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MULTIMODAL TRANSPORTATION IN UKRAINE: A DIRECTION FOR ENSURING THE SUSTAINABLE DEVELOPMENT OF THE TRANSPORT SYSTEM

Summary. *The article examines the dynamics and structure of multimodal transportation in Ukraine, with a focus on container transport, which accounts for a relatively small share of the total freight volume compared to EU countries. Multimodal transport schemes are considered as a means to optimize the country's trade, economic, and transit potential. One of the key issues in ensuring the sustainable development of the transport system is reducing CO_2 and other pollutant emissions. To achieve its environmental goals, Ukraine needs to intensify the development of a sustainable transport system, focusing on the expansion of multimodal container transportation that incorporates "clean" modes of transport, primarily railways. Conceptual requirements for establishing an environmentally sustainable system of multimodal container transport in Ukraine have been identified. Based on scenario calculations, it is demonstrated that the development of container railway transport provides both ecological and economic benefits through the reduction of CO_2 emissions.*

Key words: *multimodal transportation, Ukraine, container transport, sustainable development, CO_2 emissions, railway transport, emission reduction, transport system.*

Introduction. Over the past decades, the concept of sustainable development has evolved to encompass economic, social, and environmental dimensions. Particular attention is paid to the impact of human activity on the environment, especially climate change caused by greenhouse gas emissions. The transport sector is one of the primary sources of these emissions; therefore, transforming the transport system into a sustainable one has become a global priority. The UN General Assembly Resolution of September 25, 2015, defined 17 Sustainable Development Goals, where transport is directly linked to Goals 9 (sustainable infrastructure), 11 (sustainable cities), and 13 (climate action) [1]. Sustainable transport is defined as the provision of services and infrastructure for the mobility of people and goods that fosters economic and social development without harming future generations, while maintaining minimal emissions. This includes technological modernization, infrastructure development, and operational organization. Research indicates that multimodal transportation is an effective solution for enhancing sustainability, particularly through the use of ICT [1].

In Ukraine, the level of containerization is only 1%, compared to 45% in the EU [3]. The development of multimodal container systems can make transport more environmentally friendly and economically efficient. The National Transport Strategy of Ukraine until 2030 provides for the formation of such a system; however, conceptual issues still require further elaboration [4]. The purpose of this article is to determine the requirements for developing a multimodal container system in Ukraine, taking into account the principles of sustainable development [5].

Several factors determine research relevance. Firstly, Ukraine's lag in the development of multimodal transport compared to EU countries results in the inefficient use of the country's transit potential. Secondly, there is a need to comply with European environmental standards and reduce harmful emissions from transport, which is a priority for both the EU and Ukraine. Thirdly, the

growing need for optimization of logistics chains in modern conditions requires the development of container transportation.

Methods and Materials. The research employed a set of interrelated methods to ensure a comprehensive study of the development of multimodal container transportation in Ukraine and to assess its impact on the environmental and economic indicators of the transport system. Primarily, methods of analysis and synthesis were employed, which enabled a thorough examination of the theoretical foundations of the topic, the systematization of existing scientific approaches, and the definition of conceptual principles for developing a sustainable multimodal transport system. The analytical method was applied to explore the current state of the transport sector, the dynamics of freight volumes by different modes of transport, and the trends in the container transport market. The synthesis method, in turn, facilitated the integration of the obtained results into a coherent system of knowledge, contributing to the formulation of generalized conclusions.

To assess the efficiency of freight transport operations, identify structural shifts in cargo flows, and analyze the container transport market, statistical analysis methods were applied. These allowed for the examination of transportation dynamics over recent years, the analysis of containerization rates, and the identification of key factors influencing the development of multimodal transport. Special attention was paid to the use of a systems approach, which enabled a comprehensive view of the transport system as an interconnected mechanism encompassing infrastructural, technical, economic, and environmental components. This approach enabled the forecasting of potential development scenarios for the sector and provided an expert evaluation of prospects for improving the efficiency of Ukraine's transport system.

Scenario modeling of freight transport development was based on the extrapolation of existing trends, which enabled the prediction of potential changes in the structure of transport flows and the identification of directions for

increasing the role of container multimodal transport in the future. For calculations and analytical data processing, official statistical materials and open data from verified sources were utilized, specifically the websites of JSC Ukrzaliznytsia, the Ministry of Infrastructure of Ukraine, and the State Statistics Service of Ukraine. Additionally, the study relied on the provisions of the National Transport Strategy of Ukraine until 2030 and materials related to the implementation of the Law of Ukraine "On Multimodal Transport", which enabled an evaluation of the regulatory framework for the sector's development.

To assess the environmental impact of transitioning to more eco-friendly transportation modes and to determine the potential for reducing carbon dioxide emissions, the tools of the international platform EcoTransIT were utilized, providing calculations of CO_2 emissions for various modes of transportation. This enabled a quantitative assessment of the environmental impact of multimodal container transport development and confirmed the potential advantages of integrating railway transport into a sustainable transportation system [6]. Altogether, the applied methods ensured the scientific validity of the research results, enabled a comprehensive analysis of the issue, and allowed for the formulation of practical recommendations for the further development of Ukraine's transport sector.

