enabling them to adapt to shifting market demands and regulatory pressures [29,31,177]. Such practices not only fulfill environmental mandates but also build resilience by diversifying transportation modes and reducing vulnerabilities to fuel price volatility, directly addressing RQ1 and RQ2.

Digital transformation technologies, highlighted in Cluster 4 [Digitalization and Technological Innovation], are essential for enabling real-time monitoring, predictive analytics, and enhanced supply chain transparency. Blockchain technology, for example, improves supply chain visibility and ensures ethical sourcing during procurement by tracing materials across the supply chain, reducing risks associated with supplier disruptions, as evidenced by studies from [1,82,88,225,264,278−281]. IoT-enabled devices further support logistics optimization by providing real-time data on inventory, transportation, and potential disruptions, enabling companies to proactively mitigate risks. Studies by [264,282] emphasize the role of AI-driven predictive models in improving decision-making and recovery from disruptions, such as those experienced during the COVID-19 pandemic [82]. These technologies directly contribute to RQ1 by identifying emerging digital trends that support adaptive, real-time resilience in global supply chains.

In response to RQ2, it is evident from the bibliometric analysis that the integration of green logistics practices [e.g., low-emission fleets, optimized routing] and digital technologies [e.g., blockchain for supply chain transparency and AI for predictive analytics] are essential for building resilient automotive supply chains. For instance, Cluster 7 [Supply Chain Resilience and Risk Management] and Cluster 3 identify dominant research areas that integrate sustainability into resilience frameworks for the automotive industry. These include risk management, green supply chain management [GSCM], and digital transformation technologies. Risk management strategies, such as scenario planning and diversified supplier bases, are critical for mitigating supply chain vulnerabilities. Further, [266] argue that multi-modal logistics reduce exposure to disruptions, while redundant sourcing ensures continuity during crises. Studies highlight how automakers like Toyota and BMW have strengthened resilience by integrating risk assessments into their supply chain management [283]. Similarly, GSCM practices such as lean manufacturing and resource-efficient production align environmental goals with operational resilience. BMW′s green production initiatives, which include reducing energy and water usage, exemplify how GSCM minimizes vulnerabilities while meeting regulatory demands [284]. Digital tools such as digital twins enhance predictive maintenance, reducing downtime and improving resilience. Blockchain and IoT ensure real-time monitoring, enhancing visibility across global supply chains [264].

Despite these transformative trends, critical gaps hinder the scalability of sustainable logistics practices globally, particularly in the automotive industry. Cluster 5 (Reverse Logistics and Optimization] highlights significant barriers to implementing reverse logistics at scale, including high infrastructure costs and limited recycling networks in developing economies. For, instance, [265] argue that although reverse logistics offers environmental and operational benefits, its adoption is uneven due to logistical and financial constraints, particularly for smaller market players. Cluster 1 underscores the environmental trade-offs inherent in implementing green logistics practices. While green transportation reduces carbon footprints, challenges such as battery disposal for electric vehicles and limited charging infrastructure remain unresolved. For instance, [272] emphasize that balancing sustainability with operational feasibility requires a more nuanced approach, particularly in regions where regulatory and infrastructure support is limited. Addressing these trade-offs necessitates integrated frameworks that align environmental objectives with operational imperatives, a gap that remains underexplored in the current literature. Similarly, studies in Cluster 7 emphasize the uneven adoption of digital transformation technologies, with many small and medium enterprises [SMEs] lacking the financial and technical capacity to implement advanced tools like digital twins and blockchain. This creates disparities in resilience across the automotive supply chain, as SMEs form a critical component of the industry′s global supplier networks, highlighting the need for policy incentives to address these gaps [285]. Addressing these gaps aligns with RQ3, emphasizing the need for targeted interventions to overcome barriers and scale sustainable practices across the automotive industry.

In conclusion, sustainable logistics practices form the cornerstone for building resilient automotive supply chains capable of withstanding global disruptions and regulatory pressures. Practices like reverse logistics, green logistics, and digitalization directly address RQ1 by identifying emerging trends. Dominant research areas, such as GSCM and risk management, align with RQ2 by integrating sustainability into

resilience frameworks. Finally, the identification of gaps, including uneven digital adoption and infrastructure constraints, addresses RQ3, paving the way for further research and policy interventions. By synthesizing insights from bibliometric analysis and supporting literature, this section provides evidence that a combination of green logistics, reverse logistics, and digital technologies forms the foundation for adaptive, future-ready supply chains. However, the identified gaps in scalability and environmental trade-offs highlight the need for continued research and policy interventions to ensure the widespread adoption of these practices. These findings position sustainable logistics as a critical enabler of resilience in the automotive industry, offering both practical implications for industry stakeholders and a roadmap for future academic inquiry.

