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# LOGISTICS AND TRANSPORT INFRASTRUCTURE OF UKRAINIAN REGIONS BORDERING THE EU: DIAGNOSTICS AND DIRECTIONS OF DEVELOPME

## *Infrastruktura logistyczna i transportowa ukraińskich regionów graniczących z UE: diagnostyka i kierunki rozwoju*

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### **Streszczenie**

W artykule zbadano obecne trendy w rozwoju handlu międzynarodowego w Ukrainie oraz udział poszczególnych regionów w handlu zagranicznym towarami. Rozważano teoretyczne aspekty infrastruktury logistycznej i transportowej oraz jej komponentów. Zanalizowano międzynarodowe wskaźniki oceny poziomu rozwoju infrastruktury logistycznej i transportowej. Wskaźnik wydajności logistyki służy do oceny wydajności łańcucha logistycznego w wielu krajach. Przeprowadzono diagnozę rozwoju infrastruktury logistycznej i transportowej w regionach Ukrainy graniczących z UE. Wskaźniki infrastruktury logistycznej i transportowej są obliczane i grupowane według następujących komponentów: infrastruktura graniczna, w tym analiza punktów kontrolnych, infrastruktura usług drogowych oraz komponent instytucjonalny infrastruktury logistycznej i transportowej dla transportu towarowego. Oceniono efektywność wykorzystania infrastruktury logistyczno-transportowej w kontekście poszczególnych elementów strukturalnych. Określono problemy i kierunki rozwoju infrastruktury transportowej i logistycznej regionów Ukrainy graniczących z UE.

**Słowa kluczowe:** logistyka, infrastruktura logistyczna i transportowa, logistyka międzynarodowa, wskaźnik efektywności logistycznej, ranking, diagnostyka infrastruktury logistycznej.

## **Abstract**

The current trends in the development of international trade in Ukraine and the participation of individual regions in foreign trade in goods are studied. Theoretical aspects of logistics and transport infrastructure and its components are considered. International indices for assessing the level of development of logistics and transport infrastructure are analyzed. The logistics performance index (LPI) is used to assess the efficiency of the logistics chain in a number of countries. The development of logistics and transport infrastructure in the regions of Ukraine bordering the EU is diagnosed. Indicators of the logistics and transport infrastructure are calculated and grouped by the following components: border infrastructure, including the analysis of checkpoints, roadside service infrastructure, and the institutional component of the logistics and transport infrastructure for freight transportation. The efficiency of the logistics and transport infrastructure is assessed in terms of individual structural elements. The problems and directions of development of the transport and logistics infrastructure of the regions of Ukraine bordering the EU are identified.

**Keywords:** logistics, logistics and transport infrastructure, international logistics, logistics efficiency index, ranking, diagnostics of logistics infrastructure.

## **1. INTRODUCTION**

Ukraine's national economy has long been winning its place in the international markets for goods and services, successfully integrating into the global economy. However, Russia's invasion of Ukraine had a devastating impact on the results of Ukraine's foreign economic activity. Ukraine's transport and logistics infrastructure was a key element of the mechanism that ensured the active participation of business entities in foreign trade. The consequence of Russia's military aggression was the occupation of Ukrainian territories, the seizure and destruction of seaports, the practical blocking of the transportation of goods by sea, catastrophic damage to the logistics infrastructure almost throughout Ukraine, and the disruption of established logistics chains.

Russia's war against Ukraine, in addition to large human losses and a humanitarian crisis, has led to increased financial instability, slower economic growth, accelerated inflation, higher prices for food, fuel, and other strategic products, and changes in the global supply chain in the country's logistics.

In 2019–2021, about 20–25% of international road freight traffic was carried out through the territory of Russia and Belarus; more than two-thirds of the goods crossing the customs border of Ukraine were sold through sea checkpoints. Thus, in 2022, compared to the previous year, 21% more vehicles crossed the customs border of Ukraine with the EU countries (in particular, 64% more vehicles crossed the border with Romania)[21].

During the war, road transport became the leader in terms of imports into the country (about 11 million tons), and rail transport took second place with about 10 million tons[25].

The processes of increasing food exports by land with the use of river ports and reorientation to European markets have significantly increased the intensity of cargo flows across the Ukraine-EU border. The rapid growth of rail and road freight traffic to Poland, Slovakia, Hungary, and Romania significantly increases the burden on the transport and border infrastructure of the border regions of the Western region of Ukraine. In such circumstances, the existing capacity of the transport and logistics infrastructure is insufficient: queues form at checkpoints, deliveries are untimely and difficult to predict.

In these conditions, special attention is paid to the regions of Ukraine bordering the European Union, whose regions are far from active hostilities and now perform an important function of locating transport and logistics hubs and building new logistics systems and chains. Therefore, there is a need to assess the real state of development of the logistics and transport infrastructure of Ukraine, especially its border regions, and the potential for its development, taking into account new realities and current challenges.

## **2. ASSESSMENT OF UKRAINE'S FOREIGN TRADE**

In 2022, the volume of exports of goods decreased by 35.1%, the volume of imports of goods decreased by 24.1%, and foreign trade turnover decreased by 29.4% compared to 2021. The destruction and occupation of industrial enterprises, agricultural producers, and the destruction of transportation routes and logistics centers have reduced Ukraine's potential to export goods abroad. At the same time, this requires importing goods from abroad to meet domestic needs. The balance of foreign trade in goods in 2022 increased by 133.2% compared to 2021.

Every year until 2022, the volume of exports of goods from Ukraine to other countries increased. In 2019–2021, the share of exports in foreign trade increased from 45,2% to 48,3%. Imports of goods to Ukraine also grew, and the foreign trade balance was negative during the analyzed period, but its value decreased annually.

The data presented in table 1 indicate the foreign trade openness of Ukraine's economy, as the export quota in 2019–2022 averaged 39%. This situation is the result of the integration of the national economy into the global economic space, deepening cooperation with other countries, which objectively requires excellent transport and logistics support for international trade operations involving foreign economic operators.

**Table 1. Dynamics of Ukraine's foreign trade of goods in 2019–2023**

Indicators	Years					Growth rate in 2022 as a % of 2021
	2019	2020	2021	2022	First half of 2023	
Exports of goods, mln USD	50054,6	49191,8	68072,3	44148,8	19406,9	-35,1
Share of exports in foreign trade turnover, %	45,2	47,5	48,3	44,4	38,9	-8,1
Imports of goods, mln USD	60800,2	54336,1	72843,1	55273,5	30447,3	-24,1
Share of imports in foreign trade turnover, %	54,8	52,5	51,7	55,6	61,1	7,5
Foreign trade of goods balance of Ukraine, mln USD	110854,8	103527,9	140915,4	99422,3	49854,2	-29,4
Balance, mln USD	-10745,6	-5144,3	-4770,8	-11124,7	-11040,4	133,2
Exports to imports ratio	0,82	0,91	0,93	0,80	0,64	-14,0
Export quota, %	41,2	39,0	40,7	35,5	*	-12,8

Source: based on [11; 20].

