Dean&Francis
ISSN 2959-6130

Building Resilience: A Framework for Maritime Supply Chain Risk Management in Logistics Enterprise

Qing Li[1, *]

[1]Business School, Macau University of Science and Technology, Macau, 999078, China
*Corresponding author: 1240032301@student.must.edu.mo

Abstract:

In an era of profound shifts in global trade patterns and heightened uncertainties, maritime supply chain risk management faces critical challenges that traditional mechanisms struggle to address. This study investigates the core impediments to resilient development in maritime supply chains for logistics enterprises. Through a systematic analysis, it identifies three systemic bottlenecks: (1) a governance gap where traditional risk management mechanisms fail to cope with novel risks; (2) a collaboration gap stemming from disparate data standards that hinder industry-wide synergy; and (3) an investment gap characterized by the high costs and uncertain returns of building resilience. These three types of issues impede the resilient development of the maritime supply chain and also prevent enterprises from responding to supply chain risks and disruptions. To address these gaps, this paper proposes a multi-faceted solution: integrating resilience metrics into strategic performance appraisal systems, constructing a cost-resilience curve model to identify optimal investment timing, promoting data-sharing platforms and industry partnerships, and innovating with rental service models to lower the barrier to entry for SMEs. Finally, it emphasizes the need for multi-party collaborative efforts among the government, associations, and enterprises to build a flexible, efficient, economically sustainable, and highly resilient supply chain system.

Keywords: Maritime Supply Chain; Risk Management; Supply Chain Resilience; Data Collaboration; Logistics Optimization

ISSN 2959-6130

1. Introduction

1.1 Research Background

Currently, the global trade pattern is undergoing profound changes, with political conflicts and trade frictions intensifying, and extreme natural disasters occurring frequently [1]. Fluctuations in the maritime market, changes in new rules, the efficiency improvements brought by the digital era (along with accompanying new challenges), coupled with the gradual diversification of customer needs and the continuous escalation of industry competition, have collectively formed a highly complex and uncertain maritime supply chain environment. This study holds significant practical and theoretical significance.

From a practical perspective, the findings aim to assist enterprises in bridging the risk-generation gap, overcoming data collaboration barriers, and managing resilience costs, thereby enhancing their viability and competitiveness while maintaining industrial chain stability. Theoretically, this study deepens theories related to maritime supply chain logistics management, particularly in the field of resilient supply chains. Its innovation lies in breaking through the traditional passive response model, proposing forward-looking risk management ideas oriented toward proactive adaptation for the future, and providing new directions and paths for promoting the resilient development of supply chains.

1.2 Literature Review

Existing literature on supply chain resilience provides a foundational understanding, particularly highlighting its contextual nature and interplay with efficiency. Cohen et al. stated that each company requires specific resilience, resulting in high specificity and low formality, as each company's strategy and resilience needs are different. Although Cohen and Kouvelis interpreted a new framework after the COVID-19 pandemic and provided an overall direction for supply chain resilience to various companies, it is not applicable to all enterprises [2]. This insight indicates that the supply chain network is large and complex, and each company must consider its own current status and core competitive advantages to establish strategic cooperative relationships.

Ghulam et al. pointed out that the driving factors of supply chain resilience have a certain effect on the recovery of supply chain disruptions—this effect is a positive response—and the complexity of the supply chain also plays a positive regulatory role in supply chain resilience [3]. Therefore, complexity is not entirely negative; it can help better construct resilience systems, optimize structures, cope with more and newer supply chain risks, accumulate response experience, strengthen corporate response systems, and promote the formulation of resilience strategies and indicators.

Florian et al. illustrated the dual leverage established by supply chain resilience and supply chain efficiency: This dual resource can enhance resilience and improve supply chain efficiency. Major events highlight the fragility of the supply chain and the high demand for resilience; the dual-purpose leverage not only enables comprehensive analysis in decision-making but also better responds to global complexity through the interaction between the two [4]. For this study, such dual leverage is of great significance for building the resilience-cost model, as it clearly reflects the practical application of resilience and the results of the interaction between resilience and efficiency.

Chen et al. proposed that after COVID-19, risks have become difficult to control, and shipping companies must change their directions and strategies to help SMEs improve efficiency by identifying ineffective risk management measures [5]. A sound performance appraisal system will help the survival of SMEs or reduce uncertainties, as a complete internal system can facilitate information flow. At the same time, enterprises also need to establish partnerships to enhance sensitivity, enabling them to respond more flexibly to the market and achieve sustainable corporate development. This study has far-reaching significance and impact on this paper: through evaluations using the AHP (Analytic Hierarchy Process) model and IPA (Importance-Performance Analysis) model, it demonstrates that traditional risk management is difficult to adapt to the new paradigm.

