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Economic conditions for the introduction of transportation technologies in integrated transport systems

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Abstract. This study aims to assess the economic conditions for implementing transportation technologies in integrated transport systems in Ukraine. Integrated transport systems, comprising multiple modes of transport supported by digital technologies and unified infrastructure, are essential for enhancing efficiency, reducing environmental impact, and improving service quality. The research applies a mixed-methods approach, combining statistical analysis, forecasting techniques, and institutional analysis. Quantitative data on passenger and cargo transport were obtained from the State Statistics Service of Ukraine for 1996-2023 and analysed using Excel-based statistical and graphical tools. Forecasting was conducted using time-series methods to project future trends, while institutional analysis was employed to evaluate

the influence of policy, governance structures, and external shocks on the transport sector. The findings reveal a significant decline in transport volumes since 2014, especially after 2020. Nonetheless, Ukraine retains considerable potential for developing integrated transport systems due to its geographic position and prior infrastructural reforms. Key barriers include financial limitations, war-inflicted damage, and legal deficiencies. The study concludes that with coordinated institutional support, international cooperation, and targeted investment, the post-war context offers viable prospects for implementing integrated transport systems as part of Ukraine's sustainable development strategy.
Keywords: infrastructure, Ukraine, macroeconomics, transport policy, sustainable development

Introduction

This study examines the economic requirements for the implementation of transport technologies within integrated transport systems in Ukraine. Given the persistent geopolitical challenges and infrastructural deterioration resulting from conflict and prior crises, the adoption of advanced transport technologies is both a strategic necessity and a means to rejuvenate the national economy while adhering to global sustainable development objectives. This research is significant for its ability to guide evidence-based transport policy, encourage infrastructure investment, and strengthen Ukraine's position as a regional transit hub by implementing efficient, resilient, and ecologically friendly transport solutions.

The latest technologies are one of the main components of the country's development, as they help to increase the productivity and efficiency of industrial processes and increase competitiveness in the international market (Shtal et al., 2023; Herus, 2024). Their development is important in all areas of activity; the transportation sector is no exception: the latest technologies improve the efficiency of machine operation and allow increasing the speed of movement in a certain area through intelligent traffic and route management (Kramskyi et al., 2023). The introduction of electric vehicles and efficient engines, in turn, reduces emissions, and mobile applications and online services make use more convenient (Tropina et al., 2009; Panchenko et al., 2024). Therewith, information management systems optimise costs and planning and, in general, can be used for various needs in the company (Hsieh and Hsia, 2022). Despite this, it remains relevant to find opportunities for their implementation in countries (Martyniuk, 2024).

A substantial number of researchers have worked to assess the development of integrated transport systems in Ukraine. Thus, the development of Ukrainian logistics enterprises in general was examined by O.M. Vovk et al. (2020). They noted the role of multimodal transport and integrated transport and Logistics Complexes in the development of such enterprises. In addition, their general condition and development trends as of 2020 were described. O.K. Hryschuk et al. (2022) described how the introduction of intelligent transport systems in enterprises leads to an improvement in the efficiency of their functioning by increasing the volume of traffic; the conclusions are also confirmed by numerical calculations. G.I. Kyrychenko

et al. (2019) also came to the same conclusions about the importance of developing integrated transport systems for the country's development.

The possibilities of using integrated transport systems to solve many existing problems in the transport sector were also explored by T.E. Horodetska and P.M. Shcherbakova (2023), paying special attention to improving the quality of the service system. D.V. Medynskyi and D.L. Malyarenko (2020), in turn, described the features of passenger transportation technologies' functioning and implementation in integrated transport systems. O. Illiashenko et al. (2023), as part of their study, considered the methodology that combines safety instrumented system (SIS), SISMECA technology, and failure mode effects and criticism analysis (FMECA) for a comprehensive assessment of the security and cybersecurity of autonomous transport systems (ATS) in the context of using artificial intelligence. This study has shown the problems that exist in the context of developing functional security and cybersecurity in such systems. The researchers have formed separate general recommendations to solve these problems. S. Smerichevska et al. (2023) examined how the introduction of innovative technologies in transport enterprises correlates with ensuring the sustainable development of these companies or the country in general. Researchers noted a relationship between these variables but drew attention to the role of innovation development in ensuring sustainable development.

Thus, in the Ukrainian economic scientific literature, not enough attention is paid to the development of integrated transport systems and innovations in the industry in general. The integration of modern transportation technologies into unified transport systems has become a strategic priority for enhancing mobility, sustainability, and economic efficiency in urban and regional planning (Bulatov et al., 2020; Kryvoruchko et al., 2021). In the context of Ukraine, this process faces considerable challenges due to ongoing geopolitical instability and structural deficiencies within the transport and logistics sectors.

Notwithstanding persistent endeavours to modernise Ukraine's transport sector, the nation continues to encounter substantial obstacles in guaranteeing the efficiency, resilience, and sustainability of its transport infrastructure, particularly amid prolonged economic instability, constrained investment, and war-induced devastation. A significant practical issue is the disjointed structure of the existing transport system, which lacks connectivity across various modes and is inadequately prepared to meet increasing demands for mobility, environmental sustainability, and economic revitalisation. This research fills the gap by assessing the economic circumstances required for the implementation of integrated transport technologies, thus providing a framework for policymakers to prioritise investment, coordinate institutional efforts, and improve the sector's long-term viability. The study provides practical insights that might guide the creation of integrated, future-oriented transport infrastructure designed for Ukraine's post-war reconstruction and sustainable development objectives.

The purpose of this study is to assess the economic conditions necessary for the successful implementation of transportation technologies in integrated transport systems in Ukraine, with particular attention to current disruptions and infrastructure limitations. The research problem lies in identifying the key economic, institutional, and infrastructural barriers that hinder technological integration in transport amid war-related constraints and limited investment capacity. The central hypothesis is that, despite the adverse effects of military conflict and economic instability, Ukraine retains substantial potential for developing integrated transport systems through targeted reforms, international cooperation, and the strategic use of digital innovations.