Let's analyze the participation of Ukraine's regions in foreign trade in goods. In the first half of 2023, exports in most regions of the country were lower compared to the same period in 2022, especially in Zaporizhzhia (30.9% compared to the previous period) and Kherson (25.4% compared to the previous period) regions, which are partially occupied and on the verge of active hostilities (table 2).

**Table 2. Regional volumes of foreign trade of goods in January-June 2023\***

Region	Exports			Imports			Balance
	mln USD	in % to January-June 2022	% of the total volume	mln USD	in % to January-June 2022	% of the total volume	
Ukraine	19406,9	85,7	100,0	30447,3	120,7	100,0	-11040,4
of which							
Vinnitsya	828,0	141,9	4,3	390,9	141,0	1,3	437,2
Volyn	391,2	83,5	2,0	1234,7	146,8	4,1	-843,5
Dnipropetrovsk	2508,8	64,4	12,9	2182,2	115,1	7,2	326,5
Donetsk	110,6	63,4	0,6	19,9	19,3	0,1	90,7
Zhytomyr	294,4	86,6	1,5	560,6	148,6	1,8	-266,2

Zakarpattia	797,0	75,1	4,1	718,8	85,4	2,4	78,2
Zaporizhzhya	635,6	30,9	3,3	284,9	35,1	0,9	350,7
Ivano-Frankivsk	307,5	74,5	1,6	253,7	71,2	0,8	53,8
Kyiv	876,8	79,6	4,5	2205,2	135,4	7,2	-1328,3
Kirovohrad	483,1	127,0	2,5	142,5	124,3	0,5	340,5
Luhansk	0,1	0,7	0,0	0,6	5,5	0,0	-0,5
Lviv	1438,1	97,4	7,4	2823,3	119,3	9,3	-1385,2
Mykolayiv	558,1	65,4	2,9	257,9	54,2	0,8	300,2
Odesa	1078,3	129,0	5,6	1068,8	117,6	3,5	9,4
Poltava	741,1	66,3	3,8	386,2	56,3	1,3	354,8
Rivne	332,4	89,0	1,7	366,3	166,0	1,2	-33,9
Sumy	399,5	122,5	2,1	253,5	90,5	0,8	146,1
Ternopil	412,9	124,8	2,1	306,2	137,6	1,0	106,7
Kharkiv	381,7	84,3	2,0	708,7	129,7	2,3	-327,0
Kherson	12,6	25,4	0,1	9,8	43,0	0,0	2,8
Khmelnyskiy	431,3	128,2	2,2	322,3	108,9	1,1	108,9
Cherkasy	678,6	134,3	3,5	375,9	136,1	1,2	302,8
Chernivtsi	113,6	90,5	0,6	251,0	130,2	0,8	-137,4
Chernihiv	470,3	152,9	2,4	143,6	114,5	0,5	326,7
Kyiv city	5056,0	100,0	26,1	12981,1	135,0	42,6	-7925,1

Data exclude the territories which are temporarily occupied by the russian federation and part of territories where the military actions are/were conducted.

Source: based on[20].

Some regions located in the central and western parts of the country increased their exports of goods abroad. In particular, in the first half of 2023, compared to the same period in 2022, the highest growth rates in exports of goods were observed in Chernihiv (152.9%), Vinnytsia (141.9%), Cherkasy (134.3%), Odesa (129%), Khmelnytskyi (128.2%), Kirovohrad (127%), Ternopil (124.8%), and Sumy (122.5%) regions.

In the first half of 2023, the following regions can be distinguished, which account for a significant share of goods exports in the total volume: Kyiv city (26.1%), Dnipro (12.9%), Lviv (7.4%), Odesa (5.6%), Kyiv (4.5%), Vinnytsia (4.3%), and Zakarpattia (4.1%) regions. Among the western border regions, Lviv region has the largest exports of goods and the highest growth rates. This region has become the main logistics center connecting Ukraine with foreign markets.

Ukraine needs to import goods from abroad, as the war has resulted in the loss of production capacity and the inability to produce certain types of goods. Therefore, the growth rate of imports of goods is higher than the growth rate of exports of goods. In the first half of 2023, compared to the same period in 2022, the highest growth rates of imports of goods were observed in Rivne (166%), Zhytomyr (148.6%), Volyn (146.8%), Vinnytsia (141%), Ternopil (137.6%), Cherkasy (136.1%), Kyiv city and Kyiv region (135% and 135.4% respectively), and Chernivtsi (130.2%) regions.

Among the regions, there are those that account for a significant share of imports of goods in the total volume. In the first half of 2023, the share of imports of goods in the total value of Kyiv city was 42.6%, Lviv region – 9.3%, Dnipro and Kyiv regions – 7.2%, Volyn region - 4.1%, Odesa region – 3.5%, Zakarpattia region – 2.4%, and Kharkiv region – 2.3%. The share of imports of goods from other regions is low.

Thus, foreign trade in goods in the first half of 2023 showed signs of recovery, but the destruction of port infrastructure and the blocking of grain exports in the second half of the year will negatively affect Ukraine's foreign trade performance. Imports of goods exceeded exports, resulting in a deterioration in the foreign trade balance.

The value of exports to the EU decreased by 10%, caused by a drop in exports of most commodity groups, which is related to problems with the transit of agricultural products, temporary blocking of transit of agricultural products, and a ban on imports of grains and oilseeds by some EU member states. Therefore, the priority for the near future should be to diversify logistics routes by expanding land transport corridors to the EU in order to reduce dependence on the use of maritime transport in foreign trade[18].

### **3. THEORETICAL ASPECTS OF LOGISTICS AND TRANSPORTATION INFRASTRUCTURE AND ITS COMPONENTS**

Scientists call the peculiarities of moving material flows using infrastructure elements the infrastructure of logistics processes. Its components include:

external facilities – roads, integrated logistics service centers, railways, airports, seaports and waterways, telecommunication networks and facilities, auxiliary equipment for servicing linear and point facilities;

internal facilities – buildings and warehouses, internal roads, and other localized equipment for moving products and information.

The main tasks of the logistics infrastructure are:

- 1) storage of products using warehouse buildings and structures;
- 2) transportation of products by means of transport and manipulation equipment;
- 3) protection of products by means of a packaging system that allows modernization of vehicles, transfer of information, etc;
- 4) transformation of information of logistics processes[8].

The research of scientists in the field of logistics infrastructure has made it possible to distinguish its types: production, information, transport, warehouse, counterparty, financial and credit, economic and legal, and environmental.