4. Discussion

This study provides a comprehensive bibliometric analysis, supported by VOSviewer clusters and Biblioshiny thematic visualizations for emerging trends and dominant research areas in sustainable logistics and supply chain resilience, with a particular focus on the automotive sector. It addresses three key research questions (RQ1, RQ2, and RQ3] to uncover trends, explore influential research areas, and identify critical gaps in the integration of sustainability and resilience frameworks. The findings offer actionable insights into how sustainability and resilience can be operationalized to address the unique challenges of the automotive industry, advancing both academic understanding and practical applications.

In response to RQ1 [Emerging Trends in Sustainable Logistics Practices], this study identifies critical trends in sustainable logistics practices that contribute to enhancing supply chain resilience, particularly within the automotive sector. The bibliometric analysis, supported by thematic evolution and cluster visualizations, highlights key constructs such as digitalization, circular economy, green logistics, and adaptive management. These trends reflect evolving priorities in modern supply chains while addressing the unique complexities and vulnerabilities of the automotive industry.

Among these trends, digitalization emerges as a dominant theme, particularly evident in constructs like IoT, blockchain technology, and predictive analytics in Cluster 4 [Digitalization and Technological Innovation]. These technologies enable real-time monitoring, transparency, and predictive decision-making in supply chains. Studies such as [54,61] emphasize the role of blockchain in enhancing material traceability and IoT in improving supply chain visibility. For the automotive sector, these tools address challenges such as counterfeit materials, disruptions in supplier networks, and regulatory compliance [202,264]. Complementary tools like digital twins and machine learning further optimize resource allocation and enhance resilience in complex supply chains [82,286].

Circular economy principles, highlighted in Cluster 5 (Reverse Logistics and Optimization], play a pivotal role in addressing resource dependency and environmental concerns. Practices such as remanufacturing, recycling, and closed-loop supply chains contribute to waste reduction and resource efficiency. Studies by [143,144] emphasize the importance of reverse logistics and end-of-life vehicle recycling in minimizing waste within the automotive supply chain [176,264]. However, the integration of these practices into broader resilience strategies remains underdeveloped, presenting opportunities for creating comprehensive frameworks tailored to the specific needs of the automotive sector [69,88,242]. By linking circular economy principles with adaptive strategies, this study underscores their dual role in promoting sustainability and mitigating supply chain disruptions.

Clusters 2 [Sustainable Logistics and Environmental Management] and Cluster 3 [Transportation and Environmental Efficiency] further emphasize the importance of green logistics in reducing carbon footprints and enhancing operational efficiency. Constructs such as sustainable packaging, eco-friendly transportation, and energy efficiency align with global sustainability goals, including the EU Green Deal [245,287]. Study by [288] highlights the success of these practices in agri-food supply chains, offering adaptable insights for the automotive industry, where carbon emission reduction and eco-friendly practices are increasingly critical.

Cluster 1 (Climate Change and Adaptive Management] highlights resilience-focused constructs such as disaster management, pandemics, and adaptive management. The urgency of these strategies was underscored during the COVID-19 pandemic, with [265] emphasizing the diversification of supplier networks and the use of digital platforms for real-time visibility. Integrating green logistics with disaster management frameworks ensures operational continuity during disruptions while advancing sustainability goals, particularly in highly vulnerable sectors like automotive [46,47,144,180,221,287,289,290].

Emerging trends underscore the interconnectedness between sustainability and resilience. Practices like reverse logistics [86,248,264] and remanufacturing enhance resilience by creating closed-loop systems that mitigate supply chain risks [30,31,133,158,175,179,248]. Similarly, digitalization supports sustainability through resource optimization while strengthening resilience with predictive analytics and real-time responses [88,247,286]. This study highlights the complementary roles of these practices and the need for integrated frameworks, particularly in complex industries like automotive.

The automotive industry demonstrates distinct trends in sustainable logistics, shaped by its operational complexities and vulnerability to disruptions. Constructs from Cluster 3 [Transportation and Environmental Efficiency] emphasize the importance of energy efficiency and strategic transportation planning, while Cluster 7 [Supply Chain Resilience and Risk Management] highlights the critical challenges of regulatory compliance and resource dependency. Addressing these challenges requires tailored strategies that leverage innovative

practices and technologies. For instance, reverse logistics and recycling end-of-life vehicles [ELVs] mitigate resource dependency and environmental concerns, aligning with broader sustainability goals, as noted by [30,176,285,291]. Furthermore, the integration of Industry 4.0 technologies, such as cyber-physical systems and digital twins, further optimizes supply chain operations by enhancing resilience through predictive modeling [29,121,193,205,247]. Achieving compliance with stringent environmental standards, such as those outlined in the European Union's Green Deal, demands innovative approaches that combine green logistics with advanced digital tools [144]. Together, these strategies address the automotive sector's unique challenges, advancing both sustainability and resilience within its complex supply chain networks.

