

A STUDY OF THE CURRENT STATUS OF DIGITAL TRANSFORMATION AMONG LOGISTICS SERVICE PROVIDERS TOWARD LOGISTICS ECOSYSTEMS DEVELOPMENT FOR THE NORTHERN ECONOMIC CORRIDOR OF THAILAND

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ABSTRACT

This study aimed to investigate the current state of digital transformation among logistics service providers operating in the Northern Economic Corridor of Thailand toward logistics ecosystems development and to identify key technological, organizational, and environmental factors that influence innovation. A literature-based qualitative approach was employed to synthesize existing academic and industry data, culminating in a conceptual framework that connects digital maturity with logistics management innovation across three dimensions: process, technology, and service innovation. The findings indicated that while advanced technologies such as AI, IoT, and cloud systems were being introduced, implementation remained inconsistent due to skill gaps, limited infrastructure, and financial constraints. The study concluded with policy recommendations to accelerate digital adoption and innovation toward logistics ecosystems development in the NEC region.

Keywords: Digital Transformation, Logistics Service Providers (LSPs),
Northern Economic Corridor (NEC), Logistics Innovation.

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INTRODUCTION

In today's fast-paced, technology-driven global economy, digital transformation (DT) has become a critical catalyst for innovation, operational agility, and long-term competitiveness across multiple sectors. The logistics industry-central to global trade and supply chain networks-is experiencing significant transformation due to the rapid adoption of digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, cloud computing, and automation. These technologies not only improve process efficiency but also reshape how logistics service providers (LSPs) manage operations, deliver services, and engage with customers. In Thailand, LSPs encompass a diverse and growing ecosystem, ranging from multinational logistics corporations to small and medium-sized enterprises (SMEs) offering freight forwarding, warehousing, customs clearance, and end-to-end supply chain solutions. The logistics market was valued at approximately USD 88 billion in 2024 and is expected to grow due to rising e-commerce demand, infrastructure investments, and regional integration. Many logistics firms are now adopting digital platforms to enhance service quality, streamline operations, and respond to increasingly complex market dynamics (Hofmann & Rüsch, 2017, pp. 23-34; Warner & Wäger, 2019, pp. 326-349).

Thailand's geographic position in the heart of Southeast Asia further elevates its role as a regional logistics hub. The Northern Economic Corridor (NEC)-comprising Chiang Mai, Chiang Rai, Lampang, and Lamphun-has emerged as a key development zone under Thailand's 20 Year National Strategy (2018-2037), emphasizing digital infrastructure, cross-border connectivity, and innovation-driven growth. The Thai government has positioned digital transformation (DT) as a national strategic priority to modernize infrastructure and enhance regional competitiveness through smart and sustainable logistics ecosystems (Office of the National Economic and Social Development Council, 2023, pp. 10-15; Ministry of Digital Economy and Society, 2023, pp. 45-52; World Bank, 2023, pp. 15-18). Despite these opportunities, LSPs in the NEC face considerable challenges in embracing digital transformation. While many recognize the benefits of DT-such as improved visibility, real-time data, and supply chain integration-implementation is uneven due to infrastructure limitations, skill shortages, organizational resistance, and high investment costs. Furthermore, the lack of empirical data and a contextualized framework tailored to the socio-economic realities of the NEC undermines strategic planning and innovation efforts among regional logistics firms.

This study seeks to address this gap by synthesizing the current state of digital transformation among LSPs in the NEC, identifying key technological, organizational, and environmental factors influencing adoption, and analyzing the link between digital maturity and logistics management innovation. The ultimate goal is to propose a practical framework that supports digital capability development and enhances innovation, competitiveness, and sustainability within Thailand's Northern logistics ecosystem.

RESEARCH OBJECTIVES AND QUESTIONS

Thailand's Northern Economic Corridor (NEC)-comprising Chiang Mai, Chiang Rai, Lamphun, and Lampang-has been designated under the 20 Year National Strategy as a strategic zone for innovation, cross-border logistics, and regional connectivity within the Greater Mekong Subregion (GMS). In this context, logistics service providers (LSPs) play a critical role in facilitating the flow of goods and information. However, despite the growing relevance of digital technologies-such as AI, IoT, and cloud computing-digital adoption among LSPs in the NEC remains uneven, due to varying resource capacities, infrastructure readiness, and organizational capabilities. To address these challenges and opportunities, this study is guided by the following research objective: To synthesize the current state of digital transformation among logistics service providers (LSPs) in Thailand's Northern Economic Corridor (NEC), and to identify key factors influencing the adoption and impact of digital technologies on logistics management innovation. Correspondingly, the study aims to answer the following research questions: What is the current state of digital transformation among logistics service providers toward Logistics Ecosystems Development for the Northern Economic Corridor of Thailand?