Current State of Freight Transportation

In 2020, approximately 600 million tons of freight were transported in Ukraine, with the railway sector traditionally accounting for the largest share — 51% of the total volume. Road transport accounted for 32%, pipeline transport for 16%, and inland waterways for only 1% [7]. The COVID-19 pandemic had a significant impact on the logistics sector, resulting in an overall decline in freight transportation of 11%. The most severe drop was observed in the road transport segment, at 22%. Long-term trends indicate structural changes in the market: between 2010 and 2020, the volume of rail freight decreased by 30%, while road

transport increased by 21%, indicating a gradual shift of cargo flows toward road transport.

The level of freight containerization in Ukraine remains extremely low, at only about 1% [3], which lags significantly behind the indicators of EU countries. In 2020, the volume of container transport by rail totaled 0.32 million TEU, by road — 0.61 million TEU, and through seaports — 1.05 million TEU. Around 60% of containers in connections between ports and destinations are carried by road, primarily due to underdeveloped intermodal infrastructure, a lack of sufficient multimodal terminals, and a shortage of logistics centers.

For a long time, an imperfect legal framework was a significant barrier to the development of multimodal transportation, hindering the formation of a modern logistics system. The adoption of the Law of Ukraine "On Multimodal Transport" in 2021 marked a significant step toward creating legal conditions for sectoral development and stimulating the growth of container rail transport volumes [6]. Even before that, in 2019–2020, domestic container transportation experienced significant growth, increasing by 337.5% in 2019 and a further 11% in 2020 [8]. The network of routes also expanded considerably: the number of domestic container routes increased from 2 to 21, and international routes from 3 to 7, indicating the gradual development of logistics infrastructure.

The structure of foreign trade transportation also demonstrates dependence on specific modes of transport. In exports, maritime transport dominates, accounting for 51.5% of the total, followed by road (23.5%) and rail (11.7%). The level of containerization of export transport reaches 7.5% for maritime transport and only 0.3–0.4% for other modes. In imports, road transport prevails, accounting for 43.6%, while rail accounts for 14.1% and maritime transport for 6.5%. The containerization rate of imports is slightly higher than that of exports: 14.4% for maritime transport, while other modes account for only 0.4% [9]. This indicates substantial potential for further containerization in both domestic and international transport and confirms the need for institutional, infrastructural, and

technological measures to build a modern multimodal transport and logistics system in Ukraine.

With the onset of the full-scale armed conflict in Ukraine in 2022, the country's transport system has faced significant challenges and transformations that have significantly affected both infrastructure and public mobility behavior. Due to the destruction of transportation facilities and increased security risks, there has been a noticeable decline in the use of public transportation, as a large part of the population has been forced to change their travel habits or abandon specific routes altogether. The share of residents not using the metro increased from 7% to 21%, and the share of those not using buses rose from 15% to 38%. This reflects a sharp decline in public trust toward public transport and highlights the influence of security factors on mobility decisions. Despite the overall downward trend, road transport continues to show relative stability, as it provides greater flexibility and autonomy under martial law conditions. In contrast, environmentally friendly modes of mobility — such as cycling and walking — have also decreased in share, which can be attributed to lower street safety, restricted access to certain areas, and an overall decline in population mobility. In large cities, particularly Kharkiv, a reduction in the frequency of use across all types of public transport has been recorded, further emphasizing the profound impact of the war on the urban transport system [10].

External Challenges and Institutional Barriers

Alongside internal challenges, Ukraine also faces external factors, particularly the new environmental requirements of the European Union. With the introduction of stricter greenhouse gas emission limits since 2022, as well as the implementation of a CO_2 emissions tax, there is a significant risk of reduced competitiveness for Ukrainian transport services in the European market. Today, Ukraine's transportation sector remains highly dependent on fossil fuels, with approximately 70% of all petroleum products consumed by road transport. This not only increases the country's dependence on imported energy resources but

also poses serious environmental threats. To mitigate the impact of these factors, it is necessary to accelerate the transition to more environmentally friendly modes of transport, develop electric transport, and promote the implementation of multimodal solutions that reduce harmful emissions.

In addition, the modernization of transport infrastructure remains a crucial task — including the renovation of seaports to increase throughput capacity, modernization of railway tracks and rolling stock, improvement of road conditions, and the development of inland waterways, particularly the navigational potential of the Dnipro River, which could play a significant role in freight transportation [11].

Another major limiting factor for the development of Ukraine's transport sector is the high level of market monopolization, which negatively affects competition and the efficiency of transport services. A striking example is the activity of the state enterprise *Ukrzaliznytsia*, whose monopoly position significantly complicates private carriers' access to the market and hinders the development of innovative approaches in rail freight transportation. In some regions of the country, such as Zaporizhzhia Oblast, the monopolization of the transport market is especially evident, creating imbalances in the development of the transport system, reducing service quality, and increasing costs. Addressing this issue requires sectoral reform, the introduction of antimonopoly mechanisms, the creation of conditions for fair competition, and the attraction of private investment in transport infrastructure development.