In response to RQ2 [Dominant Research Areas in Sustainable Logistics and Supply Chain Resilience], this study reveals key research areas emphasizing the integration of sustainability principles and resilience frameworks, particularly within the automotive sector. The bibliometric analysis identifies thematic clusters that focus on circular economy practices, green logistics, digitalization, risk management, and the intersection of sustainability with supply chain management. Recent bibliometric studies such as [26,47,62,244,248,292], highlight terms such as "circular economy" and "carbon emissions" as central to sustainable logistics research as revealed by this study, while themes like "risk management" and "resilience" dominate resilience-focused studies addressing global supply chain disruptions [1,14,22,25,72,89,114,292]. These findings underscore the automotive sector's urgent need for robust frameworks that integrate sustainability and resilience to effectively manage operational complexities and disruptions [66,75–77,80,179,186,293].

A central focus of the analysis is the circular economy, which encompasses strategies like remanufacturing, recycling, and reverse logistics. These practices are pivotal in reducing environmental impact and enhancing resilience by addressing resource dependency. For instance, [143] emphasize the importance of remanufacturing in extending vehicle component lifecycles and minimizing waste, while constructs like "reverse logistics," identified in this study, highlight their role in creating sustainable logistics systems. Green logistics further complements circular economy frameworks by targeting reductions in carbon emissions and improvements in energy efficiency [221,240,251]. Studies like [144] underscore green operations initiatives, including eco-friendly transportation and optimized energy use, as crucial for mitigating vulnerabilities in the resource-intensive automotive supply chain. However, scaling these practices globally poses challenges, particularly due to varying regional regulatory standards and the resource-heavy nature of automotive operations. Tailored circular economy strategies are essential to overcoming these vulnerabilities and enhancing resilience within the automotive industry.

Digital transformation continues to shape research on sustainable and resilient supply chains. Technologies such as blockchain, IoT, and AI enhance traceability, improve decision-making, and enable proactive responses to disruptions [247]. Blockchain ensures transparency and compliance with environmental regulations, while IoT supports real-time monitoring [264]. Study by [263] further demonstrate the value of big data analytics and AI in optimizing inventory levels and forecasting demand. Despite their transformative potential, challenges like high implementation costs hinder the widespread adoption of these technologies, particularly in the automotive sector [1,24,31,49,203,246]. Empirical research validating the integration of digital tools into sustainability and resilience frameworks particularly in the automotive industry remains a critical area for further exploration.

Risk management and resilience-building strategies are integral to sustainable logistics research, with the COVID-19 pandemic reinforcing their importance. Keywords such as "risk management," "disaster resilience," and "supply chain resilience" underscore this research area's relevance. Study by [265] highlights adaptive frameworks for maintaining operations during crises, emphasizing the interplay between risk management and sustainability principles. For the automotive sector, strategies like supplier diversification, enhanced visibility, and redundancy frameworks are essential to mitigating vulnerabilities stemming from global disruptions and geopolitical risks [73,75,186,229]. For instance, [266] advocate for contingency planning and network redundancy to reduce supply chain risks in high-impact industries like automotive manufacturing.

Sustainability principles are increasingly embedded into supply chain management [SCM] frameworks, reflecting a growing emphasis on environmental considerations in operational strategies. Keywords such as "sustainability," "decision support systems," and "supply chain management" illustrate the integration of sustainable procurement, logistics, and manufacturing processes. Study by [294] emphasize the role of sustainable SCM practices in reducing resource dependency and enhancing resilience. In the automotive sector, extensive supply chain networks necessitate innovative solutions such as energy-efficient manufacturing, renewable energy sources, and compliance with emissions standards and waste management policies to meet sustainability goals [8,9,31,35,37,119,135,249,268,295]. These solutions drive the development of resilient frameworks that balance environmental performance with operational efficiency.

Transportation efficiency is another critical research area, particularly in reducing emissions and optimizing logistics operations. Keywords such as "transportation planning," "energy efficiency," and "greenhouse gases" highlight the importance of sustainable transportation strategies. For instance, [267] discussed the dual benefits of cost optimization, which simultaneously reduces CO^2 emissions and enhances resilience. Strategies such as route optimization, adopting electric vehicles,

and using alternative fuels are increasingly explored to address the automotive sector's challenges, such as high fuel consumption and emissions [8,92]. However, transitioning to sustainable transportation systems requires significant investment and coordination across global supply chains.

Despite these advancements, significant challenges remain in integrating sustainability into resilience frameworks. One prominent issue is the economic trade-off between sustainability goals and cost efficiency, particularly in the cost-sensitive automotive sector [90,118,247,296]. Further, [267] highlighted how strategies aimed at cost optimization often conflict with the adoption of sustainable practices, such as renewable energy solutions and green logistics, due to substantial initial investment requirements. Additionally, regulatory and policy barriers further complicate this integration. Disparities in global regulations for emissions and waste management hinder the harmonization of sustainability practices across regions, creating significant obstacles for global supply chain operations [37,107,136,226,295]. For example, [176] emphasized how regional variations in regulatory frameworks disrupt the implementation of cohesive sustainability strategies, underscoring the need for globally aligned policies to support resilience-building efforts.

