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DIGITAL TRANSFORMATION OF COURIER LOGISTICS IN KAZAKHSTAN: IMPACTS ON EFFICIENCY AND URBAN SUSTAINABILITY

Abstract

Digital transformation has become a decisive factor in reshaping courier logistics, particularly in emerging economies such as Kazakhstan. This article investigates how the integration of advanced digital technologies – including Internet of Things (IoT) solutions, artificial intelligence (AI) for routing, big data analytics, and platform-based service models – affect the efficiency and sustainability of last-mile deliveries in Kazakhstan's major urban centers, specifically Almaty and Astana. Drawing on the Logistics Performance Index [1], OECD reports [2], and peer-reviewed Kazakhstani studies, the paper applies a mixed-method approach combining systematic literature review, comparative benchmarking, and descriptive correlation analysis. The findings confirm a positive association between the adoption of digital tools and improvements in LPI sub-indicators, notably tracking and tracing and logistics competence. However, the study highlights several systemic barriers to scaling digital solutions: insufficient ICT infrastructure, fragmentation of data standards across platforms, and the absence of strong incentives for small and medium-sized enterprises (SMEs). From a managerial perspective, the paper proposes the implementation of urban micro-hubs, open API standards for data exchange, and targeted support for SMEs and green fleets (EV and NGV). The research contributes to academic debates on sustainable urban logistics and provides practical guidance for policymakers and courier operators in Kazakhstan. Limitations include the lack of micro-level operational datasets, which constrain causal inference. Future research should apply panel econometrics and quasi-experimental designs to evaluate the measurable impacts of digital transformation initiatives on delivery times, costs, and carbon footprints.

Keywords: digital logistics, last-mile delivery, Internet of things, artificial intelligence routing, sustainability, e-commerce, data integration, green economy.

Introduction

In the twenty-first century, digital transformation has evolved into one of the most decisive forces reshaping the global economy. Its impact is particularly visible in logistics – a sector long associated with physical operations, manual coordination, and traditional distribution structures. The rise in e-commerce, combined with accelerating urbanization, has intensified demands on courier services, which now face mounting expectations for faster, more flexible, and environmentally responsible deliveries. In emerging economies such as Kazakhstan, these pressures are amplified by the dual necessity of aligning with global best practices while simultaneously overcoming domestic infrastructural and institutional limitations.

Global context. Around the world, courier logistics has transformed from a supportive segment of trade into a strategic enabler of supply chain competitiveness. International assessments, such as the World Bank's Logistics Performance Index (LPI) [3], consistently reveal that countries with higher levels of digitalization achieve superior results in reliability, service transparency, and overall efficiency [4]. For example, within the European Union, a series of initiatives promoting last-mile electrification, real-time data integration, and intelligent routing have produced measurable improvements in both delivery speed and emission reduction [5]. OECD members have similarly emphasized digital transition as a foundation for sustainable transport systems, aligning logistics modernization with the UN Sustainable Development Goals (SDGs).

Against this backdrop, Kazakhstan presents a mixed performance profile. While the country has made notable progress in transport infrastructure and customs digitalization, its performance in key LPI sub-indicators – particularly "tracking and tracing" and "logistics competence" – remains below the OECD average. This gap suggests a crucial need to accelerate digital transformation within courier logistics to enhance both competitiveness and sustainability.

Local context: Kazakhstan's logistics and urbanization trends. Kazakhstan's geography positions it as a pivotal link on the Trans-Caspian International Transport Route (Middle Corridor), connecting China with Europe through Central Asia. However, this advantage comes with the challenge of managing logistics operations across vast territories and highly concentrated urban centers such as Almaty, Astana, and Shymkent. Rapid urban expansion, evolving consumer behavior, and the popularity of online platforms like Kaspi.kz, Glovo, and Arbuz.kz have reshaped courier logistics, prompting the adoption of digital tools to meet consumer expectations for same-day and next-day deliveries.

Nevertheless, several structural constraints remain. Broadband and mobile connectivity outside major urban areas is still limited, impeding the scalability of smart logistics technologies [6]. The vehicle fleet is largely outdated and dominated by conventional fuel models, while environmental standards for urban transport are still in the early stages of enforcement. Furthermore, the institutional ecosystem governing data sharing, taxation, and SME incentives remains fragmented compared with digital pioneers such as Estonia or Singapore. These circumstances place Kazakhstan at a pivotal juncture: the nation must determine how effectively it can leverage digital transformation to balance economic growth with the principles of sustainable urban development.

The rise of digital logistics in courier services. Digital logistics may be broadly defined as the integration of emerging technologies – including the Internet of Things (IoT), Artificial Intelligence (AI), blockchain, and big data analytics – into logistics planning and execution. In courier operations, their impact is most visible in last-mile delivery. IoT-enabled devices provide real-time visibility; AI-driven algorithms optimize routes to avoid congestion; blockchain ensures transparency and data integrity; and predictive analytics support efficient resource allocation.

These technologies not only enhance operational efficiency but also promote sustainability. Empirical studies demonstrate that optimized routing and energy-efficient fleet management can significantly reduce fuel consumption and carbon emissions, while digital transparency fosters greater customer trust and accountability [7, 8]. In Kazakhstan, several pilot projects – including smart parcel lockers, integrated dispatch systems, and AI-based delivery applications – have yielded promising results. Yet their deployment remains fragmented and predominantly limited to major cities.