The external components of the production logistics infrastructure reflect the opportunities associated with the creation and use of innovative equipment and technologies within the internal component, as well as the transfer of certain logistics operations to outsourcing, the use of information technologies and software systems for analysis, planning, support and decision-making.

The external component of the financial and credit component of the logistics infrastructure is represented by commercial banks, stock market operators, leasing companies, insurance companies, investment companies and funds[1].

Kariy O.I. and Podvalna G.V. believe that the logistics infrastructure is formed from the road transport infrastructure, pipeline infrastructure, air transport infrastructure, warehouse infrastructure, telecommunications infrastructure, maritime and river transport infrastructure, and railway infrastructure[6].

Logutova T.G. and Poltoratskyi M.M. note that the external logistics infrastructure is represented by the state strategic infrastructure, which forms its basic part and is a characteristic component of each type of transport:

- rail transport (main public railway lines and technological facilities and transmission devices located on them)
- maritime transport (hydraulic structures, public port infrastructure facilities);
- road transport (public roads);
- air transport (airfields and airfield facilities)[10].

V. A. Falovych believes that the elements of the logistics infrastructure include:

- transport communications (highways and railways, railroad sidings, etc.) warehousing (warehouses of various types and purposes, cargo terminals and terminal complexes)
- transportation units of various types of transport;
- telecommunication system;
- repair and auxiliary units that serve the transport and warehousing industry;
- information and computer system (a set of technical means and office equipment)[4].

The scientific works of scientists have made it possible to conclude that among the components of the logistics infrastructure, two groups should be distinguished – logistics and transport, each of which has its own elements.

Therefore, it is worth using the concept of “transport and logistics infrastructure”, which is a set of objects and entities of the transport and logistics infrastructure, including material, financial and information flows, performing the functions of transportation, storage, distribution of goods, as well as information and legal support of goods flows.

The transport infrastructure at the macroeconomic level includes:

- transport routes by type of transport – pipelines, transport hubs, sea, river and air ports, container terminals, railway transshipment and sorting stations, combined transport terminals
- buildings and structures for warehousing, technical equipment for cargo handling, picking, completion and packaging, loading and unloading operations, railway and automobile ramps.

Logistics infrastructure at the macro level includes:

- logistics service centers, specialized distribution centers, transport and storage facilities, logistics hubs;
- devices and means for processing and transmitting information, together with the relevant software.

Thus, the transport and logistics infrastructure includes transport, communication, warehouse and service elements[7].

#### **4. UKRAINE IN INTERNATIONAL LOGISTICS EFFICIENCY RANKINGS**

Today, Logistics Performance Index (LPI) is a universal tool for assessing the level of development of logistics infrastructure at the country level. This index has been calculated by the World Bank every two years since 2010 and allows to assess the ease of supply of goods and the development of trade logistics at the national and international levels.

International Logistics Performance Index (International LPI) provides a qualitative characterization of a country based on six components of logistics activities. The assessment is carried out by logistics professionals from trading partner countries who work outside the country being evaluated.

LPI is determined on the basis of a standardized online questionnaire and is based on the results of surveys of mainly international (transnational) logistics companies.

The survey of international logistics companies (global freight forwarders and express carriers) provides feedback on the logistics friendliness of the countries in which they operate and those with which they trade. They combine in-depth knowledge of the countries in which they operate with informed, qualitative assessments of other countries in which they trade and for which they have experience of the global logistics environment. The LPI rankings include five criteria that are used to assess the following processes: Customs, Infrastructure, International shipments, Logistics quality and competence, Tracking and tracing, Timeliness.

LPI components range from 1 to 5, with “1” indicating lower logistics performance and “5” indicating higher logistics performance. The main components of the International LPI and their weighting factors are shown in table 3.



Table 3. *Components of the International LPI and their weighting factors*

Components	The essence of the component	Weight factor
Customs	efficiency of customs and border management	0,4072
Infrastructure	quality of transport infrastructure (ports, railways, roads, information technologies, etc.)	0,4130
International shipments	ease of organization of delivery at competitive prices	0,3961
Logistics quality and competence	quality of logistics services and competence of personnel	0,4166
Tracking and tracing	the ability to track shipments	0,4106
Timeliness	the time at which the shipment reaches the customer within the planned or expected delivery time	0,4050

Source: The Logistics Performance Index[22].

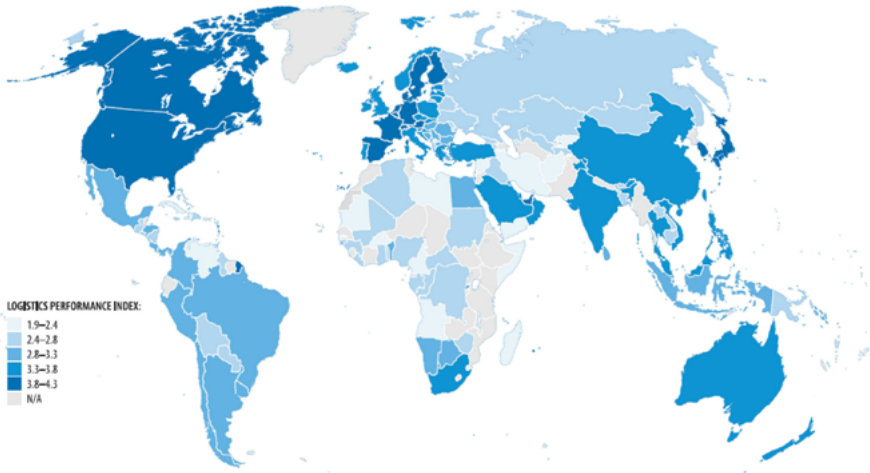
LPI consists of six sub-indices using principal component analysis (PCA), a standard statistical technique used to reduce the dimensionality of a data set. In the LPI, the inputs for PCA are the performances of countries (answers to questions 10-15), averaged across all respondents who provide data on that foreign market. Prior to PCA, the scores are normalized by subtracting the mean of the sample items and dividing by the standard deviation. To construct the international LPI, the normalized scores for each of the six original indicators are multiplied by the weight of their components and then summed[5].

The 2023 edition contains an expanded data set, consisting of a survey based on the traditional survey of logistics professionals and new key performance indicators (KPIs) measuring the actual speed of trade around the world. The new KPIs are derived from large global tracking datasets (Big Data) covering speed and delay estimates for container, postal and air freight. The new KPIs have not yet been incorporated into the construction of the LPI core indicators (country scores and rankings), which remain exclusively based on LPI study. The two categories of indicators provide a complementary but consistent understanding of logistics performance. KPIs measure time or calculate the performance of specific links (e.g., delays at ports or airports), while LPI provides survey-based, nationwide assessments of six aspects of logistics productivity.

