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LEBEDEVA Larysa,
PhD (Economics), Associate Professor,
Associate Professor at the Department of
Economics and Competition Policy
State University of Trade and Economics
19, Kyoto St., Kyiv, 02156, Ukraine
ORCID: 0000-0001-8632-5460
l.lebedeva@knute.edu.ua

ЛЕБЕДЕВА Лариса,
к. е. н., доцент, доцент кафедри економічної теорії та конкурентної політики Державного торговельно-економічного університету
вул. Кіото, 19, м. Київ, 02156, Україна
ORCID: 0000-0001-8632-5460
l.lebedeva@knute.edu.ua

SHKUROPADSKA Diana,
PhD (Economics), Associate Professor
at the Department of Economics and
Competition Policy
State University of Trade and Economics,
19, Kyoto St., Kyiv, 02156, Ukraine
ORCID: 0000-0002-6883-711X
diana.shkuropadska2016@knute.edu.ua

ШКУРОПАДСЬКА Діана,
доктор філософії, доцент кафедри економічної теорії та конкурентної політики Державного торговельно-економічного університету
вул. Кіото, 19, м. Київ, 02156, Україна
ORCID: 0000-0002-6883-711X
diana.shkuropadska2016@knute.edu.ua

RESILIENCE OF TRANSPORT LOGISTICS IN EU AND UKRAINE

The Russian-Ukrainian war has significantly complicated the global logistics. Military actions have severely disrupted transport routes, leading to supply chain disruptions and triggering economic sanctions that have impacted global supply chains. The aim of the research is to identify key factors influencing the resilience of EU and Ukrainian transport logistics during the Russian-Ukrainian war, along with governmental policies aimed at enhancing this resilience. The hypothesis posited in the article suggests that ensuring transport logistics resilience during wartime is impossible without intergovernmental coordination and cooperation in route planning, infrastructure modernization, financing, and regulatory adaptation. To achieve this research aim, a combination of general scientific and specific methods was employed: historical and logical approaches, statistical analysis and aggregation, and the logical method. The article identifies three main attributes that define transport logistics resilience: the ability to withstand shock impacts, adaptability to shock impacts, and the ability to recover after shock impacts. Key challenges in business in Ukraine due to damaged transport infrastructure and logistics

СТІЙКІСТЬ ТРАНСПОРТНОЇ ЛОГІСТИКИ ЄС ТА УКРАЇНИ

Російсько-українська війна значно ускладнила логістичну ситуацію у світі. Бойові дії серйозно пошкодили транспортні маршрути, що спричинило порушення ланцюгів поставок та призвело до введення економічних санкцій, які вплинули на глобальні ланцюги поставок. Дослідження має за мету встановити значущі фактори, що впливають на стійкість транспортної логістики ЄС та України під час російсько-української війни, а також державної політики, яка сприяла б підвищенню цієї стійкості. Висунуто гіпотезу, що забезпечення стійкості транспортної логістики в умовах війни неможливе без міждержавної координації та співпраці у сферах планування маршрутів, модернізації інфраструктури, фінансування й адаптації нормативно-правового регулювання. Для досягнення мети дослідження використовувався комплекс загальнонаукових і спеціальних методів: історико-логічний підхід; статистичний аналіз та агрегація; логічний метод. Встановлено, що стійкість транспортної логістики визначається трьома властивостями: здатністю витримувати шоковий вплив; змогою адаптуватися до шокових впливів; здатністю відновлюватися після шокових

have been highlighted. Measures to ensure transport logistics resilience in Ukraine during wartime include transparent logistics system architecture, alternative delivery routes, cooperation and building reliable partnerships, and measures for monitoring and evaluating system effectiveness. Factors influencing transport logistics resilience in Ukraine and the EU have been determined, including the efficiency of customs and border procedures, the quality of trade and transport infrastructure, ease of organizing international deliveries at competitive prices, competence and quality of logistics services, and the ability to track shipments and ensure timely delivery to destinations. A comprehensive approach is proposed, encompassing infrastructure, organizational, technological, and economic measures to ensure transport logistics resilience.

Keywords: transportation system, resilience, European Union, logistics system, russian-ukrainian war.

