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THE IMPACT OF ARTIFICIAL INTELLIGENCE AND DIGITAL TECHNOLOGIES ON SUPPLY CHAIN RESILIENCE AND LOGISTICS EFFICIENCY IN EMERGING ECONOMIES

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Abstract: Global supply chains have faced repeated shocks in recent years, while artificial intelligence (AI) and other digital technologies have moved into everyday logistics operations. This paper examines how these technologies affect supply chain resilience and logistics efficiency in emerging economies, where weaker infrastructure and limited data often magnify the cost of disruptions. Using an integrative review of peer-reviewed studies and secondary evidence from the World Bank, UNCTAD, the International Telecommunication Union and official sources for India and China, the study identifies three mechanisms through which AI and digital tools create value: visibility, prediction and coordination. These mechanisms help to shorten port delays, reduce inventory and logistics costs and speed up responses to disruptions. India's container dwell time of about three days and China's record-low logistics costs of 14.1% of GDP in 2024 illustrate the potential gains. However, the benefits depend on connectivity, interoperable data platforms and organisational capabilities, which remain uneven: only 23% of people in low-income countries use the internet. The paper concludes that emerging economies gain most when they combine shared public digital infrastructure with targeted AI applications and outcome-based performance monitoring.

Keywords: artificial intelligence; digital technologies; supply chain resilience; logistics efficiency; emerging economies.

JEL classification: L91, O33, F14

Introduction

Background

Over the past six years, global supply chains have been tested by an unusual series of shocks. The Global Supply Chain Pressure Index of the Federal Reserve Bank of New York, which combines transport cost and manufacturing indicators, reached the highest level in its history in December 2021 and remained at historically elevated levels well into 2022 (Benigno et al., 2022). Two years later, attacks on shipping in the Red Sea forced many carriers to avoid the Suez Canal, a route that normally carries about 20% of the world's container trade; by January 2024, weekly container ship transits through the canal were 67% lower than a year earlier (United Nations, 2024).

Such shocks are especially costly for emerging economies, where firms often depend on a few gateway ports and corridors and hold smaller buffers. For these countries, the challenge is not only to make logistics cheaper but also to make it more reliable.

Digital technologies are increasingly seen as part of the answer. In 2025, 88% of the organisations covered by McKinsey's global survey reported regular use of AI in at least one business function, up from 78% a year earlier, although most had not yet used it at scale (McKinsey & Company, 2025). In logistics, AI supports forecasting, routing, risk monitoring and warehouse automation, while tracking systems and data platforms connect the actors along the chain. Whether these tools actually make supply chains in emerging economies more resilient and efficient, and under which conditions, is the subject of this paper.

Literature review

Ponomarov and Holcomb (2009) treat resilience as a capability that lets a supply chain get ready for unexpected events, react once a disruption occurs and return to normal work without losing control over its structure and functions. Christopher and Peck (2004) argue that resilience has to be designed into supply chains through re-engineering, collaboration, agility and a culture of risk management, rather than added after a crisis. Both perspectives place information at the centre: a firm cannot respond quickly to a disruption that it cannot see.

A growing body of research links digital technologies with these capabilities. Ivanov et al. (2019) show how big data analytics, Industry 4.0, additive manufacturing and advanced tracking systems can help to control the ripple effect, that is, the spread of a disruption through the supply network, and they propose a framework for supply chain risk analytics. Ivanov and Dolgui (2021) develop the idea of a digital supply chain twin: a virtual replica of the supply network, updated with live data, on which managers can try out responses to a disruption before acting.

Research on AI in particular has expanded rapidly. In a review of AI applications in supply chain risk management, Baryannis et al. (2019) show that methods ranging from mathematical programming to machine learning and big data analytics are used to identify, assess and respond to risks, but they also note important gaps that remain unexplored. Toorajipour et al. (2021) map AI techniques across supply chain functions in a systematic review. Empirical evidence is more recent. Using structural equation modelling, Belhadi et al. (2024) find that AI-driven innovation is associated with stronger supply chain resilience and performance, and that this relationship is shaped by supply chain dynamism. Based on interviews with 35 experts from e-commerce supply chains, Modgil et al. (2022) identify five areas, including transparency, last-mile delivery and agile procurement, in which AI supports resilience.

Three theoretical perspectives help to explain these effects. The resource-based view treats data and analytical capabilities as resources that can create a sustained competitive advantage when they are valuable, rare and hard to imitate (Barney, 1991). The dynamic capabilities view explains how firms renew and recombine their competences when their environment changes quickly (Teece et al., 1997). Organisational information processing theory holds that organisations facing greater uncertainty can cope in two ways: by lowering the amount of information they have to handle or by expanding their ability to handle it (Galbraith, 1974). AI and digital platforms clearly belong to the second strategy.

However, most empirical studies rely on firm-level surveys, and much less is known about how AI and digital technologies affect resilience and efficiency at the level of national logistics systems in emerging economies, where public digital infrastructure, connectivity and trade facilitation play a larger role.