In response to RQ3 [Gaps in Current Research], this study identifies critical shortcomings in the integration of sustainable logistics practices with supply chain resilience, with a specific focus on the automotive sector. The analysis underscores fragmented exploration, the absence of cohesive frameworks aligning sustainability with resilience goals, and a lack of scalable solutions tailored to the industry's unique complexities.

A major issue lies in the fragmented exploration of sustainable practices, where existing research often examines these practices in isolation, limiting their collective potential to enhance resilience. For example, while [143,144] emphasize the benefits of remanufacturing and recycling for waste reduction, these practices are rarely connected to broader resilience strategies, such as adaptive management or risk mitigation. This fragmentation is evident across clusters, such as green logistics initiatives and sustainable packaging in Cluster 2 [Sustainable Logistics and Environmental Management], reverse logistics and circular economy principles in Cluster 5 (Reverse Logistics and Optimization], and transportation planning and energy efficiency in Cluster 3 [Transportation and Environmental Efficiency]. These disjointed efforts are particularly problematic for the automotive sector, where resource dependency and stringent regulatory requirements demand cohesive frameworks integrating sustainability and resilience to address complex operational challenges [30,73,293,76,79,82,86,87,144,178,242].

The limited alignment of digital technologies with resilience frameworks further exacerbates these gaps. Keywords like "decision support systems" and "predictive analytics" in Cluster 6 [Advanced Manufacturing and Decision Support Systems] suggest potential pathways for leveraging digital technologies to enhance resilience. However, studies such as [263,297] primarily discuss the benefits of IoT and big data without fully exploring their implementation in closed-loop supply chains. Similarly, keywords in Cluster 4 [Digitalization and Technological Innovation], such as "blockchain technology," "cyber-physical systems," "digital twin," and "IoT," indicate the potential of these tools to improve supply chain visibility and decision-making. While digitalization trends dominate academic discourse, studies like [54,61] highlight gaps in aligning technologies like blockchain, IoT, and artificial intelligence with sustainability goals. Blockchain, for instance, can enhance traceability in circular supply chains, ensuring compliance with environmental standards while improving operational transparency [33,34,232,280,281,298]. IoT can further support predictive analytics for resource optimization and proactive disruption management [32]. However, a notable scarcity of empirical studies validating these technologies' application in creating resilient and sustainable automotive supply chains, leaves significant room for future exploration [74,88]. This lack of practical, scalable solutions further restricts the applicability of theoretical models, underscoring a critical research gap in demonstrating the effective role of digital tools in simultaneously achieving sustainability and resilience.

Thematic evolution visualizations also emphasize an inadequate focus on frameworks addressing global disruptions, such as pandemics and geopolitical risks, highlighting the importance of aligning sustainability with resilience to mitigate future crises. Constructs in Cluster 1 (Climate Change and Adaptive Management], including "pandemics" and "disaster management," underscore emerging resilience themes. However, their connection to sustainability practices like reverse logistics and green operations remains underdeveloped. For instance, [59,265] emphasize the reliance of the automotive sector on adaptive frameworks during crises like the COVID-19 pandemic but highlight the absence of robust models that combine resilience strategies with sustainability objectives. This disconnect limits the ability to develop adaptive frameworks that address both environmental goals and crisis management [175]. In the automotive sector, combining sustainability initiatives such as recycling end-of-life vehicles or leveraging digital tools for traceability with adaptive strategies could ensure operational continuity during disruptions while advancing long-term resilience [66,80].

The automotive industry presents distinct challenges that are not sufficiently addressed in generalized resilience frameworks. Constructs in Cluster 7 [Supply Chain Resilience and Risk Management], such as "environmental policy" and "supply chain risks," highlight vulnerabilities unique to this sector, including reliance on rare earth materials, intricate global supplier networks, and compliance with stringent environmental regulations. Achieving net-zero emissions and recycling critical materials requires innovative approaches that align sustainability with resilience [31,176,180,186]. Practices like end-of-life vehicle recycling and closed-loop supply chains, as explored by [264,285], provide valuable insights but are rarely

operationalized in comprehensive resilience frameworks. Similarly, while cross-industry studies like [288] offer valuable perspectives, they do not fully address the integration of sustainability practices with resilience strategies tailored to automotive supply chains. Addressing these gaps necessitates tailored strategies that balance environmental performance with operational efficiency while navigating the complexities of the automotive supply chain.