Materials and Methods

The main source of information for conducting assessments was the website State Statistics Service of Ukraine (2024). In particular, information on the volume of passenger transportation, cargo turnover, and the volume of cargo transportation was examined. Notably, due to the beginning of a full-scale Russian invasion of Ukraine, the volume of data for the period 2022-2024 is limited. However, some data was still available, which was used for the analysis. In addition, even data up to 2022 can show trends in the development of the transport industry in the country, which allows forming separate conclusions. Data evaluation limits for most of the data were set between 2014 and 2023 (given that the collection of this type of information began only in 2014), but data on cargo volumes were taken for the period from 1996. This allowed investigating long-term trends and fluctuations in the transport sector, considering various economic and political factors that influenced these indicators. In particular, the analysis showed how changes in legislation, the investment climate, the geopolitical situation, and other factors affected the development of the transport industry in Ukraine.

Based on the assessment of statistical information, an assumption was formed regarding the further development of the situation. They were formed using the forecasting method (Hyndman and Athanasopoulos, 2021): data on the specific features of the country's economic development, the state of the transport sector, and some other factors were used for this purpose, after which they were examined (using the abstraction method to assess factors "in a vacuum" (Babbie, 2020) and subsequently assumptions were made about the development of the transport industry in Ukraine, especially in the conditions after the end of the war. The paper also identified trends in passenger and freight traffic over time to determine the impact of external factors such as economic crises, pandemics, and geopolitical events; assessed the economic conditions and investment climate in Ukraine, focusing on the availability of funding from public, private, and international sources.

The study also used the method of institutional analysis (Peters, 2019), which assessed the impact of non-economic factors on the development of the transport sector. Special attention was paid to analysing the interaction between different levels of government and the private sector in the process of managing transport infrastructure (Yescombe, 2017), which allowed assessing how effectively the state and the private sector cooperate for infrastructure development. Constructions and calculations were performed using Microsoft Excel software. In particular, tools were used for statistical analysis, plotting graphs, creating predictive models (Walkenbach, 2015), and other analytical functions. Excel allowed for efficient organising and visualising of a large amount of data, which contributed to a deeper understanding of trends and identifying key insights. The graphs and charts created in Excel helped to clearly demonstrate changes in the transport industry over the years and identify the impact of various factors on the development of the industry.

Results

Integrated transport systems comprise interconnected vehicles, infrastructure, and technology aimed at facilitating efficient, safe, and ecologically friendly travel for both passengers and cargo. Their main goal is to amalgamate various transportation modes, such as public transit, private vehicles, bicycles, and pedestrian pathways, into a cohesive, user-centric system that minimises journey duration and improves service quality (Oeschger et al., 2020; Bešinović, 2020). These systems utilise information and communication technology, including IoT-enabled infrastructure, to regulate traffic, alleviate congestion, and monitor conditions in real time, thus enhancing overall operating efficiency (Njoku et al., 2022; Zavadska and Oksenyuk, 2023). They also contribute to the reduction of accidents and emissions while facilitating integrated payment systems and enhanced logistical planning (Gao et al., 2023; Mouratidis et al., 2021; Chowdhury et al., 2018; Simić et al., 2022).

Integrated systems are essential elements of contemporary transport infrastructure, facilitating overarching objectives like enhanced quality of life, sustainable urban development, and regional economic competitiveness (Krylovskyi, 2024; Malyarets et al., 2019). Nonetheless, their execution necessitates meticulous evaluation of economic circumstances, especially given the substantial capital and operational expenditures linked to the deployment of sophisticated technologies (Kovalska et al., 2023). Essential aspects encompass access to many financing sources, such as public, private, and international, alongside favourable government policies, tax incentives, and institutional structures. The widespread adoption of integrated transport systems remains challenging, particularly in areas with fiscal and infrastructural limitations, until these conditions are addressed.

To assess the situation in Ukraine, it is also worth evaluating individual data that characterise the state and dynamics of the development of the logistics industry. Within the framework of Table 1, information is displayed in the context of cargo transportation volumes in Ukraine by mode of transport in the period from 1996 to 2021.

Table 1. Data on the volume of cargo transportation in Ukraine in the period from 1996 to 2021, million tonnes

Year	Railway station	Water	Automobile	Pipeline	Total
1996	342.6	22	1254.5	245.7	1864.7
1997	341.4	19	1249.9	236.7	1847
1998	335.1	17.8	1081.3	241	1675.2
1999	334.6	14.6	955.3	235.1	1539.6
2000	357.4	14.7	938.9	218.2	1529.1
2001	370.2	15.2	977.3	216.4	1579.1
2002	392.6	16.4	947.3	201.3	1557.5
2003	445.5	18.8	973.3	216.7	1654.3
2004	462.4	20.7	1027.4	220.9	1731.3
2005	450.3	21.4	1120.7	212.6	1805
2006	478.7	23	1167.2	203.7	1872.6
2007	514.2	24.2	1255.2	196	1989.7
2008	498.5	19.5	1266.6	186.8	1971.5
2009	391.5	9.8	1068.9	154.6	1624.8
2010	432.9	11.1	1168.2	153.4	1765.6
2011	469.3	9.9	1252.4	155	1886.5
2012	457.5	7.8	1259.7	128.4	1853.3
2013	443.6	6.3	1260.8	125.9	1836.6
2014	386.3	6	1131.3	99.7	1623.2
2015	350	6.4	1020.6	97.2	1474.3
2016	343.4	6.7	1085.7	106.7	1542.5
2017	339.6	5.9	1121.7	114.8	1581.9
2018	322.3	5.6	1205.5	109.4	1642.9
2019	312.9	6.1	1147	112.7	1578.8
2020	305.5	5.6	1232.4	97.5	1640.9
2021	314.3	5.3	1441.9	77.6	1839.1
Change	**-8.2**	**-75.9**	**14.9**	**-68.4**	**-1.4**

Source: compiled by the authors based on the data from State Statistics Service of Ukraine (2024)

The data indicate a significant and sustained decrease in pipeline transport (−68.4%) and water transport (−75.9%), both of which are capital-intensive and reliant on cross-border infrastructure and international trade dynamics. These declines correspond with Ukraine's evolving geopolitical alignments, disruptions in energy transit routes, and diminishing navigability and competitiveness of interior rivers. The relative stability of rail transport (8.2%) and the significant growth in road transport (+14.9%) indicate a modal shift influenced by more flexible and decentralised logistics requirements, especially as SMEs and regional logistics operators increasingly depend on road freight for short- and medium-haul distribution. This history signifies structural adjustments in Ukraine's economic geography, encompassing the decentralisation of industrial production and the expansion of consumer markets in urban peripheries.