Aim and research questions

The aim of this paper is to assess how AI and digital technologies influence supply chain resilience and logistics efficiency in emerging economies, and which conditions shape these effects. It addresses three research questions. **RQ1:** Through which mechanisms do AI and digital technologies strengthen supply chain resilience and logistics efficiency? **RQ2:** What evidence of these effects can be observed in emerging economies? **RQ3:** Which constraints limit the benefits, and what do they imply for policy and management? The paper contributes to the literature by connecting firm-level research findings with national and international indicators, and by highlighting the role of shared public digital platforms as an entry point for AI in emerging economies.

Methods

The study uses a qualitative research design that combines an integrative literature review with a synthesis of secondary evidence. This design suits the aim of building an explanatory framework from different streams of research rather than estimating a single effect size.

The literature review covered peer-reviewed studies on supply chain resilience, digital technologies and AI published in leading international journals, including the International Journal of Production Research, The International Journal of Logistics Management, Production Planning & Control, the Journal of Business Research and Annals of Operations Research. Studies were selected purposively, either because they are widely cited foundational works or because they provide empirical evidence on the link between AI and resilience.

Secondary evidence was drawn from four types of sources: (1) international datasets and reports, namely the World Bank's Logistics Performance Index (LPI) 2023, UNCTAD's analysis of maritime transport, the Global Supply Chain Pressure Index of the Federal Reserve Bank of New York, the Facts and Figures 2025 of the International Telecommunication Union (ITU) and the 2023 United Nations Global Survey on Digital and Sustainable Trade Facilitation; (2) industry evidence from McKinsey & Company; (3) official statistics for India and China; and (4) government press releases and portals describing digital logistics platforms. India and China were selected as the two largest emerging economies with national logistics digitalisation programmes and official logistics cost estimates.

The evidence was analysed in three steps. First, the mechanisms through which AI and digital technologies affect resilience and efficiency were identified in the literature and grouped into a framework. Second, national and international indicators were examined for patterns consistent with these mechanisms, such as changes in port dwell times, logistics costs or the use of digital platforms. Third, constraints were grouped into infrastructural, organisational and institutional factors. Because the data come from different sources and methods, figures were compared only where definitions were consistent; for example, the logistics cost ratios of India and China are discussed separately because they are calculated with different methodologies. The data cut-off date is October 2026.

Results

Mechanisms linking AI and digital technologies to resilience and efficiency (RQ1)

The literature points to three main mechanisms. The first is **visibility**. Tracking technologies, the Internet of Things, electronic documents and shared data platforms show where goods are and in what condition. Visibility shortens the time between a disruption and its detection, and digital twins turn this stream of data into an up-to-date picture of the whole

network (Ivanov & Dolgui, 2021). In the resilience cycle described by Ponomarov and Holcomb (2009), visibility mainly supports readiness and early response.

The second mechanism is **prediction**. Machine learning models forecast demand, estimate arrival times and flag risks on the basis of supplier, market or transport data (Baryannis et al., 2019; Toorajipour et al., 2021). Better forecasts reduce the need for safety stock and allow firms to act before a disruption reaches them. The third mechanism is **coordination and automation**. Optimisation algorithms plan routes, allocate capacity and rebalance inventory across locations, while automation in warehouses and terminals reduces handling time. Coordination matters most during response and recovery.

Industry evidence suggests that these mechanisms can produce large efficiency gains. McKinsey reports that companies which introduced AI-based supply chain management early achieved improvements of 15% in logistics costs, 35% in inventory levels and 65% in service levels relative to firms that moved more slowly (Alicke et al., 2021). Academic studies point in the same direction for resilience: AI-driven innovation is linked to stronger resilience and performance (Belhadi et al., 2024), and AI supports transparency, last-mile delivery and agile procurement during disruptions (Modgil et al., 2022). In both cases, AI works mainly by increasing the capacity of supply chains to process information (Galbraith, 1974).

Evidence from emerging economies (RQ2)

International data show that the largest potential gains lie at the points where goods stop moving. The World Bank's LPI 2023 covered 139 countries and, for the first time, added indicators from shipment-tracking data (World Bank, 2023a). According to the report, the sea leg between the export and destination ports lasts about 44 days on average and accounts for around 60% of total trade time, yet most of the waiting happens not at sea but in ports, airports and multimodal hubs. Digitalisation has enabled countries, particularly emerging economies, to cut port delays by as much as 70% (World Bank, 2023b).

India illustrates how digitalisation can translate into measurable improvements. Its LPI ranking rose from 44th in 2018 to 38th in 2023, and between May and October 2022 the average container dwell time in India was about three days, similar to Singapore and shorter than the seven days recorded in the United States and ten days in Germany (World Bank, 2023a; IndBiz, 2023). The Government of India linked part of this progress to cargo tracking: at the eastern port of Visakhapatnam, dwell time fell from 32.4 days in 2015 to 5.3 days in 2019 after tracking was introduced (Embassy of India, Hanoi, 2023).