впливів. Виокремлено основні проблеми бізнесу в Україні через пошкодження транспортної інфраструктури та логістики. Підкреслено заходи забезпечення стійкості транспортної логістики в Україні в умовах воєнного часу, як-от: прозорість побудови системи транспортної логістики; наявність альтернативних маршрутів доставки; кооперація та побудова надійних взаємовідносин з партнерами; заходи контролю й оцінки ефективності роботи системи. Визначено фактори, які впливають на стійкість транспортної логістики в Україні та ЄС: ефективність митних і прикордонних процедур; якість торгової та транспортної інфраструктури; легкість організації міжнародних поставок за конкурентоспроможними цінами; компетентність і якість логістичних послуг; здатність відстежувати вантажі; своєчасність доставки вантажів до місця призначення. Запропоновано комплексний підхід, що включає інфраструктурні, організаційні, технологічні та економічні заходи для забезпечення стійкості транспортної логістики.

Ключові слова: транспортна система, стійкість, Європейський Союз, логістична система, російсько-українська війна.

JEL Classification: L91, L98, O18, R40.

Introduction

Logistics and transportation ensure functioning of most industries, directly influencing development of state and competitiveness of national producers, enabling exports. The Russo-Ukrainian war has significantly impacted global logistics. The military actions have severely disrupted transport routes, leading to supply chain disruptions and economic sanctions that have affected global supply chains. The logistics sector is strategic for the development of state, ensuring budget revenues, and bringing national goods to international markets.

The processes of Ukraine's economic integration into the European Union stimulate rapid development of all sectors of economy, especially infrastructure and the transportation system. In fact, Ukraine has geographical advantages and is a convenient hub between Europe and Asia, located at the crossroads of major trans-European corridors, which enables foreign economic activities. The resilience of the transport logistics of the EU countries and Ukraine is an extremely relevant research topic, especially in the context of Russian aggression. Ukrainian and foreign researchers are actively studying aspects of transport and logistics resilience worldwide. Linkov and Palma-Oliviera (2017) state that the longer and deeper the impact of the disruption on operations, the less resilient a transport system is. Rehak et al. (2019) developed complex approach to assessing resilience of critical infrastructure elements, involving evaluation of their robustness, ability to recover functionality after the occurrence of a disruptive event and capacity to adapt to previous disruptive events. Jenelius and Mattsson (2021) made an assessment of transport resilience and key policy tools to facilitate it including mitigation measures that increase the robustness of the system and adaptation measures that increase the rapidity of recovery. Mazur et al. (2022) have developed an algorithm for choosing alternative routes with dynamic changes in the risks

of cargo transportation to strengthen transportation resilience. As for measures to facilitate transport resilience Cheimariotis et al. (2023) state that there are technical solutions, the detection and monitoring techniques, and the use of ICT and AI as enablers for resilience management and timely reaction to disruptions as well as for strategic and tactical solutions, projects develop resilience management and decision-making frameworks.

A comprehensive approach to ensuring economic resilience requires that different industries and sectors within a country are prepared to face challenges and respond to them in unity. Understanding the interconnection and interaction of these areas helps to holistically assess the economy's resilience in the context of modern realities. Among the key sectors ensuring economic resilience is the transportation industry, a vital industrial sector that handles the movement of people and goods (Umantsiv & Shkuropadska, 2023).

In the conditions of Russo-Ukrainian war, the changes that have occurred at both micro and macrolevels in the field of transport and logistics services have been shown by Osetskyi et al. (2023). Still, in extreme events in the period of war there are issues that hinder the transport resilience, transport and logistics risks that need to be researched.

The aim of the research is to find significant factors influencing the EU and Ukraine transport and logistics resilience during russo-ukrainian war and government policies that helped to promote transport and logistics resilience.

The hypothesis of the article is that ensuring the resilience of transport logistics in wartime conditions is impossible without interstate coordination and cooperation in route planning, infrastructure modernization, financing, and the adaptation of regulatory frameworks.

To achieve the aim of the research, a complex of general scientific and special methods was used: the historical and logical approach to understanding the essence of transport and logistics resilience; statistical analysis and aggregation for determining the key factors that influence transport and logistics resilience; the logical method for identifying directions to strengthen transport and logistics resilience.

The article is divided into four parts. The concept of transport and logistics resilience is presented in the first part. The state of transport logistics under martial law is assessed in the second part. An identification of key factors that influence transport and logistics resilience in EU and Ukraine is provided in the third. The directions to increase transport and logistics resilience are identified in the final fourth part.

1. The concept of transport and logistics resilience

Transport systems consist of infrastructure, management, transport users, and the interaction between these three (Jenelius & Mattson, 2021). Technical and physical infrastructure include rails, roads, terminals, airports, ports, vehicles, signals and signs. Transport users can be travellers, companies who want goods to be moved and society in general. Transport managers are the actors responsible for planning, operating and maintaining the infrastructure and services under given regulations and budgets (Jenelius & Mattson, 2021).

