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Digital Transformation of Courier Logistics in Kazakhstan: Drivers and Barriers

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ABSTRACT

In the context of accelerated digitalization of the economy, the growth of e-commerce and increasing requirements for sustainable development, courier logistics is becoming one of the key elements of the modernization of urban transport and logistics systems. The purpose of this article is to study the drivers and barriers of the digital transformation of courier logistics in Kazakhstan, as well as to develop conceptual directions for its sustainable development in the context of a smart city. The research methodology consists of an analysis of strategic and regulatory documents, a review of international scientific publications, and correlation and factor analyses. The empirical basis of the study is official statistical data from the Bureau of National Statistics and the World Bank, as well as primary sociological and expert materials. The results of the study showed that in 2023-2024, the volume of e-commerce in Kazakhstan increased from 1.60 to 2.44 trillion tenge, and the share of online marketplaces was about 85%. Correlation analysis revealed a strong positive relationship between the development of courier services and GDP per capita ($r = 0.946$; $p < 0.01$), as well as with foreign trade turnover ($r = 0.897$; $p < 0.01$). Based on the results, a matrix for digital transformation of courier logistics in Kazakhstan is proposed, and a set of strategic recommendations to improve the efficiency and sustainability of the last mile of delivery is formulated. The findings can be used to develop government policy, smart city urban programs, and digital development strategies for logistics companies.

KEYWORDS: Digital Economy, Digitalization, E-commerce, Courier Logistics, Smart Logistics, Logistics Strategy, Smart City, Urban Development

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Цифровая трансформация курьерской логистики в Казахстане: драйверы и барьеры

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АННОТАЦИЯ

В условиях ускоренной цифровизации экономики, роста электронной коммерции и усиления требований к устойчивому развитию курьерская логистика становится одним из ключевых элементов модернизации городских транспортно-логистических систем. Целью данной статьи является исследование драйверов и барьеров цифровой трансформации курьерской логистики в Казахстане, а также разработка концептуальных направлений её устойчивого развития в контексте смарт города. Методологию исследования составляют анализ стратегических и нормативных документов, обзор международных научных публикаций, а также корреляционный и факторный анализ. Эмпирическую основу исследования составляют официальные статистические данные Бюро национальной статистики РК и Всемирного банка, а также результаты первичных социологических и экспертных материалов. Результаты исследования показали, что за 2023–2024 гг. объем электронной коммерции в Казахстане вырос с 1,60 до 2,44 трлн тенге, а доля онлайн-маркетплейсов составила около 85%. Корреляционный анализ выявил сильную положительную связь между развитием курьерских услуг и ВВП на душу населения ($r = 0,946$; $p < 0,01$), а также с внешнеторговым оборотом ($r = 0,897$; $p < 0,01$). На основе полученных результатов предложена матрица цифровой трансформации курьерской логистики Казахстана и сформулирован комплекс стратегических рекомендаций, направленных на повышение эффективности и устойчивости последней мили доставки. Полученные выводы могут быть использованы при разработке государственной политики, программ развития смарт города и стратегий цифрового развития логистических компаний.

КЛЮЧЕВЫЕ СЛОВА: цифровая экономика, цифровизация, электронная коммерция, курьерская логистика, умная логистика, логистическая стратегия, умный город, городское развитие

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INTRODUCTION

Urban logistics is undergoing a profound transformation worldwide due to the convergence of digitalization, sustainability goals, and rapid growth in e-commerce. In Kazakhstan, these dynamics intersect with national development priorities outlined in the Digital Kazakhstan program, which aims to modernize infrastructure and enhance economic competitiveness through advanced technologies (Government of Kazakhstan, 2024). The expansion of online retailing has been particularly significant: the total volume of e-commerce services increased from 1.60 trillion KZT in 2023 to 2.44 trillion KZT in 2024, with online marketplaces accounting for nearly 85% of the sector (Bureau of National Statistics, 2024, 2025). This surge has placed unprecedented pressure on courier companies to improve the speed, reliability, and environmental performance of last-mile deliveries.

At the same time, Kazakhstan's major urban centers, particularly Almaty and Astana, face several structural challenges, including traffic congestion, rising carbon emissions, and inefficient use of curbside space. According to the World Bank's Logistics Performance Index (LPI) 2023, Kazakhstan scored 2.7, indicating weaknesses in logistics competence, tracking and tracing, and delivery timeliness compared to global leaders (World Bank, 2023). These shortcomings directly affect courier operations, which are highly sensitive to the quality of infrastructure and the level of digital service readiness.

International research emphasizes that "smart" courier logistics, integrating technologies such as Artificial Intelligence (hereinafter – AI), Internet of Things, blockchain, and Big Data analytics, can simultaneously enhance efficiency and reduce environmental impacts (Pan et al., 2021; Idrissi et al., 2024). Case studies have demonstrated that combining AI-driven routing with electric vehicle (hereinafter – EV) fleets and parcel lockers can reduce delivery time by 15-20%, energy consumption by 10-25%, and emissions by up to 40% (Ferreira & Esperança, 2025; Gnoni et al., 2025). However, scaling such solutions requires addressing persistent barriers, such as fragmented IT systems, insufficient digital skills among Small and Medium-sized Enterprises (hereinafter – SMEs), high upfront costs of electrification, and the absence of shared standards for data and curbside management (OECD, 2023; Syzdykbayeva et al., 2025).