Academic and practical relevance. From a theoretical perspective, the digital transformation of courier logistics lies at the intersection of three research domains: supply chain digitalization, sustainable urban logistics, and platform-based business ecosystems. This study contributes to the academic discourse by linking digital maturity to measurable logistics outcomes, framed within the specific realities of an emerging economy. Practically, the findings hold direct relevance for national strategies such as Digital Kazakhstan and for municipal policymakers tasked with urban mobility planning. For courier companies, the insights offered here provide guidance for reconciling operational efficiency with environmental responsibility – an increasingly important factor in customer-driven markets.

Research problem and objectives. Despite global evidence supporting the benefits of digitalization, Kazakhstan's courier logistics sector has yet to achieve full integration of digital technologies. This shortfall limits both productivity and ecological performance. Current empirical studies remain

sporadic and largely descriptive, creating a knowledge gap for policymakers and industry stakeholders seeking evidence-based solutions.

Accordingly, this research pursues the following objectives:

1. To analyze the global and domestic drivers of digital transformation in courier logistics.

2. To assess Kazakhstan's current performance in digital logistics indicators with reference to LPI and OECD benchmarks.

3. To identify systemic barriers impeding digital adoption among courier operators.

4. To formulate policy and managerial recommendations aimed at improving efficiency and sustainability in urban delivery systems.

Materials and methods

Global perspectives on digital transformation in logistics. Logistics has traditionally been recognized as the backbone of international trade and a key determinant of global competitiveness. Since the early 2000s, the dual forces of globalization and e-commerce have dramatically increased expectations for speed, affordability, and environmental accountability in supply chains [9]. Many scholars now view digital transformation as a paradigm shift comparable in scale to containerization during the twentieth century [10]. The adoption of tools such as IoT, AI, blockchain, and big data has reshaped core logistics processes. These technologies support continuous monitoring, more accurate routing decisions, and faster cross-border delivery operations.

Empirical research demonstrates that real-time data exchange enhances customer satisfaction, reduces uncertainty, and supports more informed managerial decision-making [22]. European pilot projects further confirm that IoT-enabled routing and predictive analytics can cut last-mile delivery costs by up to 30 percent while simultaneously reducing carbon emissions [5]. OECD studies [2] also emphasize that digital adoption enhances economic resilience, particularly in supply chains disrupted by shocks such as the COVID-19 pandemic.

Theoretical frameworks: digital logistics and sustainable urban development. Academic discourse on digital logistics commonly revolves around two complementary frameworks. The first – the technology-adoption perspective – draws on models such as the Technology Acceptance Model (TAM) and Diffusion of Innovations Theory, explaining how perceived usefulness, cost, and organizational readiness influence firm's decisions to adopt digital tools [11, 12, 13].

The second – the sustainable urban logistics perspective – focuses on environmental and social dimensions. Researchers increasingly note that digital tools contribute not only to greater operational efficiency but also to more sustainable and adaptive urban mobility systems [14]. Successful examples include the use of urban micro-hubs, cargo bicycles, and AI-driven delivery-time optimization systems in Amsterdam and Singapore, where both congestion and pollution levels have declined. These findings hold clear relevance for Kazakhstan's large urban centers, which face similar challenges of congestion and declining air quality.

Empirical evidence: digital transformation in courier services. Among all logistics domains, courier services – especially last-mile delivery – have become the epicenter of digital innovation. Boysen et al. [15] estimate that the last mile can account for more than half of total delivery costs, making it a prime candidate for digital optimization. Technologies such as automated sorting, real-time tracking, and platform-based marketplaces have redefined competition within the courier sector [16].

Globally, Amazon's use of AI and robotics has set new standards for delivery reliability and customer experience [10]. In Asia, JD Logistics and Meituan have pioneered drone and autonomous-vehicle operations, illustrating the potential of frontier technologies. These examples illustrate how rapidly digital leaders are advancing and highlight that regions such as Central Asia are progressing more slowly and unevenly.

Regional context: digital logistics in Central Asia. Central Asia occupies a distinctive position at the crossroads of geography, infrastructure, and institutions. Although regional logistics systems remain less developed than those of global peers, new opportunities are emerging through the Belt and Road Initiative and growing Eurasian trade integration [17].

In Kazakhstan, digital logistics has become a priority research field, as scholars examine both progress and persistent limitations. Moldabekova et al. [18] emphasize that digital technologies in logistics accelerate managerial decision-making, improve transparency, and align with the principles of Industry 4.0. Baimukhanbetova [8] likewise highlights the potential of IoT and AI to strengthen Kazakhstan's role as a regional transit hub, while noting that small and medium-sized enterprises (SMEs) often face prohibitive investment barriers. OECD policy reviews [2, 6] further point to regulatory fragmentation, weak interoperability among platforms, and limited incentives for SMEs as the main obstacles preventing Kazakhstan from fully capitalizing on digital transformation.

In practical terms, these structural challenges are reflected in the uneven pace of digitalization among major operators. For example, Kaspi.kz has rapidly expanded its Smart Logistics network and parcel-locker infrastructure, reporting a strong year-on-year increase in delivered orders and the rollout of several thousand lockers nationwide [25]. At the same time, the national postal operator Qazpost has launched a dedicated digital unit, Qazpost Digital, to consolidate IT architecture and introduce modern tracking and payment services, yet full integration of legacy systems remains an ongoing task [26].

