Research on the Mechanism and Path of Digital Transformation Empowering Supply Chain Resilience

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Abstract. Against the backdrop of rising global uncertainty, supply chain resilience has become a core competitive capability for sustainable enterprise operations. Traditional efficiency-oriented supply chains often exhibit significant vulnerability to external shocks. In contrast, digital transformation—driven by big data, IoT, and AI—offers a promising pathway to enhance supply chain resilience. Based on the resource-based view and dynamic capability theory, this paper systematically analyzes the enabling mechanisms through which digital transformation enhances supply chain resilience, and explores practical paths for enterprises. The research finds that digital transformation breaks down information barriers, optimizes resource allocation, and strengthens cross-node collaboration, thereby improving risk resistance, recovery capability, and adaptability. This study provides theoretical insights and practical references for enterprises seeking to build highly resilient supply chains through digital reform.

Keywords: Digital transformation; supply chain resilience; risk management; resource collaboration; dynamic capability; Information collaboration; Risk resistance

1 Introduction

In recent years, geopolitical tensions, demand fluctuations, and public health crises have repeatedly exposed the fragility of global supply chains. Traditional lean supply chains, focused narrowly on cost efficiency and minimal inventory, have shown significant weaknesses in responding to such disruptions错误!不能识别的开关参数。. Supply interruptions and logistics delays have become common, prompting recognition that efficiency alone is insufficient. Improving supply chain resilience has thus emerged as a critical priority 错误!不能识别的开关参数。. With the rapid advancement of digital technologies, digital transformation is reshaping supply chain operations. Technologies such as big data analytics, IoT, and AI are increasingly integrated into procurement, production, and logistics, enabling real-time data sharing and collaborative operations错误!不能识别的开关参数。. Digital transformation offers effective solutions to address the vulnerabilities of traditional supply chains. However, existing literature often treats digitalization and resilience separately, lacking

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systematic analysis of how digital transformation empowers resilience[错误!不能识别的开关参数。]. Therefore, this paper aims to bridge that gap by exploring the logical relationship between digital transformation and supply chain resilience, enriching theoretical research, and offering practical guidance for enterprises. In light of this research gap, this paper systematically deconstructs the enabling mechanisms of digital transformation from the perspectives of information collaboration, resource optimization, and collaborative linkage. By integrating the resource-based view and dynamic capability theory, it explains how digital technologies enhance resistance, recovery, and adaptability across supply chain networks. Furthermore, this study identifies practical pathways such as building full-chain digital control platforms, fostering cross-entity collaboration, and cultivating digital-composite talents. Through these theoretical and practical contributions, the paper provides a foundational framework for enterprises seeking to navigate uncertainty. Ultimately, this research not only advances academic discourse on digital resilience but also supports managerial decision-making in an era of increasingly volatile global supply chains.

2 Core Concepts and Theoretical Basis

2.1 Supply Chain Resilience

Supply chain resilience refers to the capability of a supply chain system to resist external shocks, quickly restore normal operations after disruptions, and make adaptive adjustments in response to changing environments[错误!不能识别的开关参数。]. This concept is multidimensional, primarily encompassing four key dimensions: resistance (the ability to withstand initial shocks), recovery (the speed and efficiency of returning to normal operations), adaptability (the capacity to reconfigure operations in response to new conditions), and collaboration (the degree of coordination among supply chain partners). Unlike traditional supply chains that pursue efficiency at flexibility's cost, resilient supply chains prioritize proactive risk prevention and cross-node collaboration as core goals. Such resilience ensures stable operation in complex and volatile environments, effectively reduces losses from external disruptions, and maintains supply chain continuity. As such, supply chain resilience has become an integral component of enterprise competitiveness.

2.2 Supply Chain Digital Transformation

Supply chain digital transformation is the process of using advanced digital technologies—such as big data, AI, IoT, and blockchain—to restructure supply chain processes and management models. With data as the core production factor, it enables digital upgrading across all supply chain links, from sourcing to delivery. It breaks down information silos, improving transparency, collaboration efficiency, and response speed. Digital transformation is not merely technology adoption; it fundamentally changes how supply chains are designed and managed. Thus, it serves as a key means

to enhance supply chain resilience, promoting a shift from reactive to proactive, data-driven management.