As a sector of material production, transport has its own product–the process of movement itself. In the logistics system, transport plays a crucial role; it is an integral part of the main functional areas of logistics. Transport offers its product–transport services–on the market for goods and services, for which it earns profit. Transport logistics is a system for organizing delivery, specifically the movement of any material items and substances from one point to another along the optimal route.

The transport system is a system-supporting subsystem of cities, agglomerations, and regions because it enables the functioning of transport flows. The resilience of the transport system lies in its ability to adapt under certain external and internal influences, ensure quality and positive changes with minimal deviations, and anticipate achieving equilibrium, socio-ecological-economic security, and a balance between socio-ecological-economic processes. It also contributes to the prevalence of reproduction rates over resource consumption rates in the process of organizing logistics flows (Averkina & Artyukh, 2018).

The formation and development of transport and logistics systems serve as indicators of the level of national economic development due to their resilience and adaptability to changes, thereby enhancing the competitiveness of the economic system. This is closely linked to the economic efficiency of business entities, economic independence, stability, and societal security (Kalycheva, 2017).

For a transportation system, resilience is the capability to recover from a disruption to an operational level similar to before the disruption in a timely manner (Linkov & Palma-Oliviera, 2017).

In scientific literature two important aspects to the resilience of transport systems are defined, such as:

Robustness. The robustness of a system determines the extent to which a deterioration of a system's functions is due to the disruption. The more robust a system, the less the system functions are affected. Transport systems are more robust or absorptive if they provide additional and alternative capacity (redundancy);

Rapidity of recovery. This is the time needed for a transport system to get back to the service level or level of operations before the disruption took place (time of recovery) (ITF, 2024; Rehak et al., 2019; Hill et al., 2017).

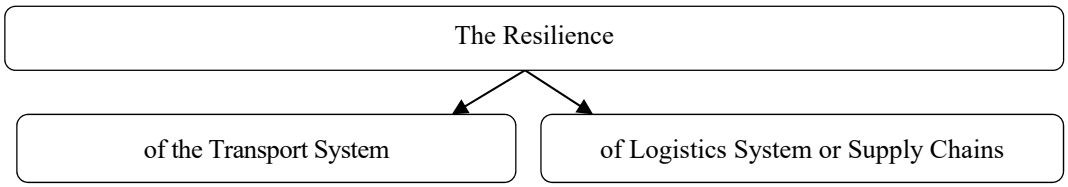
Resilience for a transport system is its ability to absorb disturbances, maintain its basic structure and function, and recover to a required level of service within an acceptable time and costs after being affected by disruptions. (Cheimariotis et al., 2023).

Transport resilience is identified at various levels (Cheimariotis et al., 2023):

- operational resilience: at the vehicle level for aviation and waterborne transport, ensuring safety and mission success against disruptions like weather, malfunctions, and traffic.
- planning and traffic management resilience: at the node and network level for aviation and rail, where disruptions can cause delays and cancellations to spread.

- surface physical infrastructure resilience: for rail, waterborne, and road transport, addressing aging, intensive use, and environmental damage through advanced monitoring systems for efficient maintenance and flow management.
- digital infrastructure resilience: ensuring robust sensor and ICT operations in communications, cloud computing, and human-machine interfaces across all transport domains.
- rolling stock and fleet resilience: implementing innovative solutions for damage detection and health monitoring of vehicles to enhance efficiency, safety, and predictive maintenance.
- critical infrastructure resilience and cybersecurity: developing frameworks for risk assessment, detection techniques, and robust ICT systems to counter physical and cyber threats.
- urban mobility resilience: integrating resilience measures across all urban transport modes.

Approaches to understanding the resilience of transport and logistics systems are presented in *Figure 1*.