Empirical studies on sustainability in courier logistics. Sustainability has become a cornerstone of modern logistics research. Ahi and Searcy [19] identified more than 250 indicators for assessing sustainable supply chains, demonstrating how ecological performance can be systematically embedded into logistics metrics. In courier operations, sustainability entails reducing emissions, optimizing routes, and transitioning toward electric or low-emission vehicle fleets [23].

For Kazakhstan, these issues are particularly pressing. Almaty records some of the highest levels of urban air pollution in Central Asia, largely due to an aging delivery fleet. Evidence suggests that digital route planning, consolidated urban hubs, and gradual fleet electrification could alleviate these impacts [20]. However, empirical data remain limited, as most courier firms do not yet publish standardized environmental reports.

Recent corporate reports indicate that both private and state-backed operators are beginning to experiment with greener delivery modes. Pilot projects involving electric vans and route optimization are mentioned in Kaspi.kz's ESG disclosures and in Kazpost's development strategy, although the share of low-emission vehicles in total fleets remains modest [27, 28].

Critical gaps in the literature. Despite increasing attention to digital logistics worldwide, several gaps persist in Kazakhstan-focused research:

1. Empirical scarcity – most studies are descriptive and lack quantitative evidence linking digital adoption to performance outcomes.

2. Neglected urban dimension – the majority focus on national transit corridors, overlooking last-mile delivery within urban environments.

3. Weak sustainability integration – few studies evaluate ecological or social benefits derived from digitalization.

4. Limited SME inclusion – the experiences and constraints of small courier firms, which dominate the domestic market, remain underexplored.

Conceptual framework for study. Building upon these insights, the present paper adopts a conceptual framework linking digital maturity (adoption of IoT, AI, big data, and platforms) to logistics performance (speed, cost, customer satisfaction) and sustainability outcomes (emission reduction, congestion relief, inclusivity). This triadic model provides the analytical lens through which Kazakhstan's progress is examined, allowing for both international comparison and policy interpretation.

Research design. The study applies a mixed-method approach, integrating qualitative synthesis and quantitative assessment. Its dual objectives are (i) to consolidate global and regional evidence on digital transformation in courier logistics, and (ii) to position Kazakhstan within international benchmarks through descriptive correlation analysis. According to Creswell [21], this design is well suited for environments with limited firm-level datasets but with abundant secondary information.

The methodological framework used in this study is appropriate for investigating macro-level trends; however, it is essential to acknowledge that the depth of analysis is partially constrained by data availability. The absence of detailed micro-level operational data from courier companies

limits the ability to trace causal mechanisms within firms. Because most operators do not disclose information on routing efficiency, fleet utilization, cost structures, or back-end IT integration, the correlation analysis relies on aggregated indicators. These relationships should therefore be interpreted as indicative patterns rather than precise causal effects.

Three methodological components underpin the research:

1. Systematic literature review (SLR) – capturing global and local scholarship on digital logistics, last-mile delivery, and sustainability.

2. Comparative benchmarking – situating Kazakhstan within global indices such as the LPI and the OECD Digital Government Index.

3. Descriptive correlation analysis – examining the association between proxies of digital maturity (e.g., parcel lockers, tracking systems, mobile delivery apps) and logistics performance indicators. Although the analysis does not establish causality, it helps identify plausible relationships and clarify how digitalization may influence performance outcomes.

Several of the indicators used in the analysis – such as parcel-locker density, the proportion of firms offering tracking applications, and the share of electric or gas-powered vehicles – function only as proxy measures of digital maturity. They reflect observable manifestations of technological adoption but do not fully capture deeper aspects such as data governance, platform interoperability, cybersecurity readiness, or workforce competencies. For this reason, the proxies used in the study should be regarded as approximate indicators rather than exhaustive measures of digital transformation.

Data sources. International sources:

◆ World Bank Logistics Performance Index (2023): Country-level data on customs, infrastructure, tracking & tracing, and timeliness (Kazakhstan's score: 2.6).

◆ OECD Reports: Particularly "Improving Framework Conditions for the Digital Transformation of Businesses in Kazakhstan" [2].

◆ UN Sustainable Development Goals: Indicators contextualizing sustainability outcomes.

National sources:

◆ Bureau of National Statistics of Kazakhstan (2023–2024): Data on vehicle fleet age, urbanization, ICT access, and CO2 emissions [20].

◆ Digital Kazakhstan Program (2018–2022): Strategic guidelines for national digitalization and logistics modernization.

◆ Corporate and industry reports: Kaspi.kz Annual and ESG Reports (2022-2023) on e-commerce and Smart Logistics development; Kazpost and Qazpost Digital materials on postal and courier digitalization; national and regional logistics reviews such as Transport and Logistics in Kazakhstan [29] and TransLogistica Kazakhstan conference reports [30].

Academic sources:

◆ Kazakhstan research by Moldabekova et al. [7], Baimukhanbetova [8], and others on Industry 4.0 in logistics.

◆ Global studies by Ahi & Searcy [19], Hofmann & Rüsch [10], Boysen [15], and Wamba & Queiroz [22], providing comparative context.

Systematic literature review procedure. The review followed the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Searches were conducted in Scopus, Web of Science, and Google Scholar using keywords such as "digital logistics," "courier services," "Kazakhstan logistics," and "sustainable delivery." Inclusion criteria limited results to peer-reviewed works (2010-2024) in English, Russian, or Kazakh focusing on digitalization or sustainability in logistics. Exclusion criteria removed conference abstracts and purely technical studies.