To bridge these gaps, future research should prioritize developing integrated circular economy models that combine practices such as remanufacturing, end-of-life vehicle recycling, reverse logistics, and closed-loop supply chains. These models must align sustainability objectives with resilience strategies to meet the automotive sector's unique demands. Further empirical validation of digital technologies, including blockchain, IoT, and AI, within sustainable logistics frameworks is essential to explore their role in enhancing resilience while supporting sustainability goals. Adaptive frameworks that align sustainable practices with global disruption management should also be developed, addressing challenges like pandemics, geopolitical risks, economic shocks, and resource dependency. Sector-specific insights are critical for addressing vulnerabilities in automotive supply chains, particularly in achieving regulatory compliance, optimizing resource utilization, and mitigating risks associated with global supplier networks. By addressing these gaps, this study contributes to the broader discourse on sustainable logistics and supply chain resilience. It emphasizes the need for cohesive frameworks that integrate fragmented practices, align digital technologies with resilience strategies, and address the specific challenges of the automotive sector. These contributions offer actionable insights for academia and industry, providing a roadmap for future research and practical applications in developing sustainable and resilient supply chains.

In perspectives to previous studies in the literature, this study bridges critical gaps in the existing literature by integrating sustainability and resilience within supply chains, focusing specifically on the automotive sector. Unlike prior analyses that often address these dimensions independently, this research delves into their intersection, highlighting sector-specific applications. It builds on foundational works such as [262], which explored sustainability's role in enhancing supply chain performance, and [121], which examined resilience strategies centered on risk mitigation. However, these earlier studies largely overlook the synergies between sustainability and resilience, particularly within the complex operational dynamics of automotive supply chains.

Expanding on bibliometric analyses such as those by [38,44], which emphasized integrating sustainability and resilience into supply chains, this study advances the discourse by identifying emerging themes like digitalization, circular economy practices, and adaptive risk management. While studies such as [264] highlight the dual role of circular economy practices in reducing environmental impact and enhancing supply chain adaptability, this research operationalizes those concepts within the automotive sector, addressing critical challenges like end-of-life vehicle recycling and compliance with environmental regulations. Similarly, this study complements [36] by analyzing research trends and thematic clusters that illustrate the transition from theoretical frameworks to actionable insights in sustainability and resilience.

Previous bibliometric reviews, including [42,58,65], mapped general trends in resilient and sustainable supply chains but lacked industry-specific focus. This study narrows its scope to the automotive sector, highlighting its unique vulnerabilities and strategies to address them. For instance, [63] provided foundational insights into resilience strategies and digital technology integration in supply chains, while [88] emphasized the role of digitalization and circular economy practices post-COVID-19. This research extends their findings by exploring the scalability of these practices within the automotive industry, which faces distinct challenges such as high resource dependency, regulatory compliance, and global supply chain disruptions.

The integration of sustainability and resilience in supply chains is increasingly relevant in addressing global challenges like climate change and the COVID-19 pandemic. Conceptual frameworks proposed by [36,38] emphasize the synergistic potential of these dimensions but often lack specific focus on the automotive context. This study contributes by identifying and analyzing emerging trends, such as renewable energy adoption and circular economy practices, which are frequently highlighted in the literature as pivotal for sustainable and resilient automotive supply chains. For example, [195] highlighted the dual challenges of reducing carbon emissions while enhancing adaptability. Through bibliometric analysis, this study synthesizes findings from the literature, including those of [85,86], to illustrate how green logistics and reverse logistics practices are frequently linked to both environmental impact reduction and resilience enhancement.

The automotive supply chain faces distinct challenges, including high resource dependency, stringent environmental regulations, and vulnerability to global disruptions. Foundational studies, such as those by [143,144], explored remanufacturing and green logistics practices but did not fully examine their role in enhancing resilience. Through bibliometric analysis, this study builds on these insights by highlighting how circular economy principles—such as reverse logistics and resource optimization—are linked to reducing environmental impact while improving supply chain adaptability.

Recent works like [71,78] emphasize resilience strategies for navigating volatile, uncertain, complex, and ambiguous [VUCA] environments. However, their focus is primarily on operational resilience, often overlooking sustainability dimensions. This study bridges this gap by emphasizing the role of sustainable logistics practices such as green logistics and circular economy principles in building resilience within the automotive sector. It also complements [242,265], who explored

green closed-loop supply chains during the COVID-19 pandemic, by providing sector-specific insights into compliance with stringent environmental policies. Study by [71], illustrate the role of government interventions, such as emissions regulations, in driving adaptive strategies. This research integrates findings from [1,72] to highlight how blockchain and AI address visibility and traceability challenges in automotive supply chains. By aligning with [74,80], who called for actionable risk mitigation strategies, this study demonstrates how digital tools and green practices are tailored to the automotive industry's complex needs.

