RESILIENCE AND SUSTAINABILITY IN SUPPLY CHAINS

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ABSTRACT

The management of supply chains grapples with the crucial intersection of resilience and sustainability in the contemporary landscape. Resilience, defined as the ability to adapt and recover from disruptions, is intrinsically intertwined with sustainability, which seeks responsible resource management without compromising future balance. It is essential to acknowledge that, while both concepts share goals of efficiency and stability, their approaches may differ, posing an additional challenge in joint optimization. Fundamental strategies, such as collaboration among chain actors, supplier diversification, and continuous risk assessment, stand as pillars to fortify the supply chain from the perspectives of both resilience and sustainability. However, it is imperative to consider that enhancing one dimension may have implications for the other, and this article delves comprehensively into the complexity of this relationship. Highlighting contemporary relevance, the research proposes to aim for effective and balanced supply chain management, recognizing the need to harmonize strategies to optimize both resilience and sustainability.

1. INTRODUCTION

In the current era, characterized by increasing global interconnection and the constant evolution of socio-economic and environmental challenges, supply chain management emerges as a critical domain requiring strategic attention. One of the key issues in supply chain sustainability is the efficient usage of the available resources. At the same time, proactive supply chain design with disruption risk considerations frequently leads to a network redundancy which implies some resource reservations in anticipation of possible disruptions. In this context, the relationship between resilience and sustainability becomes a topic of deep interest and complexity. Both concepts, share a fundamental concern for organizations' ability to face disruptions and ensure long-term operational continuity. However, this apparent convergence is only the surface of a deeper dialogue that reveals both commonalities and divergences between these perspectives.

Resilience, at its core, is defined as a system's ability to adapt and recover from disruptions, whether they be economic crises, natural disasters, or interruptions in the supply chain. It has become a cornerstone in modern risk management, offering a dynamic approach to anticipate and address unexpected adversities [1-2]. Simultaneously, sustainability presents itself as a guiding principle seeking to meet current needs without compromising the resources and capacity of future generations to meet their own needs. Sustainability encompasses environmental, social, and economic dimensions, striving for a balance between business benefit and responsibility towards the environment and society [3].

While both perspectives share the fundamental premise of ensuring long-term viability, their approaches can, at times, come into conflict. Resilience, often associated with contingency and redundancy strategies, could contradict the efficiency and environmental impact minimization principles inherent in

sustainability. Over-reliance on resilience solutions could lead to excessive resource use, contravening sustainable objectives. This highlights the need for careful balance and strategic integration to achieve truly sustainable and resilient supply chain management.

In this context, understanding the interconnected dynamics between resilience and sustainability in supply chain management becomes essential. As we face a future marked by uncertainty and the imperative need for sustainable development, the synergy between resilience and sustainability in supply chain management stands as a strategic imperative for modern enterprises.

This article aims to explore these concepts in depth, analysing their points of convergence and divergence, in the supply chain management field; and providing a comprehensive view to guide professionals and academics in the pursuit of effective and harmonious strategies.

2. RESEARCH STREAMS

A supply chain is an interconnected system of organizations, activities, information, and resources that collaborate in a coordinated manner to bring a product or service from its conception to the hands of the end consumer [4]. This process involves the efficient and synchronized management of various stages, including the procurement of raw materials, manufacturing, storage, distribution, and delivery. The supply chain extends beyond the borders of an individual company, incorporating suppliers, manufacturers, distributors, retailers, and other key players. Optimizing the supply chain aims not only to maximize efficiency and reduce costs but also to adapt to market demand, mitigate risks, and increasingly incorporate sustainability principles to address current economic and environmental challenges. Essentially, the supply chain is a vital mechanism that drives fluidity and competitiveness in the delivery of goods and services on a global scale.