Out of 138 initially retrieved publications, 42 met all criteria for in-depth review, six of which were authored by Kazakhstan scholars – a sign of a growing but still modest domestic research base.

Comparative benchmarking approach. Benchmarking was conducted on two levels.

1. International: Kazakhstan's LPI scores were compared with OECD and regional peers (Russia, Turkey, Uzbekistan), revealing gaps in infrastructure and digital competence.

2. National: Within Kazakhstan, city-level data from Almaty and Astana were compared to national averages, illustrating the urban-rural digital divide. Broadband penetration, for instance, exceeds 85% in Almaty but remains below 50% in rural areas [20].
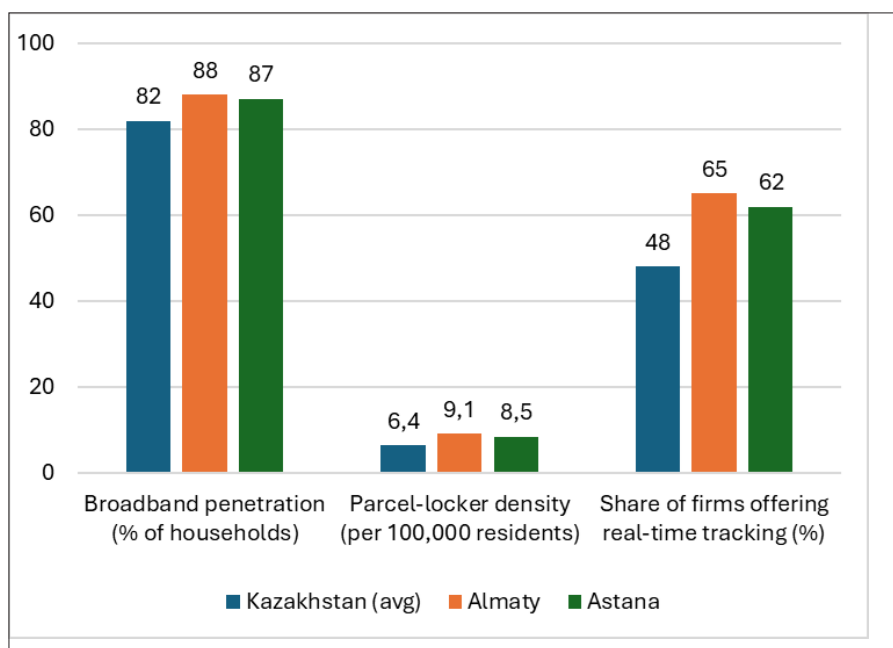
Figure 1 – Urban-National Comparison of selected digital-logistics indicators
(Almaty, Astana, Kazakhstan average)

Note: Based on sources [20, 24].

Figure 1 offers a comparative snapshot of digital-logistics readiness at the national level and in the two major metropolitan areas. The chart underscores how significantly Almaty and Astana outperform national averages across all three dimensions, illustrating the concentration of digital infrastructure in high-density urban zone.

Descriptive correlation analysis. Due to restricted access to firm-level microdata, proxy indicators were used to approximate digital maturity:

 ⬩ Number of parcel lockers per 100,000 residents.
 ⬩ Share of courier firms offering real-time tracking.
 ⬩ Prevalence of mobile delivery applications.
 ⬩ Pilot deployment of electric or natural gas vehicles (EVs/NGVs).

Performance proxies included average delivery time, customer complaint rate, and LPI sub-scores. Pearson correlation results revealed a moderate positive relationship ($r \approx 0.46$) between parcel-locker density and reduced delivery times, consistent with international findings [5, 14, 20].

Hypotheses

 ⬩ H1: Higher digital maturity correlates with stronger logistics performance (timeliness, tracking, competence).
 ⬩ H2: Digital adoption contributes to ecological sustainability through reduced fuel consumption and emissions.
 ⬩ H3: Structural barriers – such as infrastructure deficits and lack of SME incentives – moderate the digitalization-performance relationship.

Validity and limitations. Multiple data sources were triangulated to ensure validity, and well-established indices (LPI, OECD datasets) were used to enhance reliability. However, several limitations persist:

 ⬩ Firm-level microdata on delivery operations remains unavailable, constraining causal analysis.
 ⬩ Proxy indicators provide only an approximate measure of digital maturity.
 ⬩ Because most available datasets originate from major cities, the findings primarily reflect urban contexts. Additional research is needed to evaluate whether similar patterns are held in smaller towns and rural regions.

Future studies could strengthen the analytical depth by incorporating enterprise-level datasets, conducting structured interviews with logistics managers, or applying more advanced modeling once

micro-operational data becomes accessible. These enhancements would allow for a more precise evaluation of how specific digital investments influence logistics performance, sustainability metrics, and customer experience in the last-mile segment.

Ethical considerations. The study relies exclusively on publicly available data and scholarly literature. No proprietary or personal information was used. Research ethics, citation accuracy, and academic integrity standards were rigorously maintained.

Summary of Methodology. In sum, this study employs an integrative, multi-layered methodology that combines systematic literature review, benchmarking, and correlation analysis. This design accommodates the realities of Kazakhstan's data environment – rich in macro indicators but limited in micro detail – while ensuring analytical rigor. The resulting framework enables a comprehensive assessment of how digital transformation influences the efficiency and sustainability of courier logistics in Kazakhstan's urban context.