CONCEPTUAL FRAMEWORK

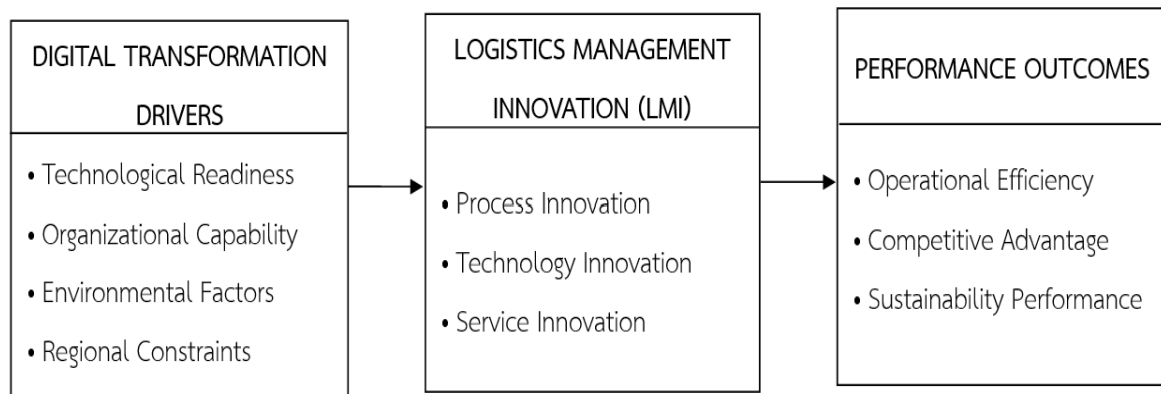


Figure 1 Conceptual Framework of Digital Transformation and Logistics Management Innovation in the Northern Economic Corridor (NEC)

Source: Developed by the authors based on Tornatzky and Fleischer (1990, pp. 45-50); Barney (1991, pp. 99-120); Grawe (2009, pp. 360-377)

LITERATURE REVIEW

Northern Economic Corridor (NEC)

The Northern Economic Corridor (NEC) is one of the four strategic corridors under the Greater Mekong Subregion (GMS) Economic Cooperation Program. Its development has been driven by major infrastructure investments and regional policy coordination aimed at facilitating trade, connectivity, and integration between China, Laos, and Thailand (Asian Development Bank, 2018, pp. 25-30). Key infrastructural milestones-such as the Kunming-Bangkok Highway and the China-Laos Railway-have significantly reduced transportation time and costs, thereby increasing cross-border trade, tourism, and logistics efficiency.

Compared with the Eastern Economic Corridor (EEC), which benefits from advanced port infrastructure and strong industrial clusters, the Northern Economic Corridor (NEC) remains more dependent on cross-border land transport and regional trade integration. While the EEC demonstrates higher digital logistics readiness, the NEC faces greater constraints related to infrastructure gaps and SME capacity.

As part of the ASEAN Economic Community (AEC), the NEC plays a key role in linking inland economies with major ports, enhancing competitiveness, and supporting inclusive growth.

However, the region still faces challenges such as 1) uneven infrastructure development, 2) cross-border regulatory misalignment, and 3) environmental and social sustainability concerns. These challenges emphasize the need for policies focused on green logistics, harmonized customs, and support for SMEs and logistics service providers (Asian Development Bank, 2018, pp. 25-30).

In summary, the Northern Economic Corridor plays a pivotal role in strengthening regional connectivity, enhancing trade efficiency, and fostering economic integration across the Greater Mekong Subregion. By linking China with Southeast Asia through improved infrastructure and policy coordination, the NEC contributes not only to economic growth but also to regional stability and cooperation. Nonetheless, balancing economic benefits with social inclusiveness and environmental sustainability remains essential for ensuring the long-term success of the corridor.