Furthermore, the slight alteration in overall cargo volume (−1.4%) throughout the 25-year span masks significant internal transformations inside the logistics system. The rising use of road transport signifies a mounting burden on infrastructure upkeep and environmental externalities, including pollution and traffic congestion (Iurchenko et al., 2024; Işık et al., 2025). It underscores the pressing necessity for intermodal integration, wherein road freight may be more effectively coordinated with rail and port logistics to optimise economic and environmental efficiencies. The post-2009 resurgence in automobile transport, despite overall economic stagnation, may suggest a sort of adaptive resilience in decentralised logistics and the function of private carriers in maintaining supply chains during challenging circumstances. These trends emphasise the significance of developing integrated transport systems to diversify mode dependencies, bolster systemic resilience, and enhance overall logistical performance, particularly in response to economic shocks and war-induced infrastructural damage.

In addition, it is worth considering in the context of passenger turnover, as shown in Table 2 and Figure 1.

Table 2. Data on passenger traffic volumes in Ukraine in the period from 2014 to 2021, million passengers per kilometre

Mode of transport	2014	2015	2016	2017	2018	2019	2020	2021	Change, %
Railway station	35 865	35 367	36 839	28 075	28 685	28 414	10 696	15 709	-56.2
Automo-bile	42 632	34 585	34 555	35 509	34 560	33 880	19 092	18 764	-56
Water	42	22	30	30	28	26	4	6	-86.2
Aviation	11 578	11 363	15 533	20 346	25 889	30 242	10 107	18 730	61.8
Tram	4 292	4 240	3 995	3 924	3 925	3 729	2 541	2 387	-44.4
Trolley-bus	6 370	6 094	5 897	6 017	5 805	5 407	3 453	3 467	-45.6
Subway	5 562	5 365	5 351	5 507	5 553	5 478	3 142	3 672	-34
Total	10 6341	97 036	102 199	99 409	104 446	107 175	49 035	62 734	-41

Source: compiled by the authors based on the data from State Statistics Service of Ukraine (2024)

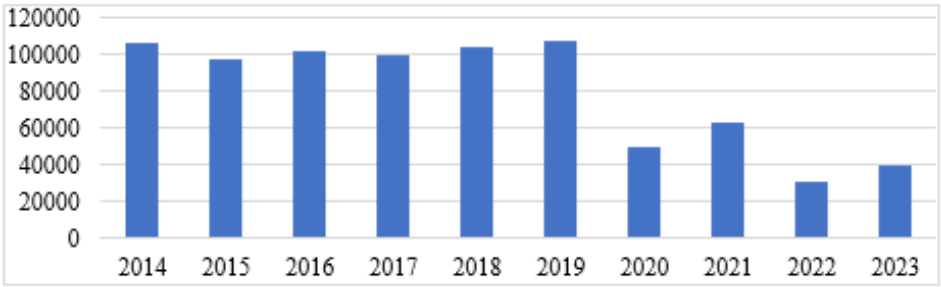

Fig. 1. Data on the volume of passenger traffic in the period from 2014 to 2023, million passengers per kilometre

Source: compiled by the authors based on the data from State Statistics Service of Ukraine (2024)

The results reveal a significant reduction in total passenger turnover, with an aggregate loss of 41% over eight years, particularly evident in historically predominant modes such as railway (–56.2%), tram (–44.4%), and trolleybus (–45.6%). This contraction indicates a systemic decline in public transport services, possibly associated with underinvestment, urban depopulation in conflict-affected areas, failing infrastructure, and diminished service frequency. The emergence of the COVID-19 pandemic in 2020 intensified this decline due to quarantine protocols and diminished commuter mobility, resulting in a significant decrease across all public transport modes between 2019 and 2020. Water transport underwent a significant decline (–86.2%), effectively rendering it nonviable as a method of urban travel.

In contrast to these decreases, the aviation sector had remarkable growth, registering a 61.8% increase during the same timeframe. This anomaly reflects Ukraine's enhanced integration into European air travel markets, the rising demand for international mobility, and a transformation in middle-class transportation preferences. Nonetheless, the growth of aircraft was predominantly focused on urban centres and failed to compensate for the widespread decline in mass transit systems. Figure 1 depicts the general decline in passenger mobility, notably marked by a significant inflection point in 2020. This visual trend underscores that Ukraine's urban and regional transport infrastructure has been significantly strained by health crises and military disruptions, necessitating recovery strategies that prioritise the modernisation of public transport, the restoration of passenger confidence, and the development of integrated, multimodal systems resilient to economic and geopolitical shocks.

It is also worth considering the data related to cargo turnover, as shown in Table 3 and Figure 2.

