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ORIGINAL PAPER

EU-ORIENTED TRAJECTORIES OF SUSTAINABLE DEVELOPMENT OF UKRAINIAN TRANSPORT SECTOR: COMPARISON WITH POLAND

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Abstract

This study examines the sustainable development of Ukraine's transport sector amid Ukraine's EU integration. It aims to assess how Ukraine's sustainable transport trajectories align with EU-27 trends, with particular focus on Poland. The system of sustainable transport and mobility indicators was constructed based on the SuM4All methodological framework, which ensures a comprehensive and coherent representation of environmental, economic, and social dimensions. The research covers three periods: before COVID-19, during the pandemic, and during Russia's aggression against Ukraine (2022–2023). The comparative analysis of efficiency, universal access, safety, and environmental performance employed official statistics from Ukraine, Poland, the EU, OECD, the World Bank, and national professional associations. The findings reveal that Ukraine's transport sector only partially follows the EU trajectories. Notably, indicators of universal access and efficiency display trends opposite to those in the EU, while road safety has been gradually improving but remains below the EU average. The environmental dimension demonstrates the strongest relative progress, which may be associated with the gradual decline in transport activity in Ukraine. These results can be used to develop scenarios for the sustainable and resilience-based transformation of Ukraine's transport sector in the process of EU integration.

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TRAJEKTORIE ZRÓWNOWAŻONEGO ROZWOJU UKRAIŃSKIEGO SEKTORA TRANSPORTU UKIERUNKOWANE NA UE: PORÓWNANIE Z POLSKĄ

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Słowa kluczowe: zrównoważony transport, rozwój sektora transportowego, Unia Europejska, Polska, Ukraina.

Abstrakt

Badanie analizuje zrównoważony rozwój sektora transportu na Ukrainie w kontekście integracji kraju z UE. Celem jest ocena, w jaki sposób trajektorie zrównoważonego rozwoju transportu na Ukrainie odpowiadają trendom w UE-27, ze szczególnym uwzględnieniem Polski. System wskaźników zrównoważonego transportu i mobilności został opracowany na podstawie podejścia metodologicznego SuM4All, które zapewnia kompleksowe i spójne ujęcie aspektów środowiskowych, ekonomicznych i społecznych. Badanie obejmuje trzy okresy: przed pandemią COVID-19, w czasie jej trwania oraz w okresie agresji Rosji przeciwko Ukrainie (2022–2023). Analiza porównawcza efektywności, powszechnego dostępu, bezpieczeństwa i wyników środowiskowych wykorzystuje oficjalne dane statystyczne Ukrainy, Polski, UE, OECD, Banku Światowego oraz krajowych stowarzyszeń zawodowych. Wyniki wskazują, że sektor transportowy Ukrainy jedynie częściowo podąża za trajektoriami UE. W szczególności wskaźniki powszechnego dostępu i efektywności wykazują tendencje odwrotne do obserwowanych w UE, podczas gdy bezpieczeństwo ruchu drogowego stopniowo się poprawia, lecz nadal pozostaje poniżej średniego poziomu UE. Wymiar środowiskowy wykazuje największy względny postęp, co może być związane z stopniowym spadkiem aktywności transportowej na Ukrainie. Wyniki mogą posłużyć do opracowania scenariuszy zrównoważonej i odpornej transformacji sektora transportu Ukrainy w integracji z UE.

Introduction

The transport system is crucial for the resilience of domestic and international supply chains and, during the war, enabled alternative routes for strategic goods. Today the sector faces large-scale reconstruction requiring rapid transformation that reflects geopolitical, defence, demographic, and production shifts (*National Transport Strategy…*, 2025; *Ukraine – Fourth Rapid Damage…*, 2025). This transformation should follow the 'build back better' principle (Modrzyńska *et al.*, 2025) and align with EU integration. Although the war has not altered Ukraine's EU-accession goals, it has slowed reforms: the transportation and storage sector shows the weakest progress in implementing the EU–Ukraine Association Agreement, with only 58% of tasks completed by 2024 (*Report on Implementation…*, 2025). In this study, we focus on the sustainable development of transport, which

serves as the framework for the expected strategic effects of reforms. The aim of the study is to assess the extent to which the sustainable development trajectories of Ukraine's transport align with EU-27 trends, as well as to evaluate Ukraine's relative position by comparing it with Poland, a neighboring EU member state with a structurally comparable transport system.