The importance of the Transportation and Storage Sector in the Northern Economic Corridor (NEC) can be show in Table 1

Table 1 Provincial-Level Contribution of Transportation and Storage Sector in the Northern Economic Corridor (NEC), 2019-2023 (*Unit: Million Baht*)

Province	Year	Transportation & Storage	Gross Provincial Product (GPP)	% Share of Transport & Storage on GPP
Chiang Mai	2019	16,764	264,067	6.35%
	2020	10,681	242,088	4.41%
	2021	10,777	239,290	4.50%
	2022	11,056	246,636	4.48%
	2023	12,637	277,477	4.55%
Lampang	2019	1,594	71,975	2.22%
	2020	1,432	71,421	2.00%
	2021	1,529	74,326	2.06%
	2022	1,631	75,387	2.16%
	2023	1,692	74,064	2.28%

Table 1 (continue)

Province	Year	Transportation & Storage	Gross Provincial Product (GPP)	% Share of Transport & Storage on GPP
Chiang Rai	2019	5,529	107,078	5.16%
	2020	4,200	102,552	4.10%
	2021	5,278	103,805	5.08%
	2022	4,818	108,174	4.45%
	2023	4,553	116,580	3.91%
Lamphun	2019	680	82,348	0.83%
	2020	694	81,919	0.85%
	2021	719	87,342	0.82%
	2022	792	90,315	0.88%
	2023	798	91,541	0.87%

Source: Office of the National Economic and Social Development Council (2019, pp. 42-47)

Table 1 presents the Gross Provincial Product (GPP) and the corresponding value of the transportation and storage sector across the four provinces comprising Thailand's Northern Economic Corridor (NEC)-Chiang Mai, Chiang Rai, Lampang, and Lamphun-from 2019 to 2023. The data include both the absolute sectoral contribution (in million baht) and the sector's share as a percentage of each province's total GPP. The analysis reveals that Chiang Mai consistently demonstrates the highest logistics output, with transportation and storage accounting for 6.35% of GPP in 2019, before declining to 4.55% in 2023. Although impacted by the COVID-19 pandemic in 2020, the sector gradually recovered in absolute terms. Chiang Rai ranks second, with a peak contribution of 5.08% in 2021, followed by a decline to 3.91% in 2023. In contrast, Lampang maintained a stable contribution around 2%, indicating steady logistics activity over the five year period. Lamphun reported the lowest share, consistently below 1%, suggesting a greater economic reliance in other sectors such as manufacturing or agriculture.

These variations underscore the uneven development of logistics infrastructure and digital capabilities across NEC provinces. The data suggests that Chiang Mai is more integrated into national logistics and supply chain systems, while Lamphun may face structural limitations in logistics-driven growth.

Table 2 Aggregate Trends of Transport and Storage sector in the NEC (2019-2023)

Year	Transport & Storage NEC	GPP of NEC	% Share
2019	6,141.64 million	131,366.96	4.68%
2020	4,251.76 million	124,494.95	3.42%
2021	4,575.87 million	126,191.04	3.63%
2022	4,573.88 million	130,128.04	3.51%
2023	4,920.04 million	139,915.37	3.52%

Table 2 aggregates the transportation and storage sector data across the entire NEC region. The total sectoral output stood at 6,141.64 million baht in 2019, representing 4.68% of total NEC GPP. This percentage declined sharply to 3.42% in 2020, primarily due to disruptions caused by the COVID-19 pandemic. Despite a modest recovery in 2021, the sector's contribution plateaued at around 3.5% from 2021 to 2023.

While the region's overall GPP grew steadily during the post-pandemic period, the logistics sector's share has not returned to pre-pandemic levels. This suggests that other economic sectors may be expanding more rapidly, or that logistics continues to face structural constraints, such as infrastructure gaps, digital skill shortages, and limited investment.