2.1 Supply chain resilience

Modern supply chains are complex networks that are exposed to disruptions, for example: operational shutdowns directly or indirectly caused by various risks such as natural disasters, political and economic factors, labour strikes, and material shortage. A supply chain network (SCN) is vulnerable to disruptions not only because of the direct impacts of those disruptions, but also because of the ripple effect (also known as risk propagation) the phenomenon that a sudden disruption at a few nodes in a SCN can spread to neighbouring nodes, and eventually adversely impact other firm [1].
Resilience within a supply chain is likened to an immune system, designed to respond to disruptions and restore the system to its initial stable state, minimizing deviations from planned performance. The perspective, termed the stability-based view, emphasizes the ability to recover from disruptions. Another viewpoint, the adaptation-based view, shifts the focus from maintaining stable states to ensuring the supply chain's adaptability and persistence in the face of disruptions, framing resilience as the ability to survive and exist. The consideration of disruption probability and the implementation of redundancy and flexibility measures characterize the predictable external conditions in the known-known scenario. Resilience is then measured based on the degree of performance deviation and

recovery effectiveness, distinguishing between disruption-free and disrupted system operation modes [5].

In terms of theory development, it is essential to discuss a transition from hindsight-based, performance deviation-oriented supply chain disruption management toward foresight-driven, proactive adaptation-based resilience, and balancing these two views in a hybrid manner. Regardless of the chosen resilience management view—often a hybrid approach—managers face the critical decision of allocating investments between redundancy (adaptability) and response (recovery). From the stability-based view perspective, resilience investment decisions involve predicting disruption probabilities, assessing the impact, analysing the costs, and proposing preparedness and recovery policies based on the balance of potential damage and resilience investments. Conversely, the adaptation-based view perspective dictates a different decision-making logic, focusing on analysing how long the system can operate in the absence of certain elements and the costs of adapted operations, recovery time, and recovery costs. This approach is applicable across all types of uncertainty, showcasing the importance of tailoring resilience investment strategies to the specific nature of disruptions [1].

In the pursuit of advancing our understanding of resilient supply chain management, this article endeavours to conceptually elucidate and quantify the fundamental drivers crucial for the development of a taxonomy of resilience. Our study considered five pivotal elements—agility, visibility, flexibility, collaboration, and information sharing. Each driver is precisely defined and analysed from a quantitative perspective, accentuating measurable indicators that play a pivotal role in fortifying and improving supply chain resilience.

- Agility: pertains to the capacity to swiftly respond to unforeseen changes in market demand or disruptions within the supply chain. Measurement involves assessing the speed with which the supply chain can adjust operations, alter production, redistribute inventories, and adapt to new circumstances without compromising efficiency.
- Visibility: refers to the ability to monitor and have real-time information on all aspects, from production to distribution and delivery. Measurement encompasses key performance indicators (KPIs) evaluating the accuracy and timeliness of available information, as well as the ability to foresee and anticipate future events.
- Flexibility: relates to the ability to adapt to changes in demand, supplies, or manufacturing processes. Measurement involves the capacity to change production, modify shipping routes, or adjust storage capacity efficiently and with controlled costs.
- Collaboration: involves close cooperation among different actors, such as suppliers, manufacturers, and distributors. Measurement includes assessing the effectiveness of communication and collaboration among participants, as well as the implementation of collaborative practices optimizing efficiency and decision-making.
- Information Sharing: entails the efficient and timely transmission of relevant data between various nodes in the supply chain. Measurement involves evaluating the frequency and quality of shared information, as well as the

utilization of technologies facilitating transparency and real-time seamless communication.

2.2. Supply chain sustainability

Sustainability in supply chain management has emerged as a critical area of focus in response to global concerns about environmental degradation and social responsibility. The increasing interconnectivity of businesses in today's globalized world necessitates a comprehensive examination of how supply chains can operate harmoniously with the environment, society, and the economy. As companies recognize the significance of sustainable practices, the integration of environmentally and socially responsible strategies into supply chain operations has become imperative for long-term viability and resilience.