Theoretical framework

Sustainable transport development is directly related to global objectives such as building sustainable infrastructure through innovation (SDG 11), halving road deaths by 2030 (SDG 3.2), and creating safe, inclusive, and resilient cities (SDGs 9 and 11) (Vieira *et al.*, 2022). It is also linked to SDGs addressing climate action (SDG 13), affordable and clean energy (SDG 7), zero hunger (SDG 2), and quality education (SDG 4) (*Global Mobility…*, 2023). The *Sustainable Mobility for All (SuM4All)* initiative integrates these goals into four pillars – *universal access, efficiency, safety,* and *green mobility* – forming the *Global Sustainable Mobility Index* (*Mobility Performance…*, 2020, 2022). This index measures progress in the movement of goods and people, as well as in population mobility opportunities. Hence, it can be regarded as the *Global Index of Sustainable Transport and Mobility*, and four pillars proposed by SuM4All – as the *Sustainable Development Goals for Transport and Mobility* (*SDTMGs*).

Sustainable development (SD) implies a balance among environmental, economic, and social dimensions, though such equilibrium remains difficult to achieve. Baum (2021) stresses that "sustainable development should prioritise social issues and challenges," while Giddings *et al.* (2002) highlight the importance of "what the policy priorities are, how decisions are made and in whose interest." Giddings *et al.* warned that separating SD dimensions causes harm – a tendency still visible in research (Del-Aguila-Arcentales *et al.*, 2022). The SDTMGs integrate environmental (*green*), economic (*efficiency*), and social (*universal access* and *safety*) dimensions, forming a coherent model of sustainable mobility (Tab. 1). Although the SuM4All framework lacks an explicit link between safety and efficiency, this relationship is implicit in SDG 9, which emphasises building resilient infrastructure and minimising risks of system failures, including transport safety. For instance, broken rails are among the causes of freight train derailments, directly linking safety and efficiency in rail transport (Liu *et al.*, 2014). The SuM4All systemic approach to sustainable transport enabled the formulation of the following research questions:

RQ1. To what extent do the sustainable development trajectories of Ukraine's transport align with the development trajectories of the EU-27 and Poland across the four SuM4All dimensions?

RQ2. How do the rates of change in sustainable development indicators of Ukraine's transport differ from those of Poland and the EU-27 across the four SuM4All dimensions?

RQ3. How do the rates of change in sustainable development indicators of Ukraine's transport differ from those of Poland and the EU-27 within each SuM4All dimension across three periods: pre-COVID, the COVID-19 period, and wartime?

Table 1

Matrix of links between the Global Sustainable Development Goals (SDGs), sub-goals and sustainable transport and mobility targets

Sustainable transport and mobility goals	Universal access (UnA)	Safety (Saf)	Green (Gr)	Efficiency (Eff)
Universal access (UnA)	SDG 5 (5.1, 5.2, 5.5)	SDG 11 (11.2)	SDG 11 (11.2 for UnA; 11.6 for Gr); SDG 9 (9.1 for UnA, 9.4 for Gr)	SDG 9 (9.1)
Safety (Saf)		x	SDG 3 (3.6 for Saf; 3.4 and 3.9 for Gr); SDG 11 (11.2 for Saf; 11.6 for Gr)	x
Green (Gr)			SDG 13 (13.1, 13.2)	SDG 7 (7.3), SDG 9 (9.4)
Efficiency (Eff)				SDG 12 (12.3, 12.C), SDG 17 (17.14)

Note: SDGs according to the 2030 Agenda for sustainable development by UN https://sdgs.un.org/2030agenda

Source: own elaboration based on Global Sustainable Mobility Report 2022 by the Sustainable Mobility for All (SuM4All^{TM}) initiative.

