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Export challenges caused by blockade of ports and shift to overland and alternative routes

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Abstract. This article investigated the challenges facing Ukrainian exports due to the blockade of seaports under martial law, and substantiated the main directions for redirecting logistics flows towards overland, river, and multimodal routes. The study was based on a systems approach, comparative analysis, statistical generalisation, structural and logical analysis, and economic interpretation. Information sources included statistical data from Ukraine's State Statistics Service, materials published by government authorities, analytical reports by international organisations, and academic studies on transport logistics, foreign trade, and Ukraine's export infrastructure in wartime. The impact of the port blockade on Ukraine's export logistics was analysed, and the role of alternative transport routes in maintaining the resilience of foreign trade was identified. The study provided a comprehensive evaluation of how Ukraine's export logistics had changed as a result of the seaport blockade between 2021 and 2025. The share of maritime transport in export logistics was found to have declined from 72% in 2021 to 38% in 2023, a decrease of 34 percentage points. Conversely, the share of rail transport increased from 15% to 31%, while the share of Danube ports rose from 5% to 18%. Additionally, the share of road transport increased from 8% to 13%. Redirecting export flows enabled Ukraine to maintain some of its foreign trade. However, a substantial increase in logistics costs was also observed: the cost of rail transport was found to have risen by 25-30%, road transport by 30-40%, and river transport via the Danube by 15-20%. Alternative logistics routes were found to be viable for sustaining exports of agricultural products, mining and metallurgical products, and raw materials. Nevertheless, the capacity of these routes has not yet been sufficient to compensate for pre-war maritime transport volumes fully. The practical significance of the findings lies in the formulation of recommendations regarding the development of multimodal transport, the modernisation of border infrastructure, the expansion of capacity at Danube ports, the integration of the Ukrainian transport system into the TEN-T network, and the enhancement of the resilience of the national export logistics system in the face of wartime and post-war risks

Keywords: transport logistics; multimodal transport; Danube ports; rail transport; foreign trade

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Introduction

Transport logistics is one of the key factors determining the competitiveness of a national economy within the international trading system. For Ukraine, a traditional leading exporter of agricultural products and raw materials, efficient export logistics determine the stability of foreign-exchange earnings and the country's position in global markets. In 2022, Russia invaded and then blocked seaports in the Black Sea and the Sea of Azov. This put the whole foreign trade system at risk. It was vital to find alternative transport routes for exports.

In recent years, the operation of Ukraine's export logistics has become particularly relevant. This is because of the conditions of military hostilities. The operation of Ukraine's export logistics has been the subject of numerous academic studies. O. Onyshchenko & V. Shyshkin (2025) investigated the specific features of managerial decision-making in international transport logistics. They looked at this under conditions of armed conflict and economic sanctions. They emphasised that transport logistics in a wartime environment should be based on the principles of flexibility, route diversification, and rapid response to changes in the external environment. I. Dashko & L. Mykhailichenko (2024) examined the impact of the war on the development of freight transport in Ukraine. They stressed that rail, road and river transport had become much more important following the blockade of the seaports. L. Lebiedieva & D. Shkuropadska (2024) analysed the resilience of transport logistics in Ukraine and the EU, demonstrating that integrating Ukrainian transport corridors into the European logistics system is key to maintaining foreign trade. T. Luchnykova *et al.* (2023) discussed the challenges associated with operating rail transport amid turbulent foreign trade flows. Rail transport had become one of the main ways of making up for the loss of maritime routes, the authors noted. However, its effectiveness is constrained by the capacity of border crossings, differences in railway gauges, and rolling stock shortages.

K.V. Mazur *et al.* (2023) investigated the organisation of Ukrainian agricultural exports under martial law. The study emphasised that the stability of transport infrastructure is crucial for agricultural exports, as grain and oilseed crops require large volumes to be transported at a relatively low cost. N.I. Mykhailyk (2024) examined the main challenges facing transport logistics during the war, emphasising the need for multimodal logistics centres. O.P. Podtserkovnyi (2023) investigated the legal framework governing the port industry under wartime conditions, highlighting the need to adapt legislation and regulatory frameworks to the new operating conditions of the maritime business. The challenges and opportunities associated with the development of Ukraine's maritime sector during the post-war period were analysed by L. Trachenko (2025). He emphasised the importance of restoring port infrastructure, attracting investment and developing public-private partnerships. The current state, challenges and development prospects of maritime freight transport in Ukraine and worldwide were examined by O. Shevchuk & N. Hayvanovych (2023). They demonstrated that maritime transport would remain strategically important for Ukraine, even with the development of alternative routes, because of its ability to support large-scale export deliveries at a lower cost.