In Kazakhstan, the context of smart courier transformation is shaped by opportunities and constraints. On the one hand, government-backed smart city initiatives in Almaty and Astana introduced smart city platforms; their limited integration with courier operations constrains potential efficiency gains (UNECE, 2023). However, the uneven pace of digital adoption across regions and firms threatens to widen disparities and limit national competitiveness (OECD, 2024).

Against this backdrop, this study examines the key drivers and barriers to digital transformation in Kazakhstan's courier logistics sector and proposes a conceptual framework to enhance its sustainability. The contribution of the paper is threefold. First, it synthesizes international best practices in smart courier logistics and adapts them to the Kazakhstani context. Second, it develops a conceptual model, the Smart Courier Transformation Matrix, that identifies opportunities, risks, and policy levers for major urban centers. Third, it formulates a set of strategic recommendations for policymakers, businesses, and city authorities aligned with Kazakhstan's national digitalization and sustainable development agendas. By providing both theoretical insights and practical implications, the study contributes to ongoing efforts to modernize Kazakhstan's courier logistics system while supporting sustainable urban growth.

LITERATURE REVIEW

The last-mile delivery segment is considered the most expensive and environmentally challenging part of supply chains, accounting for nearly 40-50% of the overall logistics costs in e-commerce (Bosona, 2020). Global studies emphasize that "smart" courier logistics, enabled by AI, IoT, blockchain, and advanced data analytics, can transform urban freight into a more sustainable system (Pan et al., 2021). Simulation-based models demonstrate that optimizing routing with AI and integrating parcel lockers can reduce failed deliveries and vehicle kilometers by up to 30% (Gnoni et al., 2025). Moreover, empirical evidence suggests that the adoption of EVs, together with AI-assisted scheduling, can reduce CO_2 emissions by up to 40% and delivery times by 15-20% (Ferreira & Esperança, 2025).

A systematic review by Idrissi et al. (2024) highlighted the synergetic role of IoT, blockchain, and AI in logistics, noting that while technical potential is high, governance challenges such as interoperability, cybersecurity, and investment risks limit adoption. These findings indicate that successful digital transformation requires not only technological readiness but also institutional and organizational frameworks.

International research has identified several recurring drivers: growing e-commerce demand, consumer preferences for real-time tracking, supportive government policies, and technological advances in electrification and automation. Conversely, barriers include high capital expenditure for fleet electrification, insufficient charging infrastructure, limited digital skills among SMEs, and fragmented IT systems (OECD, 2024). The World Bank LPI 2023 further underlined that logistics performance depends not only on infrastructure, but also on competence, regulation, and reliability – areas where emerging economies often lag (World Bank, 2023).

Smart city initiatives worldwide provide lessons relevant to Kazakhstan. UNECE (2023) profiles Almaty as a pilot city where smart infrastructure, intelligent transport systems, and urban data lakes are being introduced, although not yet fully leveraged for courier logistics. Similarly, Syzdykbayeva et al. (2025) applied graph theory to optimize Astana's logistics infrastructure, demonstrating a local methodological basis for data-driven planning. These studies confirm that Kazakhstan's urban contexts can benefit from global best practices, while requiring adaptation to national realities.

Kazakhstan's logistics sector has recently been the subject of several studies. Saktaganova et al. (2025) emphasized the opportunities and challenges of digital transformation in the national transport and logistics system, particularly regarding global integration and sustainability. Mamrayeva et al. (2022) highlight the importance of IoT, blockchain, and Big Data for Kazakhstani logistics companies but caution that limited digital skills and infrastructure remain critical bottlenecks. Kredina et al. (2022) found a strong correlation between the development of Information and Communication Technology (hereinafter – ICT) services and logistics performance in Kazakhstan, noting that postal and courier services are closely tied to Gross Domestic Product (GDP) per capita (r = 0.946*) and foreign trade turnover (r = 0.897*). These findings confirm that courier logistics are both drivers and reflections of broader economic modernization.

Despite notable progress, several critical gaps remain in the existing literature, including the limited availability of empirical case studies on Kazakhstani courier companies implementing digital technologies such as electric vehicle fleets, parcel locker networks, and AI-based routing systems; the insufficient integration of sustainability metrics, particularly emissions, energy efficiency, and curb-space utilization, into national logistics research; the absence of robust frameworks that ensure effective alignment between public policy and business strategies, especially within the context of smart city programs and courier operations; and the lack of localized methodological approaches that systematically combine international best practices with Kazakhstan's specific economic, climatic, and urban conditions.

Addressing these gaps, the present study contributes by synthesizing global evidence with local data to develop a Smart Courier Transformation Matrix and mapping key drivers, barriers, and actionable policy levers for sustainable urban logistics in Kazakhstan. Smart courier logistics refers to an integrated, technology-driven model of last-mile delivery that leverages advanced digital solutions to optimize routing, enhance operational visibility, reduce environmental impacts, and improve customer experience. Contemporary research emphasizes that such systems are fundamentally built on data-driven decision-making, enabled by real-time information from IoT infrastructure, vehicle telematics, and parcel-level tracking, which enables dynamic route optimization, accurate demand forecasting, and predictive maintenance in urban delivery systems (Chen et al., 2021; Pan et al., 2021). These capabilities are reinforced through automation and algorithmic optimization, where AI and machine learning reduce routing inefficiencies, minimize fuel consumption, and automate sorting, dispatching, and load-balancing processes (Giuffrida et al., 2022).