Table 3. The volume of traffic by mode of transport in Ukraine in the period from 2014 to 2021, million tonnes per kilometre

Mode of transport	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Change, %**
Railway station	21 0157	19 5054	187 558	191 914	186 344	181 845	175 587	180 361	-14
Automobile	37 747	34 505	37 979	41 460	42 570	48 906	42 017	46 808	24
Water	5 431	5 434	4 004	4 272	3 363	3 388	2 877	2 950	-46
Pipeline	81 824	80 676	94 379	105 434	99 240	104 528	69 282	59 171	-28
Aviation	239	211	226	275	340	296	316	346	45
Total	335 398	315 880	324 145	343 355	331 856	338 963	290 079	289 635	-14

Source: compiled by the authors based on the data from State Statistics Service of Ukraine (2024)

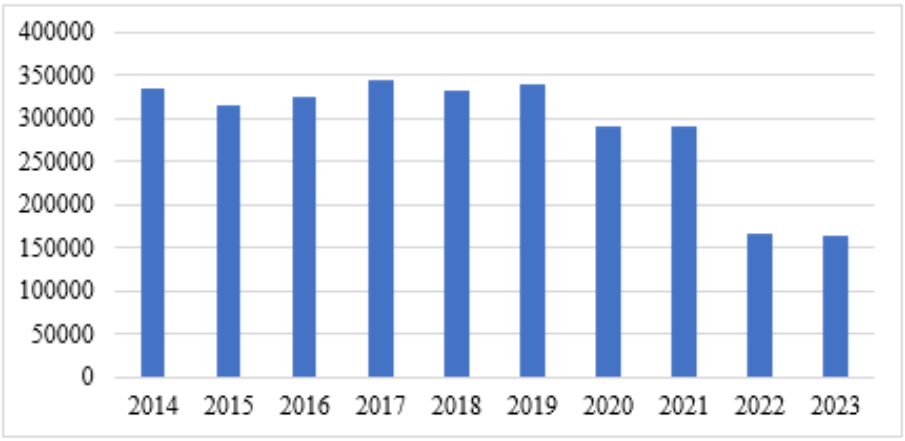

Fig. 2. Cargo transportation volumes in Ukraine in the period from 2014 to 2023, million tonnes per kilometre

Source: compiled by the authors based on the data from State Statistics Service of Ukraine (2024)

The first mild decrease from 2014 to 2021 conceals the drastic collapse that ensued post-2021, precipitated by the comprehensive Russian invasion and its catastrophic effects on infrastructure, logistical routes, and economic operations. Railway turnover, which has traditionally been the foundation of freight operations, decreased by 14%, indicating both physical damage to the rail infrastructure and a general slowdown in bulk industries such as metallurgy and coal. Pipeline transport had a substantial decline (–28%), due to problems in transit routes, diminishing hydrocarbon flows, and a geopolitical shift away from Russian supply chains.

In contrast, road freight demonstrated a 24% increase from 2014 to 2021, indicating a shift towards shorter, more adaptable domestic logistics, particularly for retail, agricultural, and humanitarian supply chains. This transition highlights the adaptability of road transport to crisis situations and its potential as a fundamental component of future integrated systems. The decline in waterborne transit (–46%) indicates underutilised inland navigation and the susceptibility of port infrastructure, especially in conflict-prone areas. Figure 2 clearly demonstrates that the fall intensified significantly post-2021, validating the war's disruptive impact on the whole freight transport sector. The findings indicate an immediate necessity to reconstruct essential freight infrastructure and recalibrate modal dependencies by investing in multimodal integration, encompassing resilient rail-road interchanges and safeguarded logistics corridors to recover throughput capacity in the post-war era.

Thus, the analysis of statistical information shows that there are substantial difficulties in the logistics sector in Ukraine. Although introducing innovations in the field may be problematic, it is still possible. Some other reasons, namely the consequences caused by Russia's full-scale invasion of Ukraine, also negatively affect

the development opportunities of this technology. The war leads to many problems in the economic development of the country (and the transport industry in particular), and affects many other components: it causes a decrease in the investment attractiveness of the country, due to which the introduction of any innovations is unrealistic (Shtal et al., 2025; Prokhorova et al., 2025). The alternative in such cases is often public funding (Rohács and Rohács, 2020) however, in the conditions of war, Ukraine spends all its funds on providing for the battlefront (social needs are financed by state support). Thus, in the current conditions, it is quite difficult to achieve success in solving this problem. Notably, before the beginning of the COVID-19 crisis and Russia's full-scale invasion of Ukraine, the introduction of integrated transport systems in Ukraine was actively developing.

The local transport infrastructure system still has substantial potential due to the favourable geographical location of the country, which allows it to be used as a transit hub between Europe and Asia (Bieliatynskyi and Ahmad Khalif, 2012). In recent years, the Ukrainian government has been actively working to modernise the transport infrastructure and integrate various types of transport (Konurbayeva et al., 2015; Destek et al., 2024). One of the main directions is the development of transportation that combines rail, road, water, and aviation transport. For example, considerable attention should be paid to developing seaports such as Odesa, Mykolaiv, and Chornomorsk to increase their capacity and efficiency.

Currently, the Mykolaiv port is non-operational due to persistent military threats and a precarious security environment, with access routes and infrastructure facing continuing disruption. This significantly restricts its ability to operate as a logistical centre and hinders its involvement in integrated system development in the short term. Consequently, any strategy for implementing integrated transport systems must pragmatically consider the cessation of operations in susceptible ports and redirect developmental initiatives towards more secure and resilient corridors, including the enhancement of rail-road connections and the optimisation of inland logistics nodes less vulnerable to conflict-induced damage. This transition highlights the necessity for flexible planning that integrates spatial and security factors into the design of Ukraine's future transport infrastructure. The possibilities for developing these areas have become very limited since the beginning of Russia's full-scale invasion of Ukraine in 2022. Moreover, marine infrastructure facilities are periodically shelled. In view of this, substantial changes in this context should be expected to occur after the end of the war.

The development of railway transport is also a priority area: Ukrzaliznytsia has actively implemented projects to modernise railway tracks, upgrade the rolling stock, and introduce high-speed railway routes. In particular, modern railway traffic management systems were introduced. In addition, electronic ticket systems have been used in public transport in major cities such as Kyiv, Lviv, Kharkiv, and Odesa, which greatly simplifies the process of paying for travel for passengers,

and the introduction of GPS navigation and traffic monitoring systems, which has improved traffic flow management and the accuracy of public transport schedules. In the cities of Ukraine, the fleet of buses, trolleybuses, and trams was actively modernised, and environmentally friendly modes of transport were introduced, in particular, electric buses: for example, electric bus routes are already operating in Kyiv and Lviv, which helps to reduce the level of air pollution in cities. Although this process has slowed down due to the beginning of a full-scale invasion, however, its development is likely to continue after the end of the war.