Transportation resilience is defined as the ability of a transportation system to move people around in the face of one or more major obstacles to normal function. These obstacles can include extreme weather events, major accidents, and equipment or infrastructure failures (Rideamigos, 2024).	Resilience refers to the time it takes supply chains to predict and avoid risk, as well as respond and recover from costly disruptions (PLS Logistics Services, 2024).
For a transportation system, resilience is the capability to recover from a disruption to an operational level similar to before the disruption in a timely manner. The longer and deeper the impact of the disruption on operations, the less resilient a transport system is (The Geography of Transport Systems, 2024).	Supply chain resiliency is the ability to respond quickly to operational disruptions through flexible contingency planning and forecasting – from material sourcing to logistics and the final delivery of products and services (SAP, 2024).
Transport system resilience can be defined as the ability to prepare for and to withstand, absorb and adapt to shocks, and to recover from the consequences in a timely and efficient manner (Jenelius & Mattsson, 2020)	Supply chain resilience is a systematic capability of the supply chain to recover in time or reach a new and more ideal state when a disturbance occurs (Christopher & Peck, 2004).
Resilience is the ability of the transportation system to resist and adapt to external or internal disturbances and then quickly return to a normal service level to meet the original travel demand (Amghar et al., 2024)	Resilience capability can contribute to logistics and supply chains by creating an ability to avoid and mitigate unprecedented disruptions (Sadeghi R., Hasan, A., 2024).
Transport system resilience refers to the sector's capacity to deal with, adapt to and recover from disruptions. The transport sector currently faces a number of disruptions related to geopolitics, climate change and energy security (International Transport Forum, 2024).	Resilience in logistics management refers to maintaining structure and processes despite radical changes (Song et al., 2022).

Figure 1. Approaches to Understanding the Resilience of Transport and Logistics Systems

Source: compiled by authors.

The resilience of transport logistics refers to the ability of transport systems to withstand, adapt to, and quickly recover from various shocks, including natural disasters, economic crises, military actions, and technological accidents. The resilience of transport logistics depends on several factors, namely:

Infrastructure Reliability: the strength and reliability of transport infrastructure, which includes roads, bridges, railways, ports, and airports. The key aspect is the ability of these structures to endure military actions, extreme weather conditions, and natural disasters like earthquakes or floods.

System Adaptability: the capacity of transport systems to quickly adapt to changes in demand for transport services, economic conditions, and technological innovations. Adaptability is linked to the implementation of new technologies, optimization of logistic routes, and improvement of transport flow management.

Effective Risk Management: the ability to anticipate, analyze, and effectively respond to potential risks and threats that negatively impact transport logistics. Effective risk management involves having emergency action plans, monitoring systems, and early warning mechanisms.

Economic Efficiency: the capacity of the transport system to maintain efficiency and competitiveness amidst economic changes and crises. Economic efficiency is related to cost optimization, diversification of income sources, and ensuring financial stability.

Environmental Sustainability: the implementation of environmentally friendly technologies and practices to reduce the negative impact on the environment, lower greenhouse gas emissions, use alternative fuels, and develop electric transport.

According to the Florida Department of Transportation (FDOT, 2023), resilience is the ability of the transport and logistics system to adapt to changing conditions, prepare for disruptions, withstand them, and recover from them. The process of ensuring resilience begins with identifying potential disruptions in the functioning of the transport and logistics system and using design tools to continue the system's operation despite these disruptions. The advantages of resilient design include: weather-resistant infrastructure; safety considerations; benefits for commuter travel; movement of goods and services; environmental protection; economic opportunities, including access to transportation and employment in this sector; long-term economic benefits; resilience design allows the transport and logistics system to quickly adapt to changing conditions.

2. The state of transport logistics under martial law

Transport is one of the fundamental sectors of the economy. Before the full-scale Russian invasion, Ukraine's transport sector had an extensive railway network, a developed network of highways, seaports and river terminals, airports, and a wide network of aviation connections, as well as public passenger transport routes, bus stations, and freight customs terminals.

As can be seen from the *Table 1* the biggest share in transportation volumes were road (74%), rail (21%) and a small portion of pipeline (5%) in 2021.

Table 1

Dynamics of freight transportation volumes in Ukraine by modes of transport

Mode of transport	2017	2018	2019	2020	2021
	million t				
rail	339	322	313	306	314
road	1122	1206	1147	1232	1121
water	6	6	6	6	5
sea	2	2	2	2	2
river	4	4	4	4	3
air	0,1	0,1	0,1	0,1	0,1
pipeline	115	109	113	97	78
Total	1582	1643	1579	1641	1518
Mode of transport	Percentage of total volume				
rail	22	20	20	19	21
road	71	73	73	75	74
water	0	0	0	0	0
sea	0	0	0	0	0
river	0	0	0	0	0
air	0	0	0	0	0
pipeline	7	7	7	6	5
Total	100	100	100	100	100

Source: compiled by the authors according to (Transport of Ukraine 2022, 2023).