At the organizational level, platform-based coordination via digital logistics platforms ensures transparent interaction among couriers, marketplaces, warehouses, and customers, supporting interoperability and service flexibility across delivery networks (Dinu, 2024). From a sustainabil-

ity perspective, electrification and green technologies, including electric vehicles, cargo bikes, and low-emission urban microhubs, play a central role in decarbonization and sustainable urban mobility (Llorca & Moeckel, 2021). In parallel, out-of-home and autonomous delivery solutions, such as parcel lockers, pick-up and drop-off points, drones, and autonomous delivery robots, help reduce failed deliveries and alleviate urban congestion (Zhang & Demir, 2025).

A review of international and national studies shows that the digital transformation of courier logistics is considered a key factor in increasing the efficiency of the last mile, reducing environmental stress, and supporting sustainable urban development. Foreign studies confirm the high potential of using AI, IoT, big data analytics, electric transport, and off-site delivery to optimize logistics processes, reduce costs and emissions, as well as improve the quality of service. An analysis of the works devoted to Kazakhstan indicates that there are objective prerequisites for the development of "smart" courier logistics, including the growth of e-commerce, the development of digital infrastructure, and the implementation of smart city initiatives in major cities. Thus, existing scientific research provides an important theoretical basis, but it underscores the need for further research focused on developing conceptual models and analysis tools adapted to national conditions.

Smart courier logistics operates at the intersection of urban logistics, digital transformation, and sustainability, aligning with global smart city frameworks. In emerging economies such as Kazakhstan, the integration of these elements is evolving but demonstrates significant potential for optimization and green transition. Thus, the purpose of this article is to study the drivers and barriers of the digital transformation of courier logistics in Kazakhstan, as well as to develop conceptual directions for its sustainable development in the context of a smart city.

MATERIALS AND METHODS

This study adopts a mixed-methods research design that integrates three complementary methodological components. First, a document analysis of Kazakhstan's national policy and strategic frameworks, including Digital Kazakhstan, OECD analytical reports, and World Bank policy diagnostics, is conducted to establish the institutional and regulatory context. Second, an empirical qualitative stage is implemented through expert interviews with courier companies and semi-structured surveys involving representatives of state-owned enterprises engaged in logistics activities. Third, the quantitative component employs correlation and factor analysis based on secondary datasets (Kredina et al., 2022; Bureau of National Statistics; World Bank LPI 2023). This triangulation provides a comprehensive perspective on global best practices and Kazakhstan's unique institutional and economic conditions.

Document analysis was employed to identify policy-level drivers and barriers shaping the digital transformation of courier logistics in Kazakhstan. The analysis covered national digitalization strategies, international policy diagnostics, and urban sustainability assessments, focusing on priorities for ICT adoption, digital services, infrastructure modernization, SME digital readiness, and the role of smart urban infrastructure in supporting courier logistics. In addition, international benchmarking evidence was used to assess systemic weaknesses in logistics performance, particularly in tracking and delivery timeliness (Government of Kazakhstan, 2024; OECD, 2023; UNECE, 2023; World Bank, 2023).

To complement secondary data, five semi-structured expert interviews were conducted with managers of leading Kazakhstani courier companies. The analysis focuses on the thematic coding of regulatory enablers and structural gaps affecting courier services. Additionally, an online survey of 32 respondents (including logistics specialists) was conducted in early 2025. The online survey and expert interviews were conducted in accordance with standard ethical principles. Participation was voluntary, informed consent was obtained from all respondents, and no personally identifiable information was collected.

The interview protocol focused on three core thematic areas, including the adoption of AI, the Internet of Things, blockchain technologies, and parcel locker systems; the technological, financial, and infrastructural barriers to fleet electrification; and the key regulatory and infrastructure bottlenecks constraining the digital transformation of courier operations. Surveys applied a 5-point Likert scale

to evaluate the perceived importance of drivers (e.g., e-commerce growth and policy support) and barriers (e.g., cost, skills, and IT fragmentation). Responses were coded thematically and cross-referenced with findings from document analysis.

Although the interview sample (n = 5) and survey sample (n = 32) were modest in size, this is consistent with the methodological practices in exploratory logistics research conducted in emerging markets. Access to courier company management is restricted because of operational confidentiality and competition concerns. Therefore, purposive sampling was used to obtain insights from key decision makers directly involved in digital transformation processes. The results are not intended for statistical generalization but provide valuable qualitative evidence to complement the correlation and policy findings.

To examine the relationships between ICT adoption, courier logistics performance, and economic development, this study applied correlation and factor analytical techniques. The core empirical basis draws on the findings of Kredina et al. (2022), who report strong positive correlations between postal and courier services and GDP per capita as well as foreign trade turnover. These findings are complemented by national e-commerce statistics for 2023–2024 obtained from the Bureau of National Statistics (2024) and by the World Bank LPI 2023 scores. All statistical procedures, including Pearson correlation analysis and principal component analysis (hereinafter – PCA), were conducted using SPSS 28. The objective was to identify structural linkages among digital logistics indicators, economic performance, and sustainability-related factors. The analytical workflow is presented in Figure 1.

