



Research on the Impact of Artificial Intelligence Technology on Supply Chain Resilience

Jing Zhang

Central University of Finance and Economics, Beijing 100081, China

Abstract: This study aims to clarify the mechanisms by which artificial intelligence (AI) technology enhances supply chain resilience (SCR) across different disruption stages, addressing the gap in existing research that lacks in-depth exploration of AI-driven dynamic capabilities and stage-specific antecedents. Guided by Dynamic Capability Theory and a four-stage SCR framework (preparedness, response, recovery, learning), the research synthesizes relevant literature to analyze AI's targeted impacts. The findings indicate that AI boosts risk identification and contingency planning in the preparedness stage, enables rapid adjustments via real-time data processing in the response stage, accelerates recovery through resource integration and network optimization, and facilitates knowledge codification for iterative growth in the learning stage. Theoretically, this study enriches Dynamic Capability Theory by specifying AI-enabled dynamic capabilities; practically, it provides enterprises with guidance to align AI applications with stage-specific SCR needs. Limitations include the absence of empirical validation, and future research should conduct quantitative tests across industries and explore differential effects of AI subtypes.

Keywords: AI, supply chain resilience, dynamic capability theory

1. Introduction

Artificial intelligence (AI) systems are endowed with human-like analytical, predictive and reasoning capabilities. By synthesizing large volumes of internal and external environmental data alongside multi-source operational data, AI generates actionable insights into enterprise demand, supply and services, thereby enabling rapid, data-driven strategic decision-making for businesses. Accordingly, they are increasingly utilized in operations and supply chain management to bolster supply chain capabilities, efficiency, and resilience[1]. Existing scholarship has examined the deployment of AI technology in supply chains from various angles. For example, Lerch et al. (2023) contrasted German manufacturing firms that adopted AI against those that did not during the pandemic, empirically substantiating that AI-adopting firms exhibit higher production resilience[2]; similarly, Modgil et al. (2022) delineated the optimal application scenarios for distinct AI technologies through interviews in the information sector[3]. Despite the manifest advantages and performance improvements of AI in supply chain management, considerable ambiguity persists in both theory and practice regarding the precise mechanisms by which AI technology amplifies supply chain resilience. Dynamic Capability Theory offers a suitable theoretical framework for this inquiry and represents the predominant lens in current research. It posits that within a rapidly changing environment, digital technologies endow enterprises with the dynamic capabilities to swiftly integrate, construct, and reconfigure internal and external resources. Nevertheless, existing studies have failed to deeply explore the nature of these dynamic capabilities or how they operate during the various stages of a disruption to enhance supply chain resilience. Consequently, addressing this gap, this study seeks to answer the following research questions:

RQ1: What dynamic capabilities does the deployment of AI technology afford enterprises, enabling them to navigate different stages of disruption?

RQ2: Which antecedents are of greater importance for resilience improvement across different stages of a disruption?

2. Theoretical Foundation

Dynamic Capability Theory (DCT) posits that in a rapidly changing dynamic environment, enterprises must possess the capacity for rapid reconfiguration; such dynamic capabilities are essential for achieving superior performance and leading over competitors[4]. Regarded as an extension of the Resource-Based View (RBV), this theory primarily seeks to explain how firms secure competitive advantage in dynamically shifting market environments[5]. While both theories address the mechanisms of gaining competitive advantage, a fundamental difference exists between resources and capabilities: resources constitute the elements that an enterprise can acquire and possess, whereas capabilities denote the rational deployment and utilization of those resources. Consequently, literature utilizing dynamic capability as a theoretical foundation emphasizes the extent to which enterprises can effectively deploy and leverage available digital technology

resources to improve performance. Digital technology mitigates the risks associated with external environmental uncertainty through its exceptional information exchange and processing capabilities, thereby bolstering supply chain resilience. For example, Modgil et al. (2023) discovered through a survey of managers across various industries that AI-driven information integration—encompassing knowledge mining, demand forecasting, and production planning—provides vital support for strategic decision-making and operations, significantly enhancing supply chain resilience[3].

