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DEVELOPMENT OF DIGITAL TRANSPORT CORRIDORS IN UKRAINE

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РОЗВИТОК ЦИФРОВИХ ТРАНСПОРТНИХ КОРИДОРІВ УКРАЇНИ

В дослідженні акцентовано увагу на значущості розвитку цифрових транспортних коридорів, враховуючи їх важливість як елементу розвитку транспортної інфраструктури України. Автори звернули увагу на той факт, що такі коридори дозволяють покращити ефективність та безпеку перевезень, скоротити час доставки товарів, знизити витрати на транспортування і збільшити конкурентоспроможність українських підприємств на міжнародному ринку. Відповідно, дослідження спрямоване на конкретизацію специфіки розвитку цифрових транспортних коридорів України, яка полягає в ідентифікації формату та особливостей забезпечення автоматизації процесів руху та логістики. За результатами дослідження доведено, що цифрові транспортні коридори України повинні діяти як мультимодальні, тобто не просто об'єднувати різні види транспорту, а передбачати, що транспортні послуги інтегровані та координовані між різними видами транспорту, що дозволяє забезпечити ефективність та оптимальність перевезень. Наприклад, у залізничних терміналах можуть бути забезпечені умови для бронювання місць для зберігання та перевантаження вантажів, що до них прибувають на дорожніх або морських транспортних засобах, забезпечуючи тим самим більш ефективну та швидку доставку вантажу до кінцевої точки. Закцентовано, що цифрові транспортні коридори України мають бути більш надійними та ефективними, а для цього їм потрібно підтримувати функціонування різних систем,

таких як системи електронного управління транспортним рухом та безпекою, системи контролю та управління транспортним рухом на кордоні, системи глобальної навігації та моніторингу, системи моніторингу якості палива та технічного стану транспортних засобів, системи інформаційної підтримки логістики та митного оформлення. Результати дослідження можуть стати основою для розробки та впровадження нових технологій та підходів до організації транспортних перевезень в Україні, що дозволять покращити транспортну інфраструктуру, зменшити час перевезень та збільшити ефективність транспортних послуг.

The research focuses on the importance of developing digital transport corridors, taking into account their significance as an element of Ukraine's transport infrastructure development. The authors emphasize that such corridors improve the efficiency and safety of transportation, reduce delivery times, lower transportation costs, and increase the competitiveness of Ukrainian enterprises in the international market. Accordingly, the study aims to specify the specifics of Ukraine's digital transport corridor development, which involves identifying the format and features of automating movement and logistics processes, including monitoring the location of vehicles, cargo, and schedules. The research findings demonstrate that Ukraine's digital transport corridors should operate as multimodal, which means not just combining different types of transportation but also integrating and coordinating transportation services between different modes of transportation to ensure efficiency and optimal transport. For example, railway terminals can provide facilities for booking storage space and handling cargo arriving on the road or sea transport, thereby ensuring more efficient and faster delivery of goods to the destination point. It is emphasized that Ukraine's digital transport corridors must be more reliable and efficient, and to achieve this, they need to maintain the functioning of various systems, such as electronic traffic and safety management systems, border traffic control and management systems, global navigation and monitoring systems, fuel quality and vehicle technical condition monitoring systems, and logistics and customs information support systems. The research results can serve as a basis for developing and implementing new technologies and approaches to organizing transportation in Ukraine which will improve the transport infrastructure, reduce transportation time, and increase the efficiency of transportation services. The research results can serve as a basis for the development and implementation of new technologies and approaches to organizing transportation in Ukraine, which will improve the transportation infrastructure, reduce transportation time, and increase the efficiency of transportation services.

Ключові слова: перевантаження вантажів; логістика; митне оформлення; транспортні послуги.
Key words: cargo overload; logistics; customs clearance; transportation services.