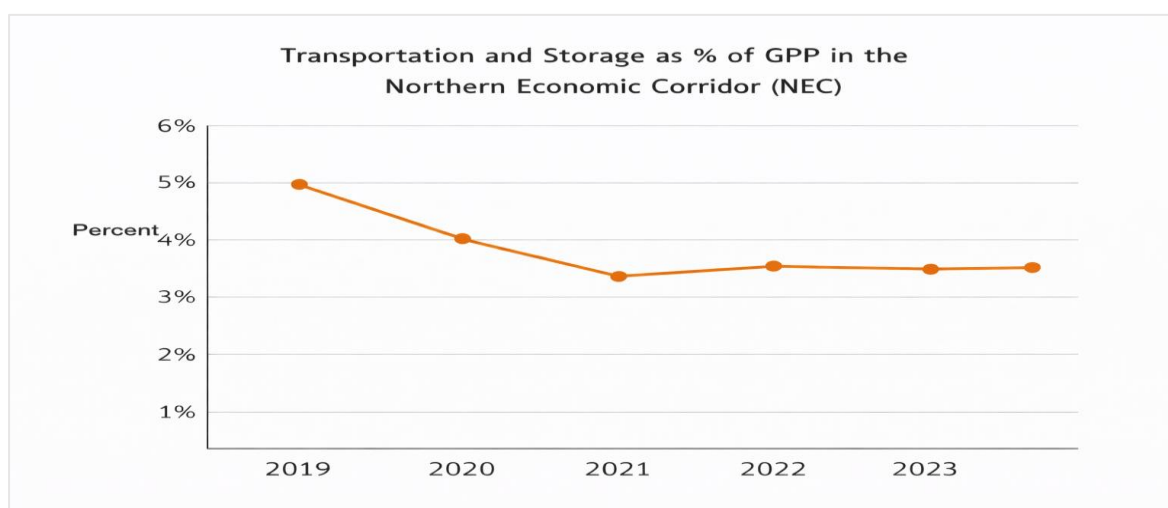


Figure 2 Transportation and Storage as a Percentage of NEC GPP (2019-2023)

Figure 2 illustrates the percentage contribution of the transportation and storage sector to the NEC's total GPP during 2019-2023. The sector experienced a marked decline in 2020, corresponding with the COVID-19 disruption, followed by a moderate recovery in 2021. However, its share stabilized at approximately 3.5% from 2021 onward.

Although total GPP demonstrated a gradual post-pandemic increase, the proportional contribution of the logistics sector remained relatively constant. This pattern indicates that sectoral growth has progressed in line with overall regional economic expansion rather than outpacing it. The findings suggest the need for targeted policy measures to strengthen productivity, digital integration, and structural competitiveness within the logistics sector.

Tables 1 and 2, along with Figure 2, illustrate the trends in the transportation and storage sector across the Northern Economic Corridor (NEC) from 2019 to 2023. At the provincial level (Table 1), Chiang Mai consistently recorded the highest logistics output, with transportation and storage contributing 6.35% of its GPP in 2019. However, this share declined to 4.55% by 2023, despite steady growth in absolute terms. Chiang Rai followed a similar trend, peaking in 2021 before declining to 3.91% in 2023. In contrast, Lampang maintained a relatively stable share of approximately 2%, while Lamphun remained below 1% throughout the period. These differences reflect uneven logistics development and digital integration across the region.

At the aggregated NEC level (Table 2), the transportation and storage sector accounted for 4.68% of regional GPP in 2019 but declined sharply to 3.42% in 2020 due to the COVID-19 pandemic. While there was modest recovery in subsequent years, the sector's share has since plateaued around 3.5%. This trend is clearly visualized in Figure 1, which depicts the downward shift in percentage contribution and a post-pandemic stagnation. Despite increases in total GPP, the slower recovery of logistics suggests that structural challenges-such as limited infrastructure, digital skill gaps, and investment barriers-continue to hinder the sector's full potential.

These findings highlight the critical role of Chiang Mai as a logistics hub and underscore the need for targeted policies to promote logistics and digital transformation across the NEC. Enhanced investment in regional transport networks, smart logistics platforms, and human capital development will be essential to unlock inclusive and sustainable growth in this sector. Thus, Logistics Ecosystems Development via digital transformation among logistics service providers (LSPs) operating will boost up economics prosperity in the economic corridor and the whole country.

Digital Transformation (DT) Theory

Digital transformation (DT) refers to the strategic integration of digital technologies—such as Internet of Things (IoT), artificial intelligence (AI), cloud computing, and big data—into core business processes (Bharadwaj, Sawy, Pavlou & Venkatraman, 2013, pp. 471-482). Theoretical frameworks supporting DT include the Technology-Organization-Environment (TOE) model (Tornatzky & Fleischer, 1990, pp. 45-50), Resource-Based View (Barney, 1991, pp. 99-120), and Dynamic Capability Theory (Teece, Pisano & Shuen, 1997, pp. 509-533), all of which emphasize the importance of aligning technology with organizational capability and environmental context. In logistics, DT enables visibility, predictive analytics, and automation, while also presenting challenges such as skill shortages, high costs, and system incompatibility. These issues are particularly relevant for SMEs in regional areas like the NEC.

Logistics Innovation Theory

Logistics innovation encompasses new technologies, processes, and service models that enhance operational performance (Grawe, 2009, pp. 360-377; Wang, Gao & Wang, 2025). It consists of three key dimensions: 1) Process innovation—e.g., lean warehousing, cross-docking, route optimization, 2) Technology innovation—e.g., RFID, robotics, blockchain, GPS tracking, and 3) Service innovation—e.g., predictive delivery, reverse logistics, cold-chain solutions. Innovation is shaped by organizational capability, technological infrastructure, and supply chain collaboration. In the NEC, logistics innovation is increasingly important to meet demands from cross-border trade and e-commerce, and to align with Thailand's green and digital logistics agenda.