LPI is an interactive benchmarking tool designed to help countries identify the challenges and opportunities they face in performing trade logistics, as well as what they can do to improve their performance. LPI is based on two components: a worldwide survey of international logistics operators in the field (global freight forwarders, freight forwarders and express carriers), providing feedback on the logistics “friendliness” of the countries with which they trade; indicators derived from global

tracking datasets (measuring speed and delays for container, postal and air transport, thus complementing the core indicator but not included in its assessment). Thus, logistics productivity is measured from two different perspectives, as LPI consists of both qualitative and quantitative indicators and helps to create logistics profiles for countries. It measures performance along the logistics supply chain in a country.

The international LPI 2023 allows comparing 139 countries (Fig. 1.)



*Fig. 1. Trade Logistics in the Global Economy, 2023.*

Source: Logistics Performance Index, 2023[2].

According to LPI ranking, Singapore, Finland, Denmark, Germany, the Netherlands, Austria, Belgium, Canada, and Hong Kong (China) have the most developed logistics systems. In the 2014, 2016, and 2018 rankings. Germany was ranked first with the best results. In 2023, Finland was ranked 2nd in the ranking. In 2018, Sweden was in 2nd place, having risen from 6th in 2014 and 3rd in 2016, and in 2023 it dropped to 11th place in the ranking.

Table 4 shows the ranking of countries and Ukraine’s place in it in 2023.

*Table 4. Ranking of countries by the International Logistics Performance Index in 2023*

Economy	Rating	LPI score	Customs score	Infrastructure score	International shipments score	Logistics competence and quality score	Timeliness score	Tracking and tracing score
Singapore		4.3	4.2	4.6	4.0	4.4	4.3	4.4
Finland		4.2	4.0	4.2	4.1	4.2	4.3	4.2
Denmark		4.1	4.1	4.1	3.6	4.1	4.1	4.3
Germany		4.1	3.9	4.3	3.7	4.2	4.1	4.2
Netherlands		4.1	3.9	4.2	3.7	4.2	4.0	4.2
Switzerland		4.1	4.1	4.4	3.6	4.3	4.2	4.2

Austria		4.0	3.7	3.9	3.8	4.0	4.3	4.2
Belgium		4.0	3.9	4.1	3.8	4.2	4.2	4.0
Canada		4.0	4.0	4.3	3.6	4.2	4.1	4.1
Hong Kong SAR, China		4.0	3.8	4.0	4.0	4.0	4.1	4.2
Sweden		4.0	4.0	4.2	3.4	4.2	4.2	4.1
United Arab Emirates		4.0	3.7	4.1	3.8	4.0	4.2	4.1
France		3.9	3.7	3.8	3.7	3.8	4.1	4.0
Japan		3.9	3.9	4.2	3.3	4.1	4.0	4.0
Spain		3.9	3.6	3.8	3.7	3.9	4.2	4.1
Taiwan, China		3.9	3.5	3.8	3.7	3.9	4.2	4.2
Korea, Rep.		3.8	3.9	4.1	3.4	3.8	3.8	3.8
United States		3.8	3.7	3.9	3.4	3.9	3.8	4.2
Australia		3.7	3.7	4.1	3.1	3.9	3.6	4.1
China		3.7	3.3	4.0	3.6	3.8	3.7	3.8
Greece		3.7	3.2	3.7	3.8	3.8	3.9	3.9
Italy		3.7	3.4	3.8	3.4	3.8	3.9	3.9
Norway		3.7	3.8	3.9	3.0	3.8	4.0	3.7
South Africa		3.7	3.3	3.6	3.6	3.8	3.8	3.8
United Kingdom		3.7	3.5	3.7	3.5	3.7	3.7	4.0
Estonia		3.6	3.2	3.5	3.4	3.7	4.1	3.8
Iceland		3.6	3.7	3.6	3.3	3.5	3.6	3.7
Ireland		3.6	3.4	3.5	3.6	3.6	3.7	3.7
Israel		3.6	3.4	3.7	3.5	3.8	3.8	3.7
Luxembourg		3.6	3.6	3.6	3.6	3.9	3.5	3.5
...								
Poland	33	3.6	3.4	3.5	3.3	3.6	3.9	3.8
...								
Ukraine	87	2.7	2.4	2.4	2.8	2.6	3.1	2.6
...								
Cameroon	135	2.1	2.1	2.1	2.2	2.1	2.1	1.8
Haiti	136	2.1	2.1	1.8	2.3	2.0	2.5	2.1
Somalia	137	2.0	1.5	1.9	2.4	1.8	2.3	1.8
Afghanistan	138	1.9	2.1	1.7	1.8	2.0	2.3	1.6
Libya	139	1.9	1.9	1.7	2.0	1.9	2.2	1.8

Source: The Logistics Performance Index, 2023[2; 22].

In the Logistics Performance Index (LPI) ranking, Ukraine ranks 87th out of 139 countries in 2023, 66th out of 160 countries in 2018, 80th in 2016, and 61st in 2014.

The LPI value for Ukraine in 2010–2023 indicates that there are changing trends in the development of the logistics sector in the country. The country demonstrated the greatest progress in 2010–2012, when it rose from 102nd to 66th position among 155 countries within two years. In 2023, there was a significant decline in Ukraine's rating due to the destruction of logistics infrastructure during the full-scale war of 2022–2023, disruption of supply chains with eastern countries, closure of air transport and complications of maritime transportation.

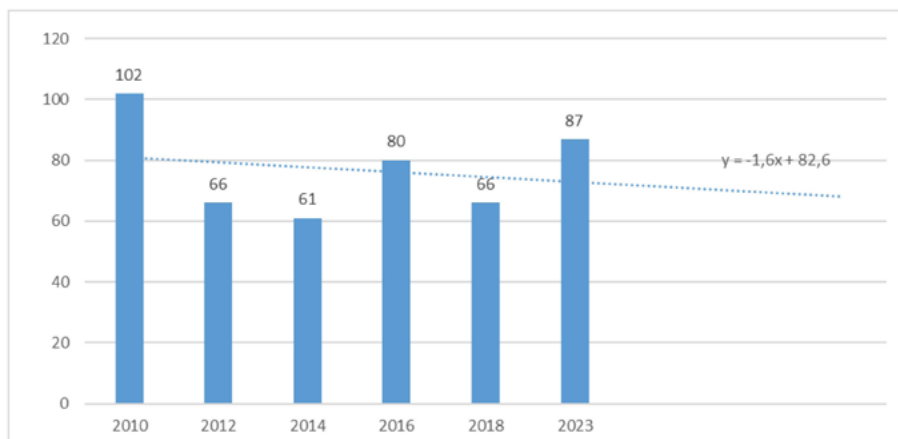


Fig. 2. Ukraine's ranking in the International Logistics Performance Index in 2010-2023. Source: The Logistics Performance Index, 2010–2023 [3].