PROBLEM SETTING (DESCRIPTION OF THE PROBLEM BEING ANALYZED IN GENERAL AND ITS CONNECTION WITH IMPORTANT ACADEMIC OR PRACTICAL TASKS)

Since 2020, the Ministry of Infrastructure has initiated processes to digitize and create a unified smart system for transportation, which is expected to culminate in the creation of a network of digital transportation corridors (as announced at the "Infrastructure Digital Day" event). Digital transportation corridors (DTCs) are an important infrastructure component for the economic development of Ukraine, based on a system of electronic roads that provide efficient transportation logistics and information exchange between different logistics process participants. Therefore, the development of such an electronic road system is capable of providing significant advantages for Ukraine. In particular, this system promotes the improvement of transportation services' quality, reduction of costs, and

increased efficiency in logistics (which, in turn, promotes increased domestic product manufacturing, increased trade volumes, and growth in international export operations). In addition, if the DTCs are integrated into the system of international transport corridors, Ukrainian manufacturers and exporters will be able to interact more effectively with foreign partners and consumers, which significantly reduces the time for searching for and delivering goods and increases the competitiveness of domestic producers. Along with other advantages, DTCs can become a key factor in the development of modern mobile and internet businesses, as they improve the logistics process of delivering goods from the warehouse to the customer, ensuring transparency and efficiency of logistics processes (which will make online commerce more attractive and accessible to consumers). The combination of these advantages allows the development of digital transport corridors to be considered one of the basic elements of Ukraine's economic development strategy.

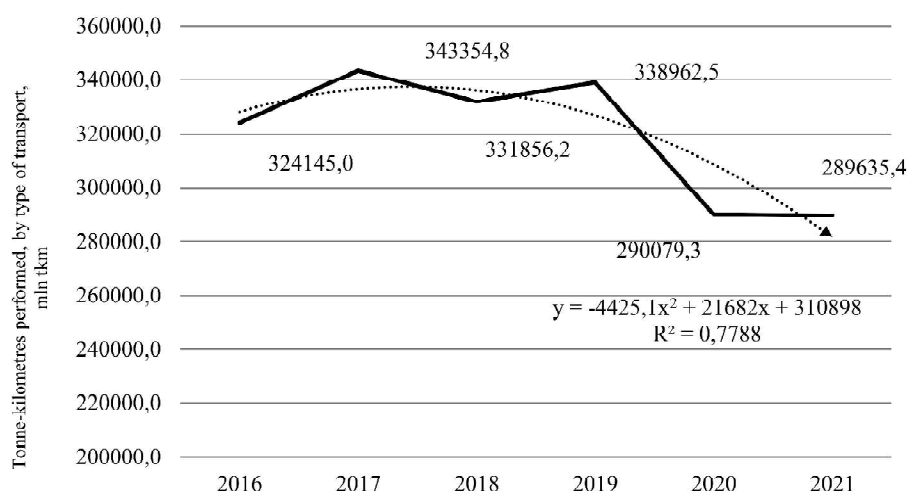


Fig. 1. Dynamics of cargo turnover in Ukraine through digital transport corridors for 2016–2021, mln.tkm

Source: compiled based on data from the State Statistics Service of Ukraine.

The analysis of the last research and publications in which the solution to this problem is begun. Among the key contributors to the exploration of fundamental issues in the development of digital transport corridors in Ukraine, the works of Companyets V.V., Polyanska N.O., Sichkarenko K.O., Tokmakov I.V., Cherednichenko O.Yu., Voitov I.M., and Palamarchuk Ya.S. stand out. The authors of this study relied on these works, taking into account the significant number of provisions aimed at defining basic processes and the specifics of evolutionary changes accompanying the development of electronic systems in Ukraine. However, despite the sufficient development of the topic, it should be noted that the research primarily pertains to the processes of forming electronic road and railway systems. For digital transport corridors in Ukraine, it is important to emphasize the multimodality aspect, as emphasized in particular in the research of Polyanska N.O. Therefore, despite significant progress in the development of electronic road and railway systems, researchers must pay attention to multimodality, which is crucial for the development of digital transport corridors in Ukraine. Unfortunately, scientific literature lacks sufficient information on ensuring multimodality in this context, which creates problems in the development of an integrated transport system in Ukraine.