Climate change is a key global megatrend, and transport is a major contributor. The sector produces 23% of GHG emissions in its member countries (excluding international shipping and aviation), with 88% coming from road transport. Only 38% of workers use low-carbon commuting modes, including 26% who rely on public transport (OECD, 2024). Climate change increases demands for transport system resilience through effects on related sectors such as agriculture and tourism, and through direct impacts like rising temperatures, floods, and "black swan" events including wars (Bolengo *et al.*, 2019). It also fosters stronger cross-sectoral integration of transport with energy and construction (Vieira *et al.*, 2022).

The quantity, quality, and productivity of transport affect both GHG emissions and mobility accessibility. Ageing assets and infrastructure are common across

Europe (Yannis & Chaziris, 2022). Vehicle age also influences road-crash frequency, though less than human factors (Thomas *et al.*, 2013). Addressing these challenges requires innovative, integrated approaches that reflect socio-economic trends and ecosystem changes. The global ageing of populations (Bianchini *et al.*, 2019) forces adaptation of transport systems (Lin & Cui, 2021). In Ukraine, ageing transport assets and population form a "symbiotic assemblage under rigid social assistance policies", with older tram and trolleybus users acting as "co-creators of urban space" (Vazyanau, 2024).

Given the overall similarity of environmental and socio-economic problems and challenges faced by the transport services sector in Ukraine and other European countries, we formulated the following hypothesis: the development of sustainable transport in Ukraine aligns with the general trajectories observed in the EU-27 and Poland across the four SuM4All dimensions, yet the pace of progress in Ukraine is comparatively slower, and the magnitude of this lag varies depending on the specific dimension.

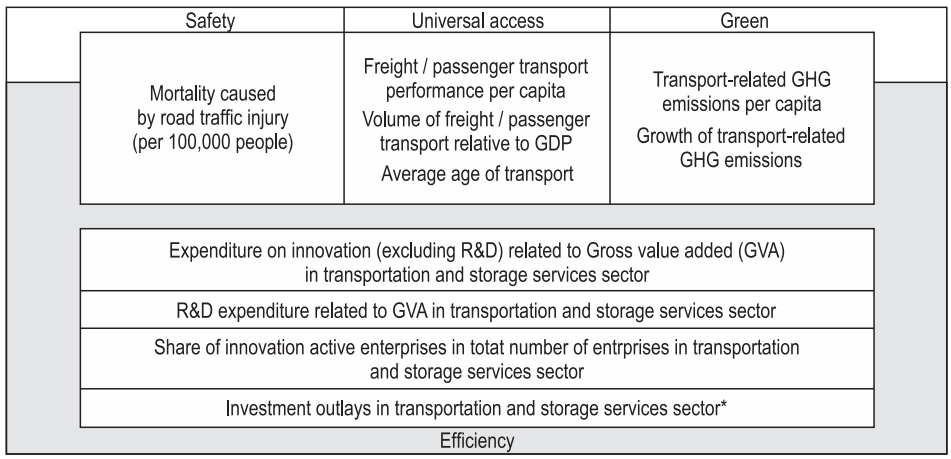
Research methodology

A review of academic literature and official reports on sustainable transport in the EU and Ukraine informed the research questions and hypothesis. A descriptive and comparative design based on the SuM4All framework structured the assessment across four dimensions: accessibility, efficiency, safety, and green mobility (Tab. 1).

Analysis used publicly available data from Eurostat, Statistics Poland, the State Statistics Service of Ukraine, national reports, EU Commission reports, OECD and World Bank datasets, and sectoral associations. The EU-27 average served as a benchmark to evaluate Ukraine's relative position and highlight Poland's transport development. Poland was chosen as a reference due to its comparable transport modes, network connections, and population size.

Empirical analysis covered three periods: pre-COVID (up to 2019), COVID-19 (2019–2021), and the war (2022–2023), with comparisons only for overlapping years. Limited data excluded 2024 and prevented full dynamic analysis from 2005, Poland's first full EU membership year. Specifically, freight and passenger volumes and investment outlays were analyzed for 2010–2023 due to data limitations.