Logistics Service Providers (LSPs) and Logistics Management Innovation (LMI)

LSPs are critical intermediaries that manage logistics activities on behalf of other firms. Their roles include transportation, warehousing, inventory management, customs clearance, and digital integration. LSPs can be classified into 1PL through 5PL based on service complexity and digital integration. In the NEC, LSPs facilitate cross-border logistics with Laos, China, and Myanmar. Their digital maturity, however, varies due to firm size, capital, leadership commitment, and workforce readiness. Leading firms leverage IoT, AI, and cloud platforms, but many SMEs lag due to infrastructure limitations and investment barriers. LMI refers to significant improvements in logistics strategies, operations, and service delivery (Grawe, 2009, pp. 360-377). It focuses on transforming logistics capabilities across process, technology, and service dimensions. Enablers of LMI include digital leadership, employee skills, innovation culture, and collaboration. LMI drives agility, resilience, and sustainability—especially important in times of disruption (Wang,

Gao & Wang, 2025). In Thailand, LMI helps support cold-chain logistics, last-mile delivery, and carbon reduction strategies in line with national sustainability goals.

Related Research in Thailand and NEC

Recent research in Thailand shows that successful DT adoption depends on leadership, digital skills, strategic vision, and ecosystem collaboration. While models like SLAPR and smart cold chains have succeeded in the Eastern Economic Corridor (EEC), the NEC still faces limitations in digital infrastructure and strategic readiness (Jing & Fan, 2024; Sumrit, 2021, pp. 719-730). Case studies show that collaborative logistics in Northern Thailand can reduce operational costs by up to 55%, but barriers such as skill gaps and change resistance remain. LSPs must build innovation culture and technical readiness to fully leverage DT (Kane, Palmer, Phillips, Kiron & Buckley, Online, 2015). Additionally, sustainability is now a core dimension of DT outcomes, aligning with global ESG goals and customer expectations.

This literature strongly supports the role of digital transformation as a strategic driver of logistics innovation. In the NEC context, theories such as TOE, RBV, and Logistics Innovation provide conceptual tools to analyze how technology, organization, and environment interact to shape innovation performance. Despite the growing awareness of DT, regional disparities in infrastructure, skills, and strategy highlight the need for tailored frameworks and policy interventions that support inclusive innovation and competitiveness in the NEC logistics sector.

RESEARCH METHODOLOGY

This study employs a systematic literature review (SLR) to examine digital transformation (DT) among logistics service providers (LSPs) in Thailand's Northern Economic Corridor (NEC). Relevant studies published between 2010 and 2024 were retrieved from major academic databases, including Scopus, Web of Science, and ScienceDirect, with complementary searches conducted via Google Scholar. Boolean keyword combinations were used to capture literature related to digital transformation, logistics innovation, technology adoption, and the Technology-Organization-Environment (TOE) framework. The review focused on peer-reviewed publications and relevant policy or institutional reports with explicit theoretical grounding, particularly those based on TOE and the Resource-Based View (RBV), and relevance to logistics systems in emerging economic contexts.

The selected studies were analyzed using thematic synthesis. Open coding was first applied to identify key determinants and outcomes of DT adoption, followed by theory-driven

categorization aligned with established organizational and innovation frameworks. Through iterative cross-study comparison, major drivers of DT adoption- technological readiness, organizational capability, environmental pressure, regional constraints, and sustainability orientation- were identified and consolidated into a structured conceptual framework. This framework explains how digital maturity shapes logistics management innovation and, subsequently, multidimensional performance outcomes within the NEC logistics ecosystem.

The synthesis provides the analytical foundation for the structured presentation of determinants (Table 3), innovation and performance outcomes (Table 4), and their integrated relationships (Table 5) in the following section.

RESULT

This section presents the findings derived from the structured literature synthesis described in the previous section. The variables and analytical dimensions presented in Tables 3 and 4 were systematically constructed based on the theoretical foundations discussed in the Literature Review, rather than being arbitrarily selected. Specifically, the determinants of digital transformation summarized in Table 3 were identified through thematic synthesis of prior studies grounded in the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990, pp. 45-50), the Resource-Based View (Barney, 1991, pp. 99-120), and Dynamic Capability Theory (Teece, Pisano & Shuen, 1997, pp. 509-533). These theoretical perspectives informed the classification of technological readiness, organizational capability, and environmental factors as primary drivers of digital transformation. In addition, contextual elements such as regional constraints and sustainability orientation were incorporated based on empirical research examining logistics ecosystems and digital readiness in Thailand and comparable regional contexts.

