Multimodal freight transportation as a direction of ensuring sustainable development of the transport system of Ukraine

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Abstract. The article analyzes the dynamics and structure of freight transport in Ukraine. It is established that container transportation in Ukraine occupies a small share in the total volume of cargo transportation compared to EU countries. In order to optimize the realization of trade, economic and transit potential of the country, multimodal schemes of cargo transportation are considered. One of the key issues in ensuring the sustainable development of the country's transport system is to reduce emissions of CO₂ and other pollutants. To achieve a set of environmental goals in Ukraine, it is necessary to intensify the formation of a sustainable transport system based on the development of multimodal container transportation with the involvement of "clean" modes of transport, primarily rail. Conceptual requirements for the formation of an environmentally sustainable system of multimodal container transportation in Ukraine are determined. Based on the calculations of the scenario, it was proved that the development of container rail transportation allows to obtain environmental and economic effects as a result of reducing CO₂ emissions.

1. Introduction

For more than 30 years, the concept of sustainable development has been evolving to encompass public thinking and is now widely represented in the academic literature and political debates. To date, there is a consensus that sustainable development in the global dimension and in any society is determined by the dynamic balance among its three components: economic, social and environmental [1]. But recently, scientific and political discourses have increasingly focused on the acuteness of the impact of economic and domestic activities of the mankind on the environment, in particular, on climate change, which is largely associated with greenhouse gas emissions. [2–4]. An important focus of addressing the global issue of reducing the impact of human activities on the environment is to transform the existing transport system to one that is fully consistent with the principles of sustainable development, i.e. sustainable transport system [5–7].

The UN General Assembly Resolution on Sustainable Development on 25 September 2015 launched 17 Sustainable Development Goals and 169 related tasks [8]. The objectives of sustainable transport are to some extent defined for the following purposes: 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation), 11 (Make cities and human
settlements inclusive, safe, resilient and sustainable), and 13 (Take urgent action to combat climate change and its impacts).

The High Level Advisory Group on Sustainable Transport (established in 2014 by the UN Secretary-General) in the report “Mobilizing sustainable transport for development” defines sustainable transport as “the provision of services and infrastructure for the mobility of people and goods – advancing economic and social development to benefit today and future generations – in a manner that is safe, affordable, accessible, efficient, and resilient, while minimizing carbon and other emissions and environmental impacts” [9]. The concept of sustainable transport is complex, which requires its consideration in three aspects: 1) technological re-equipment of the vehicle fleet and increasing the share in the volume of transport of those modes of transport that best meet the requirements of sustainability, including environmental ones; 2) development of transport infrastructure in the direction of its assistance to increase the level of sustainability of the transport system; and 3) the organization of transport operations in such a way as to ensure their consistency in all its dimensions [4, 6, 10].

Issues of sustainable development in the context of the transport system modernization and improving the organization of passenger and freight transportation are widely considered in the academic literature. Principles of sustainable transport development and conceptual provisions for the formation of an efficient transport system of the city are proposed in the articles [11] and [12]. In the latter, the author used a combination of graph theory methods to determine the prospects for the development of urban transport and optimization of the transport network. Another paper also emphasizes the importance of prioritizing the goal of ensuring the transport system sustainability in regional development strategies [13].

M. Noussan et al. consider that since the transport sector is a complex mix of different modes of transport, the efficient organization of multimodal transport is a common solution to increase the level of sustainability for both passenger and freight modes of transport [10, p.5]. The same view is shared by the authors of the report to the Club of Rome “Come on!” [4, p.145], as well as other authors who deem that the future development of the transport system is associated with multimodal transportation, especially in the context of the widespread use of ICT [14]. A separate area of research is represented by papers that attempt to assess the impact of multimodal transport on the level of sustainability, for example, on the intensity of CO₂ emissions [15], resource efficiency [16], to assess the overall synergistic effect of container shipment in a multimodal transport system [17], as well as to offer a set of indicators for assessing the quality of services in this format of transportation [18].