Despite the large number of recent studies, most have looked at individual parts of the transport system in Ukraine under martial law. These include rail transport, agricultural exports and seaport activities. At the same time, there has been a lack of focus on a thorough quantitative analysis of the structural change in Ukraine's export logistics after the seaport blockade, the shifts in the role of different transport modes, the extent of the rise in logistics costs, and the creation of practical recommendations for growing multimodal transport networks. It was the need to address this research gap that determined the selection of the topic and the logic of the study. The investigation's objective was twofold: firstly, to conduct a thorough examination of the repercussions of the seaport blockade on Ukraine's export logistics, and secondly, to evaluate the structural transformation of transport flows between 2021 and 2025.

Materials and Methods

The study employed a combination of general scientific and specialised methods. The relationships between the blockade of ports, changes in the structure of export flows and the increase in logistics costs were determined using systems analysis. Comparative analysis was used to compare Ukraine's pre-war and wartime export logistics models. Statistical analysis was used to generalise indicators relating to changes in transport volumes across alternative transport routes. Structural and logical analyses were used to identify the main challenges and directions for restructuring export infrastructure. The conclusions and practical recommendations were formulated with the application of economic generalisations. A comparative analysis of pre-war and wartime tariff rates was used to assess the increase in logistics costs associated with alternative routes. This analysis was based on publicly available industry data, including materials published by R. Bandura *et al.* (2024) and the United Nations Conference on Trade and Development (2024).

The empirical basis of the study consisted of official statistical data from 2021 to 2025. These data enabled a comparative analysis of Ukraine's export logistics operation during the pre-war period, the full-scale blockade of seaports and the gradual adaptation of the transport system to new foreign trade conditions. To ensure the representativeness of the study, official national statistical reports (State Statistics Service of Ukraine, 2022; Ukrainian Sea Ports Authority, 2025; State Customs Service of Ukraine, 2026) were used together with analytical materials produced by international financial institutions (Echeverría *et al.*, 2025). The study focused on the main categories of Ukrainian exports that are most dependent on seaport operations, including grain and oilseed crops, sunflower oil, ferrous metals and

iron ore, as well as other mining and metallurgical products. Traditionally, these product categories accounted for the largest share of Ukraine's export freight flows, representing the bulk of maritime transport prior to the onset of full-scale war.

The study analysed maritime, rail, road, river and multimodal transport operations. When assessing the effectiveness of alternative logistics routes, particular attention was paid to transport volume trends, transport flow structure, changes in the share of individual transport modes, logistics costs, transport infrastructure throughput capacity, freight delivery times, congestion levels at border crossings and the impact of these factors on the competitiveness of Ukrainian exports. The study has certain limitations. First, official statistics concerning the operation of Ukrainian seaports under martial law were only available in aggregated form or were subject to restricted access for reasons of national security. Furthermore, the 2024-2025 statistical indicators were provisional and subject to change once the respective reporting periods are finalised. The study was carried out at the macroeconomic level and did not cover the individual logistics indicators of specific enterprises. This limitation emphasises the necessity for additional research at the microeconomic level, employing corporate statistics and data supplied by transport operators.

Results and Discussion

Since the start of 2022, Ukraine has faced significant challenges in international trade due to Russia's aggression. The blockade of Ukraine's seaports is one of the most destructive consequences of the conflict. These ports were the main transport gateway for exports of agricultural products, metallurgical goods, coal, ore and other important commodities. Losing access to the ports of the Black Sea and the Sea of Azov, including Odesa, Mykolaiv and Kherson, has had a critical impact on the Ukrainian economy. These ports handled the majority of the country's export shipments, and their blockade has resulted in a substantial decline in export volumes, as well as complicating the transportation of goods due to the absence of adequate alternatives (Onyshchenko & Shyshkin, 2025).