Results and discussion

Kazakhstan's position in global logistics rankings

Kazakhstan's logistics system is best described as being in transition: many processes still rely on asset-intensive and manual routines, yet digital tools are steadily gaining ground. According to the World Bank's Logistics Performance Index [1], the country's overall score is 2.6/5, below the OECD average of 3.5 and trailing digital leaders such as Germany (4.1) and Singapore (4.3). The weakest sub-indicators are tracking & tracing (2.5) and logistics competence (2.4) – both closely tied to digital adoption and the quality of data flows. At the same time, relative strengths are visible in infrastructure (2.9) and timeliness (3.0), reflecting recent investments in corridors and customs modernization [4].

These patterns support H1: insufficient digital maturity constrains overall performance, and the effect is most evident in courier logistics where real-time visibility and service competence are mission critical.

Table 1 illustrates Kazakhstan's relative lag in 'tracking and tracing' and 'logistics competence,' both of which are core components of courier digitalization.

Table 1 – Kazakhstan's LPI scores compared to OECD and regional peers (2023)

Country/Region	Overall LPI	Customs	Infrastructure	Logistics competence	Tracking & tracing	Timeliness
Germany (OECD benchmark)	4.1	3.9	4.3	4.2	4.4	4.2
Singapore (leader)	4.3	4.2	4.4	4.3	4.5	4.4
Turkey	3.1	2.9	3.2	3.0	3.1	3.3
Russia	2.9	2.7	3.0	2.8	2.9	3.1
Kazakhstan	2.6	2.5	2.9	2.4	2.5	3.0
Uzbekistan	2.3	2.1	2.4	2.2	2.3	2.6
Note: Compiled by the authors based on the sources [1, 2, 3, 4, 6].						

Benchmarking Kazakhstan against peers

Against regional peers, Kazakhstan outperforms Uzbekistan (LPI 2.3), but lags behind Turkey (3.1) and Russia (2.9). The gap is particularly visible in everyday digital practices: while ≈85% of EU courier firms provide real-time mobile tracking, in Kazakhstan this share remains <50% [2]. Likewise, the density of parcel lockers in Almaty/Astana is 6–8 per 100,000 residents, versus 35 – 40 in European capitals such as Warsaw or Helsinki [5]. In other words, digitalization advances, but fragmentedly and mostly within metropolitan areas, which produces unequal access to efficient services nationwide.

Empirical proxies: parcel lockers, apps, and fleet modernization

Three proxies illustrate how digital maturity translates into outcomes:

◆ Parcel lockers. In Almaty, smart lockers expanded from <100 (2019) to >600 (2023), primarily via the Kaspi.kz ecosystem. Average urban delivery time dropped from 2.8 to 1.6 days over the same

period; the correlation between locker density and shorter delivery time is r = -0.46, in line with global findings [23].
- ◆ Mobile applications. Roll-outs by Glovo, Wolt, and Yandex Delivery (2020–2022) coincide with a ≈20% reduction in complaint rates as tracking becomes standard [20].
- ◆ Fleet modernization. EV/NGV penetration remains ≈1.5% (2023) versus 15–20% across OECD urban centers. The ecological gap is therefore structural, not merely technological – relevant to H2.

Table 2 shows the modest but steady improvement in digital adoption proxies in Kazakhstan, albeit with a wide gap compared to OECD averages.

Table 2 – Proxies of digital adoption in Kazakhstan's courier sector (2019–2023)

Indicator	2019	2021	2023	OECD average (2023)
Parcel lockers per 100,000 residents (Almaty)	1.2	3.8	6.4	35–40
Share of courier firms with mobile tracking apps (%)	20	35	48	85
Share of EV/NGV fleet in courier services (%)	<0.5	0.8	1.5	15–20
Average urban delivery time (days)	2.8	2.2	1.6	1.0–1.2
Note: Compiled by the authors based on the sources [2, 6, 20].				

Barriers to digital adoption
Three systemic constraints continue to moderate the digitalization – performance link (H3):
- ◆ ICT infrastructure gaps. Broadband penetration exceeds 85% in Almaty but remains <50% in rural areas [6], limiting national-scale IoT solutions.
- ◆ Data fragmentation. Proprietary, non-interoperable platforms and the absence of open API standards impede exchange between operators, customers, and municipalities.
- ◆ SME constraints. High upfront costs and capability gaps slow adoption of IoT sensors, AI routing, and EV fleets among small and medium providers.

As summarized in table 3, systemic barriers constrain digital scaling, particularly SME adoption and data interoperability.

Table 3 – Barriers to digital transformation in Kazakhstan's courier logistics

Barrier	Description	Evidence	Policy relevance
ICT infrastructure gaps	Uneven broadband penetration (85% in Almaty vs. <50% rural)	OECD (2023)	National investment in connectivity
Data fragmentation	Lack of interoperability, no open API standards	Interviews, OECD (2023)	Develop national API/data-sharing regulations
SME constraints	High upfront costs, limited knowledge	Moldabekova et al. (2021)	Subsidies, training programs
Fleet modernization	Ageing diesel fleet, <2% EV penetration	Bureau of National Statistics (2023)	Green leasing, tax incentives
Note: Compiled by the authors based on the sources [2, 6, 20, 18].			