While these studies underscore the importance of resilience and adaptability, there remains a lack of integrated frameworks that systematically address the synergistic challenges of evolving risks, data fragmentation, and cost-effectiveness, specifically within the maritime logistics context. This study seeks to fill this gap by proposing a holistic approach.

1.3 Research Framework

First, this paper starts from a macro perspective, expounds on the complexity and uncertainty under the current pattern, clarifies the important value and significance of this study from the background, and points out the innovative idea of shifting from passive response to proactive adaptation. Second, it sorts out the three core challenges in the current maritime supply chain industry, analyzes these three issues to develop specific countermeasures and solutions, and provides a preliminary solution framework and conceptualization. Finally, the conclusion emphasizes the importance and inevitability of resilient development and calls for multi-party collaboration to advance the develop-

ment of resilient supply chains. Through this structure, the paper argues that a strategic shift towards proactive resilience, supported by collaborative data platforms and innovative cost-sharing models, is essential for the sustainable development of maritime supply chains.

2. The Evolution of Maritime Supply Chain Risk Management

The paradigm of maritime supply chain risk management has evolved significantly, mirroring the increasing complexity of global trade and the nature of disruptions. Maritime transportation accounts for more than 90% of the world's total trade volume, plays a crucial role in the global supply chain, and is the main driver of globalization [6]. The concept of maritime supply chain risk management has continuously evolved with changes in the global economic and trade environment, and its development has generally shifted from traditional passive response to active prevention and control.

Before 2000, risk sources were relatively single, mainly focusing on traditional factors such as weather disasters, cargo theft, and ship accidents. These single risks led to monotonous response methods for enterprises, lacking forward-looking thinking. With the acceleration of globalization, the supply chain structure has become increasingly complex, and the scope of risks has expanded—enterprises have had to gradually adopt systematic and standardized methods for risk identification, assessment, and optimization, thereby forming a comprehensive new definition and evaluation of risks. Currently, the industry has made certain progress in technologies such as AI-powered predictive analytics for risk identification and digital twin simulations for scenario planning, with continuous improvements in system coordination and prediction capabilities. However, this progress remains unevenly distributed and often focuses on technological solutions within organizational silos, rather than addressing systemic vulnerabilities across the entire supply chain network. More and more enterprises are using data analysis and digital twin technology to enhance their resilience, while controlling costs and improving their ability to adapt to market fluctuations. Looking forward, the maturation of technologies like blockchain promises to enhance end-to-end visibility and trust, pushing the evolution towards truly integrated, full-chain risk management. Despite these technological advancements and the clear shift from passive response towards more proactive and holistic management, the industry still grapples with fundamental challenges that hinder the full realization of a resilient supply chain.

3. Core Challenges and Critical Analysis

3.1 The Adaptability Gap: Outdated Risk Frameworks

Although the development of the maritime supply chain has gradually become systematic, it still faces several core issues due to the faster evolution of risks. This fundamental mismatch between the pace of risk evolution and the speed of managerial adaptation can be termed the 'Adaptability Gap'. The first issue is that external uncertainties and system complexity are evolving rapidly, while traditional response mechanisms cannot cope with new risks. The most prominent feature of current supply chain risks is their strong unpredictability and high correlation—the tight connection between links means that solutions can only be implemented at the endpoints, with no way to gain insights during the process.

Consequently, traditional risk response methods, which predominantly rely on prediction and historical data, fail to keep pace with the emergence of novel, interconnected risks. This phenomenon indicates that it is not simply a matter of "new risks," but a fundamental transformation. The core of the challenge has shifted from optimizing a stable system to managing an inherently unstable one. The current challenge is how to manage an unstable system rather than optimize a stable one; using the known to deal with the unknown is naturally ineffective. Shifting the direction is only the initial stage of addressing the risk generation gap, but it also points out the correct path. This gap fundamentally undermines the predictability premise upon which traditional supply chain risk management is built.

3.2 Data Collaboration Problem

The second issue is that despite the continuous advancement of technical means such as intelligent assessment and scenario simulation, data standards across the industry are inconsistent, and data sharing or synchronization cannot be achieved. This leaves many enterprises (especially SMEs) in a state of data isolation, making it difficult for them to obtain real first-hand data and achieve true collaboration. This problem stems primarily from a lack of unified data standards and a culture of trust, creating severe 'Data Silos'.

Although the maturity of AI technology is rising rapidly (with the potential to leverage big data), the idealized application of AI does not match the current reality.

The prerequisite for AI to play its role is integrated, collaborative data output across the entire industry. Yet, this very prerequisite is the primary obstacle. However, due

ISSN 2959-6130

to market competition within the industry—especially the unavoidable competition between leading enterprises—there is a general lack of trust, making information sharing impossible. This contradiction leads to data stagnation and barriers: leading companies have the ability to build comprehensive internal digital systems, but these systems cannot be fully complete due to their closed nature, while SMEs are further excluded [7]. Facing such a severe "faulty" environment, SMEs struggle to obtain comprehensive information, which not only restricts their development and risk response capabilities but also hinders the collaborative development of the entire maritime supply chain.