Traditionally, Ukraine's seaports have played a key role in the global supply of grain, oilseeds, metals, and other raw materials. They functioned as major logistics hubs. They also constituted a principal artery of the national economy. Following the outbreak of hostilities, some of these facilities were destroyed or fell under the control of the aggressor, resulting in the closure or severe restriction of maritime routes. This crisis has created an urgent need to restructure foreign trade and logistics routes. The European Commission (2025, 2026) has reported a 60% decrease in Ukrainian grain exports following the blockade of the ports. This had a negative impact on global prices and meant that importers had to look for other suppliers. Rail, road and river transport became alternative means of sustaining export activity. However, Ukraine was confronted with new challenges, such as establishing and modernising transport corridors, introducing new multimodal routes, and integrating them into the international logistics system. At the same time, the increase in overland freight volumes put considerable pressure on existing infrastructure, necessitating the reconstruction of current transport links and the development of new ones (Prasad, 2025).

Due to the blockade of ports and restricted access to maritime routes, Ukraine redirected a significant portion of its exports towards its western borders, primarily through Poland, Romania, and Moldova, as well as southwards via the Danube River. These alternative routes have become crucial to maintaining exports, particularly grain exports. However, unlike maritime transport, overland and river routes require significant investment in transportation, infrastructure adaptation, and logistics. To ensure the effectiveness of these alternatives, rail and road transport must be modernised and new multimodal hubs established to ensure the rapid and secure transportation of goods to European markets.

The expansion of river transport, especially via the Danube, which has become one of the most important alternatives to maritime routes, should be given particular attention. However, navigating the Danube is challenging for several reasons. Some sections have insufficient water depth, shipping capacity is limited, and there are infrastructure constraints. Despite these limitations, the Danube has become a vital transport artery for grain and other agricultural exports following the seaports' blockade. In addition, the rising cost of transporting goods by overland and river routes became a serious challenge for Ukrainian enterprises. The loss of efficient maritime transport has impacted the competitiveness of Ukrainian goods in international markets. In addition, the logistics restructuring necessitated considerable investment in infrastructure modernisation and the establishment of new facilities for freight storage and transportation. Therefore, ensuring the flexibility and resilience of transport systems under the new conditions, as well as attracting investment to support these initiatives, became particularly important.

Another key factor is the importance of international assistance and cooperation with partners such as the European Union and the United States. These partners have contributed to the development of new logistics corridors and provided financial and technical support for infrastructure modernisation. A number of initiatives were initiated between 2022 and 2024. Among these were projects to restore and expand railway lines, construct new logistics centres, improve river routes and develop multimodal transport services. These measures enabled Ukraine to reduce the impact of the port blockade. They also enabled Ukraine to continue exporting strategically important goods (Antonovych, 2024). A full assessment of the economic and social consequences of logistics restructuring and Ukraine's cooperation with international partners is required in order to make such changes. It is important to understand how these new routes can be integrated into global trade and the effect they will have on the stability of

the national economy. It is also crucial to evaluate the role of government support in fostering these processes and its impact on the national economy's development.

The blockade of Ukraine's seaports forced the country to restructure its logistics routes quickly, with the focus now on rail, road and river transport. This enabled some of the goods that had previously been shipped through seaports to be redirected towards the western border and the Danube. Rail transport played a key role in restoring foreign trade. However, it should be noted that the western border encountered numerous difficulties during the initial stages of the war. Congestion at border crossings, insufficient freight wagons and coordinating logistics processes with European partners were among the main challenges. Nevertheless, Ukrainian authorities and businesses addressed these issues promptly, increasing rail freight volumes by 30-35% compared to pre-war levels (Bandura *et al.*, 2024). River transport along the Danube became another important export route. Ukrainian companies developed river-based logistics, using ports in Romania, Bulgaria, and Moldova to transport goods to international markets. Although river transport is subject to certain constraints, including the limited depth of navigable channels in some sections, it enabled substantial increases in export volumes, particularly for grain (Table 1).