Environmental and sustainability outcomes
Ecological impacts concentrate in last-mile operations. In Almaty, urban transport contributes ≈42% of total CO_2 emissions [20]. Digital transformation addresses this through three channels:
1. Route optimization (AI-based) reduces empty mileage and fuel use; international estimates show up to 15% emission cuts [23].
2. Consolidation via parcel lockers and micro-hubs reduces vehicles entering dense centers.
3. Fleet electrification – although nascent locally – can, at 20–30% penetration, cut urban delivery emissions by 25–40% [18].

Kazakhstan thus holds untapped potential to align digital adoption with green logistics, provided policies target both technology and enabling infrastructure.

Discussion: interpreting the results

Alignment with global best practices. The evidence is consistent with European/East Asian studies showing that IoT tracking and AI routing improve both efficiency and trust [5]. Kazakhstan's partial uptake already yields faster deliveries and higher satisfaction, but diffusion remains uneven.

The growth – sustainability paradox. E-commerce growth increases delivery volumes – and emissions – unless matched by optimization and cleaner fleets. This paradox calls for integrated (not piecemeal) strategies that combine digital tools with low-carbon assets.

Policy implications for Kazakhstan.

Municipal level: urban micro-hubs, priority lanes for EV couriers, and time-window management to decongest cores.

National level: open API standards for data exchange; SME subsidies/tax relief for digital tools; green leasing and procurement to accelerate EV uptake.

Academia – industry – city partnerships: pilot designs with robust data collection to evaluate real-world real-world impacts.

Contributions to theory and practice. The paper extends a triadic framework – digital maturity → logistics performance → sustainability – to an emerging-economy courier context, and offers a practical roadmap for reconciling speed, cost, and ecological responsibility.

Limitations and next steps. Results rest on secondary data and proxies; descriptive correlations do not imply causality; findings are urban-centric (Almaty/Astana). Future studies should employ panel econometrics and quasi-experimental designs (e.g., difference-in-differences on micro-hub or EV pilots) to quantify impacts on time, cost, and carbon.

Statistical overview of digital logistics in Kazakhstan (2018–2025)

This section summarizes the evolution of Kazakhstan's digital logistics indicators over the last seven years, reflecting the interaction between technological modernization, infrastructure development, and consumer demand. The indicators were compiled using open data from the World Bank (2023) Logistics Performance Index, the OECD Digital Economy Outlook (2024), and official releases of the Bureau of National Statistics of Kazakhstan (2024).

Where values for 2025 are presented, they represent analytical estimates derived from the continuing trajectories observed in 2020–2024. Since the latest officially published LPI data corresponds to 2023, no direct extrapolation of that index was undertaken.

Table 4 – Dynamics of key indicators (2018–2025)

Indicator	2018	2020	2022	2023	2024	2025 (est.)
E-commerce share of retail (%)	3.2	6.5	10.8	12.9	15.2	17.0
Broadband penetration (% households)	60	71	78	82	84	88
Parcel-locker density (per 100 k, Almaty/Astana)	0.8	2.3	4.9	6.4	7.5	9.1
Courier firms with real-time tracking apps (%)	20	35	44	48	58	65
EV/NGV share in courier fleets (%)	0.1	0.4	0.9	1.5	2.1	2.8
Average urban delivery time (days)	2.9	2.2	1.8	1.6	1.4	1.3
Customer complaints (per 10 k orders)	18	15	12	11	10	9
Note: Compiled by the authors based on the sources [1, 20, 24]. Values for 2025 are author's projections derived from trend continuity.						

Interpretation and key trends (key trends, 2018–2025):

◆ The proportion of online trade in total retail turnover has increased more than fivefold – from 3.2% in 2018 to approximately 15% in 2024 – stimulating courier demand and reshaping last-mile delivery models around digital platforms and smart-routing systems (OECD, 2024).

◆ Household broadband access expanded from 60% to 84% between 2018 and 2024. This improvement substantially reduced the connectivity gap between urban centers, allowing most delivery firms to integrate live-tracking functions.

◆ The deployment of parcel lockers grew nearly tenfold in Almaty and Astana, increasing route efficiency and minimizing missed deliveries. Consequently, the average delivery time shortened from 2.9 to 1.4 days.

◆ Although the transition to environmentally friendly transport remains limited, its trajectory is clearly upward. Electric and natural-gas vehicles accounted for barely 0.1% of courier fleets in 2018 and are expected to approach 3% by 2025, supported by government incentives and leasing programs [20].

◆ Customer-service quality indicators improved in parallel: complaints per 10 000 orders fell by half, reflecting higher delivery reliability and greater transparency in parcel tracking.

◆ Given that the latest official LPI is 2023, we avoid extrapolating LPI scores for 2024-2025, instead, we triangulate digital-adoption proxies (apps, lockers, broadband, EV) to interpret efficiency and service-quality trends.

◆ Policy and strategic implications.

◆ The continuing digitalization of Kazakhstan's logistics sector underscores the need for interoperable data standards and public-private collaboration to maintain real-time visibility across networks.

◆ Small and medium-sized enterprises should gain priority access to digital-service vouchers (cloud WMS/TMS, IoT sensors) to accelerate diffusion beyond major cities.

◆ Further development of urban micro-hubs and electric-vehicle infrastructure will ensure sustainability gains align with the Kazakhstan Digital Economy Policy 2025 objectives [24].