Similarly, the performance outcomes presented in Table 4 were derived from established literature on logistics innovation and digital business strategy. In particular, the three-dimensional framework of process, technology, and service innovation (Grawe, 2009, pp. 360-377; Flint, Larsson, Gammelgaard & Mentzer, 2005, pp. 113-147; Wang, Gao & Wang, 2025) guided the identification of logistics innovation as a core outcome of digital transformation. Complementary dimensions, including operational efficiency, competitive advantage, and sustainability performance, were incorporated in alignment with research on digital strategy and sustainable supply chain management (Bharadwaj, Sawy, Pavlou & Venkatraman, 2013, pp. 471-482; Seuring & Müller, 2008, pp. 1699-1710; Saberi, Kouhizadeh, Sarkis & Shen, 2019, pp. 2117-2135).

Accordingly, Tables 3 and 4 represent a theory-driven synthesis in which established conceptual frameworks informed both the selection of constructs and the structuring of analytical categories. This structured integration ensures theoretical coherence between the literature review and the reported findings, thereby strengthening the conceptual validity of the proposed framework.

First, key determinants influencing digital transformation among LSPs in the NEC are identified and structured according to the TOE-based dimensions (Table 3). Second, the innovation and performance outcomes associated with digital transformation are synthesized from the logistics innovation literature (Table 4). Finally, these determinants and outcomes are integrated into a consolidated framework that illustrates the causal linkages between digital maturity and logistics management innovation (Table 5).

Table 3 Key Factors Influencing Digital Transformation among LSPs in the NEC

Dimension	Key Factors	Theoretical Lens	Key References	Implications
Technological Readiness	IoT, AI, cloud platforms, automation, system interoperability	TOE - Technology	Bharadwaj, Sawy, Pavlou & Venkatraman (2013, pp. 471-482); Hofmann & Rüscher (2017, pp. 23-34); Zhu, Kraemer & Xu (2006, pp. 1557-1576)	Enables visibility, real-time data, operational optimization
Organizational Capability	Leadership, digital culture, employee skills, resource allocation	RBV; TOE - Organization	Barney (1991, pp. 99-120); Warner & Wäger (2019, pp. 326-349); Kane, Palmer, Phillips, Kiron & Buckley (Online, 2015)	Drives successful DT adoption and long-term innovation commitment
Environmental Factors	Government policy, NEC development plans, customer pressure	TOE - Environment	Tornatzky & Fleischer (1990, pp. 45-50); Sarkis, Gonzalez-Torre & Adenso-Diaz (2010, pp. 163-176)	Acts as external catalysts for technology investment

Table 3 (Continue)

Dimension	Key Factors	Theoretical Lens	Key References	Implications
Sustainability Orientation	Economic, environmental, and social alignment	Triple Bottom Line (TBL)	Seuring & Müller (2008, pp. 1699-1710); Saberi, Kouhizadeh, Sarkis & Shen, and (2019, pp. 2117-2135)	Encourages long-term resilience and responsible innovation

Source: Synthesized from literature review and regional analysis (2023-2024)

Table 3 synthesizes the key factors influencing digital transformation (DT) among logistics service providers (LSPs) in the Northern Economic Corridor (NEC) based on the Technology-Organization-Environment (TOE) framework. The findings indicate that technological readiness forms the foundation of digital integration, while organizational capability plays a critical mediating role in ensuring successful adoption. Environmental factors, including government policy and customer pressure, act as external drivers of transformation. However, regional constraints such as capital limitations and skill shortages may hinder progress. Sustainability orientation further reinforces the strategic alignment of digital initiatives with long-term competitiveness and responsible innovation.