Only through a combination of structural reforms, infrastructure modernization, environmental transformation, and enhanced safety can Ukraine ensure the sustainable development of its transport system under wartime conditions and during its integration into the European transport space [12].

Recommended Measures for Improving Multimodal Transportation

To enhance multimodal transportation in Ukraine, it is necessary to implement a comprehensive set of measures that align with European standards

and increase operational efficiency. These measures encompass a wide range of aspects, from infrastructure modernization to transit stimulation, and are based on expert recommendations and international programs.

Infrastructure Measures

- Synchronize infrastructure development with the requirements of the TEN-T network and the EU DG MOVE strategies, particularly regarding the creation of domestic and cross-border logistics hubs, as well as the connection of ports, airports, and railway junctions to the TEN-T network [13, 14].
- Construct multimodal freight terminals near the borders with the EU to facilitate gauge conversion between Ukrainian and European standards, which can also serve as industrial hubs [15].
- Reconstruct railway terminals in ports, such as in Chornomorsk, to ensure multimodal functionality [16].
- Modernize roads, railways, ports, and inland waterways, including the development of the Danube route in cooperation with neighboring countries such as Romania [17].
- Develop new highways and ring roads, for instance around Kyiv, to reduce transit congestion [18].

Regulatory and Legal Measures

- Improve legislation by adopting a *Law on Railway Transport* to liberalize the market, ensure equal access to infrastructure, and establish an independent regulatory authority [13, 18].
- Join international agreements, such as the *TRACECA Multimodal Transport Development Agreement*, to simplify the transit of goods between Ukraine and the EU [19].
- Adjust Ukraine's customs tariff to simplify customs clearance procedures and harmonize statistical systems with international standards [19].

- Implement the unbundling of *Ukrzaliznytsia* to prevent monopolization of infrastructure and freight operations [15].
- Introduce new safety standards for transport operations in accordance with EU norms [18].

Tariff Measures

- Develop a unified policy on transport charges and tariffs within the TRACECA framework to ensure harmonization with international partners [16].
- Establish transparent and fair tariffs through an independent railway regulator responsible for pricing and anti-monopoly oversight [15].
- Adjust tariff policy to attract private investment and promote multimodal solutions [13].
- Introduce incentives for "green" transport — for example, reduced tariffs for environmentally friendly modes of transport [1].

Technological Measures

- Implement an electronic logistics management system for the TRACECA corridor and promote digitalization in the transport sector [16].
- Apply modern technologies and materials to reduce CO_2 emissions, including alternative fuels for vessels and route optimization for lower emissions [15].
- Conduct pilot projects integrating private sector innovations, for example, through USTDA initiatives for new technology implementation [17].
- Develop flexible transport solutions such as ridesharing for crises, adapted to multimodal networks [20].

Human Resource Measures

- Overcome the shortage of qualified personnel through the modernization of *Ukrzaliznytsia* and targeted training programs [13].
- Implement EU technical assistance projects, such as *Twinning*, to strengthen institutional capacity and train specialists [16].

- Establish retraining programs for transport sector employees with a focus on digital skills and safety.
- Engage international experts to exchange best practices through conferences and workshops [17].

Institutional Measures

- Create an independent regulator to ensure market fairness and healthy competition [15, 18].
- Coordinate efforts through the Ministry of Infrastructure as the lead agency for reconstruction and modernization [17].
- Initiate new EU technical assistance projects within the frameworks of TRACECA and TEN-T [16].
- Promote public-private partnerships (PPPs) to attract investment [13].

Measures to Stimulate Transit

- Harmonize border-crossing procedures and simplify customs processes for multimodal transportation [16].
- Establish cross-border "dry ports" and logistics hubs with joint customs control by neighboring countries [15].
- Strengthen the transit of goods by joining international programs and developing multimodal TRACECA solutions [19].
- Develop TEN-T transport corridors to consolidate Ukraine's role as a key transit country between Europe and Asia [18].
- Attract investment to enhance transit potential, taking into account Ukraine's advantageous geographic position [21].

Conclusions. The development of multimodal container transportation is a key factor in ensuring the sustainability and competitiveness of Ukraine's transport system under current conditions. It represents a strategic direction that enables the optimization of logistics chains, reduces time and resource expenditures, mitigates environmental impacts, and enhances the country's transit potential. To achieve these objectives, it is necessary to comprehensively improve

the legislative framework by aligning it with the standards of the European Union, modernize transport infrastructure in accordance with multimodality requirements, stimulate competition in the carrier market through the liberalization of access to infrastructure, and ensure deeper integration of Ukraine's transport system into European logistics networks.

Scenario-based studies of container transport development demonstrate significant environmental and economic benefits, including a substantial reduction in CO_2 emissions, improved energy efficiency, increased freight volumes, and higher transit revenues. Further scientific research in this field should focus on modeling the risks associated with the operation of the multimodal transport system under wartime conditions, developing mechanisms for adapting logistics networks to crises, and implementing modern information and communication technologies to enhance freight flow management and ensure the sustainable development of Ukraine's transport sector.

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