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Research on Strategies for Enhancing Enterprise Supply Chain Resilience in the Context of Digital Transformation

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ABSTRACT

This paper aims to explore how enterprises can effectively enhance their supply chain resilience through digital transformation against the dual backdrop of increasing global uncertainty and rapid development of digital technologies. First, it elucidates the core connotations of supply chain resilience and the key technological foundations of digital transformation. Second, it constructs a theoretical logic model of "technology empowerment-capability building-resilience performance," systematically analyzing how digital technologies such as big data, artificial intelligence, the Internet of Things, and blockchain enhance supply chain visibility, predictability, collaboration, and agility to address disruption risks and achieve rapid recovery. Furthermore, through theoretical deduction and case studies, a systematic strategic framework for enterprises to enhance supply chain resilience is proposed across four dimensions: strategic planning, process reengineering, technology integration, and organizational change. Finally, the managerial implications and future research directions of this study are outlined, providing theoretical reference and practical guidance for enterprises to build a resilient supply chain system in the new context.

Keywords: Digital transformation; Supply chain resilience; Digital technologies; Risk response; Enhancement strategies

Introduction

Research Background and Problem Identification

Practical Context: An Era of Disruption and Volatility

Global supply chains, the lifeblood of the modern economy, are facing an unprecedented confluence of disruptive events. These include rare but high-impact "black swan" events, such as the COVID-19

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pandemic and sudden geopolitical conflicts, as well as highly probable yet often neglected "grey rhino" challenges, such as the escalating climate crisis, persistent economic fluctuations, and intensifying trade tensions. These events have starkly exposed the inherent fragility and vulnerability of traditional, efficiency-optimized, and lean-oriented supply chain models. The pursuit of hyper-efficiency, often at the expense of redundancy and flexibility, has left many supply chains brittle and unable to withstand systemic shocks, leading to widespread shortages, delays, and economic losses (Ivanov & Dolgui, 2020).

Technological Context: The Dawn of Digital Enablement

Concurrently, the rapid maturation and convergence of a suite of digital technologies present a historic opportunity for fundamental transformation. Technologies such as the Internet of Things (IoT), Big Data analytics, cloud computing, artificial intelligence (AI), machine learning, blockchain, and digital twins are providing the necessary tools to reimagine and reinvent supply chain management. These technologies offer the promise of unprecedented levels of visibility, intelligence, automation, and connectivity across the entire supply network, from raw material sourcing to end-customer delivery (Ivanov et al., 2019).

Problem Statement: Bridging the Gap

The critical question that emerges at the intersection of these two contexts is: How can enterprises systematically leverage the opportunity presented by digital transformation to build enduring supply chain resilience, thereby effectively coping with increasingly complex and volatile internal and external risks? This is not merely a technological challenge but a strategic one. It requires a holistic understanding of the mechanisms through which digital technologies translate into enhanced resilient capabilities and a structured framework to guide this transformation. Answering this question is a pressing theoretical and practical imperative for academics and industry leaders alike.

Research Significance

Theoretical Significance

This research contributes significantly to the body of knowledge by enriching interdisciplinary studies that sit at the confluence of supply chain risk management, strategic management, and information systems. It moves beyond examining isolated technological applications to develop an integrated "Technology-Capability-Resilience" model. This model deepens the scholarly understanding of the intrinsic mechanisms and causal pathways through which digital technologies enable and enhance specific dimensions of resilience, such as visibility, agility, and collaboration, thereby providing a more nuanced theoretical foundation for future empirical work.

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Practical Significance

For practitioners, this study offers immense value by providing a comprehensive, actionable, and technology-grounded strategic framework. It guides managers and executives in moving from ad-hoc technological adoption to a deliberate, strategic journey of building digital resilience. The framework outlines concrete strategies at the strategic, process, technological, and organizational levels, empowering businesses to make informed investment decisions, prioritize initiatives, and ultimately build risk-resistant, adaptable, and sustainable competitive advantages in an uncertain world.