In terms of index components, Ukraine's progress is observed in almost all of them, except for infrastructure. In 2010, the average score for the infrastructure component was 2.44, and in 2018 it dropped to 2.22. Ukraine demonstrates a fairly stable score in the international transportation component. However, such components as "timeliness" and "traceability" have undergone significant improvements (table 5).

Table 5. *Ukraine's score on the main components of the International LPI on a 5-point scale in 2010–2023, points*

Період	LPI	Customs	Infrastructure	International shipments	Logistics competence and quality	Timeliness	Tracking and tracing
2010	2,57	2,0	2,4	2,8	2,6	3,1	2,5
2012	2,85	2,41	2,69	2,72	2,85	3,31	3,15
2014	2,98	2,69	2,65	2,95	2,84	3,51	3,2
2016	2,74	2,3	2,49	2,59	2,55	3,51	2,96
2018	2,83	2,5	2,2	2,8	2,8	3,4	3,1
2023	2,7	2,4	2,4	2,8	2,6	3,1	2,6

Source: The Logistics Performance Index, 2010–2023[3].

In most components, the results of 2023 are close to the values of 2010. Compared to the previous study conducted in 2018, Ukraine has lost ground in the ranking due to a decrease in the efficiency of customs and border management, deterioration in the quality of logistics services, shipment tracking, and late deliveries.

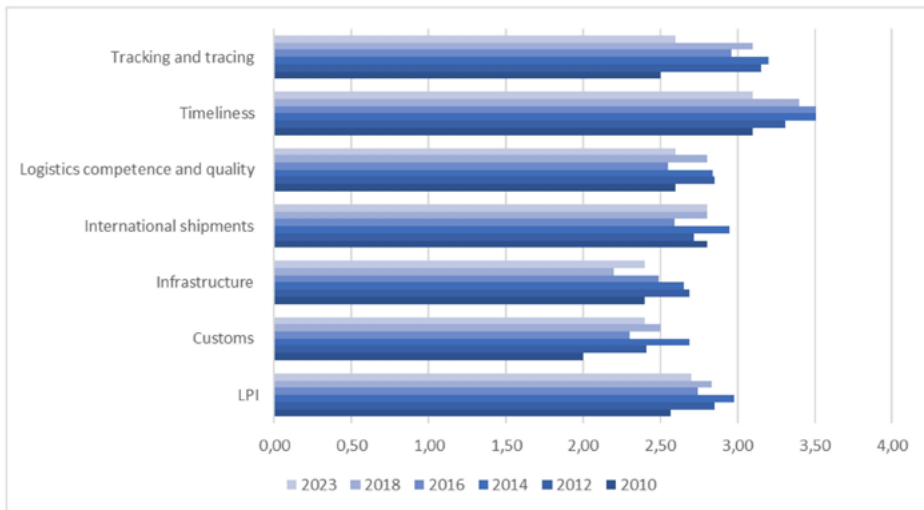
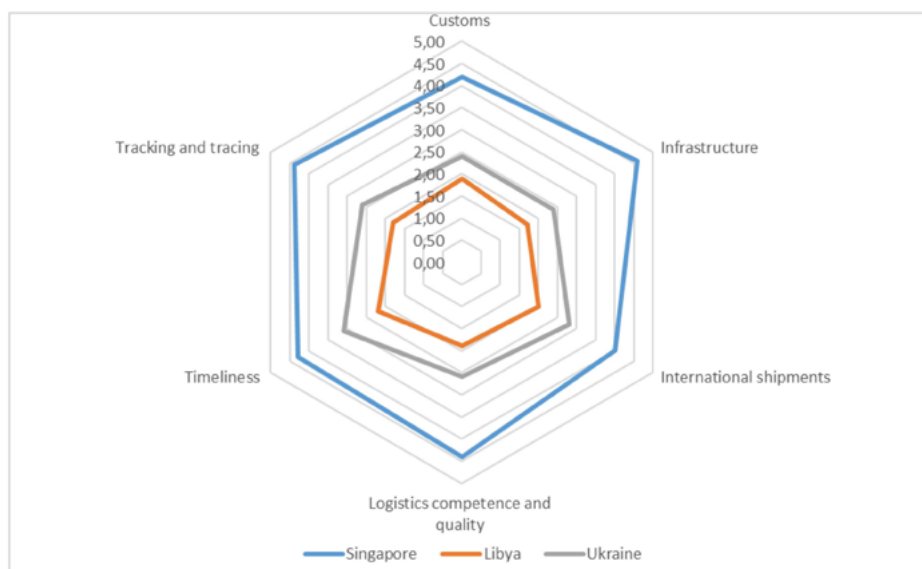


Fig. 3. Main components of the International LPI in Ukraine in 2010–2023.

Source: The Logistics Performance Index, 2010–2023[3].

Compared to Singapore, which is at the top of the ranking, Ukraine looks like a weak country. However, when compared to the weakest country in the ranking, Libya, we understand that these are averages. And the 87th place in the ranking among 139 countries in the context of war and large-scale destruction is partly a victory and a significant achievement (figure 4).



*Fig. 4.* Main components of the International LPI of Ukraine in comparison with the leader and outsider of the rating, 2023.

Source: The Logistics Performance Index, 2023[2].

Based on the diagnostic results, we can conclude that low-income countries mainly focus on logistics infrastructure and transport facilitation, while middle-income countries intend to improve logistics competencies and services, as well as trade rules. On the other hand, high-income countries are paying more attention to green logistics and information systems. This means that wealthier regions have more opportunities to promote the sustainable development of green logistics.

Thus, despite the significant potential for the development of the logistics industry, Ukraine continues to lag behind and demonstrates a deterioration in the situation during the war. To improve the situation, Ukraine needs to implement a set of measures to improve its logistics infrastructure and find new approaches to management, as well as to automate logistics processes. Only through joint efforts of the state and logistics stakeholders can the rating of the logistics efficiency index be improved and the goals set by the National Transport Strategy of Ukraine for the period up to 2030 be achieved[13].

## 5. DIAGNOSTICS OF THE LOGISTICS AND TRANSPORT INFRASTRUCTURE OF UKRAINE'S REGIONS BORDERING THE EU

The main function of the logistics and transport infrastructure for freight transportation is to ensure reliable, safe, timely deliveries of goods (international, transit,

domestic) in the required quantity to its consumers. The assessment of the logistics and transport infrastructure was carried out by the following components: border infrastructure, which includes the analysis of checkpoints, roadside service infrastructure, and the institutional component of the logistics and transport infrastructure for freight transportation.

#### *Border infrastructure*

Currently, there are 21 international border crossing points for freight transportation on the border with the EU, including 11 for road traffic and 10 for rail traffic.

There are 3 checkpoints for freight transportation in Volyn region: 1 for road transportation and 2 for rail transportation. In Lviv region, there are 6 checkpoints for freight transportation: 4 for road and 2 for rail. In Zakarpattia region, there are 9 operating checkpoints for freight transportation, 5 of which are railroad checkpoints (one of which is Pavlovo-Matyovtse). In Chernivtsi region, there are 2 checkpoints, 1 for each type of transport.