Choice of base years depended on the purpose: the first year of the time series for long-term trends, 2015 for SDGs under the 2030 Agenda, and 1990 for the goal of reducing transport GHG emissions under the European Green Deal.



* The indicator only for comparative analysis of countries, not counties and EU.

Fig. 1. Indicators of sustainable development of transport
Source: own elaboration based on SDTMGs proposed by SuM4All (Tab. 1).

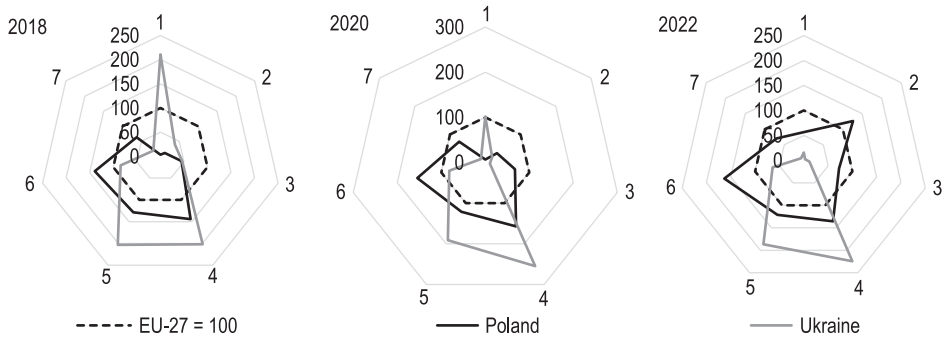
The Ukrainian indicators reflect crisis constraints (missing data from occupied areas and military movements) and require cautious interpretation, yet remain suitable for descriptive comparisons. Differences in statistical methodologies between Ukraine and the EU (European Commission, 2023, 2024) required methodological compromises, detailed in the notes to tables and figures.

Research results

The sustainable development profiles of the transport sectors of Poland and Ukraine are shown in Figure 2. These profiles illustrate the relative positions of the two countries' transport systems compared with the EU average.

The indicator *"Transport-related GHG emissions per capita"* was not included in the profile, since the corresponding values for Ukraine are almost negligible compared with the EU (0.04–0.05% relative to the EU). The European Union has set a target of reducing net greenhouse gas emissions by at least 55% by 2030 compared with 1990. In 2021, compared with 1990, the changes in GHG emissions from transport were as follows: EU + 15.7%, Poland + 228.7%, and Ukraine – 69.9%[1]. Despite this significant reduction of emissions in Ukraine, the country's transport fleet remains exceptionally old. Figure 2 demonstrates

[1] The growth rates of GHG emissions from transport were determined on the basis of *Annual European Union Greenhouse Gas Inventory 1990–2020 and Inventory Report 2022* (2022); *Poland's National Inventory Document 2025: Greenhouse Gas Inventory 1988–2023* (2025); and *Ukraine's Greenhouse Gas Inventory Report 1990–2021* (2023).



1 – Expenditures on R&D at enterprises relative to Gross value added (GVA) in transportation and storage services sector, %
2 – Expenditures on innovation activity (excl. R&D expenditures) at enterprises relative to Gross value added (GVA) in transportation and storage services sector, %
3 – Share of innovation active enterprises in total number of enterprises in transportation and storage services sector, %
4 – Mortality caused by road traffic injuries, number per 100,000 people (data for Ukraine for 2022 are unavailable; therefore, data for the EU, Poland, and Ukraine for 2021 were used in the 2022 profile)
5 – Average age of passenger cars, years
6 – Freight transport performance per capita, tonne-kilometres per capita
7 – Passenger transport performance per capita, passenger-kilometres per capita

Fig. 2. Sustainable development profiles of the transport sector in Poland and Ukraine, in % relative to the EU-27 (EU-27 = 100)

Source: own elaboration based on Eurostat database, State Statistics Service of Ukraine, European Commission (*EU transport in figures – Statistical pocketbook 2024, 2024*), European Automobile Manufacturers' Association (ACEA) (*Vehicles in use – Europe, 2018, 2021, 2022*), and Information & Analytical Group 'Auto Consulting' (Ukraine).

that the average age of passenger cars in Ukraine is far higher than in Poland and the EU, and continues to increase. This is particularly problematic in the road-transport segment, which belongs to the 'dirtiest' categories in environmental terms. In 2020, the average age exceeded the EU-27 level by 191%, and in 2022 – by 187%.