2.3 Theoretical Basis

Two complementary theoretical perspectives provide the foundation for analyzing how digital transformation enhances supply chain resilience. First, the resource-based view (RBV) posits that digital technologies and data resources constitute strategic heterogeneous resources that are valuable, rare, imperfectly imitable, and non-substitutable [错误!未找到引用源。]. When effectively deployed, these resources help enterprises integrate internal and external supply chain resources, forming unique resilience capabilities that competitors cannot easily replicate. Second, dynamic capability theory emphasizes that firms need environmental sensing and resource reconfiguration capabilities to adapt to rapidly changing environments[错误!未找到引用源。]. Digital transformation enhances these dynamic capabilities by providing real-time data for sensing risks, analytical tools for seizing opportunities, and collaborative platforms for reconfiguring resources. Together, these two theories offer a robust theoretical framework for analyzing the mechanisms through which digital transformation empowers supply chain resilience.

3 Mechanisms of Digital Resilience

3.1 Information Collaboration Mechanism

Traditional supply chains suffer from severe information asymmetry and delayed transmission between upstream and downstream partners. Suppliers lack visibility into demand changes, while manufacturers have limited insight into supplier constraints. This fragmentation leads to low risk identification efficiency and passive responses. Digital transformation addresses this by building a unified collaboration platform, enabling real-time sharing of orders, inventory, forecasts, and schedules across all nodes. With big data and AI, enterprises can capture potential risk signals—such as supplier distress or demand spikes—in advance, shifting from passive reaction to active prevention. Moreover, information transparency weakens the bullwhip effect, reducing operational fluctuations and improving supply chain stability.

3.2 Resource Optimization Mechanism

The efficiency of resource allocation directly determines how quickly a supply chain can recover when risks materialize. Digital technologies enable visual management of supply chain resources and intelligent matching of optimal allocation schemes through algorithmic approaches[错误!未找到引用源。]. When faced with supply interruptions or sudden demand surges, digital systems can rapidly screen alternative suppliers, identify backup logistics routes, and recommend dynamic resource scheduling strategies [错误!不能识别的开关参数。]. In addition, digital inventory systems powered by machine learning algorithms predict market demand with greater accuracy, allowing enterprises to optimize inven-

tory structure across different locations and echelons. This optimization avoids both shortages (which disrupt production) and overstocking (which ties up capital and increases holding costs). By enabling rapid reconfiguration of resources in response to disruptions, the resource optimization mechanism accelerates the return to normal supply chain operations after risk events.

3.3 Collaborative Linkage Mechanism

This study concludes that digital transformation enhances supply chain resilience through three mechanisms: information collaboration, resource optimization, and collaborative linkage. These collectively improve risk resistance, recovery, and adaptability[错误!未找到引用源.] . Core practical paths include building digital control platforms, promoting cross-entity collaboration, and cultivating digital talents. As a theoretical analysis, this paper lacks empirical verification. Future research should conduct multi-industry empirical studies to verify quantitative relationships and explore the differential impacts of various digital technologies on resilience dimensions[错误!未找到引用源.] .

4 Paths to Digital Resilience

4.1 Build a Full-Chain Digital Control Platform

Enterprises should increase their digital investment and integrate IoT, big data, and cloud computing technologies to construct a full-link supply chain control platform. Such a platform serves as a central nervous system for the supply chain, unifying data standards across different nodes and ensuring efficient data interconnection. On this technological foundation, enterprises should establish an intelligent risk early warning system. This system continuously monitors key risk indicators, identifies potential threats in advance, and issues graded alerts (e.g., low, medium, high risk) to relevant decision-makers. By providing data-driven support for proactive risk prevention, the control platform directly improves the supply chain's ability to resist disruptions before they escalate.

4.2 Promote Cross-Entity Digital Collaboration

Digital transformation cannot succeed in isolation; enterprises need to actively strengthen digital collaboration with upstream and downstream partners. A practical step is to encourage core suppliers to access the collaboration platform, thereby enabling joint inventory management and collaborative demand forecasting. This approach not only builds trust but also deepens integration, which further weakens the bullwhip effect and aligns production with actual market demand. Additionally, enterprises should establish a normalized communication mechanism with all supply chain partners. Such a mechanism should be transparent and continuously updated. This includes jointly formulating emergency response plans, conducting regular simulation drills, and sharing lessons learned from past disruptions. These collabora-

tive practices improve the overall risk response capacity of the entire supply chain ecosystem, rather than leaving any single node as a weak link.

4.3 Cultivate Digital Composite Talents

Human talent is the fundamental guarantee for successful digital transformation and resilience building. Technology alone cannot create resilience without skilled personnel to operate, interpret, and act upon digital systems. Therefore, enterprises should strengthen internal staff training programs to improve employees' digital application skills and supply chain risk management capabilities. Furthermore, enterprises should actively recruit composite talents who possess integrated knowledge of supply chain management and data analytics. Such individuals can bridge the gap between technical and operational functions. Finally, a sound talent incentive mechanism should be established to retain high-performing employees and encourage continuous learning. By investing in human capital, enterprises provide the intellectual support necessary for the long-term construction of digitally enabled resilient supply chains.