The analysis of academic works, as well as analytical materials covering the experience of the EU, as well as countries from other regions of the world, which have large transit flows and global logistics centres, allowed us to draw the following conclusion: to form a sustainable transport system and find tools to reduce its harmful effects on the environment, the development of a system of multimodal container transportation is becoming relevant. Due to the existing organizational and technological features, such a system can make the full cycle of transport and logistics services more environmentally friendly and cost-effective.

In [19] the analysis of the market of container transportations in Ukraine is carried out, and also the degree of fulfillment of its obligations concerning approximation of the Ukrainian legislation in the sphere of transport to the European one is defined. The authors emphasize the need for active development of container rail transportation in Ukraine, which has greater advantages than road transport, and can significantly increase the competitiveness of Ukraine in international transport markets. An analysis of the benefits of a multimodal container system involving rail transport has led to the conclusion that, as an environmentally friendly, faster and more economical mode of transport, railways play an important role in these transportations.

The formation of a multimodal container freight system (MMCF) is envisaged as a strategic task in the National Transport Strategy of Ukraine for the period up to 2030, which was approved by the Cabinet of Ministers of Ukraine three years ago [20]. However, the conceptual issues regarding the
development in the country an environmentally sustainable such system have not yet been fully resolved and are fragmentary.

The purpose of the article is to determine the conceptual requirements for the development of a MMCFS in the transport system of Ukraine, taking into account the constraints imposed on the transport policy of the country by strategic objectives for its sustainable development. The article is structured as follows. Section 2 provides an explanation of the choice of research methods and materials used to perform it. Section 3 presents the results of the research, as well as some issues for discussion and directions for further research under the proposed topic. Section 4 provides general conclusions on the directions of formation of a MMCFS in Ukraine.

2. Methods and materials
In the research, methods of analysis and synthesis were used to determine the key conceptual provisions of a MMCFS formation. Methods of statistical analysis were used to assess the performance of freight transport in Ukraine and the current state of the Ukrainian market of container traffic. A system approach was used for forecasting and expert assessment during the development of the conceptual requirements for an ecologically sustainable MMCFS. During elaborating the scenario of freight traffic development in Ukraine, the forecast of freight turnover of the country’s road and rail transport subsystems by the method of extrapolation of trends was applicated.

The study is based on statistical data and analytical materials that are posted on official websites: Ukrainian Railways Joint Stock Company, Ministry of Infrastructure of Ukraine, Ministry for Development of Economy, Trade and Agriculture of Ukraine, State Statistics Service of Ukraine. To study the institutional aspects of the formation of a MMCFS used the National Transport Strategy of Ukraine until 2030 [20], materials related to the elaborating and discussing in the Verkhovna Rada of Ukraine the draft Law “On Multimodal Transportation” [21, 20, 24], as well as relevant materials of the European Commission [7, 25]. The methodological tools of the independent platform the EcoTransIT World Initiative [26] were used in estimating the expected scale of CO₂ emissions in the scenario of freight traffic development.

3. Results and discussion
To determine the issues and requirements for the development of a MMCFS, an important task is to assess the performance of freight transport in Ukraine. According to the analytical materials of the State Statistics Committee of Ukraine, 600 million tons of cargo were transported in 2020, of which 51% accounted for rail transport. Road transport occupies 32% of the total cargo, pipeline - 16%, and domestic water transportation - only 1% (Fig. 1).