Technological innovation emerges as a critical enabler of sustainable and resilient supply chains. Studies like [285,297] the transformative potential of Industry 4.0 and 5.0 technologies, including IoT, blockchain, and AI. Studies such as [49,83] emphasize the potential of blockchain and cybersecurity in optimizing automotive supply chains and mitigating risks associated with digital transformation. This research extends their exploration by focusing on sector-specific applications, such as improving raw material traceability, real-time monitoring of disruptions, and predictive analytics for inventory optimization in automotive supply chains. Building on findings by [52,84], this study underscores the role of AI-driven predictive analytics and IoT-enabled systems in enhancing both supply chain resilience and sustainability. These insights align with the work of [29,82], which emphasize Industry 4.0 technologies' transformative role in optimizing logistics networks and ensuring compliance with environmental regulations.

This study contributes to the literature by addressing the underexplored intersection of sustainability and resilience within the automotive supply chain. Unlike previous bibliometric analyses, such as those by [36,55,65], which mapped thematic trends in sustainability and resilience, this research focuses on sector-specific challenges like regulatory compliance, geopolitical risks, and critical raw material dependencies. It provides actionable insights into operationalizing these dimensions to enhance both environmental and operational resilience. While studies like [79,184] centered primarily on risk mitigation strategies, this research adopts a holistic perspective, integrating sustainability into resilience frameworks. Complementing the findings by [76,85,86], this study demonstrates how practices like end-of-life vehicle recycling and emissions reduction enhance adaptability and sustainability within supply chains.

Compared to general bibliometric studies on supply chain resilience, such as those by [40–42], which explored resilience in developing countries and the food industry, this study highlights the unique risks faced by the automotive sector. By examining practices such as green logistics and circular economy principles in the context of challenges like electric vehicle production, as discussed by [92], this research contributes a sector-specific perspective. Insights from [54,56] further contextualize overarching trends such as green technologies in sustainable supply chain research within the specific operational and environmental goals of the automotive industry.

Building on the works of [51,93], this study emphasizes how IoT applications and blockchain technologies are tailored to meet the unique demands of automotive logistics. These technologies enhance supply chain resilience by facilitating real-time monitoring, predictive analytics, and efficient end-of-life vehicle recycling. Study by [49], highlighted blockchain's potential in optimizing automotive supply chains, and this study extends their work by exploring its integration with sustainability goals. Similarly, [38,68] provided foundational sustainability and risk management frameworks. This research builds on their findings by demonstrating how digital innovations, such as blockchain and IoT, align with green practices to strengthen supply chain resilience and environmental performance.

The scalability of green logistics strategies is another critical area explored in this study. Complementing [57], which examined these trends within small and medium-sized enterprises [SMEs]. By scaling these principles to more complex and expansive automotive supply chains, this study showcases their adaptability across various organizational contexts. Also, [91] highlighted additive manufacturing's transformative potential, particularly in reducing lead times and bolstering resilience. This study further explores these applications by linking additive manufacturing with broader circular economy practices in automotive logistics, such as remanufacturing and resource optimization. In addition, [61] emphasized the role of circular economy principles in sustainable supply chain management, which this study operationalizes specifically within the automotive logistics sector. In alignment with [63], which analyzed digital innovation and data analytics for supply chain resiliency, this study demonstrates their application to address automotive-specific challenges. It operationalizes the frameworks proposed by [36,44], with a focus on the unique logistical demands of the automotive sector. By synthesizing findings from bibliometric analyses such as [22], which addressed climate change impacts, and [43], which examined strategic alliances for resilience, this research underscores its interdisciplinary and sector-specific contributions to sustainable logistics.

Further studies, such as [47], which explored green logistics and remanufacturing, and [58,87], which mapped sustainable supply chain themes, emphasize the importance of reverse logistics and emissions reduction as critical components of a resilient automotive supply chain. Similarly, [48,299] provided broader insights into disruption risks in supply chain management, which this study narrows down to address vulnerabilities specific to automotive logistics. Additionally, [59] provided valuable insights into the application of fuzzy methods in green supply chains, highlighting their potential for enhancing decision-making in areas such as reverse logistics and emissions reduction. While this study does not directly

contextualize fuzzy methods, their relevance to adaptive strategies in the automotive sector underscores an important avenue for future research.

In conclusion, this study builds on and integrates findings from bibliometric analyses, such as those by [60,66,67], to offer a comprehensive framework tailored to the automotive sector. By addressing the dual challenges of sustainability and resilience, it advances the understanding of sustainable logistics through key trends such as circular economy practices, digitalization, and adaptive management. These findings showcase the integration of sustainability into resilience frameworks, emphasizing the sector-specific challenges and opportunities within the automotive industry. The study underscores the interconnectedness of sustainability and resilience in modern supply chains and provides actionable insights for academia and industry. By identifying critical gaps—such as the limited alignment of digital technologies with resilience frameworks and the fragmented exploration of sustainable practices—it offers a roadmap for future research. Tailored strategies, including renewable energy adoption, green logistics, and circular economy models, are proposed to address these gaps and operationalize sustainability and resilience in automotive supply chains. This contribution not only enriches the academic discourse but also delivers practical solutions for enhancing resilience in supply chains, establishing this research as a novel and impactful addition to the field.