As a result of the military actions, the transport sector has suffered greatly (*Table 2*): 95% of roads are damaged; road fatalities are the highest in Europe; wear and tear on freight and passenger wagons exceeds 85%; and the logistic cost of transporting is 40% higher compared to EU countries (Ministry of Infrastructure of Ukraine, 2023).

Table 2

The scale of road destruction in Ukraine in 2022–2024.

Region	km roads
Kherson	3.941.0
Kharkiv	3.890.8
Zaporizhzhia	3.872.3
Luhansk	2.959.4
Donetsk	2.695.2
Mykolayiv	1.809.4
Sumy	1.584.6
Chernihiv	1512. 0
Kyiv	1.402.3
Dnipro	75
Poltava	63
Zhytomyr	49.3
Odesa	0.2
In total	23.854.5

Source: compiled by the authors according to (Recovery of Ukraine, 2024).

In 2024, the Government of Ukraine, together with the World Bank Group, the European Commission, and the United Nations, published a report on the updated joint assessment of damages and needs resulting from the widescale Russian invasion. Specifically, it is estimated that USD 2.3 billion is required for the restoration of transport and logistics infrastructure (Ministry of Infrastructure of Ukraine, 2024).

At the onset of the Russian invasion, Ukraine's export capabilities were effectively paralyzed. Air connections were completely halted, and the infrastructure of airports and railways was partially destroyed. Warehouses and offices of logistics companies were demolished or damaged due to constant shelling, leading many enterprises to declare bankruptcy or relocate their operations to Western Ukraine. Before the war, international trade primarily relied on rail and sea transport. Access to the Black Sea allowed shipments to reach almost any country in the world. However, after February 24, 2022, the blockade of seaports significantly affected both the scale of trade and the distribution of transport modes. In January 2022, 80% of exports were by sea, but by April, this share had fallen to 13%. Most shipments then shifted to rail and road transport, with a significant increase in deliveries to EU countries (Development of transport and logistics in Ukraine, 2024).

Certainly, the business challenges in Ukraine arising from the damage to transport infrastructure and logistics include:

Decreased inventory levels: High risks of loss and frozen finances have led to reduced stocks of goods in warehouses.

Shortage of warehouse space: Destruction of warehouses has resulted in a deficit of storage facilities for goods.

Procurement difficulties: Blockades of port infrastructure and congestion on railways have made it challenging to procure certain goods.

Complicated logistics operations: Checkpoints, curfews, and other factors have complicated logistics operations. Planning alternative routes has become necessary due to risks of new attacks.

Transport flow challenges: Redirecting transport flows to Western Ukraine and reopening the Odessa port have partially stabilized the situation, but transportation crises persist.

Overloading European infrastructure: European infrastructure struggles to handle the high volume of Ukrainian goods, leading to delays due to different rail gauges and low equipment productivity.

Significant infrastructure damage: Bridges, roads, ports, and other facilities have suffered substantial damage from combat actions and missile strikes, further complicating logistics.

As experts in the field of logistics state resilient supply chains are characterized by four pillars (Building Resilient Supply Chains, 2023):

Visibility – the ability to illuminate the entire supply chain and create supply chain visibility as a basic for risk identification.

Flexibility – the ability to quickly adapt to disruptions without significantly increasing operational costs.

Collaboration – the ability to develop symbiotic and trust-based relationships cross functionally, as well as with supply chain partners and strategic networks.

Control – the ability to implement and execute policies and processes that increase control of the supply chain, as well as expanding the span of control in the end-to-end supply chain.

For Ukraine, according to these four directions in wartime conditions, the following measures to ensure the resilience of transport logistics are becoming relevant:

- Transparency in building the transport logistics system.
- Availability of alternative delivery routes.
- Cooperation and building reliable relationships with partners.
- Measures for monitoring and evaluating the system's effectiveness.

Understanding the complex logistics situation in Ukraine, caused by the blockade of sea ports and damage to transport infrastructure, on June 29, 2022, Ukraine and the European Union signed an Agreement on Road Freight Transport, known as the "Transport Visa Waiver." The agreement abolishes the need for Ukrainian carriers to obtain permits for bilateral and transit transportation to EU countries, thus avoiding disruptions in the export of Ukrainian products through road border crossings (Decree of the President of Ukraine No. 654/2022, 2022, 16 September).

"The Transport Visa Waiver" with the EU opens up broad opportunities for Ukraine to develop transport logistics, improve infrastructure, enhance competitiveness, and integrate into European transport networks. It is worth noting that on June 20, 2024, the agreement was extended for another year. Thus, the agreement will remain in force at least until the end of 2025 with the possibility of automatic renewal.