India has also built a shared digital layer for logistics. The Unified Logistics Interface Platform (ULIP), launched under the National Logistics Policy in September 2022, gives companies access to logistics data held in government systems through application programming interfaces (APIs). By March 2025 it connected 43 systems from 11 ministries through 129 APIs, had more than 1,300 registered companies and had processed over one billion API transactions; manufacturers use these APIs for real-time shipment arrival estimates and transporter verification (Lokmat Times, 2025). According to an official estimate prepared for the government, India's logistics costs were 7.8–8.9% of GDP in 2021–22, well below the 13–14% figure that had long been used in policy discussions (Business Standard, 2023).

China provides a second example on a larger scale. The ratio of total social logistics costs to GDP fell to 14.1% in 2024, the lowest level on record, compared with 14.4% in 2023 and 18% in 2012, and the government aims to reduce it to about 13.5% by 2027 (China Daily, 2025; Xinhua, 2024). These gains reflect many factors, including infrastructure investment, but they show the scale of the efficiency potential.

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Constraints on the benefits (RQ3)

The benefits of AI depend on the digital foundations underneath it, and these remain uneven. In 2025 about 6 billion people, or roughly three-quarters of the world's population, used the internet, but the share was 94% in high-income countries and only 23% in low-income countries. About 96% of the 2.2 billion people who remained offline lived in low- and middle-income countries, and 5G networks covered 84% of the population in high-income countries but only 4% in low-income ones (ITU, 2025). Where small carriers, warehouses and border agencies are not reliably connected, AI systems receive incomplete data and their predictions lose much of their value.

A second constraint is organisational. The adoption of AI is broad but still shallow: most organisations that use AI have not yet scaled it across the enterprise (McKinsey & Company, 2025), and reviews of AI-based supply chain risk management still identify many aspects that remain unexplored in practice (Baryannis et al., 2019). Scaling requires integrated data, skilled staff and new decision processes, which small firms often lack.

A third constraint is institutional and physical. Although the average level of implementation of trade facilitation measures worldwide reached 68.7% in 2023, cross-border paperless trade, which requires countries to recognise each other's electronic documents and data, remains far less implemented than other measures (ESCAP, 2023). Moreover, no algorithm can remove a physical bottleneck. When the Red Sea route was disrupted, AI could help carriers and shippers re-plan routes and inventories, but rerouting still added distance and time and raised global container ship demand by 12% (UNCTAD, 2024).

Discussion

Interpretation of the findings

The results suggest that AI and digital technologies improve resilience and efficiency through the same channel: they increase the capacity of supply chains to process information. Visibility, prediction and coordination correspond closely to the dynamic capabilities of sensing, seizing and reconfiguring (Teece et al., 1997), which explains why the same tools can lower costs in normal times and speed up recovery after shocks. The national evidence is consistent with firm-level research, but it does not prove that AI alone caused the observed improvements. In India and China, digitalisation coincided with large infrastructure investments whose effects cannot be separated with the available data.

An important pattern emerges from the comparison. Much of the firm-level literature describes AI adoption driven by companies that already have rich internal data. In emerging economies, a shared public digital layer can play this role. Platforms such as ULIP open government data on vehicles, ports and cargo through standard interfaces, so small firms and start-ups can build AI applications on top of them. This platform-first path may suit countries with many small firms.

The findings also point to a trade-off. AI systems that are optimised only for cost can make supply chains leaner and therefore more fragile, removing the buffers and flexibility that resilience requires (Christopher & Peck, 2004). Resilience therefore needs to be part of the objective of AI tools, for example through scenario testing in digital twins before decisions are implemented (Ivanov & Dolgui, 2021). Data quality and cybersecurity are further risks.

Conclusions and recommendations

The paper identified three mechanisms, namely visibility, prediction and coordination (RQ1); found evidence consistent with these mechanisms in shorter port delays, lower logistics costs and the rapid uptake of shared logistics data platforms, especially in India and

China (RQ2); and showed that the benefits are limited by uneven connectivity, shallow organisational adoption and weak cross-border data exchange (RQ3). Five recommendations follow for policy makers and managers in emerging economies:

1. Build shared, interoperable logistics data platforms and national single windows that give firms API access to government data, following examples such as ULIP.
2. Invest in connectivity and digital skills along transport corridors, with special attention to small carriers, warehouses and border agencies.
3. Focus AI on high-value use cases where delays are largest, such as arrival-time prediction, port and border clearance, demand forecasting and risk monitoring.
4. Make resilience, not only cost, an explicit objective of AI systems through scenario testing and digital twins, and set clear standards for data quality and cybersecurity.
5. Measure outcomes, such as dwell time, lead-time variability and logistics costs as a share of GDP, rather than the number of digital tools adopted.

Limitations and future research

The study is based on secondary data and a purposive selection of literature, so it identifies patterns rather than causal effects. The national examples come from two very large economies, and their experience may not transfer directly to smaller or landlocked countries. Future research could use firm-level panel data or quasi-experimental designs, such as the staggered introduction of digital platforms across ports, to estimate the causal effect of AI on dwell times and costs. Landlocked economies, such as those of Central Asia, also deserve closer study.

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