The examination of cargo, passenger, and freight turnover data uncovers structural deficiencies and unexploited opportunities for the establishment of integrated transport networks in Ukraine. Cargo transportation volumes, albeit influenced by long-term variations, exhibit a distinct downward trend across most transport modes since 2014, especially in the rail and pipeline sectors. Although road transport exhibits relative durability and occasional moderate growth in specific years, the general decline in cargo movement, particularly during and after 2020, highlights the vulnerability of Ukraine's transport infrastructure during economic upheavals and military disturbances. Nonetheless, the preeminence of road transport within the existing logistics framework indicates a potential for multimodal integration, particularly via enhanced interconnectivity among highways, rail terminals, and port facilities, which can augment efficiency and diminish reliance on singular freight modalities.

The statistics on passenger traffic and freight turnover underscore the pressing necessity for cohesive solutions. The significant reduction in passenger mobility, surpassing 60% from 2014 to 2023, indicates a fall in transport service availability and a change in public preferences away from conventional modes including trams, trolleybuses, and trains. These trends diminish the feasibility of independent public transport systems while concurrently advocating for integrated systems that can enhance reliability, optimise route networks, and provide seamless multimodal connectivity. The decline in freight turnover, especially in rail and pipeline transport, indicates inefficiencies that integrated systems, enhanced by digital technologies and synchronised logistics, could rectify. The numbers reveal significant vulnerabilities and indicate areas where focused investment and policy reform might facilitate Ukraine's transition to a more resilient, efficient, and sustainable transport system.

The legal framework regulating the transport sector in Ukraine is defined by several principal legislative acts, including Law No. 232/94-VR "On Transport" (1994), Law No. 3353-XII "On Traffic" (1993), Law No. 2344-III "On Road Transport" (2001), Law No. 273/96-VR "On Railway Transport" (1996), and Law No. 914-IV "On Municipal Electric Transport" (2004). Although these rules govern distinct forms of transport independently, they are devoid of a cohesive vision and regulatory frameworks for the advancement and execution of integrated transport systems. No current legislation includes measures that clearly address multimodal coordination,

interoperability of transport modes, integration of digital infrastructure, or cohesive transport planning across several administrative levels (Badovskis et al., 2017). The existing legislative framework unintentionally perpetuates fragmentation instead of fostering convergence and systemic integration.

This legal void constitutes a substantial obstacle to the execution of integrated transport systems in Ukraine. The legislative framework requires modernisation in numerous critical areas. A specific law on integrated transport systems is necessary to define their legal standing, establish intermodality principles, specify interoperability standards, and offer a foundation for unified information platforms and digital ticketing systems. Secondly, current legislation must be synchronised to eradicate discrepancies across the regulatory frameworks overseeing road, rail, urban, and freight transportation. Third, legal frameworks must facilitate cross-sectoral collaboration among governmental entities, municipalities, and commercial stakeholders. Moreover, the establishment of explicit incentives, such as tax advantages, public-private partnership frameworks, and preferential access to infrastructure financing, should be codified in legislation to draw investment and enable long-term strategic planning. In the absence of these reforms, the capacity for integrated transport networks to aid in Ukraine's post-war reconstruction and sustainable development will remain unfulfilled.

Discussion

Thus, although possible, developing integrated transport systems in Ukraine becomes quite problematic due to both traditional problems of the country's development and new difficulties associated with a full-scale invasion of Russia. The state authorities should make every effort to ensure that the country's post-war reconstruction takes place as quickly as possible, including its logistics system. That is why, after the end of the war, rapid development of the industry should be expected, and, probably, a more active introduction of Integrated transport systems technologies.

This study highlights the essential significance of public transit in facilitating the effective operation of urban transport systems. The analysis of India's experience by T. Ahmad and J.S. Chang (2020) provides pertinent comparative observations. In India, swift population growth has exacerbated the demand for urban transportation, while the public transit system has failed to keep up. Challenges including escalating rates, diminished public transit service, and heightened dependence on private vehicles have disproportionately impacted lower-income people. Notwithstanding policy initiatives, institutional deficiencies have obstructed effective execution, resulting in a decrease in public transport utilisation and intensifying urban mobility disparities.

India's situation provides valuable insights for Ukraine, especially in demonstrating how institutional capability and cost-effectiveness significantly influence the viability of public transit systems. Although Ukraine does not encounter same demographic challenges, it is contending with similar difficulties of insufficient budget, reduced public transport utilisation, and disjointed governance, particularly in the framework of post-crisis recovery. Both nations illustrate that in the absence of cohesive institutional support and equal access policies, public transit systems are susceptible to deterioration. Consequently, India exemplifies a warning for Ukraine, highlighting the necessity of synchronised policy formulation and sustained investment to avert structural deterioration and guarantee inclusive urban mobility.

As part of the study, it was noted that the introduction of an efficient public transport system plays a very important role both in the development of the country's economy and in improving the standard of living of the population. It was shown that the development of the logistics sector has a very multifaceted impact on the development of the country, and many countries, especially developing ones, should pay much more attention to these components. A survey on whether integrated passenger transport planning can provide a better standard of living for the region was conducted by B. Abramović et al. (2021). Researchers state that the results of their survey showed that the introduction of such technologies will really allow local residents to achieve a substantially better level of satisfaction with their ability to move inside settlements.

The possibilities of creating efficient public transport systems were considered in the framework of their study by R. Hrelja et al. (2020). They noted that there is a complexity in developing efficient public transport systems among various management structures. Thus, the efficiency of this type of transport implies a short waiting time, high speed of travel, punctuality, and integrated ticket systems, which requires a systematic approach that combines local and regional transport planning. Due to the complexity of this process, not all communities can achieve a high level of quality of such systems. Moreover, researchers have come to the conclusion that the presence of problems of this kind is typical for many countries of the world. Considering the studies conducted by other authors, it can be concluded that the impact of the transport industry on both the economy and society is indeed multifaceted. Therefore, state authorities should pay special attention to this area to ensure the country's qualitative development.