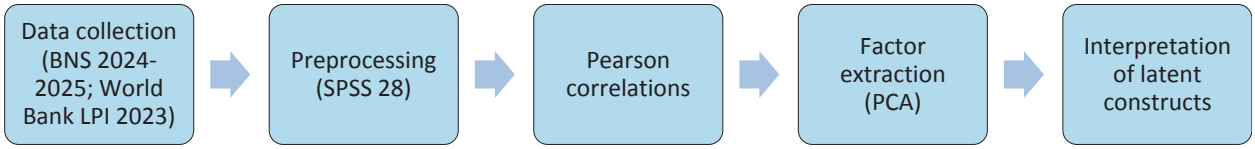

Figure 1. Analytical workflow for correlation and factor analysis

All empirical findings were synthesized into a Smart Courier Transformation Matrix, and identified drivers and barriers were systematically classified into four interrelated dimensions encompassing policy and regulation, infrastructure, technology and data, and skills and organizational capacity. This integrative framework subsequently served as the analytical basis for formulating a 12-point action plan and a strategic roadmap toward 2030, which are presented in the results section.

RESULTS

A review of Kazakhstan's strategic development documents and international assessment frameworks reveals both enabling conditions and persistent systemic constraints affecting the transition toward smart and sustainable courier logistics. The national Digital Kazakhstan Program prioritizes the expansion of ICT infrastructure, e-government services, and digital platforms, and positions logistics as one of the key sectors for modernization (Government of Kazakhstan, 2024). However, the strategy lacks operational mechanisms specifically targeting courier operations, such as incentives for EVs, the deployment of parcel locker networks, or standardized digital protocols for last-mile services. According to the OECD diagnostic report (2023), low SME digital readiness and uneven adoption of advanced ICT solutions across industries directly hinder courier companies' ability to implement technologies such as IoT tracking, AI-driven routing, and blockchain-enabled data exchange.

In the urban context, the UNECE Smart Sustainable Cities Profile (2023) for Almaty identifies several existing smart-city components – including urban data lakes, intelligent transport systems, and AFC – that could support courier telemetry, curbside allocation, and demand-responsive routing, yet integration with private logistics operators remains limited and largely uncoordinated. Additional constraints are reflected in Kazakhstan's performance on the World Bank LPI, where the country recorded an overall score of 2.7, significantly below the

OECD average of 3.5, with remarkably low scores in logistics competence (2.5), tracking and tracing (2.4), and delivery timeliness (2.6). These gaps indicate structural operational risks and highlight the vulnerability of courier service reliability under current conditions (World Bank, 2023).

Overall, the document analysis suggests that while Kazakhstan has a generally supportive policy environment for digitalization and smart-city development, implementation mechanisms specifically targeting last-mile courier logistics remain insufficiently developed. The key findings of the document analysis are summarized in Table 1.

Table 1. Document analysis results

Document	Enabler	Gap
Digital Kazakhstan	ICT infrastructure, e-services	No explicit courier standards
OECD (2023)	Policy alignment, SME support	Low SME digital readiness
UNECE (2023) Almaty	Data lakes, ITS, AFC	Weak integration with couriers
World Bank LPI (2023)	Benchmarking of logistics	Low tracking & competence scores

Note: compiled by authors based on OECD (2023), UNECE (2023), World Bank LPI (2023)

A synthesis of insights derived from international empirical studies, industry reports, and expert assessments reveals a consistent set of perceived drivers and barriers shaping the digital transformation of courier logistics in Kazakhstan. The rapid growth of e-commerce – identified in global logistics research as one of the most influential accelerators of last-mile innovation – is considered the primary driver, reinforcing demand for faster delivery, real-time parcel tracking, and an enhanced customer experience. Government-led digitalization initiatives, particularly those embedded in the Digital Kazakhstan program, further enable sectoral modernization by expanding ICT infrastructure and promoting the integration of digital platforms (OECD, 2023). International literature similarly highlights rising consumer expectations for transparency, visibility, and delivery responsiveness as a significant force behind courier service automation and data-driven optimization. At the same time, significant barriers persist. Studies on sustainable urban logistics consistently point to the high capital costs associated with transitioning to EV fleets, coupled with insufficient availability of charging infrastructure, as key constraints on low-carbon last-mile operations. Additional challenges include fragmented digital architectures across logistics operators, limited interoperability of IT systems, and the absence of standardized data-sharing protocols – factors that hinder the implementation of IoT, AI, and smart routing tools in emerging economies. Shortages of skills in both IT and logistics, documented in regional assessments and OECD diagnostics, further slow the diffusion of advanced technologies. These consolidated trends, summarized conceptually in Table 2, reflect broader global patterns shaping the adoption of smart courier logistics and highlight the structural constraints faced by Kazakhstan's logistics ecosystem.