Table 4 Outcomes of Digital Transformation among LSPs in the NEC

Performance Area	Key Indicators	Key References	Outcome Description
Logistics Innovation	Process, technology, service innovation	Grawe (2009, pp. 360-377); Flint, Larsson, Gammelgaard & Mentzer (2005, pp. 113-147); Wang, Gao & Wang (2025)	Drives agile and value-added logistics solutions
Operational Efficiency	Cost reduction, lead time, service accuracy, transparency	Hofmann & Rüsch (2017, pp. 23-34); Porter & Heppelmann (2015, pp. 96-114); Zhu, Kraemer & Xu (2006, pp. 1557-1576)	Enhances resource use, responsiveness, and decision-making
Competitive Advantage	Market agility, differentiation, strategic alignment	Bharadwaj, Sawy, Pavlou & Venkatraman (2013, pp. 471-482); Warner & Wäger (2019, pp. 326-349); Christopher (2016, pp. 72-75)	Strengthens positioning and adaptability in dynamic markets
Sustainability Performance	Energy efficiency, emission reduction, social responsibility	Seuring & Müller (2008, pp. 1699-1710); Saberi, Kouhizadeh, Sarkis & Shen (2019, pp. 2117-2135); Sarkis, Gonzalez-Torre & Adenso-Diaz (2010, pp. 163-176)	Supports ESG goals and green logistics transformation

Source: Synthesized from empirical findings and thematic analysis (2023-2024)

Table 4 outlines the primary performance outcomes observed among logistics firms undergoing digital transformation in the NEC. These outcomes span across four key domains: innovation, operational efficiency, competitive advantage, and sustainability performance. First, DT stimulates continuous logistics innovation, enabling firms to redesign workflows, incorporate smart technologies, and offer differentiated services. This innovation is closely linked to operational efficiency, where digital tools reduce lead times, improve accuracy, and enhance visibility across

the supply chain. Moreover, firms that leverage digital strategies effectively report stronger competitive advantage through improved market responsiveness and service customization. Lastly, DT contributes directly to sustainability performance, facilitating green logistics practices and strengthening social accountability. These outcomes reinforce the strategic importance of DT not only as a technological upgrade but as a catalyst for multidimensional transformation.

Table 5 Integrated Framework Linking Drivers and Outcomes of Digital Transformation

Drivers of DT	Linked Outcomes	Key Relationship Insights	Key References
Technological Readiness	Innovation, efficiency, competitiveness	Infrastructure maturity leads to faster transformation and enhanced performance	Bharadwaj, Sawy, Pavlou & Venkatraman (2013, pp. 471-482); Hofmann & Rüscher (2017, pp. 23-34); Zhu, Kraemer & Xu (2006, pp. 1557-1576)
Organizational Capability	Innovation, agility, long-term success	Acts as mediator between technology and strategic outcomes	Barney (1991, pp. 99-120); Warner & Wäger (2019, pp. 326-349); Kane, Palmer, Phillips, Kiron & Buckley (Online, 2015)
Environmental Pressure	Adoption speed, compliance, investment decisions	Stimulates urgency and aligns firm action with policy and customer needs	Tornatzky & Fleischer (1990, pp. 45-50); Sarkis, Gonzalez-Torre & Adenso-Diaz (2010, pp. 163-176)
Sustainability Orientation	Resilience, stakeholder trust, social impact	DT aligned with sustainability supports long-term performance and ESG alignment	Seuring & Müller (2008, pp. 1699-1710); Saberi, Kouhizadeh, Sarkis & Shen (2019, pp. 2117-2135)

Source: Author's synthesis based on DT and LMI frameworks

Table 5 presents an integrated view linking the identified DT drivers (independent variables) with corresponding performance outcomes (dependent variables), forming the basis of the study's conceptual framework. The table demonstrates that technological readiness and organizational capability are consistently associated with enhanced innovation, competitiveness, and strategic agility. Meanwhile, environmental pressures, such as policy directives and customer demand, influence the speed and direction of DT adoption. The impact of regional constraints is also significant, particularly in limiting innovation potential among SMEs. However, organizations that embed sustainability orientation into their DT strategy tend to realize more resilient, long-term performance gains. This integrated perspective underscores the interconnected nature of the DT process, suggesting that success depends on holistic alignment between internal capacity, external environment, and long-term strategic goals.

The conceptual framework was developed through a systematic synthesis of the reviewed literature on digital transformation and logistics innovation. The process began with the identification of recurring determinants of digital transformation through thematic analysis, highlighting key constructs such as technological readiness, organizational capability, environmental pressure, regional constraints, and sustainability orientation.

These determinants were organized under established theoretical lenses, particularly the Technology-Organization-Environment (TOE) framework and the Resource-Based View (RBV), to ensure theoretical consistency. Innovation-related outcomes were then derived from the logistics innovation literature and structured into three primary dimensions-process, technology, and service innovation-along with broader performance outcomes, including operational efficiency, competitive advantage, and sustainability performance.