The organizations face numerous challenges in their pursuit of environmentally and socially responsible operations. One significant challenge involves the complexity of supply chain networks, which often span across diverse geographic locations and involve multiple stakeholders [4]. Balancing economic objectives with environmental and social goals requires a delicate equilibrium, as companies seek to minimize their ecological footprint, ensure fair labour practices, and maintain cost-effectiveness. Moreover, the dynamic nature of global markets and regulatory landscapes adds an additional layer of complexity, requiring supply chain managers to adapt continuously to evolving sustainability standards [6].

Amidst the challenges, there are significant opportunities for organizations to enhance sustainability in their supply chains. Collaborative efforts across industry sectors, fostering transparency, and leveraging technology for real-time monitoring and data-driven decision-making are among the promising avenues. Implementing circular economy principles, such as recycling and reusing materials, can contribute to resource efficiency and waste reduction. Additionally, the integration of sustainable sourcing practices, ethical labour standards, and the development of green logistics solutions are key components of a holistic sustainability strategy [7]. As companies navigate this landscape, it is crucial to recognize that sustainability is not merely a compliance requirement but a strategic imperative that can yield long-term benefits, including enhanced brand reputation, reduced operational risks, and improved overall resilience in the face of global challenges.

2.3 Theory of the relationship between resilience and sustainability in the supply chain

Numerous strategies have been proposed to integrate sustainability and resilience within supply chain management. In many instances, the conventional triple bottom line dimensions of sustainability have expanded to include constructs such as risk and knowledge, reflecting their increasing importance [1]. However, recognizing the complexity and urgency of sustainability, scholars have advocated for more holistic approaches. This holistic perspective is essential due to conflicting objectives and inherent trade-offs.

Within the literature, varying viewpoints exist regarding the relationship between sustainability and resilience. Some studies posit that sustainability acts as a precursor to resilience and that sustainability practices can positively enhance resilience.

Conversely, others maintain that while the two are related, they may not necessarily be correlated, implying that strategies to improve one may not necessarily benefit the other. Notably, certain studies highlight a negative relationship between disruption risk and environmental practices, suggesting that risks can impede the implementation of green practices.

Recognizing the importance of integrating sustainability and resilience, many recent studies emphasize the need for a combined approach [2]. However, it is noteworthy that several investigations primarily focus on sustainability and risk, rather than sustainability and resilience [3]. The field of sustainability risk studies has also garnered attention, emphasizing the need to manage risks stemming from social, ecological, and ethical supply chain challenges. Traditional risk management approaches often overlook these dimensions.

3. CONCLUSIONS AND RESEARCH GAPS

To help set some general foundation for a research agenda, we use this review to identify several gaps. To help set some general foundation for a research agenda, we use this review to identify several gaps.

1. There is a noticeable difficulty in integrating resilience and sustainability as comprehensive topics in supply chain studies. The focus tends to lean heavily towards environmental sustainability, neglecting the broader triple bottom line dimensions. Additionally, the prevalent use of risk concepts overshadows the alternative perspective offered by resilience.

2. The integration of sustainability and resilience is deemed crucial, yet there is a scarcity of studies in this research area. There is a need to explore the trade-offs, synergies and impact of coordination, information sharing, vulnerability outsourcing and vertical integration.

3. There is limited guidance on practices that could simultaneously enhance sustainability and resilience in supply chains. The development of Key Performance Indicators (KPIs) and performance metrics is essential for assessing integrative relationships and outcomes comprehensively.

4. Recognizing that industry characteristics may influence antecedents, practices, and outcomes differently, there is a call for inter- and intra-sectoral investigations. Understanding the potentially heterogeneous impacts on sustainability and resilience is crucial.

5. The complexity of relationships raises questions about whether a single, clear explanatory theory can fully capture the understanding of sustainable and resilient supply chains. The emerging constructs, concepts, and theories need empirical testing, practical application, and validation in real industries. The field has advanced theoretically ahead of practical implementation, especially in the realm of sustainability. Bridging this gap requires empirical evidence and applications in diverse industries.

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