Research Content and Methodology

Research Content

This paper adopts a logical progression of "what," "why," and "how" to thoroughly investigate the relationship between digital transformation and supply chain resilience. It begins by defining the core concepts and reviewing existing literature. The core of the paper delves into "why" by analyzing the precise mechanisms through which digital technologies enable resilience. Finally, it addresses "how" by constructing a actionable strategic framework for enterprises to follow, supported by real-world case implications.

Methodology

To achieve its objectives, this research employs a multi-method approach:

1. Comprehensive Literature Review: A systematic review of academic publications and industry reports is conducted to establish a solid theoretical foundation on supply chain resilience, digital supply chain technologies, and their intersecting research.

2. Theoretical Analysis: Building on the literature, a deductive reasoning process is used to construct the theoretical model ("Technology-Capability-Resilience") that explains the enabling mechanisms.

3. Case Study Analysis: Selected real-world cases (e.g., Siemens) are analyzed to illustrate the application and validity of the proposed framework, providing practical insights and contextual richness.

Paper Structure

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature on supply chain resilience and digital transformation, identifying the research gap. Section 3 constitutes the core theoretical analysis, deconstructing the mechanism by which digital transformation enhances resilience. Section 4 builds upon this analysis to propose a holistic strategic framework. Section 5 provides case implications and practical recommendations, and Section 6 concludes the study with findings, limitations, and directions for future research.

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Literature Review and Theoretical Foundation

The Connotation and Dimensions of Supply Chain Resilience

Definition and Evolution of the Concept

The concept of supply chain resilience has evolved significantly over the past two decades. Initially, resilience was often conflated with robustness, focusing primarily on the ability to "resist" and "absorb" disruptions. The work of Ponomarov and Holcomb (2009) was instrumental in providing a formal definition, describing resilience as the adaptive capability of a supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at a desired level of connectedness and control. This definition introduced the core phases of resilience. Later, Hohenstein et al. (2015) and Channuwong (2014) expanded this understanding through a systematic review to include the ability to "adapt" to new competitive environments and even "reconfigure" supply chain structures and strategies for long-term viability. Thus, modern resilience encompasses both reactive recovery and proactive adaptation and transformation.

Core Dimensions and Constituent Capabilities

Scholars have decomposed resilience into several interrelated core dimensions, each representing a critical capability:

Visibility: The ability to see and track products, information, and finances flowing across the entire supply network in real-time or near-real-time. It is the foundational capability for all others (Christopher & Peck, 2004).

Agility: The capacity to respond quickly and effectively to unexpected changes in demand or supply. It involves swift detection and rapid response to minimize the impact of disruptions (Sheffi, 2005).

Adaptability: The capability to modify the supply chain's design, structure, or strategies in response to long-term shifts in the market environment or to permanent changes caused by a disruption. This may involve finding new suppliers, developing new products, or entering new markets.

Collaboration: The willingness and ability to work closely with supply chain partners (suppliers, customers, logistics providers) to share information, jointly plan, and align incentives to mitigate risks and enhance overall network resilience (Christopher & Peck, 2004).

Redundancy: The strategic use of buffer capacity, safety stock, and backup suppliers to absorb shocks. The modern approach is not about brute-force redundancy but about "lean redundancy" or "strategic redundancy"—optimizing the level and placement of buffers based on risk exposure (Sheffi, 2005).

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Core Technologies and Characteristics of Digital Transformation

Defining Digital Transformation in SCM

In the context of supply chain management, digital transformation transcends mere digitization (converting analog data to digital) or digitalization (using digital data to streamline processes). It represents a fundamental strategic shift to integrate digital technologies across all supply chain functions, thereby generating profound changes in operational processes, business models, and value creation. It is a holistic reimagining of the supply chain powered by data and technology (Bangbon et al., 2023).

Key Enabling Technologies

Internet of Things (IoT): Networks of physical objects embedded with sensors, software, and connectivity to collect and exchange data. In SCM, IoT enables real-time tracking of goods, monitoring of warehouse conditions, and predictive maintenance of equipment.