Formulating of article purposes (the purpose of the study). The purpose of the article is to specify the unique characteristics of the development of digital transport corridors in Ukraine. This involves identifying the format and features of automating movement and logistics processes, which includes monitoring the location of transport vehicles, cargo, and schedules.

The paper's main body with full reasoning of academic results. At present, a network of digital transport corridors is already operating in Ukraine. It is built mainly on systems of information support of logistics and customs registration, which operates the basis of the transport portal of electronic services e-transport.gov.ua, which unites electronic services in all spheres of the transport industry in one system, in particular, there are possibilities of reservation of permits for international transportation, post-control, obtaining of permits for oversized trans-

portation, e-protocols. For certain transport hubs within the digital corridors, public control and transparency of the permit issuance process have been implemented (including organized broadcasts from permit issuance points in cities such as Kovel, Goloby, Lviv, Vinnytsia, Khmelnytskyi, Borispol, and Korosten), as well as e-waybills (an electronic document that certifies the right to carry out cargo transportation) [3]. DTCs operate based on the national network of international transport corridors, which is formed based on the "Crete" transport corridor network, the Europe-Asia transport corridor network, the Baltic-Black Sea

transport corridor network, and the TRACECA transport corridor network [3; 4]. It should be noted that in 2021, the cargo turnover through the designated digital transport corridors amounted to 289,635.4 mln. tkm. However, it is specific that the indicator shows a negative trend, as illustrated by the data in Figure 1. In particular, even compared to 2016 (which showed the lowest value of cargo turnover for the analyzed period — 324,145 mln. tkm), in 2021 the indicator decreased by 10%.

It should be noted that in Ukraine, digital transport corridors are formed based on the e-transport.gov.ua transport portal for electronic services and cover the most developed railways (which account for 62.27% of the total cargo turnover), as well as accompanying roadways (which account for 16.16% of the total cargo turnover), waterways (1.01% of the total cargo turnover), pipelines (20.42% of the total cargo turnover), and airways (0.12% of the total cargo turnover). In this case, the only cargo turnover that remained relatively stable over the period from 2016 to 2021 was railway cargo turnover, which fluctuated within the range of 175,587.1-191,914.1 mln.tkm. Additionally, during the same period, the total cargo turnover of road transport increased (from 37,978.6 to 46,808.1 mln.tkm). The peculiarities aren't typical for the movement towards the creation of an integrated digital transport system that unites different types of transport, as evidenced by changes in the volume and structure of cargo turnover through different routes of digital transport corridors in Ukraine from 2016 to 2021 (see Figure 2).

This does not allow for effective and optimal control of cargo transportation from one point to another, taking into account the different types of transport that can be used at different stages of transportation. For example, cargo may be transported from a production base to a railway terminal by truck, after which it is transferred to a railway platform and transported to a port. Afterward, the cargo may be transported by sea transport to the endpoint.

At the same time, logistics and customs support systems are not adapted to such processes and need to be duplicated for each mode of transport.

The situation is especially difficult in the presence of reverse transport operations (if the cargo is reloaded onto

a transport vehicle and transported in the opposite direction to the final destination). Therefore, the changes in cargo turnover through different routes of digital transport corridors in Ukraine mentioned above are caused not only by the difficulties of multimodality due to a single-mode approach to development but also by the limitations of the logistics and customs support system (as currently, electronic traffic management and safety control systems, border control and management systems, global navigation and monitoring systems, road toll transit payment systems, fuel quality monitoring systems, and vehicle technical condition monitoring systems are practically not yet implemented).

In particular, part of the strength functioning of DTCs based on the network of "Cretan" transport corridors formed by a system of roads, railways, ports, and other transport objects, which provide Ukraine's connection with Europe and Asia. Within such a corridor, e-waybill systems, permit booking for international transport, post-control, oversize permit issuance, and e-protocols have already been implemented. Digitalization currently covers [3]:

Cretan Transport Corridor No. 3 (including its railway section passing through the following transport hubs: Mostyska — Lviv — Krasne — Ternopil — Khmelnytskyi — Zhytomyr — Kozyatyn — Kyiv);

Cretan Transport Corridor No. 5 (including road, rail, and extension of the Organization for Cooperation of Railways No. 5, which encompasses the following transport hubs: Krakovets — Lviv — Rivne — Zhytomyr — Kyiv; Chop — Stryi — Lviv; Lviv — Krasne — Ternopil — Khmelnytskyi — Zhytomyr — Kozyatyn — Kyiv (Darnytsia) — Poltava — Kharkiv — Kupyansk — Topoli).