Among the automobile checkpoints, Yahodyn-Dorohusk has the largest design capacity for the passage of freight vehicles (800 freight vehicles). The capacity of the Krakivets-Korchova (Poland), Uzhhorod-Vysne Nemecke (Slovakia), Tisa-Zahony (Hungary), and Porubne-Siret (Romania) checkpoints is high, with a capacity of 500 trucks[16].

All road border crossing points on the border with Poland are characterized by a significant overload of actual throughput compared to their design capacity. Border crossing points on the border with Slovakia, Hungary, and Romania are operating at the limit of their design capacity. Some of them are characterized by lower vehicle throughput rates relative to their design capacity.

Among the railroad checkpoints, Chop-Cierna nad Tisou (Slovakia) has the highest design capacity of 2000 freight cars per day. The three largest in terms of design capacity also include Volodymyr – Hrubieszow (Poland) and Pavlove-Matyovce (Slovakia).

In 2021, 268105 freight cars and 10641 thousand tons of cargo passed through the Volodymyr - Hrubieszow checkpoint, which accounted for 29% of the cars and 33% of all cargo passed through the border with the EU, respectively.

In 2020, the share of freight transportation by rail to neighboring EU member states in the total amount of rail transportation across all sections of the state border of Ukraine amounted to 46% (in 2013 – 41%). The Ukrainian-Polish section of the state border accounts for one third of all freight transportation by road (table 6).

Table 6. *Characteristics of the border infrastructure of Ukraine's border regions (with EU countries) in 2022*

Regions	Capacity of checkpoints for road traffic (day)				Capacity of checkpoints for rail traffic (day)			
	Trucks, units	% to the total amount	Cargoes, thousand tons	% to the total amount	Freight cars, units	% to the total amount	Cargoes, thousand tons	% to the total amount
Volyn region	954	27	10,5	22,4	812	31,88	31,2	35,06
Lviv region	1343	38	18,4	38,6	182	7,15	5,66	6,36
Zakarpathian region	867	24,5	12,14	25,9	1423	55,87	48,68	54,7
Chernivtsi region	307	8,7	4,87	10,4	130	5,1	3,45	3,88
Odesa region	66	1,9	1,02	2,17	-	-	-	-
Total	3537	100	46,93	100	2547	100	88,99	100

Source: according to the State Customs Service of Ukraine[19].

Lviv region has the largest capacity of checkpoints for road traffic. As of 2022, 38% of trucks and 38.6% of all cargo passed through road checkpoints in Lviv region. With a design capacity of 970 trucks, the actual capacity is 1348 trucks per day. The Volyn region also exceeded the design capacity (954 vehicles against the design capacity of 800 vehicles per day). Other regions do not fully utilize the design capacity. The development of the network of checkpoints for freight transportation should take into account the specifics of the functioning of the entire network of checkpoints on the Ukraine-EU border.

The capacity for rail transportation is highest in Zakarpattia and Volyn regions (1423 and 812 freight cars per day, respectively). At the same time, the capacity utilization in the Zakarpattia region is low compared to the design capacity – 27% (design capacity of 5270 freight cars per day). Other regions' rail transport capacities are also underutilized: Volyn region – 65%, Chernivtsi region – 18%. Lviv region is characterized by an excess of actual capacity over the design capacity in terms of rail traffic.

As of 2022, railway checkpoints for freight transportation on the Ukraine-EU border were operating at a third of their design capacity. The formation of queues at these checkpoints is due to a lack of rolling stock, the lack of integration of the national and European rail networks, and the inability of the latter to handle the much higher volumes of cargo during the war.

#### *Roadside service infrastructure*

As of the beginning of 2022, there were 1,045 parking and parking facilities for vehicles on public roads of national importance. Their number ranged from 16 in Donetsk region (on the territory controlled by Ukraine) to 238 in Zhytomyr region. On average, the number of parking spaces ranged from 4 to 42 for trucks.

These parking lots offered various service facilities, including recreation areas, food outlets, retail outlets, gas stations, service stations, hotels, motels, campsites, etc. Every second such parking lot is equipped with a rest area/stop, parking lot, or



TIR parking. Every third has a food outlet, cafe or gas station, while only 12% have service stations.

The border areas of the Western region of Ukraine account for 20% of the total number of parking lots and parking spaces for vehicles. There are 39 in Volyn region, 29 in Zakarpattia, 55 in Lviv, 37 in Ivano-Frankivsk, and 46 in Chernivtsi. Almost half of them are located on international roads - 42%. A little more than a third of the parking lots and parking areas for vehicles are located on roads of national importance. The total area of such parking lots in the border regions ranges from 60 to 100,000 square meters with a capacity for trucks from 2 to 600 units [16].

At the end of 2020, there were 6609 gas stations in Ukraine. There were 166 in Volyn region, 266 in Zakarpattia, 351 in Lviv, 173 in Ivano-Frankivsk, and 180 in Chernivtsi. With the exception of Lviv and Ivano-Frankivsk regions, the number of gas stations in the rest of the regions has increased compared to 2013.

The characteristics of roadside service infrastructure are shown in table 7.

Table 7. *Characteristics of roadside service infrastructure in the border regions of the Western region of Ukraine in 2022*

Regions	Frequency of placement of parking lots and parking spaces*, km	Average size of parking lots and parking spaces, number of parking spaces	Frequency of placement of gas stations**, km
Volyn region	149	42	46
Lviv region	150	21	21
Zacarpathian region	114	15	13
Ivano-Frankivsk region	106	4	20
Chernivtsi region	63	6	17
Ukraine	152	13	25

\* Calculated as the ratio of the length of public roads with a hard surface to the number of parking lots and parking spaces.

\*\* Calculated as the ratio of gas stations to the number of parking lots and parking spaces.

Source: compiled according to the State Statistics Service of Ukraine[20].

Chernivtsi and Zakarpattia regions are characterized by a higher frequency of parking lots and parking spaces and gas stations. In terms of the number of parking spaces, Volyn region is significantly ahead of the other regions.

Among the border regions of the Western region of Ukraine, Zakarpattia Oblast has the highest level of roadside service infrastructure development.

*Institutional component of the logistics and transport infrastructure of Ukraine for freight transportation*

Integration of the national transport network into international transport corridors (ITC) creates additional incentives for economic growth, in particular, by realizing its transit potential, increasing passenger and freight traffic, improving transport and logistics infrastructure, expanding opportunities to attract investment from European funds, developing multimodal transportation, etc.

