Resilience and Sustainability of Supply Chains Facing Global Challenges: A Systematic Literature Review

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Abstract. Supply chain (SC) resilience has become a critical concern as globalization increases vulnerability to various types of disruptions. Effective disruption management requires appropriate analytical and decision-support tools. To identify key challenges, aggravating factors, and their impacts on supply chain performance, this study conducts a systematic literature review of existing models addressing resilience and sustainability issues. A content analysis was performed on a corpus of 24 peer-reviewed articles, following a rigorous and transparent selection methodology. The review synthesizes fragmented research into structured categories of challenges and strategies, and proposes an initial integrative model to improve both the resilience and sustainability of supply chains across sectors. The findings provide a foundation for future empirical research and model-based optimization frameworks.

1 Introduction

Companies now compete as part of interconnected supply chains, where efficiency is essential to meet fast-changing customer demands and shorter product cycles. Supply chains have shifted from cost-oriented models to value-driven and demand-focused systems. Although Supply Chain Management (SCM) is a relatively recent discipline, it has become a strategic priority under globalization to optimize complex structures and enhance performance.

Resilience, has become increasingly critical as supply chains face growing exposure to disruptions. Supply chain digitization improves efficiency, interconnectivity, and data-driven decision-making, strengthening resilience. However, neglecting risks can lead to severe operational interruptions.

This article reviews the main challenges of multi-level supply chain management and existing approaches to resilience and sustainability. It aims to identify key issues and analyze quantitative methods that support decision-making in complex and uncertain environments.

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2 Research Methodology

This study conducts a systematic literature review (SLR) to identify challenges and approaches for enhancing supply chain sustainability and resilience, following the phases of planning, conducting, and reporting.

3 Phase 1: Planning the Review

This research aims to identify sustainability and resilience challenges in multi-level supply chains and the approaches used to address them through a systematic review.

3.1 Research Questions

The first objective of this research is to develop research questions concerning the sustainability and resilience challenges faced by multi-level supply chains, and the various strategies implemented to address these challenges. We selected a suitable database, developed search strings, defined inclusion and exclusion criteria, and established quality assessment criteria. Each of these steps is described in detail below.
Q1) What are the main categories of challenges impacting the resilience and sustainability of multi-level supply chains?
Q2) What strategies and approaches are companies currently implementing to overcome these challenges within multi-level supply chains?

3.2 Data Sources

The table below presents the electronic databases used for the literature review, including the sources consulted, the types of documents searched, and the selection criteria applied.

Table 1. Electronic databases and search parameters used in the systematic literature review.

Electronic databases	Science direct (sciencedirect)
	Researchegate (researchgate.net)
	Scopus (www.elsevier.com)
Searched articles	Journal articles
Applied research	Articles with keywords supply chain, resilience, sustainability
Language	English
Publication period	2017 --- 2024
Search mechanism	Digital libraries vary in their search mechanisms and capabilities; consequently, our search strings have been adapted to optimize the relevance and efficiency of the results obtained.

3.3 Search Strings

The complete research chains have been developed using key terms relating to challenges and approaches to supply chain sustainability and resilience. These terms are drawn from existing research articles on supply chain management. The research chains, together with the corresponding data sources consulted for this study, are listed in Table 2.

Table 2. Search string used.

Keywords	Database
Supply chains and sustainability	Science direct
Supply chain resilience	Researchegate
Supply chain risk management	Scopus / Researchegate

3.4 Inclusion Criteria

The following criteria were used to select relevant literature to explore from search strings for data extraction:

- Each article must be published in a journal or presented at a conference.
- Articles must be related to the sustainability and resilience of supply chains.
- Articles containing our research chains in their titles are selected.
- The introduction and conclusion of these articles are then examined.
- In the next phase, all the introductions and conclusions of these articles are carefully read.
- All articles are then studied in depth.
- Articles must be written in English.
- Only articles published between January 2017 and January 2024 are considered.

3.5 Exclusion Criteria

Exclusion criteria discard irrelevant results from the total selected literature associated with search strings. Here are the exclusion criteria for the current search:

- Eliminate articles that do not contain our search strings.
- In the case of repetition, only the most complete and recent version of the published article is included.

3.6 Primary Study Selection

Initially, 50 research papers were identified using predefined search strings across the online repositories listed in Table 1. These databases included Scopus, ScienceDirect, SpringerLink, IEEE Xplore, and ResearchGate. The retrieval process was conducted in alignment with the inclusion and exclusion criteria defined in Section 3.4 & 3.5, ensuring that only studies explicitly addressing supply chain resilience, sustainability, or their integrated modeling approaches were considered.
During the screening phase, duplicate records and papers that did not meet the relevance threshold (e.g., those focusing solely on logistics performance, isolated risk management, or non-industrial contexts) were excluded. After applying these criteria, the corpus was reduced from 50 initially evaluated studies to 21 final articles, which demonstrated sufficient methodological rigor, conceptual clarity, and thematic alignment with the objectives of this review.