Cretan Transport Corridor No. 5 (road section — branches 5a and 5b, which connect the following transportation hubs: Chop/Uzhhorod — Stryi — Lviv and Storozhnysia — Uzhhorod — Mukacheve and Kosyn — Mukacheve).

Cretan Transport Corridor No. 7 (water section that passes through the Danube River, via the ports of Ismail and Reni).

Cretan Transport Corridor No. 9 (railway section that passes through the following transportation hubs:

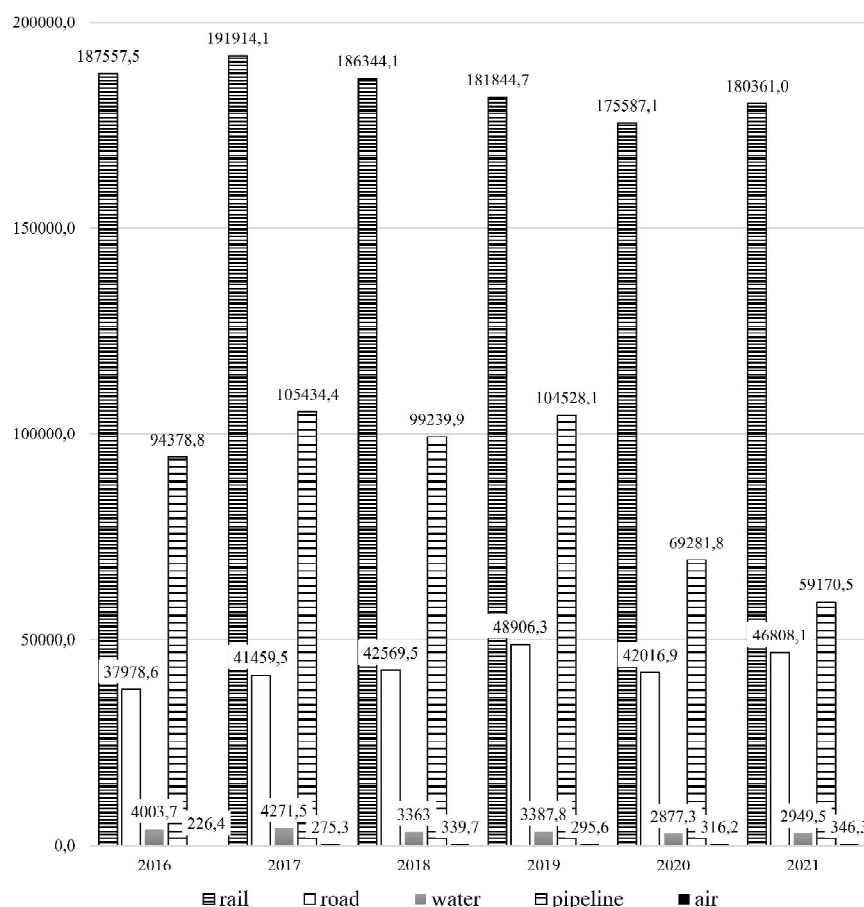


Fig. 2. Changes in the volume and structure of cargo turnover through different routes of digital transport corridors in Ukraine from 2016 to 2021, in mln.tkm

Source: compiled from data of the State Statistics Service of Ukraine.

Hornostayivka — Chernihiv — Kyiv — Koziatyn — Zhmerynka — Rozdilna — Kuchurhan), as well as its railway branches (through the following transportation hubs: Rozdilna — Odesa/Ilyichevsk and Nizhyn — Konotop — Khutir Mykhailivskyi — Zernovo).