Table 2. Drivers and barriers identified through the survey

Factor	Mean score (1-5)	Category
E-commerce growth	4.8	Driver
Government (Gov't) digitalization support	4.2	Driver
Consumer demand for faster delivery	4.0	Driver
High cost of EV transition	4.6	Barrier
Lack of charging infrastructure	4.4	Barrier
IT fragmentation	4.2	Barrier
Shortage of skilled personnel	4.0	Barrier

Note: compiled by the authors

A consolidated analysis of international literature, policy reports, and expert insights reveals a coherent set of drivers and barriers shaping Kazakhstan's transition toward smart courier logistics. Global studies emphasize that rapid e-commerce expansion continues to reshape last-mile logistics by accelerating demand for real-time visibility, faster delivery, and automated routing solutions. This tendency aligns with Kazakhstan's Digital Kazakhstan agenda, which strengthens ICT capacity yet does not provide targeted mechanisms for EV deployment, parcel locker networks, or interoperability standards for courier ecosystems (OECD, 2023). International research further shows that consumers increasingly expect transparent and time-sensitive delivery services, pushing companies toward data-driven optimization and IoT-enabled tracking. At the same time, multiple structural constraints persist. Transitioning to EV fleets remains financially burdensome and technologically challenging for SMEs, as studies on emerging markets confirm. These barriers were also reflected in expert interviews: a courier company manager from Almaty noted that "we are interested in EVs, but without public charging stations and financial incentives, this is not realistic for SMEs". At the same time, another respondent highlighted that the integration of courier operations with municipal smart-city data platforms "remains unclear and poorly coordinated". Such practitioner perspectives correspond with OECD findings on SME capability gaps and limited digital readiness, underscoring the need to harmonize private-sector innovation with public infrastructure investments. Additional challenges, including fragmented IT systems, a lack of standardized data-sharing protocols, and persistent shortages of ICT-skilled logistics personnel, are widely documented in global supply chain digitalization research.

Using combined datasets from Kredina et al. (2022), the Bureau of National Statistics (2024), and the World Bank Logistics Performance Index (2023), an exploratory correlation and factor analysis was conducted to examine structural linkages between digital infrastructure, logistics performance, and macroeconomic indicators. The results indicate a strong and statistically significant association between the development of ICT services and the expansion of postal-courier activities, both of which closely align with national economic performance, as reflected by a high positive correlation with GDP per capita ($r = 0.946$, $p < 0.01$). A similarly strong correlation was identified between courier service activity levels and foreign trade turnover ($r = 0.897$, $p < 0.01$), suggesting that courier logistics play an increasingly important role in supporting Kazakhstan's trade-driven economic model – consistent with global findings on the interplay between trade intensity and last-mile distribution capacity. Moreover, the LPI tracking and tracing dimension demonstrated a significant positive correlation with national courier delivery performance ($r = 0.812$, $p < 0.05$), reinforcing the notion that improvements in digital tracking capability are closely linked to greater reliability and transparency in last-mile operations. These empirical relationships, derived from internationally recognized logistics indices and official national statistics, underscore the systemic nature of digital transformation in Kazakhstan's courier sector and provide quantitative evidence that ICT development, logistics digitalization, and economic performance evolve in an interdependent manner.

The correlation analysis confirmed strong relationships between ICT adoption, courier services, and GDP per capita. The detailed results are presented in Table 3.

Table 3. Correlation Matrix

Variable	Courier service	GDP per capita	Foreign trade	LPI Tracking
Courier services	1.000	0.946**	0.897**	0.812*
GDP per capita	0.946**	1.000	0.914**	0.765*
Foreign trade	0.897**	0.914**	1.000	0.732*
LPI Tracking	0.812*	0.765*	0.732*	1.000

Note: compiled by the authors

The obtained correlation coefficients indicate a strong positive relationship between the volume of courier services and GDP per capita, as well as between courier services and foreign trade turnover. Factor analysis using PCA yielded three latent factors, with a Kaiser–Meyer–Olkin (KMO) measure

of sampling adequacy of 0.72, jointly explaining 68% of the total variance. The extracted factors were interpreted as follows: digital infrastructure readiness, encompassing ICT development, broadband penetration, and AI/IoT adoption; operational efficiency, reflected by LPI indicators related to tracking and tracing, delivery timeliness, and delivery success rates; economic impact, represented by GDP per capita, foreign trade turnover, and e-commerce activity.

The distribution of the eigenvalues, with factor loadings visualized through a scree plot in Figure 2.