4 Phase 2: Review Results

To enhance the clarity and synthesis of the analysis, the results of the literature review are organized into three main categories of challenges, each summarized in synthetic tables (Tables 3–5) and illustrated by figures (Figures 1–3). These tables replace lengthy descriptive passages to provide a more structured overview of the findings

4.1 Categories of challenges impacting the resilience and sustainability of multi-level supply chains

Our analysis of the 21 articles in the literature review revealed a wide range of issues, which we have chosen to structure in the form of categories. This approach, which reflects our original approach, not only clarifies the diversity of the issues identified, but also enables us to better pinpoint priority areas for in-depth, targeted analysis.
In the face of constant change, the supply chain is seen as vulnerable to risk [1]. Risk and resilience are intrinsically linked, with risk defined as the expected outcome of an uncertain event [2]. Risks can be classified into several categories, including internal risks (supply, demand, infrastructure) and external risks (regulatory, legal and bureaucratic) [3]. Supply chain resilience is defined as its ability to adapt and recover from disruptions, while maintaining business continuity [4]. It includes several dimensions such as prevention, resilience, responsiveness, recovery and continuity, as well as learning and continuous improvement [3]. Building a resilient supply chain requires proactive, reactive and anticipatory/awareness strategies, as well as trade-offs between flexibility and redundancy [4].

4.2 Category 1: Lack of supply chain resilience

Category 1 encompasses structural and operational weaknesses that undermine the capacity of multi-level supply chains to resist and recover from disruptions. These issues often arise from excessive cost-reduction strategies, globalized sourcing, and insufficient coordination between partners. Table 3 summarizes the main sub-categories and key findings from representative studies.

Table 3. Key challenges affecting multi-level supply chain resilience.

Sub-category / Issue	Description / Key Insights	Representative Studies
Hidden Costs & Global Disruptions	Globalized sourcing and cost-reduction strategies increase vulnerability, leading to higher indirect costs, delays, and management complexity.	[5], [6]
Vulnerability to LFHEs	Low-frequency, high-impact events (pandemics, natural disasters) disrupt global networks and expose weak recovery capacities.	[7], [8]
Uncertainty & Variability	Poor coordination between demand forecasting and transport planning due to lack of supply chain visibility (SCV).	[9], [10]
Multi-level and Geographical Dispersion	Complex, geographically spread networks require regional risk management and flexibility to cope with disruptions.	[11]

As shown in Figure 1, these challenges form a coherent structure where operational vulnerabilities and geographical dispersion jointly weaken resilience mechanisms.

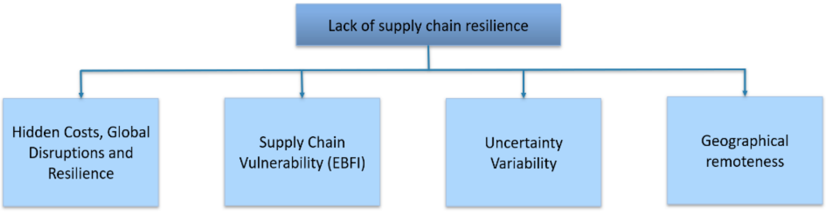

Fig. 1. Structural overview of Category 1 challenges: operational vulnerabilities, geographical dispersion, and their combined impact on supply chain resilience.

4.3 Category 2: The challenge of integrating sustainability into supply chain management

The second category focuses on sustainability-related challenges. While sustainability is increasingly integrated into supply chain design, firms still face difficulties balancing economic competitiveness with environmental responsibility. Table 4 summarizes the main sustainability-oriented challenges and insights reported in the literature.

Table 4. Sustainability integration challenges in supply chain management.

Sub-category / Issue	Description / Key Insights	Representative Studies
Regulatory Pressure & Environmental Risks	Limited preparedness for environmental disruptions; lack of detailed mitigation strategies and compliance mechanisms.	[12]
Competition vs Environmental Awareness	Firms must balance competitiveness with sustainability, requiring long-term investment in green practices and technologies.	[12]
Sensitivity of Green Supply Chains	Green systems can be fragile and costly to maintain during disruptions, affecting operational continuity.	[12]
Integration of Reverse Flows	Reverse logistics and recycling processes remain difficult to incorporate into traditional linear supply networks.	[13]

Figure 2 highlights how sustainability integration intersects with economic and environmental dimensions, revealing systemic tensions between efficiency and ecological responsibility.