![Figure 1. Structure of freight transportation by modes in Ukraine during 2010 – 2020.](image)

During 2020, there was a decrease in the volume of goods transported by all modes of transport by more than 11% compared to 2019, the main reason for which was the introduction of transport restrictions during quarantine measures against COVID-19. The largest reduction in freight traffic occurred in road transport, by almost 22%. The annual decrease in freight traffic by rail for the period from 2010 to 2020 should also be noted.
During this period, transportation by this mode decreased by almost 30%, although the volume of freight traffic by road increased by 21%, i.e. there was a gradual reorientation of freight traffic from rail to trucks. The level of containerization of transportation in Ukraine is only 1%, while in the EU it reaches 45%. The volume of container traffic in Ukraine in 2020 amounted to: rail - 0.32 million TEU, road transport - 0.61 million TEU. At the same time, 1.05 million TEUs were processed by seaports. That is, 60% of container traffic between seaports and destinations is provided by road [22]. This situation in the Ukrainian market of container transportation is a consequence of the imperfection of the transport and logistics infrastructure and the lack of full state support for the development of multimodal terminal complexes.

The lack of an effective legal mechanism for regulating multimodal container traffic has significantly limited the rights of participants in transport chains and hampered transformation processes in the sector. Therefore, the much-needed Law of Ukraine on Multimodal Transportation, which has been under discussion for the past two years and has just been adopted as a basis, has already begun to yield positive results, stimulating the growth of container traffic by rail (Table 1).

Table 1. Dynamics of container transportation by rail of Ukraine.

| Year | Volume of transported goods, total (million tons) | Changes, % | Volume of transported goods in containers | Share of container cargo in total, % |
|------|-----------------------------------------------|------------|------------------------------------------|-------------------------------------|
|      |                                              |            | International | Domestic | Total |                     |
|      |                                              |            | million tons | million tons | million tons |                     |
|      |                                              |            | Changes, %   | Changes, % | Changes, % | Changes, % |
| 2017 | 339.5                                        | -          | 5.42         | -          | 0.66       | 6.08       | 1.79               |
| 2018 | 322.3                                        | -5.07      | 0.73         | -86.53     | 1.33       | 101.52     | 2.06               | 66.12              | 0.64               |
| 2019 | 312.9                                        | -2.92      | 0.66         | -9.59      | 2.87       | 115.79     | 3.53               | 71.36              | 1.13               |
| 2020 | 305.5                                        | -2.36      | 0.55         | -16.67     | 3.18       | 10.80      | 3.73               | 5.67               | 1.22               |

Despite the significant decline in containerized freight transport by rail up to 2018, their volume then increased annually solely due to transportation on domestic routes. Thus, in 2019, the volume of containerized cargo handled within Ukraine actually increased by 337.5% compared to 2017 and amounted to 132944 TEU. During 2020, the positive dynamics continued – the growth rate of almost 11% compared to the previous year.

During this period, there was a significant expansion of the route network of container trains in domestic directions. In 2017, the transportation of containers within Ukraine was carried out only on two routes, and in 2020 their number increased to 21. The international container network of railway transport in Ukraine also continues to expand, but not as actively as domestic. From 2017 to 2020, the number of main container transportation routes outside Ukraine increased from 3 to 7.

In 2020, there was a reduction in merchandise exports and imports of the country compared to 2019 by 1.7% and 11%, respectively. The largest share in the modes structure of transport services for the export of goods is occupied by maritime transport (51.5%). 23.5% of goods were exported by road. The railway delivered 11.7% of export cargo. The level of containerization of Ukrainian merchandise exports by sea is 7.5%, rail and trucks - 0.3% and 0.4%, respectively. The largest share of imported goods to Ukraine was transported by trucks (43.6%). The railway provided 14.1% of imports, and sea transport - 6.5%. The level of containerization of Ukrainian imports by sea is 14.4%, rail and road transport - 0.4% each.

Given the prospects for economic cooperation between China and Ukraine, it is necessary to continue to expand the container network of Ukrainian railway transport in this geographical direction. In addition, it is important to develop rail container transportation with EU countries. The key reference point here should be the level of trade and economic cooperation with European partner countries, the main of which are Poland, Germany, the Netherlands, the Baltic States and through the international corridors TEN-T (Rhine-Danube and Mediterranean ones).