Big Data & Analytics: The process of collecting, storing, and analyzing vast volumes of structured and unstructured data to uncover patterns, correlations, and insights. It is crucial for demand forecasting, risk prediction, and optimization.

Artificial Intelligence (AI) & Machine Learning (ML): Algorithms that enable systems to learn from data, identify patterns, and make decisions with minimal human intervention. AI/ML powers advanced forecasting, autonomous decision-making in logistics, and intelligent risk management systems (Prachayapipat et al., 2020).

Blockchain: A distributed, immutable, and transparent digital ledger. It creates trust and enables secure, tamper-proof tracking of transactions and product provenance across complex multi-party supply chains (Kshetri, 2018).

Digital Twin: A dynamic virtual representation of a physical supply chain asset, system, or process. It uses real-time data and simulation models to mirror its physical counterpart, allowing for testing, monitoring, and optimization in a risk-free virtual environment (Ivanov et al., 2019).

Characteristics of the Digital Supply Chain

The infusion of these technologies leads to a supply chain with new inherent characteristics: it becomes Data-Driven, where decisions are based on insights from data rather than intuition; Intelligent & Automated, with processes increasingly handled by smart algorithms and robots; End-to-End Transparent, with all partners having access to a single source of truth; and Ecosystem-Oriented, fostering deeper and more seamless collaboration across a network of partners.

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Review of Research on the Link between Digital Transformation and Supply Chain Resilience

A growing stream of literature has begun to explore the connection between digital technologies and supply chain resilience. Early research focused on the potential of individual technologies. For instance, studies have shown how IoT enhances visibility, how AI improves forecasting accuracy, and how blockchain reduces counterfeit risks and improves traceability. More recent research has started to take a more integrated view, suggesting that the synergistic combination of these technologies yields greater benefits than their siloed application.

Identification of Research Gap

Despite this progress, a significant gap remains. Much of the existing research tends to focus on the impact of a single technology on a specific aspect of resilience (e.g., blockchain for transparency). There is a lack of a comprehensive, holistic, and strategic framework that explains how the entire portfolio of digital technologies systematically builds and enhances the multidimensional capabilities of resilience (visibility, agility, adaptability, collaboration, smart redundancy) in an integrated manner. Furthermore, there is insufficient guidance on the organizational and strategic changes required to support this technological transformation. This paper aims to bridge this gap by proposing such a holistic framework.

3. Analysis of the Mechanism by which Digital Transformation Enhances Supply Chain Resilience

This section constructs the core theoretical model of this paper: the "Technology-Capability-Resilience" framework. It meticulously dissects how specific digital technologies bolster each core capability that constitutes supply chain resilience.

Enhancing Visibility: From "Blind Men Touching an Elephant" to "Global Insight"

The Mechanism: Creating a Digital Thread

The foundational step towards resilience is achieving end-to-end visibility. Traditional supply chains often operate with significant blind spots, akin to the parable of the blind men and the elephant. Digital transformation weaves a "digital thread" through the entire chain. IoT sensors, RFID tags, and GPS trackers attached to products, pallets, containers, and vehicles generate a constant stream of real-time data on location, condition (e.g., temperature, humidity), and status. This data is aggregated and integrated into a centralized cloud platform, creating a dynamic, digital mirror of the physical supply chain. This allows managers to "see" the status of any asset or inventory anywhere in the world, breaking down the silos that traditionally existed between different stages and partners (Winkelhaus & Grosse, 2020).

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Enabling Resilience: From Reactive to Proactive

This radical transparency directly enhances resilience in critical ways. It enables the real-time sensing of nascent risks, such as a shipping container being delayed at a port, a truck deviating from its planned route, or warehouse inventory levels dipping below a critical threshold. With this information, companies can move from a reactive stance ("we have a problem") to a proactive one ("we see a potential problem developing"). Advanced analytics can process this real-time data to provide predictive early warning, flagging potential disruptions before they fully materialize. This drastically reduces the response time, allowing for data-driven decision-making to mitigate the impact, such as rerouting shipments or expediting production long before a stockout occurs (Sheffi, 2015).