A significant step in providing financial support for Ukraine's transport logistics was the signing of the Agreement on Ukraine's participation in the "Connecting Europe Facility" program on June 6, 2023, through which the EU allocated 33 billion euros for the development of Ukrainian transport infrastructure (Law of Ukraine No. 3469-IX, 2023, 21 November). The agreement allows Ukraine to collaborate with the EU in developing border infrastructure, border crossings, and the transport network, which will strengthen logistical connections and enhance the resilience of Ukraine's transport system in wartime conditions.

3. Factors of transport logistics resilience

Ensuring the resilience of transport logistics is a complex process that requires the continuous identification of factors that determine challenges and opportunities for the system. One of the tools for comparative analysis of countries' logistics profiles is the Logistics Performance Index (LPI). The LPI helps countries compare the challenges and opportunities they face in the field of transport logistics and identify ways to improve system efficiency.

The resilience of transport logistics is closely linked to the Logistics Performance Index (LPI), as it evaluates the efficiency of countries' logistics systems, including transport infrastructure and supply chain management. Sustainable transport logistics depends on the availability of high-quality

infrastructure, which is crucial for ensuring the uninterrupted delivery of goods even in challenging crisis conditions.

One of the components of the LPI is the ease of arranging international shipments at competitive prices. Resilient transport logistics implies a country's ability to maintain reliable and cost-effective transportation regardless of external factors. The LPI also measures the frequency of on-time deliveries, and resilient transport logistics aims to minimize delays and disruptions in supply, which is important for maintaining a high LPI score.

Another component of the LPI is the efficiency of customs clearance. Reliable transport logistics includes fast and transparent customs processes, contributing to logistics resilience in the face of growing trade volumes and complex supply chains. The quality of services, such as transportation, customs clearance, and brokerage services, is also part of the LPI. The higher the level and quality of these services, the more resilient the transport logistics system is. The ability to effectively monitor cargo at all stages of its movement is a key condition for ensuring transport logistics resilience, and this aspect is also considered in the LPI.

The World Bank calculates the LPI to assess the performance of countries' logistics systems. The Logistics Performance Index is an interactive tool based on a worldwide survey of on-the-ground operators (global freight forwarders and express carriers) and quantitative data on the performance of key components of the logistics chain.

As shown in *Figure 2*, Ukraine's LPI has been at an average level within the range of 2.5–3 over the past 15 years, reaching its peak value (3) in 2014 and its minimum (2.5) in 2007. Until 2014 and the start of military actions, the index gradually increased, followed by a decline until 2016, a gradual recovery in 2018, and a drop in 2023, which resulted from the COVID-19 crisis and the onset of large-scale hostilities in 2022. In contrast, the EU's LPI has been higher, fluctuating within a smaller range of 3.4–3.6, indicating that the EU's logistics system is more stable and resilient.

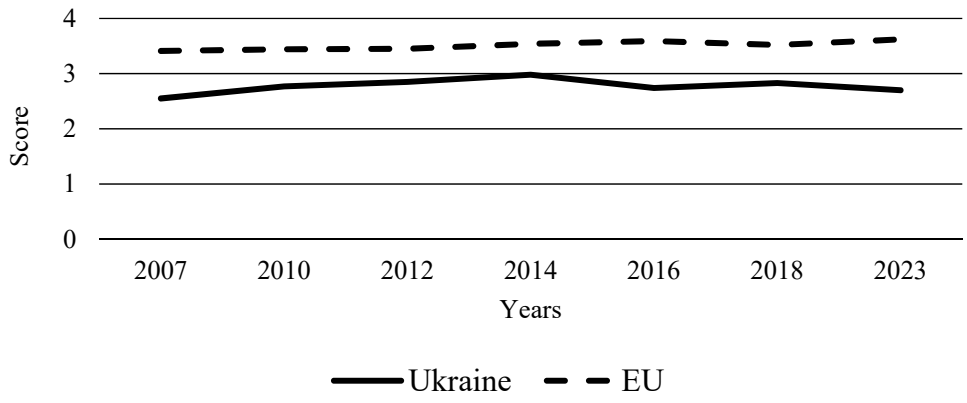


Figure 2. Ukraine and EU member states
in Logistics Performance Index, 2007–2023

Note: overall (1=low to 5=high).

Source: compiled by the authors based on data (The World Bank, 2023).