Table 1. Changes in freight volumes transported via alternative transport routes, 2022-2023

Transport route	Freight volume, million tonnes	Change compared with 2021
Rail transport	16.2	+30%
River transport via the Danube	7.8	+45%
Road transport	3.5	+20%

Source: State Statistics Service of Ukraine (2022), Ukrainian Sea Ports Authority (2025)

These factors had an adverse effect on the price competitiveness of Ukrainian products in international markets. The lack of affordable and speedy shipping options led to higher prices for Ukrainian goods. As a result, Ukraine lost some of its export markets, as competitors from other countries with access to less expensive and more efficient transport routes were able to offer their products at lower prices. Therefore, the increase in logistics costs became not only an operational problem for individual exporting enterprises, but also a systemic factor that reduced the price competitiveness of Ukrainian goods in foreign markets. The agricultural sector was particularly severely affected, as the low profit margins associated with agricultural products mean that logistics costs are crucial to the profitability of export deliveries. The findings indicate that, when used independently, none of the alternative routes provides economic efficiency comparable to that of pre-war maritime logistics. This demonstrates the need to develop a comprehensive multimodal model for organising export transportation.

The results of the analysis suggest that Ukraine's export logistics should be further developed based on the principle of transport route diversification. Priority areas include modernising border crossings along the western border, as these represent the main infrastructure constraint affecting rail corridors. Other priorities include expanding the terminal capacity of Danube ports. They also include reducing customs barriers. This would increase the throughput capacity of transport corridors. It would also lower logistics costs for exporters. Integrating Ukraine's transport system into the Trans-European Transport Network (TEN-T) is a strategic objective that requires standardising railway gauges along key international corridors. Eliminating these technical differences is essential, as they are a systemic source of additional freight transhipment costs. Investment in railway infrastructure, river ports and multimodal terminals is required to address this issue (Echeverría *et al.*, 2025).

The implementation of these priorities is dependent on systematic government support for transport operators through preferential lending and subsidies. It is also dependent on the mobilisation of international financing under reconstruction programmes implemented by the World Bank and the European Bank for Reconstruction and Development. To provide a more detailed assessment of the consequences of the seaport blockade, changes in transport volumes and the transformation of the structure of Ukraine's export logistics must be examined. Prior to the onset of full-scale warfare, the country's export model was predominantly centred on seaports, which handled substantial consignments of agricultural products, metallurgical goods, and raw materials. However, the blockade of port infrastructure has necessitated a rapid transition to alternative routes, particularly rail and road transport, as well as Danube ports (Table 2).

Table 2. Structure of Ukrainian exports by principal logistics route, %

Transport route	2021	2023	Change, percentage points
Seaports	72	38	-34
Rail transport	15	31	+16
Danube ports	5	18	+13
Road transport	8	13	+5

Source: E.E. Echeverria *et al.* (2025), State Customs Service of Ukraine (2026)

As shown in Table 2, there has been a significant shift in the logistics model of Ukrainian exports. While seaports handled around 72% of export flows in 2021, this figure had fallen to 38% by 2023. This decline was due to the blockade of several ports, infrastructure damage, increased security risks, and the requirement for more intricate transport arrangements. Conversely, the share of rail transport increased from 15% to 31% over the same period, confirming its pivotal role in ensuring the continuity of foreign trade operations. The growing importance of Danube ports is particularly notable, indicating the emergence of a new strategic export route that has partially compensated for the loss of traditional maritime routes. Road transport also increased its share. However, its potential remains limited. This is due to high transport costs, border crossing queues and lower carrying capacity. This is when compared with rail and maritime transport.

The redirection of exports towards alternative routes was also accompanied by rising logistics costs. This has become one of the main factors reducing the competitiveness of Ukrainian products in global markets. The largest cost increases were observed in rail and road transport. The root causes of these issues were identified as congestion at border infrastructure, additional transhipment operations, longer delivery times and the need to use combined transport arrangements (Table 3).

