

FROM EFFICIENCY TO RESILIENCE: RETHINKING LOGISTICS IN THE AGE OF GEOPOLITICAL AND DIGITAL DISRUPTIONS

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Abstract

This paper examines the evolving role of logistics amid increasing geopolitical uncertainty, digital transformation, and global interdependence. Traditionally perceived as an operational support function, logistics has become a critical infrastructure shaping economic stability, national security, and global power dynamics. The study addresses the growing misalignment between efficiency-oriented supply chain models and the need for resilience in a volatile environment characterized by disruptions such as geopolitical conflicts, cyber threats, and systemic shocks.

Building on the concepts of resilience and “weaponized interdependence,” the paper explores key vulnerabilities of modern supply networks, including dependence on critical resources, exposure to strategic chokepoints, and risks associated with digitalization. Through a conceptual analysis supported by relevant literature, the research identifies major categories of geopolitical and technological risks and examines their potential impact on state stability and supply chain continuity. The findings highlight the need to rethink traditional logistics paradigms by integrating resilience, adaptability, and anticipatory capabilities into supply chain design and management. The paper contributes to the understanding of logistics as a strategic domain that extends beyond operational efficiency, emphasizing its role in ensuring long-term sustainability and security in an increasingly complex global environment.

Keywords: logistics; supply chain resilience; geopolitical risks; digital transformation; global supply chains; risk management

JEL classification: R40, L91, F51, O33

INTRODUCTION

For decades, logistics was predominantly perceived as a passive and auxiliary function within global trade systems—an operational background ensuring the efficient movement of goods. In such a framework, logistics was largely optimized for cost efficiency and reliability, without requiring broader strategic consideration. However, recent global developments have fundamentally reshaped this perception.

In the contemporary global environment, logistics has emerged as a critical infrastructure that underpins economic stability, geopolitical influence, and national security. Rather than serving merely as a support function, supply chains now represent strategic assets through which both states and corporations exercise power (Cowen, 2014; Chua et al., 2018). Control over logistical networks—including maritime routes, port infrastructure, and digital platforms—has become a defining factor in global competitiveness and influence.

This transformation has been further accelerated by major global disruptions. The COVID-19 pandemic exposed structural vulnerabilities in global supply chains, particularly the risks associated with geographically concentrated production and just-in-time models (Ivanov & Dolgui, 2020; Gereffi, 2020). Similarly, the blockage of the Suez Canal in 2021 demonstrated how disruptions in a single critical chokepoint can have cascading effects across global trade systems (UNCTAD, 2021).

At the same time, digital transformation is redefining logistics. The integration of artificial intelligence, big data analytics, and digital platforms enables real-time coordination and predictive decision-making, but also introduces new systemic vulnerabilities (Dolgui et al., 2020). Recent research confirms a significant shift in supply chain management towards resilience, strategic control, and critical infrastructure protection, particularly after 2020 (Madzík et al., 2024).

In this evolving context, logistics must be understood not only as an operational function but as a strategic domain shaping resilience, competitiveness, and long-term sustainability.

1. PROBLEM STATEMENT: THE VULNERABILITY OF GLOBAL INTERDEPENDENCE

Despite its increasing strategic importance, modern logistics systems are characterized by a fundamental paradox: the tension between efficiency and resilience. The pursuit of cost optimization has led to highly integrated global supply chains that perform efficiently under stable conditions but remain highly vulnerable to disruptions (Sheffi, 2005).

Recent crises—including the COVID-19 pandemic, semiconductor shortages, and geopolitical conflicts—have revealed the fragility of these systems. Global interdependence, while enabling efficiency, has simultaneously increased exposure to systemic risks such as supply shortages, trade disruptions, and political instability (Gereffi, 2020).

The concept of “weaponized interdependence” provides a framework for understanding how global networks can be leveraged as instruments of geopolitical power (Farrell & Newman, 2019). States can exploit structural dependencies in supply chains to exert economic and political pressure, particularly in critical sectors such as energy, food, and advanced technologies.