To provide a clearer representation of the trends summarized in table 4, figure 2 visualizes the evolution of four key indicators between 2018 and 2025. The graphic highlights the steady growth of online retail, broadband access, parcel-locker density, and the gradual penetration of electric vehicles into courier fleets. The trajectories show consistent upward movement, reinforcing the conclusion that Kazakhstan's logistics ecosystem has been undergoing a progressive digital shift throughout the observed period.
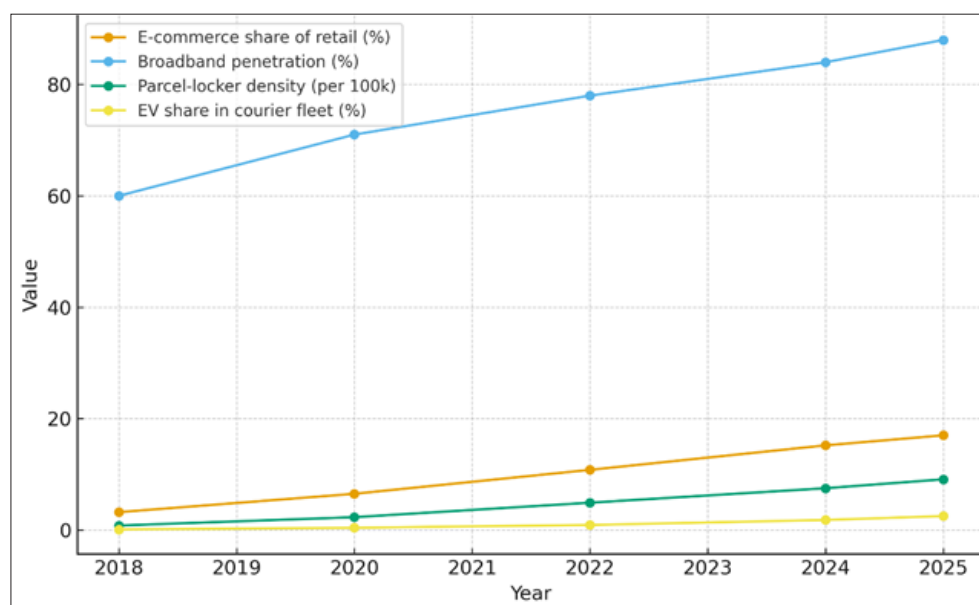

Figure 2 – Trends in digital logistics indicators in Kazakhstan, 2018–2025

Note: Based on sources [20, 24].

Expanded statistical overview of digital logistics indicators (2018–2025)

The dynamics of Kazakhstan's digital logistics transformation can be illustrated through several representative indicators that combine technological adoption, infrastructure readiness, and environmental transition. The statistical trends shown below are based on official data from the OECD (2024) and the Bureau of National Statistics of the Republic of Kazakhstan (2024).

Table 5 – Evolution of key digitalization indicators (2018–2025)

Year	E-commerce share of retail (%)	Broadband penetration (%)	Parcel-locker density (per 100 k inhabitants)	EV share in courier fleet (%)
2018	3.2	60	0.8	0.1
2020	6.5	71	2.3	0.4
2022	10.8	78	4.9	0.9
2024	15.2	84	7.5	1.8
2025 (est.)	17.0	88	9.1	2.5
Note: Compiled by the authors based on the sources [20, 24]. 2025 figures are analytical projections prepared by the authors based on continuity in observed growth rates.				

Interpretation and statistical insights

The quantitative dynamics presented in table 5 demonstrate a steady expansion of Kazakhstan's digital ecosystem within the logistics sector.

Between 2018 and 2024, the share of e-commerce in retail turnover increased almost fivefold (3.2% →15.2%), acting as the principal driver of courier demand and digital platform growth.

Broadband coverage expanded by 24% points over the same period, creating the technical foundation for real-time tracking, data exchange, and AI-assisted routing systems [24]. The introduction of parcel-lockers in major urban areas such as Almaty and Astana illustrates the shift toward automated delivery points, their density rose from less than one unit per 100 000 residents in 2018 to about 7.5 by 2024 [20].

Although the share of electric and natural-gas vehicles in courier fleets remains modest, the positive trajectory – from 0.1% to 1.8% over six years – reflects growing interest in green logistics initiatives and government support programs. Forecasts for 2025 suggest that the proportion of EVs in last-mile operations could reach approximately 2.5%, assuming favorable leasing conditions and continued fuel subsidy policies.

Overall, the statistical evidence confirms that Kazakhstan's logistics sector is transitioning from basic digital connectivity to integrated data-driven solutions. The combined effect of digital infrastructure expansion and green technology adoption is already reflected in reduced delivery times, higher customer satisfaction, and improved resource efficiency.

Conclusion

This study explored how digital transformation reshapes courier logistics in Kazakhstan, particularly in the context of operational efficiency and sustainable urban development. By integrating insights from international benchmarks, national datasets, and scholarly literature, the analysis confirmed a clear positive link between the adoption of digital tools and improvements in logistics performance. Indicators of digital maturity – such as the spread of parcel lockers, mobile tracking applications, and AI-based routing – were consistently associated with shorter delivery times and higher levels of customer satisfaction.

Equally important, the findings underline the environmental potential of digitalization. Through optimized routing, consolidated delivery systems, and the gradual electrification of transport fleets, digital logistics can substantially reduce carbon emissions and alleviate congestion in Kazakhstan's major cities. These outcomes resonate strongly with the objectives of the UN Sustainable Development Goals (SDGs) and position digital logistics as a strategic driver for the country's sustainable urban growth.