Cretan Transport Corridor (road section — branches 9a and 9c, which connect the following transportation hubs: Novi Yarilovychi — Chernihiv — Kipti — Kyiv — Liubashivka — Platonove; Liubashivka — Odesa/Ilyichevsk and Bachivsk — Kipti).

Cretan Transport Corridor No. 9 (water section that passes through the Dnipro River, via the ports of Kyiv, Cherkasy, Kremenchug, Dnipropetrovsk, Dneprodzerzhinsk, Zaporizhian, Mykolaiv, and Kherson).

Of all the sections of the "Crete" transport corridors listed above, only the ones designated for automobiles have the ability for extended booking of permits for

international transportation (including an integrated identification system, id.gov.ua, online application and payment, quick document verification, and booking a specific permit form for a particular carrier). This process takes up to 3 minutes for users of such corridors. In addition, all automobile sections of the Crete Transport Corridors have:

- Fast post-control, where each registered permit can be traced from the moment of its booking or printing until crossing the border and returning to the permit issuance point (with data exchange with customs providing real-time tracking of criminals who attempt to forge permits or violate their use [5; 6]);

- An expanded system for obtaining permits for oversized transportation (through the integrated identification system, id.gov.ua, online application and payment, significant speeding up of the procedure).

Before Russia's large-scale invasion of Ukraine through its seaports, more than 70% of the country's total commodity exports were carried out through them. However, their operation is now blocked, along with other transport corridors due to the penetration of their material infrastructure into the combat zone. Additionally, Ukraine's airspace is closed. As a result, there is an active re-orientation of cargo flows to transportation types such as railways that pass through the Crete digital transport corridors. However, this transport method does not currently provide adequate security, including the lack of a "smart road" system to detect technical failures of cargo structures and dangerous situations on the railway. This issue is particularly important due to the technical and organizational incompatibility of Ukraine's and the EU's railway systems, as well as the limited capacity of the railway systems in EU countries to handle the increased cargo flow from Ukraine resulting from Russia's invasion.

The promising Crete water Transport Corridor No 7 is currently of interest as it could become a parallel route for transporting products produced in Ukraine, with particular interest from the domestic agricultural sector. However, the ports of Izmail and Reni require dredging, development of port infrastructure, and access roads. In addition, there is currently no system in place for booking permits for international transportation through these ports or for post-control.

Among others, the Europe-Asia digital transport corridor network can be identified, which although creates great potential for the development of the transport and logistics sector in Ukraine, is not fully realized (due to the onset of hostilities). In particular, at present, full digitization only covers the Europe-Asia railway section (which runs through the transport hubs of Chop-Lvov-Krasne-Ternopol-Zhmerynka-Fastiv-Znamianka-Dnipro) [3]. Within this section, there are possibilities for booking permits for international transportation, post-control, and obtaining permits for oversized transportation. Currently, the following possibilities are established:

- Continuous monitoring of railway freight flows;
- Electronic interaction of foreign economic activity participants with transport and logistics companies and state control authorities;

- Data exchange in the volumes necessary for business processes to be carried out by the system participants.

However, such a single-modal approach to the development of Europe-Asia digital transport corridors leads to the overloading of railway transport infrastructure and delays in cargo delivery, as other modes of transport are underdeveloped and there is no coordination between them.

As for the automobile branch of the Europe-Asia transport corridors (which cover the following transport hubs: Yagodyn-Kovel-Sarny-Korosten-Kyiv-Poltava-Kharkiv-Debaltseve-Izvaryne and Kharkiv — Goptivka) [3], the idea of implementing the E-protocol and E-waybill system has only been started at present.

The process of digitalization of the Europe-Asia transport corridors is complicated by the presence of certain transport and railway hubs located close to or within the conflict zones, and the associated consequences. The implementation of modern information systems providing continuous monitoring, electronic interaction between foreign economic activity participants and transport-logistics companies, and state control authorities along the automobile branch of the corridor (which includes the following transport hubs: Yahodyn-Kovel-Sarny-Korosten-Kyiv-Poltava-Kharkiv-Debaltseve-Izvaryne and Kharkiv — Goptivka) is currently suspended. This is because this project, along with the railway branch, was a partial component of the "One Belt, One Road" global initiative aimed at increasing trade and investment activity between China and the countries of Eurasia.