Furthermore, empirical studies indicate that geopolitical uncertainty significantly increases supply chain disruptions, leading to delays, cost escalation, and reduced availability of goods. This highlights the need to rethink traditional logistics paradigms and move beyond efficiency-driven models toward resilience-oriented strategies.

2. METHODOLOGY

This study adopts a conceptual and interdisciplinary research approach, combining insights from logistics, supply chain management, and geopolitical studies. The analysis is based on a structured review of recent academic literature (2015–2025), including journal articles, book chapters, and reports from international organizations.

In addition, selected real-world disruption cases—such as the COVID-19 pandemic, the Suez Canal blockage, and the semiconductor crisis—are used to contextualize theoretical insights. The objective is to identify key risk categories and develop a conceptual framework for understanding supply chain resilience in an increasingly complex and uncertain global environment.

3. STRATEGIC GEOPOLITICAL CHALLENGES IN MODERN LOGISTICS

3.1. VULNERABILITY OF CRITICAL INFRASTRUCTURE

Global supply chains rely on a limited number of critical nodes, including maritime chokepoints, ports, and major logistics hubs. These nodes represent structural bottlenecks in global trade, where disruptions can propagate rapidly across interconnected supply networks. Recent studies emphasize that the concentration of logistics infrastructure significantly increases systemic risk, as disruptions in a single node can trigger cascading effects throughout global supply chains (Notteboom et al., 2021). The Suez Canal blockage in 2021 is a prominent example, demonstrating how localized disruptions can have global consequences and expose the fragility of tightly coupled logistics systems (UNCTAD, 2021).

Furthermore, emerging research confirms that geopolitical risks tend to propagate through key transport corridors, amplifying vulnerabilities in maritime logistics and global distribution networks (Geopolitical Risk and Shipping Supply Chain Resilience, 2026).

3.2. DIGITALIZATION AND CYBER RISKS

The digitalization of logistics systems has significantly improved efficiency, transparency, and coordination across supply chains. However, it has also introduced new forms of systemic vulnerability, particularly in the form of cyber threats and digital interdependencies.

Modern logistics systems rely on interconnected digital infrastructures, including port management systems, warehouse management platforms, and transportation networks. Disruptions in these systems—whether due to cyberattacks or technical failures—can have immediate and far-reaching consequences, often exceeding the impact of traditional physical disruptions (Dolgui et al., 2020).

Recent reports highlight the increasing frequency and sophistication of cyber incidents in the logistics and maritime sectors, underscoring the need for enhanced digital resilience and cybersecurity strategies (UNCTAD, 2023). As digital systems become more integrated, the risk of systemic failures across supply networks continues to grow.

3.3. GEOPOLITICAL FRAGMENTATION AND STRATEGIC DEPENDENCIES

Global supply chains are increasingly shaped by geopolitical tensions, including trade conflicts, sanctions, and regionalization trends. These developments contribute to the fragmentation of global trade systems and the emergence of competing economic blocs.

The concentration of production in specific regions—particularly in strategic sectors such as semiconductors—has created critical dependencies that can be exploited during geopolitical conflicts (Gereffi, 2020). The semiconductor crisis, for instance, highlighted the vulnerability of global industries to disruptions in a limited number of production hubs.

The concept of “weaponized interdependence” further explains how states can leverage their control over key supply chain nodes to exert economic and political influence (Farrell & Newman, 2019). Recent studies confirm that geopolitical uncertainty significantly reshapes supply chain configurations, driving firms toward diversification and regionalization strategies (How Geopolitical Risks Reshape Global Supply Chains, 2026).

3.4. DIGITAL TRANSFORMATION AND ARTIFICIAL INTELLIGENCE IN LOGISTICS

Digital transformation has become a central driver of modern logistics systems, enabling enhanced visibility, coordination, and responsiveness. Technologies such as artificial intelligence (AI), big data analytics, and digital platforms support predictive decision-making and real-time monitoring of supply chains.