This study also described the importance of introducing innovative technologies to the industry in general. In turn, the advantages of using artificial intelligence in the development of intelligent transport programmes were described by L.S. Iyer (2021). The researcher emphasised that machine learning algorithms are mainly used to predict congestion and manage routes. Developed countries actively use technologies of this kind, in particular, requiring their introduction by enterprises

and corporate leaders. However, some organisations and governments are hesitant to introduce artificial intelligence due to concerns about risks and weak adoption of the technology among citizens. In addition, researchers noted the presence of problems associated with the use of artificial intelligence, consisting in the need to analyse huge amounts of data and the lack of knowledge in this area to conduct more effective research. However, the current study did not pay attention to how artificial intelligence technologies can be applied to improve the situation in the transport sector. The use of the latest technologies in this area really remains very important, and this is observed more and more actively in developed countries.

Within the framework of this study, attention was drawn to the fact that the development of integrated transport systems plays an important role in the context of achieving sustainable development goals as one of the important components of innovation in such enterprises. This becomes another reason for the need to pay special attention on the part of the state to this component, given the role of achieving the sustainable development goals for most countries of the world (which define them as the main ones in their own long-term policies). The impact of intelligent transport systems on energy-saving and emission-reduction in transport systems was also examined by Z. Lv and W. Shang (2023). The researchers stated that to meet the goals of peak carbon dioxide emissions and carbon neutralisation, the transport sector should focus on creating a green and civil transport system. In turn, intelligent transport systems play a crucial role in optimising existing transport infrastructure to improve services and reduce congestion, accidents, and pollution. The researcher writes that representatives of state authorities should contribute to this, first of all, due to the presence of substantial opportunities for this, in particular, financial ones.

In the context of addressing one of the goals of sustainable development, namely improving gender equality, M. Pirra et al. (2021) also conducted a study. They noted that the formation of transport systems should provide, among other things, a high-quality security environment for women, especially in countries where there are substantial difficulties with this. S. Kraft et al. (2022) noted that the proliferation of automobiles and the development of integrated transport systems is an effective approach to improving the quality of the country's transport system. They wrote that integrated transport systems are innovative solutions for organising urban and regional public transport by combining different modes of transport into one coordinated system. Researchers also conclude that the need and relevance of applying this approach may vary depending on the territory. Thus, it has been shown that in large cities, this is more important than in small towns due to the prevalence of road transport and the active use of public transport.

Building on the findings of R. Earley and P. Newman (2021), which emphasize the necessity of resilient, digitally enabled, and inclusive transport systems in Asia during the COVID-19 crisis, the current study situates Ukraine's transportation sector within a comparable paradigm of stress and transformation. While R. Earley

and P. Newman underscore the importance of flexible transport planning, digital infrastructure, and sustainability to withstand pandemics, the present study illustrates how Ukraine's progress toward integrated transport systems has been significantly hindered by compounding shocks, namely, the COVID-19 pandemic and the full-scale Russian invasion. Despite structural deficiencies and substantial wartime disruptions, the analysis demonstrates that Ukraine, like many Asian nations during the pandemic, must prioritize investment in digital infrastructure and institutional coordination to enhance multimodal integration, optimize mobility services, and align with Sustainable Development Goals. Future-ready transport systems require not only technological modernization but also resilient governance frameworks capable of navigating complex crises while maintaining progress toward sustainable urban mobility (Clichici et al., 2024).

F. Cavallaro and S. Nocera (2022), in turn, paid more attention to how integrated transport systems can be implemented to improve the efficiency of cargo transportation. Researchers wrote that the introduction of integrated transport systems can substantially facilitate the opportunities for truck transportation, thereby facilitating the functioning of the logistics industry, and positively influence the functioning of the country in other ways, namely, positively influence the social component of the country's development, attract additional investment from abroad. Indeed, as noted in the study on the possibilities of implementing integrated transport systems in Ukraine, the introduction of this kind of technology can bring a large number of advantages for the country, both in terms of economic and other components. Therefore, this is very relevant for many highly developed countries, but for developing economies, this process is much slower. Ukraine has even more difficulties in this context, given the full-scale invasion of Russia. After its completion, the country has all the chances and opportunities to improve the development of its own logistics system.

Conclusions

As part of the study, it was shown that integrated transport systems offer a transformational approach to the modernisation of transport, combining different modes of transportation and using advanced technologies to create efficient, safe, and environmentally friendly networks. They are designed to optimise interaction between public transport, private vehicles, bicycles, and pedestrian paths, thereby improving mobility and the quality of services for users. Their implementation allows improving the quality of life of the population and the quality and efficiency of transport operations, and reducing the negative impact on the environment. The introduction of traffic management systems helps optimise traffic flows and reduce traffic congestion, which is especially important for large cities.

In Ukraine, the transport sector faces numerous challenges, including economic instability and the impact of external factors such as the COVID-19 pandemic and the ongoing war with Russia. These problems have led to a decline in both passenger and freight traffic, which has made it difficult to implement innovative transport solutions. Despite these obstacles, Ukraine's strategic geographical location and ongoing efforts to modernise its transport infrastructure highlight the potential for the development of integrated transport systems. Before the pandemic and the full-scale Russian invasion, Ukraine was actively working on integrating various modes of transport and modernising infrastructure. The projects included the development of seaports, the modernisation of railway tracks, and the introduction of high-speed routes. Cities such as Kyiv, Lviv, Kharkiv, and Odesa have introduced electronic ticket sales systems, GPS navigation and traffic monitoring to improve the efficiency of public transport. However, the war substantially hindered these efforts, infrastructure was often the target of attacks, and economic conditions worsened.

The paper concluded that to fully realise the benefits of integrated transport systems, the country must address funding gaps and regulatory shortcomings that hinder progress. It is important for future research to assess the possibilities of implementing intelligent and multimodal transport systems and the formation of smart cities in Ukraine.

BIBLIOGRAPHY

[1] Abramović, B., Šipuš, D. and Jurešić, D., 2021. A preparatory survey in integrated passenger transport planning: A case study. Transportation Research Procedia, 53.