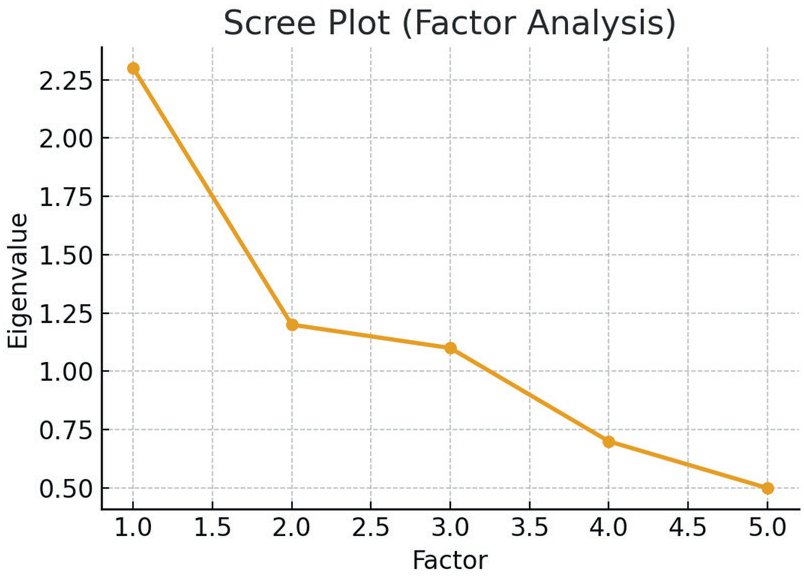

Figure 2. Scree Plot of factor analysis

The results of the factor analysis showed the contribution of each factor to the overall variance. The graph shows a clear break in the curve after the third factor, which indicates that it is advisable to identify three latent factors. The first three components have eigenvalues above unity and collectively account for 68% of the total variance. The first factor characterizes digital infrastructure readiness and includes indicators for the development of ICT, broadband access, and the implementation of AI and IoT-based solutions. The second factor reflects the operational efficiency of courier logistics and is related to tracking, timely delivery, and successful order fulfillment. The third factor describes the economic impact and includes GDP per capita, foreign trade turnover, and e-commerce volume. Thus, Figure 2 confirms the stable three-factor data structure and justifies the use of this model to analyze the interrelationships between digitalization, courier logistics efficiency and economic development.

A holistic synthesis of the empirical results, policy analysis, and international evidence indicates that Kazakhstan's transition toward smart courier logistics is shaped by a combination of mutually reinforcing drivers and persistent structural constraints. The expansion of e-commerce continues to be a significant catalyst, increasing demand for faster, more reliable, and digitally supported last-mile delivery – an effect widely documented in the global urban logistics literature. National-level initiatives such as the Digital Kazakhstan program further strengthen enabling conditions by expanding ICT infrastructure and supporting the digital transformation of key service sectors (OECD, 2023), while ongoing smart-city investments – including urban data lakes and ITS in Almaty and Astana – create additional technological foundations for courier route optimization, telemetry, and curbside management (UNECE, 2023). International studies provide robust evidence that the adoption of AI-driven routing, IoT-based tracking, and EV fleets improves operational efficiency and reduces environmental externalities across last-mile logistics networks. However, these enabling forces are counterbalanced by systemic barriers. Kazakhstan's relatively low performance in the World Bank Logistics Performance Index (2023) – particularly in logistics competence and tracking – highlights operational vulnerabilities that

directly affect courier service reliability. SME digital readiness remains limited, with skills shortages in ICT and logistics continuing to slow technology adoption (OECD, 2023). High capital expenditure requirements for EV fleet upgrades, charging infrastructure, and parcel locker deployment also restrict the feasibility of large-scale technological modernization. Furthermore, the absence of unified regulatory standards for curbside allocation, data interoperability, and cross-platform data-sharing creates institutional fragmentation and inhibits coordinated innovation across the courier ecosystem. Collectively, these integrated findings form the analytical basis for the Smart Courier Transformation Matrix presented in

Table 4 underpins the 12-point strategic action plan proposed in the discussion section.

Table 4. Smart courier transformation matrix in Kazakhstan

Layer	Driver (opportunity)	Barrier (risk)	Actionable lever (2025-2030)
Policy & Regulation	Digital Kazakhstan: city smart-mobility agendas	Fragmented rules for lockers/curbspace; data-sharing uncertainty	National guidelines for lockers & microhubs; city curbspace APIs; standard service-level/open-data clauses in municipal procurement
Infrastructure	ITS, data lakes, AFC; emerging hubs	Limited depot/charging footprint; curb conflicts	Public-private microhubs; depot electrification; kerbside booking and enforcement tools
Technology & Data	AI routing, telematics, EVs; blockchain for chain-of-custody	Legacy Transport Management System (TMS)/ Warehouse Management System (WMS); interoperability gaps	Reference architecture (open APIs, event streams); city mobility-data trusts; pilot blockchain for high-value/temperature-controlled flows
Skills & Organization	Growing analytics talent pools	SME digital skills gaps	National upskilling vouchers; vendor-supported “digital twins” sandboxes; shared services for SMEs

Note: compiled by the authors

Content analysis of the policy documents highlights that national strategies (Digital Kazakhstan and smart city programs) provide strong foundations for digital infrastructure but lack mechanisms tailored explicitly to courier operations. The correlation results reinforce this finding: indicators of ICT development and tracking performance strongly correlate with courier sector output, suggesting that systemic digital capabilities drive operational efficiency.

Interviews and survey responses provided a micro-level validation of these structural patterns. While respondents confirmed that ICT infrastructure and smart city tools facilitate digital adoption, they also identified operational barriers, such as EV costs, fragmented IT systems, and skill shortages. This combination of macro- and micro-level insights demonstrates that Kazakhstan’s courier logistics transformation depends not only on policy frameworks but also on organizational capabilities, internal investments, and interoperability solutions.

DISCUSSION

The results confirm international evidence that digitalization of last-mile logistics improves both efficiency and sustainability. Studies in Europe and Asia have shown that combining AI-assisted routing with EVs and parcel lockers reduces emissions and delivery costs (Ferreira & Esperança, 2025; Gnoni et al., 2025). Similarly, in Kazakhstan, correlation analysis demonstrated a strong relationship between courier services and GDP per capita ($r = 0.946$), validating Kredina et al. (2022), who argued that courier services act as economic drivers.