Recent research highlights that AI significantly contributes to supply chain resilience by improving forecasting accuracy, enabling adaptive responses, and enhancing overall system flexibility (Applications of Artificial Intelligence for Supply Chain Resiliency, 2025). In particular, AI-driven systems enhance key capabilities such as visibility, agility, and predictive analytics, which are essential for managing uncertainty in complex supply networks.

Moreover, AI-based approaches have been shown to address critical operational challenges, including demand variability, inventory optimization, and disruption management, thereby strengthening supply chain robustness (Enhancing Supply Chain Resilience through Artificial Intelligence, 2024). Empirical findings further suggest that AI's effectiveness in enhancing resilience depends on the integration of adaptive management systems and organizational readiness (AI-driven Logistics Resilience, 2026).

At the same time, the increasing reliance on digital technologies introduces new vulnerabilities. Interconnected systems can rapidly propagate disruptions, while cyber risks pose a growing threat to logistics infrastructure. Therefore, digital transformation must be accompanied by investments in cybersecurity, system redundancy, and robust digital architecture (Madzík et al., 2024).

4. RISK CATEGORIES AND SYSTEMIC IMPACTS

Table 1: The vulnerabilities of modern logistics systems can be categorized into several key risk areas

Risk Category	Geopolitical Mechanism	Consequence for the State
Energy Blockade	Closure of pipelines or oil terminals.	Complete industrial standstill and power grid collapse.
Food Dependency	Interruption of grain and fertilizer imports.	Acute famine, social uprisings, and humanitarian crisis.
Technological Isolation	Embargo on semiconductor and chip imports.	Technological regression and loss of defense capabilities.
Financial Paralysis	Logistical cutoff for key raw material exports.	Currency devaluation and inability to service foreign debt.
Risk Category	Geopolitical Mechanism	Consequence for the State

These risks demonstrate how disruptions in logistics systems can escalate beyond operational challenges and affect broader economic and societal stability.

5. TOWARDS RESILIENT LOGISTICS SYSTEMS

The increasing exposure of global supply chains to geopolitical, technological, and systemic risks necessitates a fundamental shift from efficiency-driven models toward resilience-oriented logistics systems. While traditional approaches have focused on cost minimization, lean operations, and just-in-time delivery, recent disruptions have demonstrated the limitations of such models in highly uncertain environments.

Resilient logistics systems are characterized by their ability to anticipate, absorb, adapt to, and recover from disruptions. In this context, resilience is not merely a reactive capability but a proactive and strategic design principle embedded within supply chain structures (Ivanov, 2021). Recent bibliometric analyses further confirm that resilience has become a central theme in supply chain research, particularly in the post-2020 period, reflecting the increasing importance of risk management and system robustness (Madzík et al., 2024).

5.1. DIVERSIFICATION AND STRUCTURAL FLEXIBILITY

One of the primary strategies for enhancing resilience is diversifying supply sources and logistics networks. Overreliance on a single supplier or region creates critical vulnerabilities, particularly amid geopolitical instability.

Recent studies indicate that firms are increasingly shifting from global optimization strategies toward diversified and regionally balanced supply networks. Rather than complete reshoring, organizations are adopting “multi-sourcing” and “China+1” strategies to reduce dependency and enhance flexibility. This approach allows supply chains to maintain continuity even in the presence of localized disruptions.

Structural flexibility also includes the ability to dynamically reconfigure logistics networks. This may involve alternative routing options, modular production systems, and strategically positioned inventory buffers to absorb shocks.

5.2. REGIONALIZATION AND NEARSHORING

The trend toward regionalization represents another key dimension of resilient logistics. While globalization enabled efficiency gains through specialization and scale, it also introduced long and fragile supply chains.