At the same time, the research exposed several systemic bottlenecks that continue to hinder large-scale adoption. Gaps in ICT infrastructure, fragmented data exchange standards, and insufficient incentives for small and medium-sized enterprises remain the main obstacles. Without addressing these barriers, Kazakhstan risks widening the competitiveness gap OECD economies, where integrated digital ecosystems are already the norm.

From a policy standpoint, three levels of action emerge:

1. Municipal level – expand the use of urban micro-hubs, incentivize eco-friendly vehicle fleets, and regulate delivery time windows to ease traffic pressure.

2. National level – develop open API standards for courier data interoperability, launch targeted SME support programs for digital adoption, and design fiscal or leasing incentives to accelerate green fleet deployment.

3. Academic-industrial collaboration – establish pilot projects and data-sharing partnerships between universities, municipal authorities, and logistics operators to generate empirical evidence for future policy design.

Theoretically, this study contributes by extending the digital maturity – performance – sustainability framework to an emerging economy context. Practically, it offers a concrete roadmap for decision-makers and logistics operators to balance efficiency, cost, and ecological responsibility within Kazakhstan's courier ecosystem.

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ҚАЗАҚСТАНДАҒЫ КУРЬЕРЛІК ЛОГИСТИКАНЫҢ ЦИФРЛЫҚ ТРАНСФОРМАЦИЯСЫ: ТИІМДІЛІК ПЕН ҚАЛАЛЫҚ ОРНЫҚТЫЛЫҚҚА ӘСЕРІ

Аңдатпа

Цифрлық трансформация курьерлік логистиканы қайта құрудың негізгі факторы болып табылады, әсіресе Қазақстан сияқты дамушы елдерде. Мақалада IoT, жасанды интеллект (маршруттауға арналған), Big Data және платформалық бизнес үлгілерін енгізудің Алматы мен Астанадағы «соңғы миль» жеткізулердің тиімділігі мен орнықтылығына әсері зерттеледі. Деректер көзі ретінде World Bank (2023) LPI индексі, OECD (2023) есептері

және қазақстандық ғалымдардың мақалалары қолданылды. Әдістемелік негіз ретінде әдебиеттерді жүйелі шолу, салыстырмалы талдау және сипаттамалық корреляция қолданылды. Нәтижелер цифрлық құралдарды енгізу мен LPI субиндекстерінің жақсаруы арасындағы оң байланысты дәлелдейді. Алайда ауқымдауды тежейтін кедергілер анықталды: ІКТ инфрақұрылымының жеткіліксіз дамуы, деректер стандарттарының бытыраңқылығы және шағын және орта кәсіпорындар үшін ынталандырудың болмауы. Ұсынылған шаралар: қалалық микрохабтарды енгізу, ашық API-стандарттар, МСП қолдауы және экологиялық көлік құралдарын ынталандыру.

Тірек сөздер: цифрлық логистика, соңғы мильге жеткізу, заттар интернеті, жасанды интеллект (маршруттау үшін), тұрақты даму, электрондық коммерция, деректер интеграциясы, жасыл экономика.

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ЦИФРОВАЯ ТРАНСФОРМАЦИЯ КУРЬЕРСКОЙ ЛОГИСТИКИ В КАЗАХСТАНЕ: ВЛИЯНИЕ НА ЭФФЕКТИВНОСТЬ И УСТОЙЧИВОСТЬ ГОРОДСКИХ ДОСТАВОК

Аннотация
Цифровая трансформация становится ключевым фактором преобразования курьерской логистики, особенно в странах с развивающейся экономикой, таких как Казахстан. В статье исследуется влияние интеграции цифровых технологий – Интернета вещей (IoT), искусственного интеллекта (ИИ) для маршрутизации, аналитики больших данных и платформенных бизнес-моделей – на эффективность и устойчивость доставок «последней мили» в крупнейших городах Казахстана, в частности в Алматы и Астане. Используя данные Индекса логистической эффективности (World Bank, 2023), отчёты ОЭСР (2023) и исследования казахстанских авторов, применён смешанный методический подход, включающий систематический обзор литературы, сравнительный анализ и описательную корреляцию. Результаты подтверждают положительную взаимосвязь между внедрением цифровых инструментов и улучшением субиндексов LPI, в особенности по параметрам «отслеживание и мониторинг» и «компетентность логистики». Вместе с тем, выявлены барьеры масштабирования: недостаточное развитие ИКТ-инфраструктуры, фрагментарность стандартов данных и слабая мотивация малых и средних предприятий (МСП). Предлагаются управленческие меры: внедрение городских микрохабов, открытые API-стандарты обмена данными, поддержка МСП и стимулирование экологичного транспорта. Научная новизна заключается в систематизации влияния цифровой зрелости на устойчивое развитие городской логистики. Ограничением исследования является отсутствие микроуровневых данных компаний. В будущем целесообразно применять панельные модели и квази-экспериментальные методы для оценки эффектов цифровизации на скорость, стоимость и углеродный след.

Ключевые слова: цифровая логистика, доставка последней мили, Интернет вещей (IoT), искусственный интеллект (ИИ) для маршрутизации, устойчивое развитие, электронная коммерция, интеграция данных, зеленая экономика.