

# Presenting a conceptual model to identify the dimensions, components, and applications of a resilient green supply chain

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## Abstract

Resilient green supply chains integrate sustainability and robustness, enabling businesses to adapt to disruptions while prioritizing environmental responsibility. This research proposes a conceptual model that identifies crucial dimensions, components, and applications of resilient green supply chains. The study highlights critical dimensions such as sustainability, flexibility, risk management, and technological integration by synthesizing existing literature and applying a systematic approach. Components like supplier collaboration, circular economy practices, and renewable energy adoption are emphasized as vital for achieving resilience. Furthermore, practical applications, including disaster recovery frameworks and eco-friendly procurement strategies, are explored to demonstrate the model's relevance in real-world scenarios. The proposed model provides a holistic perspective, offering strategic insights for stakeholders seeking to enhance environmental and operational performance. This study is a foundation for future research and practical implementations, addressing the growing need for sustainable and resilient supply chain systems in today's dynamic global environment.

**Keywords:** Resilient green supply chain, sustainability, supply chain resilience, circular economy, risk management, eco-friendly practices, green logistics, technological integration.

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## 1- Introduction

The global economy is increasingly interconnected, with supply chains as critical backbones for industries worldwide. However, as these networks become more complex, they are more vulnerable to various disruptions. Natural disasters, geopolitical instability, pandemics, and cyberattacks can have cascading effects, causing delays, increased costs, and even total operational shutdowns. Simultaneously, growing environmental concerns, driven by climate change, resource depletion, and stricter regulations, compel organizations to reevaluate their sustainability practices. Against this backdrop, the Resilient Green Supply Chain (RGSC) concept has gained prominence as a strategic solution, merging the principles of resilience and sustainability to build supply chains that are environmentally responsible and robust against disruptions (Aliahmadi et al., 2013).

This study proposes a conceptual model to identify the dimensions, components, and applications of RGSCs. It aims to bridge the gap between theory and practice, offering actionable insights for academics, policymakers, and practitioners striving to create supply chains that balance economic, environmental, and social imperatives (Nozari, 2023).

Traditional supply chains have been predominantly focused on cost efficiency and speed, often at the expense of sustainability and adaptability. For decades, the emphasis on lean practices and global outsourcing has optimized operations but left supply chains vulnerable to shocks. Recent events, such as the COVID-19 pandemic, highlighted the fragility of global supply networks, where disruptions in one region caused widespread ripple effects. Coupled with increasing pressure to reduce environmental impact, businesses now face a dual challenge: to ensure operational continuity while meeting sustainability goals (Nozari et al., 2022).

The intersection of resilience and green supply chain management is relatively unexplored yet increasingly vital. In the context of supply chains, resilience refers to the ability to anticipate, adapt to, and recover from disruptions. On the other hand, green supply chain management focuses on minimizing environmental impacts through waste reduction, energy efficiency, and adopting renewable resources. Integrating these two paradigms creates a synergistic framework that protects supply chains against shocks and aligns with global sustainability objectives (Najafi et al., 2022).

Organizations that embrace RGSCs stand to gain significant advantages. Resilient supply chains can quickly recover from disruptions, minimizing losses and maintaining customer trust. Green supply chains, meanwhile, reduce environmental impacts, enhance brand reputation, and comply with regulatory requirements. Together, these attributes enable organizations to achieve long-term competitiveness and operational excellence.

The remainder of this paper is organized as follows: Section 2 delves into the theoretical underpinnings of RGSCs, presenting a detailed literature review. Section 3 outlines the proposed conceptual model, discussing its dimensions, components, and applications. Section 4 illustrates the model's practical relevance through case studies and examples. Finally, Section 5 concludes the study with key findings, implications, and recommendations for future research. This study lays the groundwork for advancing RGSCs as a critical framework in modern supply chain management by addressing the intertwined challenges of sustainability and resilience.

## 2- Literature Review

The concept of resilient green supply chains (RGSCs) represents the convergence of two significant paradigms in supply chain management: resilience and sustainability. While these domains have traditionally been studied separately, recent research highlights the growing necessity of integrating them to address modern supply chain challenges. This literature review synthesizes critical studies that explore the dimensions, components, and applications of RGSCs, providing a foundation for the conceptual model proposed in this research.