3.3 The Investment Dilemma: High Costs and Uncertain Returns

Beyond technical and operational challenges, a fundamental economic barrier—the Investment Dilemma—impedes resilience building.

The third issue is the high cost of building a risk management system, the huge investment in talents and funds, and the difficulty in balancing cost and efficiency. Building a resilient supply chain requires redundant construction, technological upgrading, and talent investment—more importantly, it requires enterprises across the entire chain to bear the costs of joint construction. However, enterprises focus on returns when conducting business and need to consider whether resilience construction is necessary based on the severity of risks.

Given the probabilistic nature of high-impact disruptions, many companies perceive resilience investments as an option with uncertain returns, leading to under-investment from a system-wide perspective. This issue has become a dilemma for decision-makers. It represents a typical 'collective action problem': while all actors would benefit from a resilient ecosystem, no single entity has sufficient incentive to bear the initial costs alone, for fear of being at a competitive disadvantage. Making new decisions will harm the interests of most stakeholders, so it is difficult for the entire industry to take the first step in building a resilient supply chain. At the same time, it is also hard to change the existing models of the entire supply chain (e.g., inventory management, cost control, and prediction considerations). These issues restrict the risk resistance capabilities of both enterprises and the entire supply chain; decisions regarding measuring and avoiding supply chain risks have made little substantive progress, and building an efficient, collaborative, and economically feasible resilient supply chain has become a global challenge for supply chains.

4. Proposed Strategies and Solutions

4.1 Strategic Integration: Embedding Resilience into Corporate DNA

To address the first issue—the gap caused by the mismatch between the speed of risk changes and the update speed of risk management systems—improvements need to be made at the conceptual level. The core principle is to shift from treating resilience as a peripheral KPI to making it a central strategic objective, thereby institutionalizing adaptive capabilities. Taking resilience as one of the core elements is crucial for the industry's contribution to global connectivity, trade, and sustainable development [8]. Resilience should be integrated into all aspects: for example, incorporating resilience assessment into employees' performance appraisals, and requiring management to implement resilience strategies—focusing not only on costs and efficiency but also on resilience strategies, such as quantifying redundancy strategies (e.g., inventory retention time, backup supplier capacity), robustness (e.g., system hardening), and recovery capabilities (e.g., Time-to-Recover metrics).

To operationalize these strategic indicators and provide a quantitative basis for decision-making, it is critical to construct a cost-resilience curve model. Second, a cost-resilience curve model should be constructed. Building resilience requires balancing the efficiency of complex systems [9]. The optimal point can be identified through the curve, clearly demonstrating the leverage relationship between the two. The curve can be divided into four zones: (1) The Inefficient Zone: Characterized by low resilience and low cost, it is extremely fragile— a single risk disruption may damage the entire chain. (2) The Increasing Zone: This represents a stage where relatively little cost investment yields significant returns, with the fastest growth rate of the resilience index; reaching the peak of this zone is the "sweet spot" with the highest rate of return for investors. (3) The Decreasing Zone: Requires enterprises to cope with a decline in returns, with costs (especially marginal costs) increasing; enterprises need to consider whether to continue investing carefully. (4) The Uneconomical Zone: Tends to saturation with high costs, making it impractical. This integrated approach enables enterprises to move from ad-hoc risk response to proactive resilience budgeting and strategic planning.

4.2 Build Data Platforms and Shipping Alliances

To solve the second issue—digital barriers caused by inconsistent and uncoordinated data—it is suggested that a platform be established that integrates and provides open

data, making data real-time and visualized. The solution hinges on fostering collaboration over competition in non-core areas, creating a 'co-opetition' framework for data governance. Key data (such as port throughput, current political news, and weather dynamics) can be displayed intuitively, and even the positions of merchant ships and port conditions can be monitored in the digital world.

At the same time, a joint partnership network should be built to establish friendly strategic relationships with various suppliers and even competitors (e.g., shipping alliances). The dominant position of shipping alliances may also have a profound impact on container shipping emissions and green shipping investment [10]. Shipping alliances directly change the operating costs of shipping companies through capacity sharing and related economies of scale.

4.3 Innovative Financing: Lowering the Barrier through 'Resilience-as-a-Service

To tackle the third issue—high construction costs hindering forward-looking development—the solution lies in popularizing and promoting resilience models, and finding ways to lower the threshold for resilience investment. This necessitates a paradigm shift from capital-intensive ownership to operational-expense-based access models, democratizing advanced risk management tools. Large enterprises should be encouraged to open up their services and permissions, enabling SMEs to use their third-party platforms without large-scale investment (e.g., through leasing, renting, or subscription models).