The network of digital transport corridors from the Baltic Sea to the Black Sea was developed based on the EU4Digital project (aimed at preparatory actions and implementing EU developments in Eastern partner countries to test the technological approach to information exchange, regulatory environment, and organizational agreements within and between Eastern partner countries [1]). Currently, it covers a railway section (with transport hubs Yagodyn / Izov — Kovel — Zdolbuniv — Kozatin — Zhytomyr — Rozdilna — Odesa / Ilyichevsk) and a road section (with transport hubs Yagodyn — Kovel — Lutsk — Ternopil — Khmelnytskyi — Vinnytsia — Uman — Odesa / Ilyichevsk) [3].

In particular, for the Ukrainian section, EU4Digital experts have developed a three-year program and identified preparatory actions for establishing a DTC between the Baltic and Black Seas, allowing for a seamless cross-border exchange of logistical information through the transport corridor between the Baltic and Black Seas [2]. The section also features the ability to book permits for international transportation and obtain permits for oversized transportation, and e-protocols. However, the capacity of the Baltic-Black Sea transport corridors is practically unused as Ukrainian ports remain virtually blocked since the start of Russia's full-scale invasion (partially operating only within the framework of the Istanbul agreements, which provide for the unblocking of several seaports for only 120 days).

The digital transport corridor TRACECA is currently operating in limit mode. Specifically, the railway section

(through the transport hubs Izov-Kovel-Zdolbuniv-Kozyatyn-Zhmerynka-Rozdilna-Odesa) and the road section (through the transport hubs Yagodin-Kovel-Lutsk-Ternopol-Khmelnitsky-Vinnitsa-Uman-Odesa) are operational [3]. However, the waterway section of the route through the transport hubs of Ilyichevsk-Poti/Batumi/Derince/Varna remains practically blocked since the beginning of the full-scale invasion of Russia. Nevertheless, within this corridor, the following have been implemented:

- Implementation of "smart road" systems for controlling and managing traffic at the border (which allows for reducing waiting time at the border and improving border crossing control);

- Implementation and full support of all electronic service transport portals on e-transport.gov.ua.

Based on the above, it should be noted that the necessary development of all digital transport corridor networks in Ukraine should be comprehensive, rather than selective, and should become a mandatory element of its post-war recovery.

CONCLUSIONS FROM THIS STUDY AND PROSPECTS FOR FURTHER EXPLORATION IN THIS AREA

According to research, digital transport corridors in Ukraine should function as multimodal ones, meaning that they should not only unite different modes of transportation (road, rail, sea, air) but also ensure that transport services are integrated and coordinated among different modes of transportation, which allows for efficient and optimal transportation. For example, railway terminals can provide facilities for booking storage and handling of cargo that arrive by road or sea transportation, thus providing more efficient and faster delivery of cargo to the final destination.

Digital transport corridors in Ukraine need to be more reliable and efficient, and to achieve this, they need to support the functioning of various systems such as electronic traffic management and safety systems (which allow real-time information about the condition of roads, bridges, tunnels, level crossings, traffic jams, and other dangerous situations), border traffic control and management systems (necessary to reduce waiting time for cargo at the border and improve control over its crossing), global navigation and monitoring systems (needed to monitor the location of the cargo and other vehicles in real-time and track their movement along the route), fuel quality and vehicle condition monitoring systems (which will ensure road safety and reduce emissions of harmful substances into the atmosphere), and logistics and customs information support systems.

Digital transport corridors in Ukraine should include systems that can help reduce waiting times at borders, ensure road safety, reduce emissions of harmful substances into the atmosphere, and improve the overall quality of transportation infrastructure in Ukraine.

The research results can serve as a basis for the development and implementation of new technologies and approaches to organizing transportation in Ukraine, which will improve the transportation infrastructure, reduce

transportation time, and increase the efficiency of transportation services.

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