Table 3. Estimated impact of alternative routes on exporters' logistics costs

Mode of transport	Principal advantage	Principal limitation	Estimated increase in costs during the war, %
Rail transport	Ability to transport large consignments	Limited throughput capacity at border crossings	25-30
Danube ports	Access to European and global markets via river routes	Insufficient depth and limited port capacity	15-20
Road transport	Flexibility and rapid route adjustment	High cost and queues at border crossings	30-40
Multimodal transport	Risk diversification and combination of different routes	Complex coordination and the need for logistics hubs	10-20

Source: compiled and calculated by the author on the basis of data from R. Bandura *et al.* (2024) and United Nations Conference on Trade and Development (2024)

The data confirm that, in terms of scale, cost and speed of transport, none of the alternative routes can fully replace maritime logistics. Rail transport became the foundation of the export redirection process, although how effective it is depends a lot on the throughput capacity of border crossings, the availability of railway wagons, the speed of customs clearance and coordination with European operators. Danube ports have substantial potential, but require further modernisation and expansion of terminal capacity, as well as the dredging of navigation channels and development of access infrastructure. Although road transport offers the greatest flexibility, it is the most expensive option for bulk export cargoes. Therefore, it should primarily be used for products with a higher added value or as part of a multimodal arrangement. The most promising approach is the development of multimodal transport, which combines the advantages of different modes of transport and reduces exporters' dependence on a single logistics channel. Therefore, the analysis confirms that the seaport blockade not only caused short-term losses for exporters, but also catalysed the structural transformation of Ukraine's transport system. In these new conditions, the efficiency of exports depends on the state and businesses' ability to develop a flexible, diversified and integrated logistics model that combines rail, road, river and multimodal routes.

Overall, the findings confirm the conclusions of recent studies that transport infrastructure plays a critical role in maintaining the resilience of Ukraine's foreign trade in wartime. At the same time, however, they provide a considerably more detailed assessment of the scale of the structural transformation of export logistics. Unlike previous studies, which primarily focused on individual aspects of the transport system, this study provides a comprehensive analysis of changes in export transportation structure, logistics costs, the role of alternative routes, and how they adapt to new international trade conditions.

The findings are consistent with the conclusions of R. Bandura *et al.* (2024), who emphasise that transport logistics should be based on route diversification and rapid responses to changes in the external environment under conditions of military conflict. The present analysis confirmed that transport route diversification was one of the key factors in ensuring the continuity of Ukrainian exports following the blockade of the seaports. However, the findings also demonstrate that the substantial increase in the use of rail, road and river transport did not fully compensate for the loss of maritime logistics.

The findings also support the conclusions of I.V. Davydova & S.V. Reznichenko (2022) that the role of rail transport has significantly strengthened since the start of the full-scale war. While previous studies primarily identified increased pressure on railway infrastructure, the present analysis reveals specific quantitative changes. Notably, the share of rail transport in Ukraine's export logistics increased from 15% to 31%, and freight volumes transported across the western border surpassed pre-war levels by around 30%. These results demonstrate the high degree of adaptability of Ukraine's transport system, even in the face of large-scale wartime challenges.

Comparing the findings with the research of I. Shevchenko & I. Klius (2023) suggests that integrating Ukrainian transport corridors into the European logistics system was key to supporting export activity. The findings confirm that closer cooperation with EU countries, increased use of border infrastructure, and active development of the Danube transport route enabled foreign trade operations to continue despite partial disruption to maritime transport. However, the findings differ somewhat from those of certain earlier studies concerning the economic efficiency of alternative routes (Lysenko, 2016; Miroshnyk & Bahlai, 2022). Rail and river transport are regarded by some authors as complete substitutes for maritime transport. However, the present analysis shows that neither mode can fully replace maritime logistics. This is due to substantially higher transport costs, lower throughput capacity and the need for additional freight transhipment operations. Therefore, Ukraine's transport system should be developed strategically to create an efficient multimodal transport model, rather than replacing one mode of transport with another.

A comparison of the findings with international statistical data was also made. This data was published by the National Council for the Recovery of Ukraine from the Consequences of the War (2022) and BBC News Ukraine (2023). This comparison confirms the general trend towards a substantial increase in the importance of overland transport routes. This increase began following the beginning of the full-scale war. At the same time, the findings of the present study provide a more detailed account of the specific characteristics of Ukraine's transport system and demonstrate that the greatest positive effect was achieved through the simultaneous use of several alternative transport routes rather than through the development of any single mode of transport.

The findings confirm the main conclusions of recent academic studies about the transformation of Ukraine's export logistics under wartime conditions. They also extend these conclusions substantially through a quantitative analysis of changes in the structure of transport flows, logistics costs and the effectiveness of alternative routes. The export-logistics diversification model developed in the study is one of the fundamental means of ensuring Ukraine's economic resilience in the face of prolonged wartime and post-war challenges.