The Logistics Performance Index consists of six key factors (*Table 3*):

1. The efficiency of customs and border procedures.
2. The quality of trade and transport infrastructure.
3. The ease of arranging competitively priced international shipments.
4. The competence and quality of logistics services.
5. The ability to track consignments.
6. The timeliness of deliveries to the destination.

Table 3

Ukraine and EU member states in Logistics Performance Index, 2023

Country	LPI score	Customs score	Infrastructure score	International shipments score	Logistics competence score	Tracking & tracing score	Timeliness score
Finland	4.2	4	4.2	4.1	4.2	4.2	4.3
Netherlands	4.1	3.9	4.2	3.7	4.2	4.2	4
Denmark	4.1	4.1	4.1	3.6	4.1	4.3	4.1
Germany	4.1	3.9	4.3	3.7	4.2	4.2	4.1
Austria	4	3.7	3.9	3.8	4	4.2	4.3
Sweden	4	4	4.2	3.4	4.2	4.1	4.2
Belgium	4	3.9	4.1	3.8	4.2	4	4.2
France	3.9	3.7	3.8	3.7	3.8	4	4.1
Spain	3.9	3.6	3.8	3.7	3.9	4.1	4.2
Italy	3.7	3.4	3.8	3.4	3.8	3.9	3.9
Greece	3.7	3.2	3.7	3.8	3.8	3.9	3.9
Estonia	3.6	3.2	3.5	3.4	3.7	3.8	4.1
Ireland	3.6	3.4	3.5	3.6	3.6	3.7	3.7
Poland	3.6	3.4	3.5	3.3	3.6	3.8	3.9
Luxembourg	3.6	3.6	3.6	3.6	3.9	3.5	3.5
Latvia	3.5	3.3	3.3	3.2	3.7	3.6	4
Portugal	3.4	3.2	3.6	3.1	3.6	3.2	3.6
Lithuania	3.4	3.2	3.5	3.4	3.6	3.1	3.6
Slovenia	3.3	3.4	3.6	3.4	3.3	3	3.3
Croatia	3.3	3	3	3.6	3.4	3.4	3.2
Czech Republic	3.3	3	3	3.4	3.6	3.2	3.7
Slovakia	3.3	3.2	3.3	3	3.4	3.3	3.5
Malta	3.3	3.4	3.7	3	3.4	3.4	3.2
Romania	3.2	2.7	2.9	3.4	3.3	3.5	3.6
Bulgaria	3.2	3.1	3.1	3	3.3	3.3	3.5
Hungary	3.2	2.7	3.1	3.4	3.1	3.4	3.6
Cyprus	3.2	2.9	2.8	3.1	3.2	3.4	3.5
Ukraine	2.7	2.4	2.4	2.8	2.6	2.6	3.1

Source: compiled by the authors according to (The World Bank, 2023).

As can be seen from the *Table 3* the top countries with a Logistics Performance Index in 2023 are Finland, Netherlands, Denmark, Germany, Austria, Sweden, and Belgium, with a general LPI score of 4 and above. The strongest sides in a logistics performance according to LPI in the European Union countries are generally Logistics competence, Tracking and tracing and Timeliness, the weakest sides in the logistics are Customs efficiency and International shipments. So, at the Top-ranking countries the weakest Customs score have a Netherlands, Germany, Austria. Denmark and Sweden have the lowest international shipments score. The highest performing scores in Logistics competence, Tracking & tracing, Timeliness have Finland,

Netherlands, Denmark, Germany, Austria. Other European Union countries, have a medium performance score (3.9–3.2.) having the highest scores in France, Spain, Italy and Greece and the least performing countries – Romania, Bulgaria, Hungary, and Cyprus.

Ukraine has rather lower low LPI score of 2.7 comparing to European Union countries. The weakest part of country score are customs and infrastructure score, among the highest are international shipments and timeliness. Therefore, the reserves for increasing the resilience of Ukraine's transport system should focus on improving the efficiency of customs services and developing an effective transport infrastructure, which has been particularly affected during military actions.

Transport services are an important component of the export of commercial services in many countries. The share of transport services in the total export of commercial services varies depending on the country's economy. For example, in 2022, the share of transport services in the total export of commercial services was (The World Bank, 2022):

Worldwide in general – 24.00%;

In China – 40.00%;

In the United States – 10.00%;

In the EU – 24.00%.

These data highlight the significance of transport services for international trade and indicate their important role in the development of the commercial services sector of each country. The transport services (% of commercial services exports) of Ukraine and EU countries from 2012 to 2022 are shown in *Figure 3*.