5. Conclusions

This study provides a comprehensive examination of the intersection between sustainable logistics practices and supply chain resilience, with a specific focus on the automotive sector. Through bibliometric analysis and thematic clustering, the research identifies key trends such as green logistics, circular economy principles, and digital transformation as essential drivers for enhancing supply chain adaptability and mitigating vulnerabilities. These findings underscore the transformative potential of integrating sustainability into resilience frameworks, particularly in industries characterized by complex, global supply chains. By addressing three key research questions, this study further delineates emerging trends, dominant research areas, and critical gaps, advancing both academic understanding and practical applications.

The analysis reveals that green logistics and circular economy principles, including reverse logistics, remanufacturing, and resource optimization, are pivotal for reducing environmental impact while simultaneously strengthening supply chain resilience. Digital technologies, such as blockchain, IoT, and AI, further enhance transparency, traceability, and predictive decision-making, enabling more agile and robust supply chain operations. However, the findings also underscore the fragmented adoption of these practices, with limited alignment between sustainability goals and resilience frameworks, particularly in the automotive sector. This fragmentation highlights the need for cohesive and scalable solutions tailored to the specific operational complexities and regulatory requirements of the industry.

This study also emphasizes the critical challenges of achieving regulatory compliance, reducing carbon emissions, and adapting to climate change, which remain key priorities for sustainable supply chains. By linking environmental goals with operational strategies, the research provides actionable insights for integrating sustainable practices into resilience frameworks, addressing both immediate disruptions and long-term vulnerabilities. The research highlights sector-specific strategies, such as leveraging Industry 4.0 technologies, implementing closed-loop supply chains, and aligning with global environmental standards, as vital for operationalizing sustainability within the automotive sector.

Despite its contributions, this research identifies an urgent need for empirical validation of the proposed frameworks, particularly in diverse industry and regional contexts. Addressing these gaps will provide more robust evidence on the measurable impact of sustainable logistics practices on supply chain resilience. Additionally, the automotive sector's unique challenges, such as high resource dependency and stringent environmental regulations, demand tailored strategies that balance sustainability goals with operational efficiency. This study further emphasizes the importance of cross-industry comparisons to identify transferable best practices, offering a broader perspective on how integrated frameworks can drive resilience across global supply chains.

In conclusion, this study contributes to the discourse on sustainable supply chain management by offering a nuanced understanding of how sustainability and resilience intersect in the context of modern supply chains. The findings underscore the importance of adopting integrated approaches that combine environmental sustainability with technological advancements to build robust, adaptable supply chains. By addressing critical gaps and providing actionable recommendations, this research lays the groundwork for future studies and practical applications, particularly in high-impact sectors like automotive. It bridges critical gaps in the literature by aligning sustainability and resilience, providing both a theoretical foundation and practical roadmap for advancing sustainable and resilient supply chain frameworks.

6. Limitations

While this study provides significant insights into the intersection of sustainable logistics and supply chain resilience, certain limitations must be acknowledged. The bibliometric analysis relies primarily on data extracted from the Scopus database. Scopus is widely recognized for its extensive coverage of high-quality, peer-reviewed publications, advanced citation tracking, and compatibility with bibliometric tools like VOSviewer and Biblioshiny. While Scopus provides a comprehensive and multidisciplinary range of peer-reviewed literature, the inclusion of other databases, such as Web of Science, might have yielded additional insights. However, given

Scopus's extensive coverage and high-quality indexing, this database was deemed adequate for capturing the primary trends, influential authors, and key themes within the fields of sustainable logistics and supply chain resilience. Nonetheless, this reliance may limit the comprehensiveness of the research landscape analyzed. Future studies should consider integrating multiple databases to ensure broader coverage, cross-validation of findings, and a more robust analysis of emerging studies and perspectives.

Another limitation lies in the static nature of the bibliometric approach, which does not account for the dynamic evolution of sustainable logistics and resilience practices over time. Longitudinal studies and real-time analyses are needed to capture the progression and adaptation of these practices in response to global challenges, such as climate change and geopolitical disruptions. Incorporating such methodologies would enhance understanding of the temporal dimensions of sustainability and resilience integration. The absence of empirical validation represents another critical limitation. While the study establishes strong theoretical connections between sustainable logistics practices—such as green logistics, circular economy principles, and digital technologies—and supply chain resilience, it lacks primary data collection or case studies to substantiate these relationships. Empirical investigations are necessary to measure the tangible impact of these practices on resilience, particularly in industries like automotive, where the complexity of supply chains magnifies the challenges of achieving sustainability goals.

Regional and industry-specific variations were also not deeply explored in this research. Contextual factors, such as regulatory environments, cultural influences, and economic conditions, significantly shape the adoption and effectiveness of sustainable logistics practices. Future studies should prioritize examining these variations to provide more actionable insights tailored to specific industries or regions. Despite these limitations, this study lays a robust foundation for further exploration and serves as a valuable resource for academics and practitioners. Addressing these gaps through empirical validation, real-world case studies, and contextual analyses will strengthen the field's understanding of how sustainable logistics can effectively enhance supply chain resilience.