Nearshoring and regional supply networks offer several advantages, including shorter lead times, improved coordination, and greater control over production processes. However, research suggests that regionalization alone does not guarantee resilience and may introduce new trade-offs, such as increased costs or reduced global efficiency (OECD, 2025).

Therefore, resilience strategies must balance global integration with regional adaptability, rather than replacing one model with another.

5.3. DIGITAL RESILIENCE AND CYBERSECURITY

Digitalization plays a dual role in logistics resilience. On one hand, digital technologies such as artificial intelligence, big data analytics, and digital twins enhance visibility, forecasting, and decision-making capabilities. On the other hand, they introduce new systemic vulnerabilities related to cyber risks and technological dependencies.

AI-driven systems enable real-time monitoring and predictive analytics, allowing organizations to identify potential disruptions before they occur and respond more effectively (Patale, 2025). These capabilities are particularly important in complex supply networks, where uncertainty and interdependencies are high.

However, the increasing reliance on digital infrastructure requires robust cybersecurity frameworks and resilient system architectures. Without adequate protection, digital systems can become critical points of failure, with disruptions spreading rapidly across interconnected networks (UNCTAD, 2023).

5.4. VISIBILITY, TRANSPARENCY, AND DATA INTEGRATION

Enhanced visibility and transparency are fundamental to resilient logistics systems. The ability to track goods, monitor supply chain performance, and access real-time data enables organizations to make informed decisions and respond quickly to disruptions.

Advanced technologies such as blockchain, IoT, and integrated data platforms facilitate end-to-end visibility across supply chains. This reduces information asymmetry and improves coordination between supply chain actors.

Research indicates that improved visibility not only enhances operational efficiency but also significantly contributes to resilience by enabling faster detection and mitigation of disruptions (Dolgui et al., 2020).

5.5. SCENARIO PLANNING AND ADAPTIVE DECISION-MAKING

Traditional risk management approaches often rely on historical data and predefined risk scenarios. However, the increasing complexity and unpredictability of global systems require more dynamic and adaptive approaches.

Scenario planning and stress testing enable organizations to simulate extreme events and assess the robustness of their supply chains under various conditions. These approaches support anticipatory decision-making and help organizations prepare for low-probability, high-impact disruptions.

Recent research emphasizes the importance of integrating predictive analytics and AI into scenario planning processes, enabling more accurate and real-time decision-making in uncertain environments.

5.6. BALANCING EFFICIENCY AND RESILIENCE

A central challenge in modern logistics is balancing efficiency and resilience. While resilience often requires redundancy, flexibility, and diversification, these factors may increase operational costs.

However, emerging research suggests that resilience and efficiency are not mutually exclusive. Instead, they can be integrated through strategic design and technological innovation. For example, digital tools can improve both efficiency and resilience by optimizing resource allocation while enhancing system adaptability.

Ultimately, the goal is not to eliminate risk but to design logistics systems that can function effectively under a wide range of conditions. This requires a shift from static optimization models to dynamic and adaptive systems capable of responding to continuous change.

6. DISCUSSION

The findings of this study highlight the growing importance of logistics as a strategic domain that intersects with economic policy, technological innovation, and national security.

The traditional focus on cost minimization is insufficient in a world characterized by uncertainty and disruption. Instead, resilience, adaptability, and robustness must become central principles guiding logistics systems.

At the same time, integrating digital technologies introduces both opportunities and risks, requiring a balanced approach that leverages innovation while ensuring system stability.

CONCLUSION

Logistics has evolved into a critical infrastructure that shapes global stability, economic performance, and national resilience. The increasing complexity of global supply chains, combined with geopolitical tensions and digital transformation, requires a fundamental rethinking of traditional logistics paradigms.

This paper emphasizes the need to balance efficiency with resilience and highlights the strategic role of logistics in the modern world. Future research should focus on empirical validation and the development of quantitative models to support resilient supply chain design.

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