Resilience is critical for supply chains operating in today's volatile environment. According to Christopher and Peck (2004), resilience refers to a supply chain's ability to anticipate, absorb, adapt to, and recover from disruptions. The authors emphasize that building resilience requires a combination of proactive strategies, such as risk assessment, and reactive measures, including flexible sourcing and rapid response mechanisms. Similarly, Sheffi (2005) highlights the importance of agility and redundancy in creating robust supply chains capable of enduring unpredictable challenges. These

studies underscore resilience as a dynamic capability that enables firms to maintain operational continuity and meet customer demands even under stress.

Technology also plays a pivotal role in enhancing resilience. For example, Ivanov and Dolgui (2020) discuss the use of digital tools, such as artificial intelligence (AI), predictive analytics, and digital twins, to improve risk forecasting and decision-making. Their work demonstrates that advanced technologies enable supply chains to identify potential vulnerabilities and implement timely interventions. However, while resilience-focused research provides valuable insights, it often overlooks the environmental impacts of these strategies, pointing to the need for integrated frameworks that incorporate sustainability.

Green supply chain management (GSCM) focuses on minimizing the environmental footprint of supply chain activities. Sarkis (2012) defines GSCM as integrating sustainable environmental practices into supply chain processes, including procurement, manufacturing, distribution, and reverse logistics. These practices aim to reduce waste, lower greenhouse gas emissions, and promote resource efficiency.

One of the critical frameworks in GSCM is the circular economy, which advocates for the continuous use of resources through recycling, remanufacturing, and reuse (Geissdoerfer et al., 2017, Rahmaty & Nozari, 2023). This model enhances sustainability and mitigates supply chain risks associated with resource scarcity. Another critical aspect of GSCM is green procurement, which emphasizes sourcing materials from environmentally responsible suppliers. Zhu, Sarkis, and Lai (2008) highlight the importance of supplier collaboration in achieving green objectives, noting that sustainable supply chains require strong partnerships across the value chain.

Despite the advances in GSCM research, existing studies often fail to address the resilience aspect of green supply chains. While green practices reduce long-term risks, they may inadvertently create vulnerabilities. For instance, reliance on renewable energy sources can expose supply chains to disruptions caused by weather variability. These trade-offs highlight the need for integrated approaches that balance sustainability with resilience.

Integrating resilience and sustainability in supply chains is a relatively recent area of inquiry. According to Ghadge, Dani, and Kalawsky (2012), the combined framework of RGSCs addresses the dual challenge of mitigating environmental impact and enhancing operational robustness. The authors propose that resilience and sustainability are complementary rather than conflicting objectives, as sustainable practices often reduce risk. For example, diversifying suppliers to ensure continuity during disruptions can also promote ethical sourcing, a key component of GSCM.

A comprehensive study by Fahimnia, Sarkis, and Davarzani (2015) explores the synergies between resilience and sustainability. The authors identify common strategies, such as inventory management, flexible transportation, and green technologies that enhance resilience and reduce environmental impact. Their work provides a valuable foundation for conceptualizing RGSCs as integrated systems prioritizing long-term viability and immediate adaptability.

However, research also highlights the challenges of integrating these paradigms. Seuring and Müller (2008) argue that the transition to RGSCs requires overcoming organizational silos, as sustainability and resilience are often managed by separate teams. Additionally, cost considerations can impede the adoption of integrated strategies, as green practices and resilience measures often entail significant upfront investments.

Emerging technologies are critical enablers of RGSCs. For instance, blockchain technology improves transparency and traceability, ensuring compliance with sustainability standards while enhancing resilience against fraud and counterfeiting (Saber et al., 2019). Similarly, the Internet of Things (IoT) facilitates real-time monitoring of supply chain activities, enabling firms to identify and respond to disruptions quickly (Kumar et al., 2021).