This approach provides an opportunity to create optimal conditions for the export of goods and will be a profitable alternative for the import to Ukraine (transit) of containers from European deep-water ports (Hamburg, Rotterdam).
The full functioning of the future MMCFS in the country can significantly expand the opportunities to increase the share of “clean” modes of transport, including rail and inland waterway, through the organization of multimodal logistics chains. The openness of the Ukrainian economy should also be borne in mind, which means for the country's transport system a significant dependence of its performance on imports and exports, as well as the need to comply with established requirements (economic, technical and environmental) supply of goods to international markets.

Increasing environmental restrictions in the EU and the introduction of additional taxation of harmful substances' emissions into the air since 2022, causes high risks for the transport sector of Ukraine to lose its market share. The main reason for this is the lack of necessary regulatory, organizational, economic, infrastructural and technological conditions to ensure “clean” transportation schemes, namely multimodal transportation.

In order to harmonize Ukraine's transport policy with the European Green Course and create a sustainable multimodal transport system on this basis, it is necessary to implement effective solutions to reduce the dependence of the transport sector on petroleum products through the introduction of green technologies. At the present stage, the Ukrainian transport industry almost does not use such technologies and depends on oil supply not only in technical but also in pricing aspects. Thus, in 2019, Ukraine imported 15.7 million tons of petroleum products with a total value of 9.94 billion USD, of which 70% was consumed by road [23]. That is why the development of environmentally friendly modes of transport in Ukraine, which include rail and water transport, based on the organization of more efficient schemes of delivery of goods with a high level of reliability and safety, will not only provide economic benefits but also help reduce the harmful impact of the transport sector on the ecosystem [32-33].

We have developed a scenario for the development of freight transportation in Ukraine under the following conditions: 1) gradual transfer of 30% of freight traffic by road to rail by 2030; 2) the level of containerization of railway transport by 2030 should reach 45% (current level of containerization in the EU). The results of calculations show that the implementation of such a scenario for 2022–2030 years can have an environmental effect by reducing CO₂ emissions by 11.7% compared to the baseline scenario (without changing the trend). If we take into account the estimated cost of one tonne of CO₂ emissions in the EU of 30 euros, the savings will be 88.7 million euros. Thus, the obtained data confirm the environmental and economic prospects for the development of multimodal container transportation on "clean" modes of transport for the formation of a competitive and environmentally sustainable transport system of Ukraine.

The following discussion issues and topics for further research should be noted: taking into account the impact of the implementation of the MMCFS development scenario on the social component of sustainable development both in the transport sector and in the country as a whole; determining the amount of investment required to create the necessary infrastructure to service the MMCFS. Also, one of the key issues is that the environmental effect of increasing the share of rail transport in freight in the case of the MMCFS development scenario can be offset by the fact that electricity for trains can be generated by using fossil fuels, i.e. environmentally “dirty” sources. This means that both further research and the direct implementation of this scenario must be conducted comprehensively, taking into account all side effects and risks.

4. Conclusions
The analysis of freight transport in Ukraine shows that rail transport occupies the largest share in the overall structure of freight modes. However, container traffic in Ukraine accounts for a small share of total freight transported (1%) compared to EU countries (45%). The positive dynamics of freight transportation in containers on domestic railway routes was revealed, which indicates the prospects for further development of this market segment.

The openness of the Ukrainian economy indicates the dependence of transport performance on imports and exports, which requires the state transport policy to take regulatory and economic measures to ensure compliance with the transport sector of existing economic, technical and
environmental requirements for the supply of goods to international markets. In order to bring the ecological parameters of the country's transport system closer to the parameters corresponding to the EU Green Deal, Ukraine needs to intensify work on the formation of a competitive, environmentally and energy-efficient transport sector, and primarily concentrate attention to the development of multimodal container transportation using mostly "clean" modes of transport.

Based on scenario calculations, it is proved that the development of container rail transportation allows to obtain environmental and economic effects as a result of reducing CO₂ emissions.

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