Table 8. *Characterization of international transport corridors that run through the territory of the border regions of Ukraine in 2022*

Regions	Total length, km	The length of the international road, km	Share of MTC coverage by roads of international significance, %
Volyn region	271,4	158,4	58,36
Lviv region	639,9	639,9	100
Zacarpathian region	404,4	225,1	55,7
Ivano-Frankivsk region	127,6	0	0
Chernivtsi region	145,7	86,8	59,6

Source: Planning schemes for Volyn, Lviv, Zakarpattia, Ivano-Frankivsk, and Chernivtsi regions.

Among the border regions, Lviv Oblast is the only one with a 100% coverage of internationally important roads. In addition, it outperforms other border regions in terms of the number and length of ITCs. At the same time, Ivano-Frankivsk region is the only region with a share of international roads in its ITC coverage of zero. The project routes of the Crete No. 5 and Europe-Asia ITCs pass through this region via roads of national, regional, and local importance. The length of the ITC (127.6 km) in Ivano-Frankivsk region is also the smallest. Despite the fact that in other regions the share of ITC coverage by international roads is more than 50%, certain road sections need to be brought up to the appropriate standards, in particular, reconstruction or construction.

During the war, which has been going on since 2022, problems in the field of logistics infrastructure have become more acute. Thus, the difficulties faced by Ukrainian business in the context of the war include:

- refusal to accumulate (financial difficulties, the danger of storing goods in warehouses due to the possibility of attacks from the aggressor);
- change in warehouse conditions: (relocation of large hubs from the center of eastern to western Ukraine, where there is no warehouse space of the required size);
- difficulties with the procurement of goods (limited assortment and suppliers, blocking of ports and load on the railway infrastructure);
- complications of logistics operations (checkpoints, inspections, curfews, and it is also necessary to plan backup routes in advance, as there is a risk of new attacks);

- disruption of supply chains (no possibility of air and sea delivery, limited rail transportation);
- a significant increase in fuel prices for refueling vehicles;
- lack of drivers to transport goods, which increases delivery time;
- complications in the transportation of commercial goods, as humanitarian and military cargoes (food, water, clothing, hygiene products, medicines, ammunition) are prioritized;
- congestion of routes (the only way to import and export goods to Europe is through the western border, which creates a heavy load, queues, and thus delays)[14].

## **6. DIRECTIONS FOR THE DEVELOPMENT OF LOGISTICS AND TRANSPORT INFRASTRUCTURE IN THE REGIONS BORDERING THE EU**

In Ukraine, as in most EU countries, road transport has remained the leader in terms of freight transported over the past 10 years. It accounts for more than 75% of all transportation. The total share of river, sea and air transport in freight transportation in Ukraine remains extremely small and amounts to about 0.4% of the total volume of domestic freight transportation. At the same time, in neighboring EU countries, it ranges from 2.6 to 18.7%.

In terms of rail freight turnover, Ukraine is comparable to the total freight turnover of four neighboring EU countries. Ukraine's developed railroad network makes it likely to play an important role in the European freight market in the future. Its freight turnover is 50% higher than that of the German railways, which is the leader in the EU.

Transport communications are still one of the constraints to enhancing the potential of Ukraine's logistics and transport infrastructure. The length of high-speed roads in the country remains extremely small, and the technical condition of the road transport network is unsatisfactory. During 2010–2023, it was in the Customs and Infrastructure components that Ukraine demonstrated the lowest scores in the Logistics Performance Index[2; 3].

Among the border regions of the Western region of Ukraine, Lviv region is characterized by the highest level of development of transport networks. Other regions are above the average level in Ukraine. In the post-war period, the restoration and development of transport communications and transport infrastructure (transport interchanges, bridges, etc.) should take into account the needs of domestic and foreign markets in terms of freight volumes and logistics and provide for the active introduction of smart and energy-efficient transport technologies.

The lack of a comprehensive and systematic state policy in the development of freight transportation by rail has led to a 58.1% drop in freight car production in 2021 and a 70.1% drop in 2020. In 2021, only 1213 units of the railcar fleet were produced, in 2020 – 3241 units[16; 17].

The decline in demand for railcar production and the failure to realize the potential of production facilities to produce railcars that meet domestic requirements and standards have led to the decline of the railcar industry. Moreover, the production base of the enterprises allows them to meet both domestic and foreign demand for their products.

Based on the currently available data on the design capacity of road border crossing points for freight transportation, the border crossing points with Poland are operating beyond their design capacity, while the border crossing points with Slovakia, Hungary, and Romania are operating at the limit of their design capacity. This is one of the reasons for the formation of huge queues at the border and one of the significant deterrents to the growth of international and transit freight traffic.

In order to plan to increase the capacity of the road checkpoint network, it is necessary to assess (update) the design capacity, taking into account the modernization measures already taken (introduction of modern information solutions, increase in the number of lanes, duration of customs, phytosanitary and other types of control, etc.

The development of intermodal and container terminals will help to increase the potential of the logistics and transport infrastructure by increasing its capacity, expanding the geography of transportation, expanding the list of transport and logistics services, developing all types of transport, attracting investment resources, etc. In the EU, the share of containerized transportation reaches 45%. However, in Ukraine, unlike in the developed world, their share in the total rail traffic remains extremely low. According to various estimates, it ranges from 0.5 to 2.3% [16].

An equally important component of the development of logistics and transportation infrastructure in the road transportation sector is the further development of roadside service infrastructure. This will help to ensure that truck drivers comply with the work and rest schedule.

An important factor in the further development of the road freight transport market is compliance with the current European Directive on vehicle weights and dimensions in order to harmonize national rules, facilitate cross-border transportation, and contribute to energy efficiency and emissions reduction [19].

The loss of part of the transit potential and closed borders in the East and North are changing the priorities for planning and restoring transport infrastructure and creating new transport corridors. Logistics routes have also undergone significant changes. Carriers that used to transport cargo to France, Spain, and Italy before the war have shifted to other destinations, including Romania, Bulgaria, and Poland. This had a direct impact on the European freight market.

In 2022, the logistics industry in Ukraine faced new challenges, including fuel shortages and the introduction of power outage schedules, and adapted to modern realities: the operation of gas stations during air raids or power outages, the operation of customs terminals for import and export clearance, and the blackout at checkpoints.

The reorientation of the main international and transit freight traffic towards Ukraine's western border has increased the burden on the border infrastructure of

the border regions. This has resulted in the periodic formation of huge queues of trucks and railcars in front of checkpoints.