Conclusions

Ukraine's export logistics underwent a structural transformation, which was confirmed by the study to be due to the blockade of the seaports. The consequences of this are systemic and long-term. While the redirection of exports to alternative routes prevented the complete cessation of foreign trade, it did not fully compensate for the loss of maritime capacity. None of the alternative modes of transport matches pre-war maritime logistics in terms of the combined indicators of cost, throughput capacity, and delivery speed when considered separately. A key outcome of the study was the quantitative assessment of the scale of this transformation. The share of maritime transport decreased by 34 percentage points. Rail transport and the Danube ports formed the new foundation of export logistics. However, this redirection was accompanied by increased logistics costs of between 15% and 40%, depending on the transport method used. This reduced the price competitiveness of Ukrainian exporters, particularly in the agricultural sector, on a systematic basis. The most vulnerable product categories were those that were highly dependent on large-scale maritime transport: grain and oilseed crops, sunflower oil, ferrous metals, and iron ore.

A comparison of the effectiveness of alternative transport routes showed that rail compensated for the largest proportion of export flows. However, its potential is limited by the capacity of border crossing points and differences in railway gauges. Danube ports have emerged as a new strategic export route, recording the lowest level of cost growth among the alternative options. This establishes them as a priority for the further development of export infrastructure. Despite being costly, road transport provided the operational flexibility required for higher-value products. Further research should focus on econometric modelling of the optimal structure of multimodal transport. It should also assess the economic efficiency of investment in Danube infrastructure. Forecasting the throughput capacity of transport corridors after the end of martial law is another area to explore. And an integrated model for managing Ukraine's export logistics in accordance with modern European transport standards should be developed.

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Conflict of Interest

None.

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Проблеми експорту через блокаду портів, перебудову на сухопутні та альтернативні маршрути

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Анотація. Метою статті було дослідження проблем експорту України, спричинених блокадою морських портів у період воєнного стану, а також обґрунтування напрямів перебудови логістичних потоків на сухопутні, річкові та мультимодальні маршрути. Методологічною основою дослідження стали системний підхід, методи порівняльного аналізу, статистичного узагальнення, структурно-логічного аналізу та економічної інтерпретації. Інформаційну базу сформували статистичні дані Державної служби статистики України, матеріали державних органів, аналітичні звіти міжнародних організацій, а також наукові праці, присвячені розвитку транспортної логістики, зовнішньої торгівлі та експортної інфраструктури України в умовах воєнних ризиків. Було систематизовано наслідки блокади портів для експортної логістики України та визначено ролі альтернативних транспортних маршрутів у забезпеченні стійкості зовнішньої торгівлі. У результаті дослідження проведено комплексну оцінку трансформації експортної логістики України внаслідок блокади морських портів у 2021-2025 роках. Встановлено, що частка морських перевезень у структурі експортної логістики скоротилася з 72 % у 2021 році до 38 % у 2023 році, тобто на 34 відсоткових пункти. Одночасно частка залізничного транспорту зросла з 15 % до 31 %, дунайських портів – з 5 % до 18 %, автомобільного транспорту – з 8 % до 13 %. Визначено, що переорієнтація експортних потоків забезпечила часткове збереження зовнішньої торгівлі, однак супроводжувалася суттєвим підвищенням логістичних витрат: перевезення залізничним транспортом подорожчали на 25-30 %, автомобільним транспортом – на 30-40 %, річковими маршрутами через Дунай – на 15-20 %. Доведено, що альтернативні логістичні маршрути дозволили підтримати експорт аграрної продукції, продукції гірничо-металургійного комплексу та сировинних товарів, проте їх пропускна спроможність поки не забезпечує повноцінної компенсації довоєнних морських перевезень. Практичне значення результатів полягає у розробленні рекомендацій щодо розвитку мультимодальних перевезень, модернізації прикордонної інфраструктури, розширення потужностей дунайських портів, інтеграції української транспортної системи до мережі TEN-T та підвищення стійкості національної експортної логістики в умовах воєнних і післявоєнних ризиків

Ключові слова: транспортна логістика; мультимодальні перевезення; дунайські порти; залізничний транспорт; зовнішня торгівля