AI and machine learning also play a transformative role by enabling predictive capabilities. Ivanov, Dolgui, and Sokolov (2019) discuss how AI-driven models can optimize supply chain design, balancing cost, resilience, and sustainability trade-offs. However, while technology offers significant potential, its implementation must align with organizational goals and stakeholder expectations to realize its full benefits.

Despite significant progress in resilience and sustainability research, several gaps remain. First, there is limited empirical evidence on the practical implementation of RGSCs, particularly in emerging markets. Second, existing frameworks often focus on specific industries, such as manufacturing, limiting their generalizability. Third, the role of external factors, such as regulatory policies and

consumer behavior, in shaping RGSCs is underexplored. This study addresses these gaps by proposing a holistic model integrating resilience and sustainability across diverse contexts.

The literature underscores the importance of integrating resilience and sustainability to create robust, flexible, and environmentally responsible supply chains. While resilience ensures operational continuity in the face of disruptions, sustainability aligns supply chain practices with long-term environmental goals. By synthesizing insights from resilience theory, GSCM, and technological advancements, this review highlights the need for comprehensive frameworks that address the complexities of modern supply chains. The proposed conceptual model builds on these insights, offering a structured approach to designing and implementing RGSCs.

### 3- Methodological Framework

The methodological framework for this research is designed to systematically develop and validate a conceptual model that identifies the dimensions, components, and applications of a resilient green supply chain (RGSC). This framework integrates qualitative and quantitative research methods, ensuring a comprehensive approach to theory development and practical validation.

### 4- Research Design

The study adopts an exploratory research design aimed at synthesizing existing knowledge and uncovering new insights into integrating resilience and sustainability within supply chains. The research progresses in three stages:

- Stage 1: Literature Review and Theoretical Analysis—to establish a theoretical foundation, a systematic review of existing studies on supply chain resilience, green supply chain management, and their intersection is conducted.
- Stage 2: Expert Consultation—Industry practitioners' and academic experts' insights are gathered to refine the identified dimensions and components.
- Stage 3: Case Study Analysis—Real-world applications are analyzed to validate and illustrate the conceptual model's practical relevance.
- The proposed model is validated through expert feedback and real-world case studies.
- Expert Validation: A panel of industry and academic experts reviews the model and provides feedback on its theoretical and practical robustness. Based on their suggestions, revisions are made.
- Case Study Validation: The model is tested against case study findings to ensure alignment with real-world practices and outcomes.

Table 1 shows the Summary of the Framework.

**Table 1:** Summary of Framework

<b>Stage</b>	<b>Objective</b>	<b>Method</b>
Literature Review	Identify dimensions and components of RGSCs	Systematic review of academic sources
Expert Consultation	Refine dimensions and components	Semi-structured interviews
Case Study Analysis	Validate and illustrate model applications	Document analysis and interviews
Conceptual Model Development	Develop an integrated RGSC framework	Synthesis of findings
Validation and Refinement	Ensure model robustness and applicability	Expert panel and comparative analysis

### 5- Research Findings

The findings of this study provide a comprehensive understanding of the dimensions, components, and applications of Resilient Green Supply Chains (RGSCs). Based on a literature review, expert consultations, and case studies, the findings are organized into three key areas:

dimensions, components, and applications. These findings are visualized in a conceptual framework to highlight their interrelationships.

#### 1. Dimensions of RGSCs

The dimensions represent the foundational attributes of RGSCs, encompassing resilience and sustainability principles:

##### 1. Sustainability:

- Focuses on reducing environmental impact and promoting eco-friendly practices.
- Includes dimensions such as carbon footprint reduction, resource efficiency, and compliance with environmental regulations.

##### 2. Resilience:

- Refers to anticipating, adapting to, and recovering from disruptions.
- Key attributes include agility, adaptability, redundancy, and risk management.

##### 3. Technological Integration:

- Highlights the role of advanced technologies such as AI, IoT, blockchain, and digital twins in supporting RGSCs.
- These technologies enable predictive analytics, real-time monitoring, and enhanced transparency.

##### 4. Collaboration and Partnerships:

- Emphasizes supplier collaboration, stakeholder engagement, and cross-industry partnerships for achieving shared sustainability and resilience goals.