Through iterative cross-study comparison, consistent linkages between digital maturity drivers and innovation outcomes were identified and consolidated into an integrated model. The framework conceptualizes digital maturity as a multidimensional construct comprising technological, organizational, and environmental readiness that influences logistics management innovation (LMI) and subsequent performance outcomes. Accordingly, the model illustrates the relationship: Digital Maturity Drivers → Logistics Management Innovation → Performance Outcomes, reflecting the interconnected dynamics of digital transformation within the NEC logistics ecosystem and providing a foundation for future empirical validation.

DISCUSSION

This study synthesized existing literature on digital transformation (DT) and its implications for logistics service providers (LSPs), with particular emphasis on Thailand's Northern Economic Corridor (NEC). The findings confirm that DT is not merely a technological upgrade but a multidimensional transformation process that reshapes organizational structures, strategic orientations, and operational practices.

First, DT facilitates logistics innovation across processes, technologies, and service models. Digital tools such as cloud platforms, AI, and IoT enable LSPs to redesign workflows, enhance real-time visibility, and develop more customer-centric services. This is particularly important for NEC-based firms that often operate with limited legacy systems. Second, DT significantly improves operational efficiency by reducing lead times, lowering costs, and improving service accuracy. However, technological potential alone is insufficient without adequate human capital, digital integration, and training. Third, DT contributes to sustainable competitive advantage. Digitally mature firms can respond proactively to market changes and integrate into cross-border logistics networks, which is crucial for NEC's role within the Greater Mekong Subregion. Fourth, DT enhances sustainability performance by enabling green logistics practices, such as route optimization and digital traceability, while supporting ethical and socially responsible operations.

The findings of this study indicate that technological readiness alone is insufficient to ensure successful digital transformation among LSPs in the NEC. As reflected in Table 3, organizational capability and environmental pressures significantly shape adoption outcomes. Moreover, the integrated framework in Table 5 demonstrates that digital maturity drivers influence logistics management innovation, which in turn enhances operational efficiency, competitive advantage, and sustainability performance. These findings contribute to the existing literature by contextualizing TOE and RBV frameworks within a regional logistics ecosystem in an emerging economy.

From a theoretical perspective, this study proposes a multidimensional framework linking DT enables to performance outcomes. From a managerial standpoint, firms should invest not only in technology but also in leadership, workforce readiness, and collaborative innovation. In conclusion, DT is a strategic transformation that reshapes how logistics firms innovate, compete, and contribute to sustainable development. For NEC-based LSPs, DT represents a powerful engine for smart, resilient, and inclusive growth, provided that structural barriers are addressed through coordinated policy and industry efforts.

RECOMMENDATIONS

Based on the findings, this study proposes integrated recommendations aimed at enhancing digital transformation (DT) readiness and innovation performance among logistics service providers (LSPs) in Thailand's Northern Economic Corridor (NEC). At the policy level, the study recommends establishing a regionalized strategy such as a "Smart Logistics NEC Program" under relevant ministries to support infrastructure development and provide financial incentives. Public-Private Partnerships (PPPs) should be promoted to create innovation hubs or "Digital Sandboxes" to pilot technologies like AI, IoT, and blockchain. Furthermore, targeted workforce development programs, particularly digital logistics certifications, should be implemented in collaboration with local educational institutions to address critical skill gaps. At the organizational level, LSPs are encouraged to invest in scalable and interoperable technologies, beginning with foundational systems (e.g., TMS, WMS) before progressing to AI-based analytics and IoT tools. Equally important is the cultivation of a digital and innovation-driven culture through leadership commitment and cross-functional teams or "digital champions." Strengthening collaboration across the supply chain, including co-developing digital platforms with key partners, is vital to maximizing DT benefits. Finally, for academic advancement, the study recommends future research focused on empirical validation using methods such as AHP, SEM, or Fuzzy Delphi; comparative analysis between NEC and other regions; and longitudinal studies to track DT impact over time on firm performance and sustainability.

Recommendations for Future Research

To further enrich understanding of digital transformation in logistics, future research should consider the following:

Empirical validation of the conceptual framework through analytical methods such as AHP (Analytic Hierarchy Process), SEM (Structural Equation Modeling), or Fuzzy Delphi.

Comparative case studies between LSPs in the NEC and those in other economic corridors to identify regional differentiators and common success factors.

Longitudinal studies that investigate the progression of DT adoption over time and its long-term impact on organizational resilience, innovation outcomes, and sustainability performance.

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