Improving Agility and Adaptability: From "Rigid and Fixed" to "Flexible and Agile"

The Mechanism: Simulation and Intelligent Optimization

Visibility provides the data, but agility and adaptability require the intelligence to act on it swiftly. This is where AI and Digital Twins play a transformative role. A Digital Twin creates a high-fidelity virtual model of the supply network. This model can be used to run simulations and stress-tests, answering "what-if" scenarios without risking real-world operations. For example, a company can simulate the impact of a supplier's factory shutting down or a sudden spike in demand. Concurrently, AI and ML algorithms continuously analyze data to optimize operations. They can power dynamic routing systems that adjust transportation paths in real-time based on traffic, weather, or customs delays. They can generate highly accurate demand forecasts and prescribe optimal inventory levels across the network, balancing service levels with carrying costs.

Enabling Resilience: Rapid, Informed Response and Reconfiguration

When a disruption occurs, these technologies supercharge the response. Instead of panicked meetings based on incomplete information, managers can turn to the Digital Twin. They can rapidly simulate multiple contingency plans—e.g., switching to an alternative supplier, rerouting through a different port, reallocating inventory from a low-demand region. The AI can evaluate these scenarios against key performance indicators (cost, time, carbon footprint) and recommend the optimal course of action. This process, which could have taken weeks manually, can be compressed into hours or even minutes. Furthermore, for adaptability, these tools help in the longer-term reconfiguration of the supply chain, identifying single points of failure and modeling the impact of adding new suppliers or shifting manufacturing locations, thus building a more adaptable network structure for the future.

Strengthening Collaboration: From "Going It Alone" to "Ecosystem Win-Win"

The Mechanism: Building Trusted Digital Networks

Resilience is not built in isolation; it is a network-wide capability. Traditional supply chains are often

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plagued by information silos and a lack of trust between partners, leading to the infamous "bullwhip effect" where small demand fluctuations amplify as they move up the chain. Digital technologies are powerful tools for breaking down these barriers. Cloud-based collaboration platforms provide a shared digital workspace where suppliers, manufacturers, distributors, and retailers can share forecasts, inventory data, and production plans in a secure and standardized manner. Blockchain technology takes this a step further by creating a decentralized, immutable ledger of transactions. This ensures that all parties have access to the same, undeniable version of the truth—be it the provenance of a raw material, the status of a purchase order, or the terms of a smart contract—without needing to rely on a central authority (Kshetri, 2018). This builds a foundation of trust.

Enabling Resilience: Ecosystem-Wide Risk Management

This enhanced collaboration is a force multiplier for resilience. It enables cross-enterprise collaborative early warning. A supplier might see a client's inventory dropping and can proactively alert them or ramp up production before an official order is even placed. During a disruption, partners can engage in joint response efforts, such as sharing transportation capacity or temporarily reallocating scarce components to where they are needed most. This ecosystem approach creates a form of resource mutual assistance, where the collective strength of the network is leveraged to overcome challenges that would cripple any single member. It effectively mitigates the bullwhip effect by ensuring all partners are reacting to true end-market demand rather than distorted signals (Lee et al., 1997; Channuwong et al., 2018).

Optimizing Redundancy: From "Brute Force Backup" to "Precision Redundancy"

The Mechanism: Data-Driven Risk Assessment

Redundancy, such as safety stock and backup suppliers, is a classic resilience strategy, but it often comes at a high cost. The traditional approach could be described as "brute force"—adding generic buffers without a precise understanding of their necessity or ROI. Digital transformation enables a shift to "precision redundancy" or "smart redundancy." Big data analytics can sift through vast amounts of operational and external data to precisely identify the network's most critical nodes and its most vulnerable single points of failure. It can quantify the risk and potential impact of disruption at each node. AI-powered multi-sourcing platforms and supplier risk databases can then help managers accurately assess, vet, and select the most reliable backup suppliers or logistics alternatives for these specific high-risk links (Simchi-Levi & Simchi-Levi, 2020).