Unfortunately, official statistics on the average age of other transport modes in Ukraine are not available, although there are data on the age and continuing ageing of rolling stock by specific modes. At the end of 2023, 56.5% of diesel locomotives and 58.8% of freight wagons were 26–40 years old; 84.2% of passenger rail carriages were older than 28 years; 41.7% of diesel and 69.1% of electric locomotives exceeded 40 years; 50.2% of trolleybuses, 89.3% of trams, and 86.2% of subway carriages were older than 16 years – the oldest age group recorded in official statistics (*Transport of Ukraine…,* 2024). The average age of inland-waterway vessels in 2020 was 36 years (Bassani *et al.*, 2023). The slow pace of renewal of electric transport, which has the smallest environmental impact, indicates that fleet ageing does not contribute to a decrease in GHG emissions.

Another factor affecting emissions is transport performance. The average annual growth of freight and passenger transport performance (Tab. 2) demonstrates the widening gap between Ukraine and the EU, particularly Poland, during 2005–2023.

Table 2

Average annual growth of freight and passenger transport performance, % change compared to previous year

	2005–2013	2014–2018	2019–2021	2022–2023
Freight transport performance				
European Union – 27 countries	+0.1	+2.1	+1.1	–0.5
Poland	+2.4	+4.0	+2.3	+1.3
Ukraine	–0.1	–1.8	–2.0	–15.0
Passenger transport performance				
European Union – 27 countries	+0.5	+1.7	–4.5	+9.8
Poland	+1.7	+3.5	–2.3	+9.5
Ukraine	+0.1	–3.6	–7.9	–11.9

Note: Explanation of the selected time periods for analysis: 2005 – the first full year of Poland's membership in the EU; 2014 – the beginning of Russia's invasion of Ukraine, the occupation of Crimea and parts of the Donetsk and Luhansk regions; 2019–2021 – the COVID period; 2022 – the beginning of Russia's full-scale invasion of Ukraine.

Source: own elaboration based on the Eurostat database, the State Statistics Service of Ukraine, and the European Commission (*EU Transport in Figures – Statistical Pocketbook 2024*, 2024).

The performance of freight and passenger transport in Ukraine lags behind that of the EU and shows an opposite trend compared with Poland, both in per capita terms (Fig. 2) and relative to GDP (Fig. 3).

The trajectories of freight and passenger transport in Ukraine indicate a long-term decline in transport accessibility. Transport performance – particularly passenger transport – has deteriorated sharply since 2014, following the first phase of Russia's invasion. The pandemic affected Ukraine's transport sector more severely than that of the EU and Poland, demonstrating lower system resilience. The full-scale invasion in 2022 caused an additional collapse in performance indicators. Although the temporary suspension of civil aviation due to hostilities is expected to be lifted after the war, improving the productivity of the transport sector remains a major challenge for businesses as well as for regional and national governance.

The renewal and expansion of transport services require consistent annual investment. The dynamics of total investment in the transportation and storage services sector in Poland and Ukraine are presented in Figure 4.