5 Conclusion and Outlook

This study concludes that digital transformation improves supply chain resilience through three mechanisms: information collaboration, resource optimization, and collaborative linkage. These collectively enhance risk resistance, recovery, and adaptability. Building digital control platforms, promoting cross-entity collaboration, and cultivating digital talents are identified as the core effective practical paths. This paper is primarily theoretical and lacks empirical verification. Future research should address this by conducting multi-industry empirical analyses to verify quantitative relationships between digital transformation initiatives and resilience outcomes. Further studies could also systematically explore the differential impacts of various digital technologies—such as AI versus blockchain—on distinct resilience dimensions, thereby deepening both theoretical and practical value.

6 The Moderating Role of Organizational Readiness

While the previous sections have outlined the mechanisms and paths through which digital transformation enhances supply chain resilience, the effectiveness of these mechanisms may vary depending on contextual factors. This section extends the theoretical framework by introducing two key moderating variables: organizational readiness and environmental uncertainty. Organizational readiness refers to the extent to which an enterprise possesses the necessary digital infrastructure, managerial support, and employee skills to implement digital transformation initiatives. Even with advanced digital technologies, firms lacking readiness may fail to fully realize the resilience-enhancing effects. For instance, the information collaboration mechanism described in Section 3.1 requires not only IoT and big data platforms but also a culture

of data sharing and cross-functional trust. Therefore, organizational readiness moderates the relationship between digital transformation and supply chain resilience, particularly in the resource optimization and collaborative linkage mechanisms. Environmental uncertainty—stemming from demand volatility, geopolitical risks, or natural disasters—can either amplify or dampen the effects of digital transformation on resilience. Under high uncertainty, real-time data and predictive analytics become more valuable, strengthening the positive impact of digital transformation on resistance and recovery capabilities. Conversely, in stable environments, the marginal benefits of further digitalization may diminish. Thus, firms should tailor their digital transformation strategies according to the level of environmental uncertainty they face.

Managers should carefully assess both internal readiness and external uncertainty before investing in digital resilience initiatives. Future empirical studies could rigorously test the moderated mediation model proposed here, using cross-industry survey data. Additionally, longitudinal case studies would help uncover how the moderating effects evolve over time.

7 Future Research Prospects

In addition to the empirical and technological directions mentioned above, future research should further expand the theoretical boundaries of digital transformation-enabled supply chain resilience in several underexplored areas. First, future studies should investigate the dynamic evolution process of resilience capabilities over time. Most existing studies, including this one, adopt a static perspective, treating resilience as a relatively stable outcome. However, as digital technologies continue to upgrade and supply chain environments fluctuate, resilience capabilities may undergo nonlinear changes, such as tipping points, path dependence, or even resilience decay. Longitudinal case studies and simulation modeling, such as system dynamics or agent-based modeling, could help uncover these temporal dynamics. Second, the dark side or potential costs of digital transformation for supply chain resilience deserves attention. While digitalization enhances information visibility and coordination, it also introduces new vulnerabilities, such as cybersecurity risks, over-reliance on single digital platforms, and algorithmic biases in automated decision-making. Future research could explore how enterprises can balance digital empowerment with digital risk control, and under what conditions the negative effects of digitalization might outweigh its benefits. Third, cross-cultural and cross-national comparative studies are urgently needed. Most existing literature focuses on developed economies or large multinational enterprises, with limited attention to small and medium-sized enterprises in emerging markets, which often face distinct constraints in digital infrastructure, talent availability, and institutional support. Comparative research across different institutional environments would reveal how contextual factors moderate the effectiveness of digital strategies, offering more tailored policy recommendations for diverse economic settings. Fourth, future research should adopt interdisciplinary perspectives. Supply chain resilience is not merely an operations management issue but also intersects with behavioral economics, organizational psychology, and public policy. For example, how

do managers' cognitive biases affect digital investment decisions under uncertainty? How do government regulations shape digital collaboration among supply chain partners? Incorporating insights from other disciplines would enrich the theoretical foundation and practical relevance of this field. Finally, as technologies such as generative AI, digital twins, and quantum computing mature, future research should examine how these emerging tools can further revolutionize supply chain resilience. Exploring use cases, implementation barriers, and performance metrics for these technologies will be a promising frontier for both scholars and practitioners.

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