However, our interview data highlighted context-specific barriers: high CAPEX for EV fleets, insufficient public charging, and fragmented IT systems. These challenges echo the OECD (2023) findings on Kazakhstan’s uneven digital readiness for SMEs and weak ICT adoption. Simultaneously, smart city initiatives in Almaty and Astana (UNECE, 2023) offer unique opportunities for da-

ta-driven courier integration, aligning with Pan et al. (2021), who emphasized the importance of integrating freight into smart city frameworks.

Kazakhstan stands at a crossroads: without the rapid scaling of smart courier solutions, urban congestion, emissions, and delivery failures may intensify. However, with coordinated action, courier logistics can act as a catalyst for sustainable urban development.

The integrated findings of the study point to a set of strategic implications for policymakers, logistics firms, and urban authorities, highlighting the need for coordinated institutional, technological, and regulatory action to accelerate the development of smart courier logistics in Kazakhstan. At the policy level, international evidence emphasizes that the successful diffusion of last-mile innovations requires clear national standards for parcel locker deployment, curbside allocation rules, and interoperable open-data protocols, alongside targeted financial incentives that reduce the cost burden associated with the transition to electric delivery fleets. For private sector actors, global best practices demonstrate that investment in AI-based routing solutions, cloud-enabled TMS and WMS, and out-of-home delivery channels – such as parcel lockers and pick-up/drop-off (PUDO) points – significantly enhances operational efficiency and service reliability, particularly when firms collaborate with municipalities to pilot microhubs and shared urban consolidation spaces. From the perspective of city governments, integrating courier operations into existing smart-city platforms, expanding ITS, and enabling kerbside management through standardized APIs represents an essential step toward aligning private innovation with public digital infrastructure, a challenge frequently reported in assessments of Kazakhstan's digital-readiness and SME capability gaps (OECD, 2023; UNECE, 2023). These multidimensional implications are synthesized in Table 5, which outlines the Smart Courier Transformation Matrix – a structured mapping of strategic priorities across three governance layers (state, business, and urban authorities). The table highlights how regulatory standardization, digital investment, and cross-sector integration jointly form the foundation for a coherent national strategy capable of supporting scalable, technology-enabled, and sustainable last-mile logistics solutions.

Table 5. Strategic action plan for smart courier logistics in Kazakhstan for 2025-2030

Action	Stakeholder	Expected impact
1. National standards for parcel lockers	Gov't, SMEs	Reduce failed deliveries, improve accessibility
2. Microhub corridors in Almaty & Astana	Cities, couriers	Optimize curbspace, cut congestion
3. EV transition compacts	Gov't, banks, SMEs	Accelerate decarbonization
4. Charging infrastructure expansion	Utilities, cities	Enable electrification at scale
5. Open kerbside APIs	Cities, IT firms	Reduce dwell time, improve turnover
6. Interoperable tracking standards	Marketplaces, SMEs	Improve LPI "tracking" scores
7. Locker federation across operators	Couriers, marketplaces	Enhance convenience, efficiency
8. Green procurement mandates	Gov't, State-owned enterprises (SOEs)	Lead by example for EV adoption
9. Digital Maturity Vouchers for SMEs	Gov't, donors	Build IT/AI capacity
10. Regulatory sandboxes	Gov't, startups	Pilot AI/blockchain in delivery
11. Shared KPI dashboard	Cities, couriers	Transparency & benchmarking
12. University-led living labs	Academia, SMEs	Experimentation, training, innovation

Note: compiled by authors

The proposed roadmap to 2030 synthesizes empirical evidence, stakeholder needs, and global best practices into a phased strategy to advance smart courier logistics in Kazakhstan. As shown in Figure 3, the roadmap begins with a foundational stage (2025-2026) in which the emphasis is placed on piloting parcel locker networks and urban microhubs in Almaty and Astana – an approach widely recognized for reducing congestion and failed deliveries in large metropolitan areas. During this initial phase, support mechanisms such as digital maturity vouchers for SMEs and preferential EV leasing

programs through green financial institutions can help overcome the cost-related barriers that have been extensively documented in emerging markets. The roadmap then transitions into a scaling phase (2027-2028), characterized by the consolidation of parcel locker ecosystems into a federated model enabling cross-operator interoperability, the expansion of open kerbside management APIs across major cities, and the introduction of a public KPI dashboard tracking logistics sustainability metrics – an approach consistent with OECD recommendations for improving transparency and digital governance in logistics systems (OECD, 2023). The final integration phase (2029-2030) envisions nationwide convergence of interoperability standards for parcel lockers, tracking systems, and data-sharing protocols, combined with the electrification of 30-40% of the courier fleet and the full incorporation of last-mile logistics into national decarbonization and smart mobility strategies.

CONCLUSIONS

This study provides the first integrated assessment of drivers and barriers to smart courier logistics in Kazakhstan, combining literature, document analysis, expert interviews, and correlation-factor methods. The study also has several limitations that should be acknowledged. First, the limited number of expert interviews (n = 5) constrains statistical generalization; however, the use of methodological triangulation through surveys and secondary data sources enhances the overall reliability of the findings. Second, the analysis is affected by data gaps, as disaggregated microdata from individual courier operators were unavailable, necessitating reliance on national statistics and international indices. Third, the results remain time-sensitive, as ongoing policy reforms and regulatory changes may alter digitalization priorities, underscoring the need for continuous monitoring and future updates.