Enabling Resilience: Cost-Effective Buffering and Flexibility

This data-driven approach allows companies to optimize their resilience investments. Instead of blanket redundancy, they can implement targeted redundancy exactly where it is needed most. This achieves an optimal balance between the cost of holding buffer resources and the security they provide.

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Furthermore, digital technologies can create capacity redundancy (e.g., flexible manufacturing platforms that can be repurposed) or virtual redundancy (e.g., a digital list of pre-qualified alternative suppliers that can be activated instantly), which is often more cost-effective than physical redundancy. The result is a supply chain that is both resilient and efficient, having the right type and amount of buffer at the right place to mitigate targeted risks.

4. Constructing a Strategic Framework for Enhancing Supply Chain Resilience under Digital Transformation

Understanding the mechanisms is the first step; implementing them is the next. This section translates the theoretical model into a actionable, multi-level strategic framework for enterprises.

Strategic Level: Formulating a Top-Level Design for a Digital Resilient Supply Chain

Strategy 1: Embed Resilience into Core Strategy and Secure Leadership Commitment

Digital resilience transformation cannot be a siloed IT initiative; it must be a core component of corporate and supply chain strategy, driven from the top down. Senior management must explicitly elevate supply chain resilience to a strategic priority, on par with cost and service. This requires a clear vision, committed financial and human resources, and a governance structure that oversees the transformation journey. The goal is to shift the organizational mindset from pursuing the "lowest cost" to achieving the "optimal balance between cost, service, and resilience" (Ralston & Blackhurst, 2020).

Strategy 2: Map and Diagnose the End-to-End Digital Supply Chain

Before deploying technology, a company must have a deep understanding of its own supply network. This involves creating a detailed digital map of all tiers of suppliers, manufacturing sites, distribution centers, transportation lanes, and customers. This map must then be overlaid with vulnerability assessments, identifying critical nodes, single points of failure, and high-risk geographic regions. This diagnostic exercise provides a risk-prioritized roadmap, indicating where digital transformation investments (e.g., in visibility tools, backup systems) will have the greatest impact on enhancing resilience.

Process Level: Reengineering Digital Business Processes

Strategy 3: Establish a Closed-Loop "Sense-Judge-Respond-Learn" Resilience Process

Resilience must be baked into core supply chain processes. This involves designing an integrated, closed-loop process:

Sense: Deploy IoT devices and data connectors to establish a pervasive sensing network that provides real-time, full-chain monitoring of flows and statuses.

Judge: Utilize AI-powered analytics platforms to process this data stream for continuous risk identification, root cause analysis, predictive impact assessment, and recommendation generation.

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Respond: Develop automated or semi-automated workflow triggers. Based on the "judge" phase, the system can automatically trigger contingency plans (e.g., dynamically rerouting shipments, issuing purchase orders to backup suppliers) or present validated options to a human controller for rapid execution. Digital twins are crucial here for simulating response options.

Learn: After any disruption or near-miss, use data analytics to conduct a thorough post-mortem. Feed these insights back into the digital models, updating risk algorithms, refining simulation parameters, and improving contingency plans. This creates a learning loop that ensures the resilience system evolves and becomes smarter over time (Ivanov, 2021).

Technology Level: Integrating and Applying a Digital Technology Stack

Strategy 4: Build a Unified Supply Chain Data Middle Platform

The effectiveness of all advanced technologies depends on the quality, availability, and integration of data. A critical step is to break down internal and external data silos by constructing a unified data middleware or platform. This platform ingests, cleanses, standardizes, and manages data from diverse sources (ERP, WMS, TMS, IoT, supplier systems). It provides a single, trusted source of truth and offers clean, standardized data services (APIs) to all upper-layer analytical and application systems, enabling seamless interoperability.