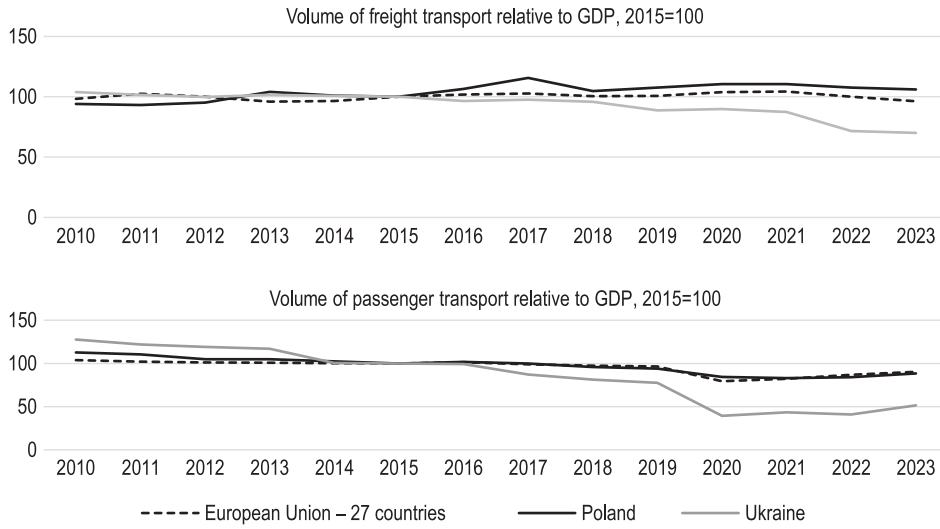


Fig. 3. Volume of freight and passenger transport in the EU, Poland, and Ukraine [2], in % change compared to 2015 (chain-linked volumes, at 2015 exchange rates)
Source: own elaboration based on Eurostat database, State Statistics Service of Ukraine, and European Commission (*EU transport in figures – Statistical pocketbook 2024, 2024*).

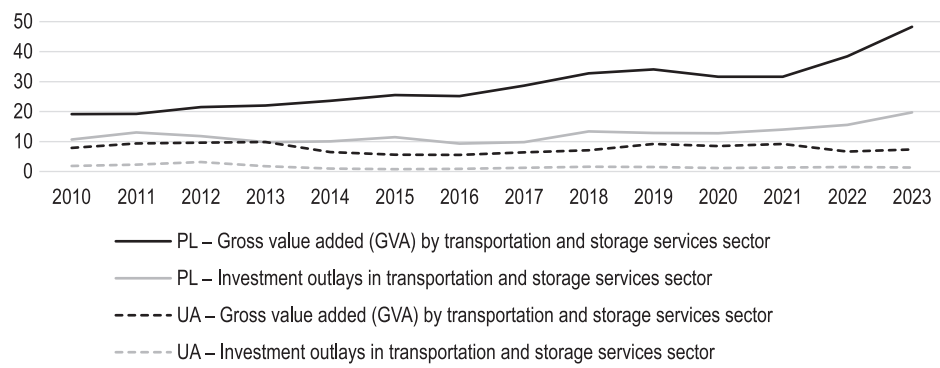


Fig. 4. Value of investment outlays in transportation and storage services sector and Gross value added by transportation and storage services sector of Poland and Ukraine in 2010–2023, in current prices, in million EUR
Source: own elaboration based on Eurostat database (online data code: nama_10_a64), Statistics Poland and State Statistics Service of Ukraine.

[2] In the calculation of the freight transport performance indexes for the EU and Poland, the indicator *"Road transport performance adjusted for territoriality"* was replaced with *"Road transport: national and international haulage"* to enable comparative analysis with Ukraine. In the calculation of Ukraine's index, pipeline transport was limited to *oil pipeline* only, to ensure comparability with the EU and Poland.

The contribution of the sector to GDP in Poland has been growing at a faster rate than investment itself, which confirms the effectiveness of these investments. In Ukraine, the contribution of the sector to GDP has not increased, which may indicate a policy aimed at maintaining only a certain level of investment efficiency within the sector.

The efficiency of investment in Poland's transport subsector is confirmed by progress in freight and passenger transport performance (Tab. 3). The increase in transport productivity occurs despite the fact that the land and pipeline transport subsector consistently receives a smaller share of total investment than warehousing and support activities, for example, in 2023 it accounted for 23.3% versus 75.6%. In Ukraine, the opposite allocation is typical, with land and pipeline transport receiving the larger share and warehousing and support activities the smaller, for example, in 2023 the shares were 71.7% and 23.6%, respectively. However, the total volume of investment in Ukraine remains significantly lower than in Poland.