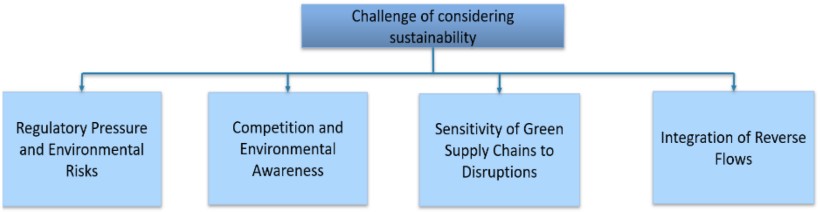

Fig. 2. Category 2 – Sustainability integration challenges in supply chain management.

4.4 Category 3: Risk Management in Operations and Supply Chains

The third category concerns the lack of methodological and operational maturity in risk management practices across supply chains. While several studies acknowledge the role of risk quantification and intervention mechanisms, their application remains fragmented. Table 5 provides a synthesis of the main risk management challenges.

Table 5. Risk management challenges and intervention mechanisms in multi-level supply chains.

Sub-category / Issue	Description / Key Insights	Representative Studies
Risk Measurement	Absence of standardized indicators and limited methods for quantifying uncertainty and risk exposure.	[14]
Intervention Design	Insufficient detail on the nature, scope, and cost-effectiveness of interventions across supply chain actors.	[14]
Final Participant Definition	Ambiguity in identifying the ultimate actor affected by disruptions (manufacturer, distributor, or end consumer).	[14]

As illustrated in Figure 3, effective risk management requires an integrated perspective linking risk identification, assessment, and mitigation across all levels of the supply chain.

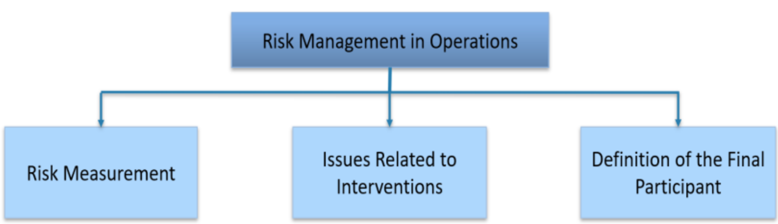

Fig. 3. Category 3 – Risk management challenges and intervention mechanisms in multi-level supply chains.

4.5 Summary of issues related to the resilience and sustainability of the supply chain

In conclusion, it is important to emphasize that the supply chain is a complex structure, composed of several levels ranging from the initial supplier to the final consumer. This complexity, exacerbated by multiple issues that we have grouped into categories and subcategories such as the instability of logistical flows, technological vulnerabilities, and intersectoral dependencies, increases the chain's sensitivity to external disruptions. Among the aggravating factors identified through our analysis are, for example, geographical remoteness, the multi-level aspect, and regulatory uncertainty. This complexity leads to the emergence of what [15] call a "nervous supply chain." It is characterized by delivery delays, stock shortages, and increased emergency costs, which can lead to customer dissatisfaction. The management of this nervousness relies on strategies aimed at mitigating the effects of fluctuations and uncertainty by enhancing visibility, communication, and responsiveness to changes in demand or market conditions.

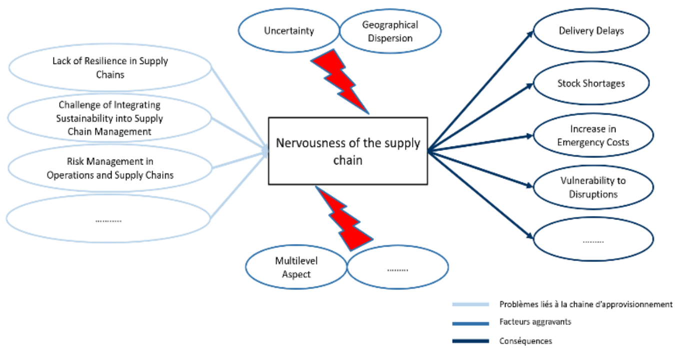

Fig. 4. Nervousness of the supply chain.

In summary, supply chains face risks from high-impact events, regional disruptions, and environmental challenges. Robust strategies are needed to enhance resilience, and existing approaches are examined to provide practical recommendations for improving supply chain performance.