[2] Ahmad, T. and Chang, J. S., 2020. Lessons learned from the experience of Indian policies towards sustainable transport systems. Transportation Research Procedia, 48.

[3] Babbie, E.R., 2020. The Practice of Social Research (15th ed.). Cengage Learning.

[4] Badovskis, M., Briede, J., Danovskis, E., Dupate, K., Karkliņa, A., Ketners, K., Liholaja, V., Rodiņa, A. and Strada-Rozenberga, K., 2017. Public law. In: The Law of the Baltic States, 191-275. Cham: Springer.

[5] Bešinović, N., 2020. Resilience in railway transport systems: A literature review and research agenda. Transport Reviews, 40 (4).

[6] Bieliatynskyi, A. and Ahmad Khalif, A. M., 2012. Methodology of implementation of technologies for passenger transport in integrated transport systems. Proceedings of National Aviation University, 47 (2).

[7] Bulatov, N. K., Balabaev, O. T., Arpabekov, M. I. and Bobeev, A. B., 2020. Formation of a transport and logistics center within the boundaries of a transitive economy. Research in Transportation Business and Management, 37.

[8] Cavallaro, F. and Nocera, S., 2022. Integration of passenger and freight transport: A concept--centric literature review. Research in Transportation Business & Management, 43.

[9] Chowdhury, S., Hadas, Y., Gonzalez, V. A. and Schot, B., 2018. Public transport users' and policy makers' perceptions of integrated public transport systems. Transport Policy, 61.

[10] Clichici, D., Drăgoi, A.-E., and Timuș, A., 2024. Monetary support and state aid under the pandemic challenges in Romania: A comparative approach. Romanian Journal of European Affairs, 1, 67-85.

[11] Destek, M. A., Hossain, M. R., Manga, M. and Destek, G., 2024. Can digital government reduce the resource dependency? Evidence from method of moments quantile technique. Resources Policy, 99.

[12] Earley, R., and Newman, P., 2021. Transport in the Aftermath of COVID-19: Lessons learned and future directions. Journal of Transportation Technologies, 11(02), 109–127.

[13] Gao, Z., Huang, H. J., Guo, J., Yang, L. and Wu, J., 2023. Future urban transport management. Frontiers of Engineering Management, 10 (3).

[14] Herus, O., 2024. Peculiarities of investment support for industries in the current environment. Economics, Entrepreneurship, Management, 11 (1).

[15] Horodetska, T. E. and Shcherbakova, P. M., 2023. Use of integrated management systems to improve the quality of transport services. In: Proceedings of the International Scientific and Technical Conference "Smart Transport and Integrated Transport Technology", 8. Kyiv: State Biotechnological University.

[16] Hrelja, R., Khan, J. and Pettersson, F., 2020. How to create efficient public transport systems? A systematic review of critical problems and approaches for addressing the problems. Transport Policy, 98.

[17] Hryschuk, O. K., Petryk, A. V., Kozlov, A. K. and Bura, O. M., 2022. Principles of building integrated systems for managing transport and production processes of international orientation. Academic Notes of V.I. Vernadsky Taurida National University. Series: Technical Sciences, 33 (72(1)).

[18] Hsieh, H., and Hsia, H., 2022. Can continued anti-epidemic measures help post-COVID-19 public transport recovery? Evidence from Taiwan. Journal of Transport & Health, 26, 101392.

[19] Hyndman, R.J. and Athanasopoulos, G., 2021. Forecasting: Principles and Practice (3rd ed.). Melbourne: OTexts.

[20] Illiashenko, O., Kharchenko, V., Babeshko, I., Fesenko, H. and Di Giandomenico, F., 2023. Security-informed safety analysis of autonomous transport systems considering AI-powered cyberattacks and protection. Entropy, 25 (8).

[21] Işık, C., Ongan, S. and Islam, H., 2025. Global environmental sustainability: the role of economic, social, governance (ECON-SG) factors, climate policy uncertainty (EPU) and carbon emissions. Air Quality Atmosphere and Health, 18 (3).

[22] Iurchenko, M., Nyzhnychenko, Y., Rudyk, N., Zolotarova, O. and Stakhurska, S., 2024. Harnessing Renewable Energy for Sustainable Economic Growth and Environmental Resilience. Grassroots Journal of Natural Resources, 7 (3).

[23] Iyer, L. S., 2021. AI enabled applications towards intelligent transportation. Transportation Engineering, 5.

[24] Konurbayeva, Z. T., Madiyarova, E. S. and Rakhimberdinova, M. U., 2015. Algorithm for generating competitive potential of engineering within the regional economy. Actual Problems of Economics, 168 (6).

[25] Kovalska, L., Barskyi, Yu. and Onishchuk, V., 2023. Logistics business processes in entrepreneurship: Essence and types. Economic Forum, 13 (4).

[26] Kraft, S., Halás, M., Klapka, P. and Blažek, V., 2022. Functional regions as a platform to define integrated transport system zones: The use of population flows data. Applied Geography, 144.

[27] Kramskyi, S., Kolodinskyi, S. and Zakharchenko, O., 2023. Conceptual model for managing the phases of implementation of infrastructure projects and programmes in the post-war period. Scientific Bulletin of Mukachevo State University. Series "Economics", 10 (3).

[28] Krylovskyi, V., 2024. Increasing the financial potential of investment activity of business entities. Economics, Entrepreneurship, Management, 11 (2).

[29] Kryvoruchko, O., Dmytriiev, I., Poyasnik, G., Shevchenko, I. and Levchenko, I., 2021. Transport and logistics services as a component of the transport complex and their quality management. Problems and Prospects of Development of the Road Transport Complex: Financing, Management, Innovation, Quality, Safety - Integrated Approach, 1.

[30] Kyrychenko, G. I., Strelko, O. G., Berdnychenko, Yu. A., Petrikovets, O. V. and Pavlyuk, E. I., 2019. Modern trends in the development of the multimodal cargo transportation system. Academic Notes of V.I. Vernadsky Taurida National University. Series: Technical Sciences, 30 (69(2(3))).