7. Future Research Directions

This study highlights critical intersections between sustainable logistics and supply chain resilience, while also identifying several key areas for future research. Building on the findings, subsequent studies should address the need for empirical investigations that measure the tangible impact of sustainable logistics practices—such as green logistics, circular economy principles, and digital technologies—on enhancing supply chain resilience. Future research should focus on developing integrated frameworks that combine these practices and evaluate their collective impact on resilience outcomes. Researchers can implement empirical validation through case studies, industry-specific analyses, and primary data collection to substantiate these theoretical connections and provide actionable insights for practitioners. In particular, longitudinal studies and case-specific analyses are vital for understanding how these practices influence supply chain adaptability over time and across diverse industry contexts.

To address methodological limitations in this study, future research should incorporate data from multiple bibliometric databases, such as Web of Science, alongside Scopus. This multi-database approach would enhance the comprehensiveness and robustness of the research landscape by capturing a broader range of perspectives and emerging studies, while addressing the inherent limitations of relying on a single database. Cross-validation of findings through such integration would further strengthen the reliability of insights into the research landscape.

Future research should also focus on quantifying the economic, social, and environmental impacts of supply chain disruptions. For industries with global and intricate supply chains, such as automotive, disruptions can have far-reaching consequences, including job losses, supply shortages, and social instability. Researchers could explore methods such as scenario analyses, economic modeling, and stakeholder interviews to capture these broader implications, particularly in resource-intensive sectors like automotive. Understanding the interplay between regulatory compliance, operational efficiency, and sustainability goals in these disruptions would provide deeper insights, offering actionable strategies for mitigating both immediate and long-term risks.

The integration of emerging technologies—blockchain, AI, IoT, and digital twins—into sustainable logistics practices requires further exploration. While this study emphasizes the potential of these technologies to enhance transparency, efficiency, and risk management, empirical validation of their effectiveness in real-world scenarios is necessary. Empirical methods, such as simulation studies, pilot projects, and comparative analyses, could assess the effectiveness and scalability of these technologies in improving supply chain visibility and resilience. For instance, studies could investigate how digital tools facilitate real-time monitoring and predictive analytics in the automotive sector, ultimately enhancing supply chain adaptability. Additionally, examining the cost-effectiveness, scalability, and implementation challenges of these technologies across different industries and regions would provide a deeper understanding of their practical applications, particularly in resource-intensive sectors like automotive.

The application of circular economy principles—such as reverse logistics, resource optimization, and closed-loop supply chains—presents a promising area for further investigation. Case studies and experimental research could evaluate the long-term performance of these strategies in mitigating disruptions and reducing environmental impact. Research could also explore the scalability of circular economy models across different industries and regions. Future studies should focus on how these principles can align with advanced digital tools to

develop cohesive frameworks that simultaneously address resilience and sustainability.

Future studies should also examine regional and sector-specific variations in the adoption of sustainable logistics practices. Comparative research across diverse sectors—such as healthcare, electronics, and agriculture—could uncover best practices, identify gaps, and offer actionable insights for developing sector-specific resilience frameworks. Understanding how local regulatory frameworks, cultural factors, and economic conditions shape the implementation and effectiveness of these practices is critical for developing tailored strategies.

Social and ethical dimensions of supply chain practices warrant greater attention in future studies. Survey-based research and qualitative methods, such as interviews and focus groups, could examine labor standards, environmental justice, and the role of sustainability in fostering trust and collaboration among supply chain stakeholders. The adoption of green transportation, route optimization, and climate-resilient logistics systems could also provide insights into building supply chains capable of real-time adaptation to environmental challenges.

Lastly, investment in resilient and sustainable infrastructure represents a crucial avenue for research. For the automotive industry, this entails exploring the role of renewable energy, energy-efficient manufacturing, and smart logistics systems in supporting localized production and reducing dependency on vulnerable global supply chains. Mixed-method approaches, combining quantitative assessments and qualitative case studies, could explore the effectiveness of these investments in aligning sustainability objectives with operational goals and resilience factors. Future research should address the interplay between infrastructure investments and policy frameworks, such as government regulations, international standards, and public-private partnerships, to enhance their collective impact on sustainability and resilience. By addressing these directions, future research can expand the understanding of sustainable logistics and resilience, providing the theoretical and empirical foundations needed to navigate the complexities of an increasingly volatile global supply chain environment.

Conflict of Interest Statement

The authors declare that there is no conflict of interest in the study.

CRediT Author Statement

Shereen Abdelaziz: Conceptualization, resources, data curation, methodology, writing – original draft preparation.
Munjiati Munawaroh: Supervision, validation, review & editing.

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