5 Phase 3: Discussion

In the current context of economic globalization and climate change, supply chains face increasing risks and uncertainties. Disruptive events such as the COVID-19 pandemic, natural disasters, and geopolitical crises significantly affect production, distribution, and logistics operations. These disruptions expose vulnerabilities in global infrastructure and logistics networks, resulting in product shortages, delivery delays, and increased operational costs—highlighting the "nervousness" of modern supply chains.

- **Linking Challenges and Strategies**: The analysis of the literature reveals that the challenges identified in Tables 3–5—ranging from structural weaknesses and lack of visibility to sustainability integration gaps and insufficient risk management—can be mitigated through targeted strategies. Adaptive measures such as supply diversification, digitalization, AI-enabled forecasting, Industry 4.0 technologies, and enhanced coordination among multi-level partners are central to improving both resilience and sustainability. For instance, multi-regional sourcing mitigates the impact of localized disruptions, while green logistics practices address environmental vulnerabilities.
- **Integration Gaps between Resilience and Sustainability**: Despite advances, the literature shows limited integration of resilience and sustainability strategies. Most studies treat these dimensions separately, resulting in suboptimal solutions. For example, while sustainability initiatives often prioritize environmental goals, they may inadvertently reduce operational flexibility, thereby compromising resilience. Conversely, resilience-focused strategies may overlook environmental and long-term sustainability considerations. Our synthesis highlights the need for integrative models that simultaneously account for economic, environmental, and operational performance.
- **Comparison with Previous Reviews**: Compared with prior systematic reviews, this study provides a more structured analytical synthesis of 24 recent studies, clearly categorizing challenges and linking them with potential mitigation strategies. Earlier reviews primarily described issues narratively or focused on

single dimensions (resilience or sustainability), whereas our approach emphasizes the interconnectedness of challenges and strategies and the identification of gaps in integrative practices.

- **Implementation Considerations**: While strategies are promising, implementation is context-dependent. No "one-size-fits-all" solution exists, as each supply chain exhibits unique vulnerabilities and operational characteristics. Effective adoption requires customized solutions tailored to specific network structures, industry sectors, and regional constraints. Moreover, selecting appropriate metrics and monitoring mechanisms is critical to evaluate both resilience and sustainability outcomes.

6 Conclusion and perspective

This study provides a comprehensive examination of low-frequency, high-impact disruptive events affecting global supply chains, emphasizing their implications for both resilience and sustainability. Events such as pandemics, geopolitical tensions, or natural disasters cause cascading disruptions, revealing structural fragilities, limited visibility, and inadequate coordination mechanisms across multi-tier networks.

Key Contributions

• Structured Categorization of Challenges: The study introduces a systematic framework that classifies supply chain disruptions into three overarching categories—structural, operational, and contextual—thereby enabling a holistic understanding of vulnerabilities rather than treating them as isolated issues.

• Analytical Synthesis of 20 Studies: Through a cross-comparison of empirical and conceptual works, the review identifies recurring weaknesses (e.g., dependency on single suppliers, lack of flexibility, insufficient digital integration) and assesses the strengths and limitations of mitigation strategies currently used in literature.

• Proposal of an Integrative Model: Unlike previous reviews that often treated resilience and sustainability as distinct or sequential dimensions, this study proposes a unifying conceptual model that jointly optimizes both. This integrative approach fills a key research gap by addressing the dynamic interdependence between short-term responsiveness and long-term sustainability objectives.

Novelty and Added Value

The originality of this work lies in its dual analytical perspective: (1) a multi-level analysis of supply chain vulnerabilities, spanning strategic, tactical, and operational dimensions; and (2) a concurrent integration of resilience and sustainability parameters within a single modeling framework. Whereas prior reviews tended to focus either on sustainability metrics or on recovery-oriented resilience mechanisms, our study explicitly links both domains, providing a foundation for the co-design of resilient–sustainable systems.

Implications and Future Research Directions

Future investigations should move beyond descriptive assessments of disruptions to develop hybrid, data-driven models that quantify trade-offs and synergies between resilience and sustainability. Specifically:

- Explore multi-objective optimization approaches combining resilience metrics (e.g., recovery time, adaptability) with sustainability indicators (e.g., carbon footprint, resource efficiency).
- Employ digital enablers such as AI, digital twins, and blockchain to simulate real-time responses and enhance transparency across multi-tier supply networks.

- Extend research to context-specific analyses (e.g., energy transition, electric vehicles, critical raw materials) to validate the generalizability of the proposed framework.

Overall, this study not only consolidates fragmented insights from the existing literature but also establishes a conceptual and methodological foundation for designing integrative, technology-enabled models that simultaneously strengthen resilience and sustainability. It thus offers both scholars and practitioners a forward-looking roadmap for building adaptive, responsible, and future-proof global supply chains.

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