A number of measures have already been taken to increase the capacity of checkpoints in 2022–2023[15; 23; 24; 26]:

- the organization of traffic at certain checkpoints on the Ukrainian-Polish border was changed. From September 1, 2022, until the end of 2022, the movement of freight vehicles with a permissible maximum weight of more than 7.5 tons was carried out through four checkpoints: “Rava-Ruska, Krakivets, Shehyni, and Yahodyn. Passenger cars and passenger buses remained unchanged at these checkpoints, with the exception of Yahodyn, where passenger cars were temporarily not allowed;
- modernization of certain checkpoints. In particular, the number of lanes for trucks at Krakivets–Korczowa was increased from 4 to 10;
- measures were agreed with the Polish side to optimize the work of phytosanitary and veterinary services;
- new checkpoints for trucks without cargo were opened (Krasnoilsk–Vikovu de Sus, Nyzhankovychi–Malkhovice, Dyakivtsi–Rakovets);
- introduction of the e-queue (eCheck) on the Ukrainian–Polish border at the Yahodyn checkpoint in a test mode on December 12, 2022;
- resumption of railway communication with Romania by reconstructing a wide gauge in the direction of Galati (Romania).

Areas for improving the efficiency of the transport and logistics infrastructure include:

- formation of the global transportation market, development of new land routes; development of combined and containerized transportation;
- increase in the level of intellectualization of transport systems and transport and logistics infrastructure facilities;
- spread of new forms of financing for transport sector development projects;
- infrastructure development and integration of various types of land transport;
- active implementation of innovations in the railway transport activity;
- harmonization of regulatory and legal regulation of transport and logistics activities, unification of technical standards and transport and logistics technologies;
- organization of container trains;
- creation of modern terminal and warehouse complexes in the border regions that are as far away from active hostilities as possible;
- expanding the portfolio of cargo transportation services (door-to-door and just-in-time delivery);
- reduction of cargo handling time[9].

The potential for developing the logistics and transport infrastructure of Ukraine’s regions bordering the EU will also be enhanced:

- development of warehousing facilities in locations close to border crossings with Poland, Hungary, Romania and Slovakia;
- increasing investment in the construction of elevators;

- implementation of projects for partial or full integration of the railway infrastructure with the European one;
- development of alternative routes, including for container transportation;
- further development of multimodal transportation services.

Ukraine should take an active position in developing new transportation corridors and improving existing ones. With new logistics routes bypassing Russia and Belarus being built, the country's transport infrastructure could become an important component of new trade routes. Ukraine's domestic freight transportation system needs to integrate river and air ports to a greater extent, as their potential is currently underutilized.

In general, to clearly understand the directions of further development of the logistics and transport infrastructure of Ukraine and its regions, it is necessary to conduct a comprehensive assessment of the prospective volumes and directions of cargo flows through the territory of Ukraine in the long term.

## 7. CONCLUSIONS

Ukraine and its border regions have significant potential to increase international and transit freight traffic. An important prerequisite for its realization is the formation of an effective institutional environment integrated into the European economic area by ensuring the fulfillment of the tasks stipulated by the EU-Ukraine Association Agreement in terms of transport, adaptation of the European and Ukrainian freight markets to the requirements of the European Green Deal, and development of cooperation within the Eastern Partnership transport panel[27].

Improvement of the state border crossing infrastructure, in particular in terms of increasing the capacity of the EU-Ukraine customs border, should include optimization and stimulation of rail freight transportation; restoration and increase of the cargo handling capacities of railway terminals; development of a network of intermodal and transshipment terminals; creation of cross-border logistics hubs with the introduction of joint control by the authorities of neighboring countries and simplification of border crossing procedures for multimodal transport.

## REFERENCES

1. Bondarenko, O.S. (2015). Justification of the essence of logistics infrastructure and its role in the management of financial flows of enterprises. Investments: practice and experience. No. 8. P. 51-55. URL: [http://www.investplan.com.ua/pdf/8\\_2015/13.pdf](http://www.investplan.com.ua/pdf/8_2015/13.pdf)
2. Connecting to Compete (2023). Trade Logistics in an Uncertain Global Economy. The World Bank. P.74.

3. Connecting to Compete Report: Trade Logistics in the Global economy, The World Bank. 2007, 2010, 2012, 2014, 2016, 2018. URL: <https://lpi.worldbank.org/international/global>
4. Falovich, V.A. (2017). The use of logistics infrastructure in the supply chain. *Economy and society*. Issue No. 10. URL: [https://economyandsociety.in.ua/journals/10\\_ukr/68.pdf](https://economyandsociety.in.ua/journals/10_ukr/68.pdf)
5. Hrynychak, N. (2020). Statistical aspects of logistics performance index calculation and application. *Ekonomika ta derzhava*, vol. 3, pp. 138–143. DOI: 10.32702/2306-6806.2020.3.138
6. Kary, O.I., Podvalna, G.V. Logistics infrastructure of Ukraine in world ratings. URL: <https://science.lpnu.ua/sites/default/files/journal-paper/2018/mar/9644/ilovepdf-com-41-49.pdf>
7. Kharchenko, M.V. (2020). Transport and logistics infrastructure and its place in the socio-economic system of enterprises of Ukraine. *Economic space*. No. 153. URL: <http://srd.pgasa.dp.ua:8080/bitstream/123456789/5054/1/Kharchenko%20Maryna.pdf>
8. Krykavskiy, E.V. (2006). *Logistics. Basics of the theory: a textbook*. 2nd ed., add. and processing. Lviv: Lviv Polytechnic National University, Intellect-West. 456 p.
9. Kuzmenko, A.V. (2015). Theoretical foundations of the development of transport and logistics infrastructure of railway transport of Ukraine. *Mykolaiv National University named after V.O. Sukhomlynskyi*. Issue 5. <http://global-national.in.ua/archive/5-2015/96.pdf>
10. Logutova, T.G. (2017). Logistics infrastructure as an integral part of industrial enterprises association. *Theoretical and practical aspects of economics and intellectual property*. Vol. 15. P. 288–292.
11. Ministry of Finance of Ukraine. URL: <https://index.minfin.com.ua/ua/economy/gdp/eximp/>
12. Mitsenko, N.G., Mishchuk, I.P. (2022). The essence and problems of functioning of the international logistics system in extreme conditions. *Bulletin of the Lviv University of Trade and Economics. Economic sciences*. No. 68. URL: <http://journals-lute.lviv.ua/index.php/visnyk-econom/article/view/1168/1103>
13. National transport strategy of Ukraine for the period up to 2030: Decree of the Cabinet of Ministers of Ukraine dated 30.05.2018 No. 430. Official website of the Verkhovna Rada of Ukraine. Access mode: <https://zakon.rada.gov.ua/go/430-2018-%D1%80>
14. Negoda, A., Rusak, D. (2023). *International Logistics and Global Supply Chains: A Study Guide in Outlines*. 268 p.
15. Poland simplifies border crossing: list of goods. URL: <https://agronews.ua/news/polsha-sproshhuye-prohodzhennya-kordonu-perelik-tovariv/>
16. Prytula, H.M. (2023). Development of the logistics and transport infrastructure of the border regions of the Western region of Ukraine. Comparative systematic assessment: scientific and analytical report. State University “Institute of Regional Studies named after M. I. Dolishnyi National Academy of Sciences of Ukraine”. Lviv, 87 p.