Table 3

Selected indicators of transportation and storage services sector in Poland and Ukraine

Indicator and country	units of measurement	2015	2018	2021	2023
Poland					
Investment outlays (total)	billion EUR	11.4	13.4	14	19.7
	% change compared to 2015	100	+17	+23	+73
Share of land and pipeline transport sub-sector in total investment outlays in sector	% of total	28.0	20.2	26	23.3
	% change compared to 2015	100	–28	–7	–17
Freight transport performance	billion tonne-kilometres	346.1	404.6	459.6	471.4
	% change compared to 2015	100	+17	+33	+36
Passenger transport performance	billion passenger-kilometres	273.4	314.5	284.9	341.2
	% change compared to 2015	100	+15	+4	+25
Ukraine					
Investment outlays (total)	billion EUR	0.8	1.6	1.4	1.4
	% change compared to 2015	100	+107	+81	+81
Share of land and pipeline transport sub-sector in total investment outlays in sector	% of total	43.4	61.9	63.6	71.7
	% change compared to 2015	100	+43	+46	+65
Freight transport performance	billion tonne-kilometres	264.9	272	255.7	179.8
	% change compared to 2015	100	+3	–3	–32
Passenger transport performance	billion passenger-kilometres	97.1	104.4	62.7	39.4
	% change compared to 2015	100	+8	–35	–59

Note: Explanation of the selected time periods for analysis: 2018 – the year preceding the COVID outbreak; 2021 – the year before Russia's full-scale invasion of Ukraine; 2023 – the second year of the war in Ukraine.

Source: own elaboration based on the Eurostat database, Statistics Poland, and the State Statistics Service of Ukraine.

The increase in transport productivity depends on both investment and enterprise-level innovation. The innovation activity of Ukraine's transport declined during 2018–2022 (Fig. 2), with the share of innovation-active enterprises and innovation expenditures (excluding R&D) lagging behind the EU. R&D expenditures exceeded the EU level in 2018 (210.9%) and 2020 (101.8%), yet transport performance did not reflect their effectiveness. The innovative activity indicators of Poland's transport sector also remain below the EU-27 average but show steady progress, reaching 126.3% of EU-27 innovation expenditures in 2022, with transport performance indicators confirming efficiency of innovation efforts. In both countries, innovation is higher in warehousing, support, and postal/courier activities than in the transport.

Notably, in 2022, the share of innovation-active enterprises increased, although innovation intensity declined: the number introducing new products fell by 43.75% and those introducing new business processes by 23.07%. The stronger focus on process innovations reflects the need to address logistical challenges.

Conclusions

This article assessed the extent to which the sustainable transport development trajectories of Ukraine align with EU-27 and Polish trends across the four SuM4All dimensions. The hypothesis that Ukraine is generally moving in a European direction was only partially confirmed: safety has gradually improved, accessibility and efficiency have deteriorated, and the formal reduction in GHG emissions has resulted from declining transport activity rather than genuine decarbonisation. Comparison with Poland showed that Polish indicators display steady positive progress across all sustainability dimensions, while the divergence from Ukraine stems from Poland's ability to ensure continuous development and infrastructure modernisation. Poland's experience in sustainable transport development may serve as a reference point for Ukrainian reforms.

Before the COVID-19 pandemic, Ukraine's transport sector demonstrated certain positive trends, yet the gap from EU averages remained substantial. The pandemic and the 2022–2023 war further worsened accessibility and efficiency. The pandemic period revealed the higher vulnerability of Ukraine's transport system to crisis shocks. To develop the transport sector in line with EU objectives and Polish experience, a comprehensive transformation is required with a focus on efficiency and universal accessibility. This should be achieved through faster legislative reforms, strengthened institutional capacity, the introduction of targeted programmes for financing innovative renewal, and improved marketing of transport services.

The key contribution of this study is the presentation of a systemic view of sustainable transport development dynamics in Ukraine in the context

of its alignment with EU-27 trajectories on the path toward EU integration. The findings provide an empirical foundation for further research on the sustainability of Ukraine's transport sector and underscore the importance of differentiated monitoring of each dimension during the ongoing and post-war recovery and Ukraine's integration into the EU.

Translated by the Author

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