[31] Law of Ukraine No. 232/94-VR "On Transport", 1994 [online]. Available at: https://zakon.rada.gov.ua/laws/show/en/232/94-%D0%B2%D1%80#Text [Accessed: 5 June 2025].

[32] Law of Ukraine No. 2344-III "On Road Transport", 2001 [online]. Available at: https://zakon.rada.gov.ua/laws/show/en/2344-14#Text [Accessed: 5 June 2025].

[33] Law of Ukraine No. 273/96-VR "On Railway Transport", 1996 [online]. Available at: https://zakon.rada.gov.ua/laws/show/en/273/96-%D0%B2%D1%80#Text [Accessed: 5 June 2025].

[34] Law of Ukraine No. 3353-XII "On Traffic", 1993 [online]. Available at: https://zakon.rada.gov.ua/laws/show/en/3353-12#Text [Accessed: 5 June 2025].

[35] Law of Ukraine No. 914-IV "On Municipal Electric Transport", 2004 [online]. Available at: https://zakon.rada.gov.ua/laws/show/en/1914-15#Text [Accessed: 5 June 2025].

[36] Lv, Z. and Shang, W., 2023. Impacts of intelligent transportation systems on energy conservation and emission reduction of transport systems: A comprehensive review. Green Technologies and Sustainability, 1 (1).

[37] Malyarets, L. M., Babenko, V. O., Nazarenko, O. V. and Ryzhikova, N. I., 2019. The modeling of multi-criteria assessment activity in enterprise management. International Journal of Supply Chain Management, 8 (4).

[38] Martyniuk, R., 2024. Electric transport as one of the ways to achieve climate neutrality in Europe: Problems of development and legal regulation in Ukraine. Law. Human. Environment, 15 (2).

[39] Medynskyi, D. V. and Malyarenko, D. L., 2020. Technologies of passenger transportation in integrated transport systems. In: Materials of the Scientific and Technical Conference of Students, Postgraduates, Doctoral Students and Young Scientists "Innovative Technologies", 244-251. Kyiv: National Aviation University.

[40] Mouratidis, K., Peters, S. and van Wee, B., 2021. Transportation technologies, sharing economy, and teleactivities: Implications for built environment and travel. Transportation Research. Part D, Transport and Environment, 92.

[41] Njoku, J. N., Nwakanma, C. I., Amaizu, G. C. and Kim, D., 2022. Prospects and challenges of Metaverse application in data-driven intelligent transportation systems. IET Intelligent Transport Systems, 17 (1).

[42] Oeschger, G., Carroll, P. and Caulfield, B., 2020. Micromobility and public transport integration: The current state of knowledge. Transportation Research. Part D, Transport and Environment, 89.

[43] Panchenko, A., Voloshina, A., Fatyeyev, A., Rezvaya, K. and Mudryk, K., 2024. Changing the Output Characteristics of a Planetary Hydraulic Motor. In: Lecture Notes in Mechanical Engineering, 304-313. Cham: Springer. https://doi.org/10.1007/978-3-031-63720-9_26.

[44] Peters, B.G., 2019. Institutional Theory in Political Science: The New Institutionalism (4th ed.). Edward Elgar Publishing.

[45] Pirra, M., Kalakou, S., Carboni, A., Costa, M., Diana, M. and Lynce, A. R., 2021. A preliminary analysis on gender aspects in transport systems and mobility services: Presentation of a survey design. Sustainability, 13 (5).

[46] Prokhorova, V., Kravchenko, O., Shkurenko, O., Babichev, A. and Polivantsev, A., 2025. Study of priority directions of economic recovery of Ukraine based on scenario modelling. Economics of Development, 24 (1).

[47] Rohács, J. and Rohács, D., 2020. Total impact evaluation of transportation systems. Transport, 35 (2).

[48] Shtal, T., Butenko, O., Kot, O., Kozub, V. and Malakhov, V., 2025. Modelling economic productivity of Ukraine in the context of military challenges. Scientific Bulletin of Mukachevo State University. Series "Economics", 12 (2).

[49] Shtal, T., Ptashchenko, O., Rodionov, S. and Kurtsev, O., 2023. Implementation of modern marketing tools in entrepreneurial activity. Economics of Development, 22 (4).

[50] Simić, V., Ivanović, I., Đorić, V. and Torkayesh, A. E., 2022. Adapting urban transport planning to the COVID-19 pandemic: An integrated Fermatean fuzzy model. Sustainable Cities and Society, 79.

[51] Smerichevska, S., Poberezhna, Z., Mykhalchenko, O., Shtyk, Y. and Pokanevych, Y., 2023. Modeling and evaluation of organizational and economic support for sustainable development of transport enterprises: innovative and ecological aspects. Financial and Credit Activity: Problems of Theory and Practice, 4 (51).

[52] State Statistics Service of Ukraine, 2024. Cargo and passengers transported, cargo and passenger turnover [online]. Available at: https://www.ukrstat.gov.ua/operativ/operativ2022/tr/pvp_vp_new/arh_pvp_22_u.htm [Accessed: 5 June 2025].

[53] Tropina, A. A., Lenarduzzi, L., Marasov, S. V. and Kuzmenko, A. P., 2009. Comparative analysis of engine ignition systems. IEEE Transactions on Plasma Science, 37 (12).

[54] Vovk, O. M., Kovalchuk, O. M. and Kovalchuk and Yu. O., 2020. Patterns of development of transport enterprises in conditions of structural shifts in regions. Problems of the Systemic Approach in Economics, 3 (77).

[55] Walkenbach, J., 2015. Excel 2016 Bible: The Comprehensive Tutorial Resource. Wiley.

[56] Yescombe, E.R., 2017. Public-Private Partnerships in Sub-Saharan Africa: Case Studies for Policymakers (World Bank Group) [online]. Available at: https://ppp.worldbank.org/library/ppps-sub-saharan-africa-case-studies-policymakers [Accessed: 5 June 2025].

[57] Zavadska, O. and Oksenyuk, K., 2023. Present information technologies in transport and warehouse logistics. Economic Forum, 13 (4).