##### 5. Regulatory and Policy Alignment:

- Examines how compliance with global standards and local regulations influences RGSC design and implementation.

#### 2. Components of RGSCs

The components are the actionable elements that organizations can implement to operationalize RGSC principles:

##### 1. Supplier Collaboration:

- Promotes ethical sourcing, green procurement, and shared risk management frameworks.

##### 2. Renewable Energy Use:

- Encourages the adoption of renewable energy in operations and logistics.

##### 3. Circular Economy Practices:

- Includes recycling, remanufacturing, and reuse to minimize waste and enhance resource efficiency.

##### 4. Risk Management Frameworks:

- Comprises strategies for risk assessment, scenario planning, and disruption response.

##### 5. Green Logistics:

- Involves sustainable transportation methods, optimized routing, and eco-friendly packaging.

##### 6. Technological Tools:

- Utilizes AI for predictive analysis, blockchain for traceability, and IoT for real-time data tracking.

#### 3. Applications of RGSCs

The applications demonstrate how the dimensions and components are utilized in real-world contexts:

##### 1. Manufacturing:

- Integration of circular economy principles, such as closed-loop systems, to reduce resource consumption and waste.

##### 2. Retail:

- Adoption of green procurement and logistics to meet consumer demand for sustainable products.



### **Key Insights and Contributions**

The proposed conceptual model identifies five critical dimensions—sustainability, resilience, technological integration, collaboration and partnerships, and regulatory alignment—as the foundational pillars of RGSCs. These dimensions are operationalized through six actionable components: supplier collaboration, renewable energy use, circular economy practices, risk management frameworks, green logistics, and technological tools. By linking these dimensions and components to real-world applications in industries such as manufacturing, retail, energy, and healthcare, the study bridges the gap between theoretical constructs and practical strategies.

This research contributes to the field in several ways:

1. **Theoretical Advancement:** It extends existing theories of supply chain resilience and green supply chain management by integrating them into a unified framework. This synthesis provides a novel perspective on how these concepts can complement each other to achieve long-term supply chain robustness and environmental sustainability.
2. **Practical Relevance:** The model is a roadmap for organizations to enhance their supply chains' resilience and sustainability. The study offers actionable insights for supply chain managers, policymakers, and other stakeholders by detailing specific components and strategies.
3. **Scalability and Flexibility:** The model's applicability across diverse industries and adaptability to various organizational contexts make it a versatile tool for addressing the dynamic challenges of global supply chains.

### **Implications for Practice**

The findings underscore the importance of adopting a holistic approach to supply chain management that balances environmental goals with operational resilience. Organizations are encouraged to invest in AI, IoT, and blockchain technologies to enhance transparency, predictive capabilities, and real-time decision-making. Furthermore, fostering collaboration across the supply chain ecosystem—through partnerships with suppliers, customers, and regulatory bodies—is essential for achieving shared sustainability and resilience objectives.

In addition, the study highlights the role of circular economy practices in minimizing waste and maximizing resource efficiency. By integrating renewable energy into supply chain operations and embracing green logistics, organizations can align with global sustainability standards while building resilience against future disruptions.

### **Future Research Directions**

While the conceptual model provides a robust foundation, several areas warrant further investigation. Future research could explore the quantitative validation of the model through longitudinal studies or large-scale surveys. Additionally, examining the interplay of cultural, economic, and technological factors in RGSC implementation across different regions could yield deeper insights. Emerging technologies such as digital twins and autonomous systems also present opportunities for enhancing RGSC practices and should be studied further.

### **Concluding Remarks**

In conclusion, this research addresses a critical need in contemporary supply chain management by presenting a comprehensive framework for Resilient Green Supply Chains. By emphasizing the integration of resilience and sustainability, the model equips organizations with the tools to navigate an increasingly volatile and resource-constrained world. The findings underscore the urgency of adopting RGSC practices and provide a roadmap for organizations committed to achieving operational excellence and environmental stewardship. As global challenges continue to evolve, the principles outlined in this study will remain pivotal in shaping future supply chains.

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