The overall findings of this study demonstrate that Kazakhstan's courier logistics sector is shaped by a dynamic interplay of technological, institutional, and economic factors that collectively determine the pace of transition toward a smart and sustainable last-mile ecosystem. The analysis confirms that the most significant enabling forces include the rapid growth of e-commerce, the expansion of government-supported digital programs such as Digital Kazakhstan, and the steady development of smart-city infrastructure – particularly data lakes and ITS in Almaty and Astana – which together create a favorable technological environment for the adoption of advanced logistics solutions (OECD, 2023; UNECE, 2023). At the same time, structural barriers persist, including low performance in logistics competence and tracking indicators reported in the World Bank LPI (2023), substantial digital-readiness gaps among SMEs, high capital expenditures associated with fleet electrification and parcel locker deployment, and the absence of standardized protocols for curbside management and data-sharing across operators. The exploratory correlation analysis conducted using data from Kredina et al. (2022), the Bureau of National Statistics (2024), and the World Bank (2023) further reinforces these findings by demonstrating strong linkages between courier activity, GDP per capita, and foreign trade turnover. These empirical relationships underscore the strategic importance of courier services for Kazakhstan's broader economic modernization and highlight the interdependence between logistics digitalization, macroeconomic performance, and trade intensity.

Based on these insights, the study proposes a coherent 12-point action plan and a structured 2030 roadmap designed to align policy instruments, infrastructure investment, and business-level digital adoption. By integrating sustainability and digitalization perspectives – two dimensions that have traditionally been examined separately in the Kazakhstani logistics literature – this research contributes a novel analytical framework in the form of the Smart Courier Transformation Matrix, which can serve as a methodological foundation for policymakers and practitioners seeking to design coordinated interventions across regulatory, technological, and institutional domains. Nevertheless, several important areas remain underexplored and require further research. First, large-scale, empirical case studies of Kazakhstani courier firms, including national operators such as Kazpost as well as private platforms such as Glovo Kazakhstan and regional SMEs, are necessary to capture how AI-based routing, IoT telemetry, EV fleets, and parcel locker systems are adopted and adapted in real organizational settings. Such micro-level investigations would complement the predominantly macroeconomic and policy-focused evidence presented in this study. Second, further research should employ cost-benefit mod-

eling, system dynamics simulations, and life cycle assessment tools to examine the economic and environmental trade-offs associated with smart courier technologies in Kazakhstan's urban context. Third, comparative analyses across key logistics hubs – Almaty, Astana, Shymkent, and Aktobe – would provide deeper insights into how differences in density, infrastructure, and governance influence the scalability of smart logistics solutions. Fourth, future studies must address critical issues related to data governance, privacy, interoperability, and digital sovereignty, particularly as cities and logistics firms move toward integrated open-data ecosystems and API-based kerbside management. Finally, the application of advanced statistical techniques, such as structural equation modeling (SEM), causal inference methods, and machine learning-based prediction models, could significantly strengthen causal understanding and provide robust forecasting tools for evaluating courier performance across various digital transformation scenarios.

From a theoretical standpoint, the study advances the integration of smart-city theory, last-mile delivery research, and digital transformation literature in the context of an emerging economy. By conceptualizing the relationships among policy frameworks, digital infrastructure, technological capabilities, and workforce skills, the Smart Courier Transformation Matrix provides a platform for developing future analytical models that more systematically connect these domains. The policy implications point to the importance of developing national standards for parcel locker networks, curbside allocation, and data-sharing protocols; expanding financial incentives – including subsidies, tax relief, and EVs leasing programs – to reduce adoption barriers for SMEs; and embedding courier logistics explicitly into sustainable urban mobility and national decarbonization strategies in line with international environmental commitments (OECD, 2023). For business leaders and courier companies, the results emphasize the immediate performance gains achievable through investment in cloud-based TMS/WMS platforms, AI-enabled routing tools, and digitally enabled out-of-home delivery channels. Strengthening collaboration with municipal authorities on microhub and locker pilots can reduce congestion and delivery failures. At the same time, workforce development, particularly digital skills training for drivers, dispatchers, and IT staff, remains essential for ensuring that technological upgrades translate into operational improvements.

In conclusion, Kazakhstan is well-positioned to accelerate the evolution of its courier logistics sector by strategically combining digital innovation with sustainability-oriented planning. Achieving this transformation will require the coordinated implementation of the 12-point action plan developed in this study, alongside targeted research efforts that empirically test the feasibility and impacts of smart solutions. If these measures are implemented cohesively by policymakers, businesses, and city authorities, Kazakhstan's courier sector can emerge as a regional benchmark for sustainable, data-driven, and technologically advanced urban logistics by 2030.

AUTHOR CONTRIBUTIONS

Conceptualization and theory: AS and MB; research design: AS and MB; data collection: AS and MB; analysis and interpretation: AS and MB; writing draft preparation: AS and MB; supervision: AS and MB; correction of article: AS and MB; proofread and final approval of article: AS and MB. All authors have read and agreed to the published version of the manuscript.

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