This "on-demand service" model ensures that enterprises have strong support in risk response, allowing small enterprises to access prediction or simulation technologies previously only available to large enterprises—creating a win-win situation for leading companies and SMEs. This model effectively transforms high fixed costs into variable costs for SMEs, while creating a new, scalable revenue stream for large platform providers, aligning economic incentives across the ecosystem.

For platform providers, this model provides motivation for R&D and generates sustainable revenue; it also accelerates the acquisition of management experience by start-ups and injects impetus into leading companies to build resilient supply chains.

5. Conclusion

5.1 Synthesis of Findings and Implications

This research has systematically identified and addressed three critical impediments to resilience in the maritime supply chain ecosystem. This study analyzes the current status and challenges faced by logistics enterprises in maritime supply chain risk management under the new situation. In summary, building a resilient supply chain is imminent, and achieving this goal requires the joint efforts of the entire industry to achieve synergy in strategies, concepts, technologies, data, models, and other aspects. This aligns with the proposed framework, where logistics enterprises must formulate resilience strategies grounded in the cost-resilience curve, industry associations are pivotal in establishing data standards and facilitating alliances, and government bodies should provide policy support that incentivizes the adoption of 'Resilience-as-a-Service' models, especially for SMEs.

5.2 Theoretical and Practical Contributions

Theoretically, this study contributes a structured framework that integrates the often-disparate concepts of strategic resilience indicators, data collaboration economics, and innovative financing, offering a more holistic understanding of maritime supply chain risk optimization. Practically, it provides managers with a decision-support tool (the cost-resilience curve) and actionable strategies (e.g., RaaS models) to navigate the trade-offs between efficiency and resilience, particularly empowering SMEs to enhance their risk responsiveness.

5.3 Limitations and Avenues for Future Research

This study mainly relies on macro overviews and literature-based theoretical reasoning, lacking sufficient empirical data support—it cannot fully calibrate commercial data such as risk disruption data, and lacks accurate, real-time dynamic data. Although a data platform is proposed, the focus is only on solutions rather than technical implementation. Future research will integrate more cases of small and medium-sized logistics enterprises, track the efficiency and feasibility of methods such as shipping alliances and data platforms, and integrate interdisciplinary knowledge into the theoretical system to better respond to risks.

References

[1] Bag, Surajit, and Sachin Kumar Mangla. Investigating the role of smart and resilient supplier management practices in the circular economy: a supply chain practice view perspective. Business Strategy and the Environment, 2025, 34(4): 3919-3939.

[2] Morris Cohen, Cui Shiliang, Sebastian Doetsch, Ricardo Ernst, Arnd Huchzermeier, Panos Kouvelis, Hau Lee, Hirofumi Matsuo, Andy A. Tsay. Bespoke supply-chain resilience: the gap between theory and practice. Journal of Operations Management, 2022, 68(5), 515-531.

[3] Hussain Ghulam, Nazir Mian Sajid, Rashid Muhammad

ISSN 2959-6130

Amir, Sattar Maheen Abdul. From supply chain resilience to supply chain disruption orientation: the moderating role of supply chain complexity. Journal of Enterprise Information Management, 36(1), 70-90.

[4] Lucker, Florian, Timonina-Farkas, Anna, Seifert, Ralf W. Balancing resilience and efficiency: A literature review on overcoming supply chain disruptions. Production and Operations Management, 34(6), 1495-1511.

[5] Yin, Hengbin et al. A study on the assessment of risk management performance in maritime start-ups: evidence from China. Maritime Policy & Management, 2022, 50(6), 818–832.

[6] Zhou Yusheng, Kum Fai Yuen. Prepare for the sustainability era: A quantitative risk analysis model for container shipping sustainability-related risks. Journal of Cleaner Production, 475, 143661.

[7] Pruyn, Jeroen, and Edwin van Hassel. Frontiers in Maritime Transport Chains: Digital and Organizational Innovations in Maritime Transport and Port Operations. Frontiers in Future Transportation, 2022, 3: 869530.

[8] Yui-yip Lau, Qiong Chen, Mark Ching-Pong Poo, Adolf K.Y. Ng, Chung Chui Ying. Maritime transport resilience: A systematic literature review on the current state of the art, research agenda and future research directions. Ocean & Coastal Management, 2024, 251, 107086.

[9] Stephanie Galaitsi, Margaret Kurth, &Lgor Linkov Resilience: Directions for an uncertain future following the COVID-19 pandemic. GeoHealth, 2021, 5(11), e2021GH000447.

[10] Shang Tianyu, Wu Hao, Wang Kun, Dong Yang, Jiang Changmin, Yang Hangjun. Would the shipping alliance promote or discourage green shipping investment?. Transportation Research Part D: Transport and Environment, 2024, 128, 104102.