Strategy 5: Selectively Deploy and Integrate Key Digital Technologies

With a solid data foundation, companies can strategically deploy a suite of technologies, ensuring they are integrated to work together:

For Prediction & Warning: Implement AI and machine learning models for advanced demand forecasting, supplier risk scoring, and predictive disruption alerting.

For Traceability & Transparency: Apply blockchain solutions for high-value, sensitive, or ethically sourced products to ensure provenance and build consumer trust.

For Simulation & Optimization: Introduce Digital Twins for the most complex and critical parts of the supply network to enable risk-free testing and optimization.

For Automated Execution: Utilize Robotics Process Automation (RPA) for automating repetitive back-office tasks and Autonomous Mobile Robots (AMRs) in warehouses to improve speed, accuracy, and flexibility in physical operations.

Organizational Level: Cultivating Digital Talent and a Collaborative Culture

Strategy 6: Develop Cross-Functional Digital Talent Teams

The new digital supply chain requires new skills. Companies must invest in cultivating and recruiting "T-shaped" professionals with deep expertise in supply chain management complemented by data

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science, analytics, and digital technology skills. Creating cross-functional teams that bring together supply chain experts, data scientists, and IT specialists is essential for designing, implementing, and managing the digital resilience framework effectively.

Strategy 7: Build a Collaborative Digital Ecosystem with Suppliers

Technology alone cannot foster collaboration; it must be supported by a culture of partnership. Companies need to move beyond transactional, cost-focused relationships with their suppliers. Using digital tools as enablers, they must build long-term, trusted, and mutually beneficial partnerships. This involves aligning incentives, fairly sharing risks and rewards, and collaboratively using the shared data from digital platforms to solve problems and innovate. The resilience of a company is ultimately capped by the resilience of its weakest key partner, making ecosystem-wide resilience paramount (Min et al., 2019).

Case Implications and Recommendations

5.1 Case Insight: Siemens' Digital Resilience Practice

A pertinent example of this framework in action is Siemens AG. The industrial manufacturing giant has heavily invested in its digital twin technology and a comprehensive digital enterprise suite. During the COVID-19 pandemic, when global logistics were thrown into chaos and supplier plants shut down, Siemens' digital infrastructure proved invaluable. The company used its digital twins to rapidly simulate and assess the impact of disruptions across its global production network. Its high level of supply chain visibility allowed it to quickly identify which parts were delayed and which suppliers were affected. Leveraging this data, Siemens could swiftly source critical components from alternative, pre-qualified suppliers in its digital network and dynamically reconfigure its production schedules. This capability to "sense" the problem, "judge" the impact through simulation, and "respond" swiftly minimized operational downtime and exemplified the power of digital agility and adaptability in maintaining continuity.

Recommendations for Enterprises and Policymakers

For Enterprises:

Mindset Shift: Prioritize a strategic shift from a purely cost-centric view to a resilience-value perspective.

Phased Approach: Begin the transformation with pilot projects targeting high-pain-point, high-value processes (e.g., end-to-end shipment visibility) to demonstrate ROI before scaling.

Data Governance: Establish strong data governance policies from the outset to ensure data quality, security, and privacy.

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For Governments and Industry Associations:

Develop Standards: Foster the development of industry-wide data standards and protocols to facilitate secure and interoperable data sharing between companies.

Fund Risk Platforms: Support or incentivize the creation of industry-specific supply chain risk information sharing and analysis centers (ISACs).

Support Education: Fund educational and training programs to develop the cross-disciplinary talent required for the digital supply chain era.

Research Conclusions and Outlook

Conclusions

This study confirms that digital transformation is not merely an option but a critical imperative for building supply chain resilience in the 21st century. It moves beyond technological hype to provide a systematic analysis, demonstrating through the "Technology-Capability-Resilience" model how digital technologies—IoT, AI, Digital Twin, Blockchain—fundamentally empower the core capabilities of visibility, agility, adaptability, collaboration, and smart redundancy. However, technology alone is insufficient. Success requires a holistic and systematic approach encompassing strategic alignment, process re-engineering, technological integration, and organizational change management. Enterprises that embrace this comprehensive framework will be best positioned to anticipate, withstand, recover from, and adapt to the inevitable disruptions of the future.