Current literature suggest that researchers view AI and other digital technologies as unique technological assets, their ultimate impact within an organization is contingent upon the extent to which the organization can leverage these assets to acquire or bolster the dynamic capabilities necessary for navigating turbulent environments. Yet, given the complexity of disruptions and the multi-stage nature of supply chain resilience, this generalized explanation is clearly inadequate to encapsulate and elucidate the specific mechanisms by which AI technology enhances supply chain resilience at each distinct stage of a disruption. Addressing this gap constitutes the theoretical frontier that this study seeks to expand.

3. A Four-Stage Framework for Supply Chain Resilience

Supply chain resilience is defined as the capability of a supply chain to rapidly adapt and recover when encountering internal and external disruptions. Furthermore, recent research grounded in socio-ecological complex systems theory extends the notion of “recovery” to “iterating” towards a superior ecological state. Despite the conceptual straightforwardness of the definition, supply chain resilience remains a complex and multi-faceted research domain. The absence of practical and direct metrics means that scholars continue to debate the precise factors constituting supply chain resilience. Given that supply chain resilience is typically latent and unobservable in practice, managers must infer accurate perceptions of it by observing the coping processes of relevant enterprises during specific disruption events[6]. Consequently, the evaluation of supply chain resilience is typically categorized into four stages: disruption preparedness, disruption response, disruption recovery, and disruption learning (growth). A review of the measurement scales commonly utilized in eight representative empirical studies over the past three years reveals the following:(1) in the preparedness stage, the primary focus is on the supply chain’s ability to monitor and identify risks and to formulate contingency plans; (2) in the response stage, emphasis is placed on the enterprise’s capacity to react rapidly while maintaining its existing supply chain structure and operations amid the disruption; (3) in the recovery stage, the predominant concerns are the speed of recovery and the ability to restore the system to pre-disruption levels. In contrast, (4) regarding the learning stage, most researchers have yet to acknowledge the critical importance of accumulating disruption response experience and knowledge management for the construction of supply chain resilience.

4. The Impact of Artificial Intelligence on Supply Chain Resilience

Artificial Intelligence (AI) is defined as the integration of fundamental theories, methods, and techniques investigating the use of computer hardware and software to simulate specific intelligent human behaviors. Through powerful data processing capabilities that emulate human cognition, AI technology empowers enterprises to better identify risks, sense the environment, and make intelligent decisions, thus bolstering supply chain adaptability and agility[7]. Existing scholarship regarding AI application in supply chains converges on two primary streams: First, the exploration of application scenarios within supply chain management, especially in the context of supply chain resilience. For example, Modgil et al. employed case interviews to analyze how AI technology processes information across the post-disruption phases of identification, analysis, reconfiguration, and recovery, providing decision support to managers and enhancing supply chain resilience[3]. Second, the mechanisms underlying the impact of AI technology on supply chain resilience. Notably, Belhadi et al. (2022) classified AI technology into four categories: Human Thinking Techniques (HTT), Human Acting (HAT), Rational Thinking Techniques (RTT), and Rational Acting (RAT). They subsequently examined the applicability of these four technologies in relation to four antecedents of supply chain resilience: supply chain reconfiguration, collaboration, agility, and risk management culture[7].

Drawing on existing literature on AI’s impact on SCR and the four-stage framework of SCR, we can delineate AI’s targeted effects on SCR capabilities across each disruption stage. In the preparedness stage, AI’s predictive analytics and risk monitoring capabilities enable early identification of potential disruptions and refinement of contingency plans. During the response stage, its real-time data processing and intelligent decision-support empower rapid adjustments while preserving core operational structures. For the recovery stage, AI-driven resource integration and network optimization accelerate the restoration of pre-disruption performance levels. In the learning stage, AI facilitates knowledge codification of response experiences and iterative process optimization, transforming recovery into proactive resilience growth, aligning with the socio-ecological complex systems theory’s emphasis on superior post-disruption states.

5. Discussion

This study explores AI's impact on supply chain resilience (SCR) via dynamic capability theory and a four-stage framework. The findings reveal AI's targeted value across disruption stages: enhancing risk identification in preparedness, enabling rapid responses, accelerating recovery through resource integration, and fostering iterative learning. Theoretically, it enriches dynamic capability theory by specifying AI-driven capabilities. Practically, it guides enterprises to align AI applications with stage-specific SCR needs. Limitations include a lack of empirical validation; future research could test the framework quantitatively across industries and explore AI subtypes' differential effects.

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