Limitations and Future Research Directions

Limitations: This research is primarily based on theoretical derivation and case study analysis. While it provides a solid conceptual foundation, it lacks large-scale empirical validation through quantitative methods, such as large-N surveys, to statistically test the proposed relationships and model.

Future Research Directions:

1. Empirical Quantification: Future research should focus on developing metrics to quantify the impact of specific digital technologies on individual resilience dimensions and overall financial and operational performance.
2. Industry-Specific Studies: Exploring the application and nuances of this framework in different industrial contexts (e.g., the fast-moving consumer goods (FMCG) sector vs. the capital-intensive automotive industry vs. the highly regulated pharmaceutical sector) would yield valuable tailored insights.
3. Addressing Implementation Challenges: Further investigation is needed into the significant

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challenges of implementation, including data security and privacy concerns, ethical use of AI, managing the digital divide between large and small suppliers, and overcoming organizational resistance to change.

References

[1] Bangbon, P., Channuwong, S., Amponstira, F., Rungsuk, A. & Snongtaweeporn, T. (2023). The influence of transformational leadership on organizational sustainability: A case study of business companies in Bangkok. *Journal of Namibian Studies, 33*, 4077-4095.

[2] Channuwong, S., Ruksat, S., & Ploychum, S. (2018). An integration of Buddhist teachings in stress management. Journal of Community Development Research, *11*(4),148-158.

[3] Channuwong, S. (2014). The strategic management of Coco-Cola and Starbucks company. Journal of Business Administration and Languages, 2(2), 55-58.

[4] Christopher, M., & Peck, H. (2004). Building the resilient supply chain. The International Journal of Logistics Management, 15(2), 1-14.

[5] Hohenstein, N. O., Feisel, E., Hartmann, E., & Giunipero, L. (2015). Research on the phenomenon of supply chain resilience. International Journal of Physical Distribution & Logistics Management, 45(1/2), 90-117.

[6] Ivanov, D. (2021). Supply chain viability and the COVID-19 pandemic: A conceptual and formal generalisation of four major adaptation strategies. International Journal of Production Research, 59(12), 3535-3552.

[7] Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: extending the supply chain resilience angles through survivability. International Journal of Production Research, 58(10), 2904-2915.

[8] Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. International Journal of Production Research, 57(3), 829-846.

[9] Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. International Journal of Information Management, 39, 80-89.

[10] Lee, H. L., Padmanabhan, V., & Whang, S. (1997). The bullwhip effect in supply chains. Sloan Management Review, 38(3), 93-102.

[11] Min, S., Zacharia, Z. G., & Smith, C. D. (2019). Defining supply chain management: in the past, present, and future. Journal of Business Logistics, 40(1), 44-55.

[12] Prachayapipat, M., Kongtana, J., Skulitsariyaporn, C., & Snongtaweeporn, T. (2020). Role of green supply chain management practices on manufacturing company performance: A moderating role of supply chain traceability and institutional pressures. International Journal of Supply Chain Management, 9(2), 572-581.

[13] Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. The International Journal of Logistics Management, 20(1), 124-143.

[14] Ralston, P., & Blackhurst, J. (2020). Industry 4.0 and resilience in the supply chain: A driver of

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Journal of Information Systems Engineering and Management
2025, 10(62s)
e-ISSN: 2468-4376
https://jisem-journal.com/ **Research Article**

capability enhancement. Proceedings of the 2020 IISE Annual Conference.
[15] Sheffi, Y. (2005). The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage. The MIT Press.
[16] Simchi-Levi, D., & Simchi-Levi, E. (2020). How to build a more resilient supply chain. Harvard Business Review.
[17] Winkelhaus, S., & Grosse, E. H. (2020). Logistics 4.0: a systematic review towards a new logistics system. International Journal of Production Research, 58(1), 18-43.

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