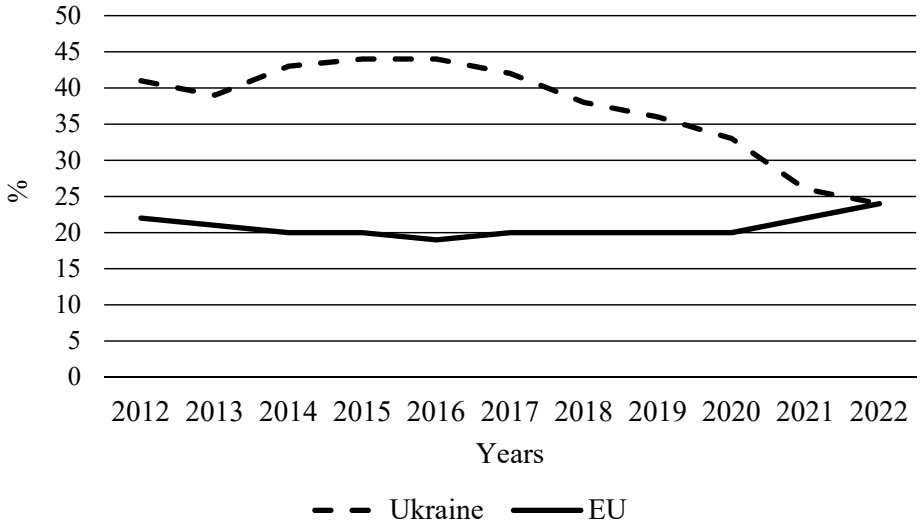


Figure 3. Transport services (% of commercial service exports) of Ukraine and EU member states, 2012–2022

Source: compiled by the authors based on data (The World Bank, 2022).

As can be seen from the *Figure 2* the percent of transport services is a commercial service exports in Ukraine in the recent 10 years have been

ranging around 20% and increasing in the recent years to 24% in 2022. On the contrary to Ukraine, in the European Union percentage of transport services in the commercial services exports have been declining steadily in the last 10 years from around 40% to the 24% in 2022.

In conditions of military actions, the transport infrastructure of the European Union plays a crucial role in ensuring the efficiency and speed of cargo delivery from China to Ukraine via Poland. The EU has a developed network of road, rail, sea, and air routes, which provide a high level of accessibility and connectivity between countries. This helps to reduce transportation costs and delivery times, which is important for businesses planning to export or import goods.

The impact of the EU's transport infrastructure on the choice of delivery routes is as follows:

- Developed road network in the EU allows for the use of road transport for short-distance deliveries within Europe, facilitating the rapid delivery of goods to destinations in the Ukrainian market.
- The EU's railways are an efficient means of transporting goods over long distances, particularly from China to Poland. This reduces the environmental impact of road transport and lowers delivery costs.
- European seaports provide access to deep-water docks for large vessels, enabling the efficient organization of international shipments of goods from Asia to Europe and subsequent delivery to Ukraine via Poland.
- Air transport in Europe offers a high level of service and speed, making it attractive for the delivery of perishable and valuable goods.

Optimizing routes through the European Union allows businesses to reduce transportation costs and increase delivery speed. This makes their goods more competitive in the market and ensures customer satisfaction with the speed and quality of service. Optimized routes help avoid congestion and reduce the time needed to cross borders, which is crucial for fast-moving goods. Additionally, this enhances the efficient use of transport vehicles and resources, positively impacting the environment. Route optimization also helps businesses reduce the risks of goods loss during transportation and ensure their safety (RAU, 2024).

4. Directions for ensuring the resilience of the transport and logistics system

Russian aggression has posed a significant challenge not only for Ukraine but also for EU countries, necessitating a general consolidation and optimization of all societal processes in general and the reformatting of transport logistics in particular. Ensuring the resilience of the transport and logistics system is a crucial task in the context of guaranteeing the uninterrupted movement of goods and materials, especially during crises and emergencies. The key directions for ensuring the resilience of the transport and logistics system are presented in *Table 4*.

Table 4

Directions for ensuring resilience of the transport and logistics system

Directions	Essence
Infrastructure measures	
Modernization and expansion of infrastructure	Regular upgrading and maintenance of roads, railways, ports and airports to ensure their reliability and durability.
Diversification of transport routes	Creation and use of alternative routes to reduce dependence on one route and ensure continuity of transport in case of problems.
Integration of multimodal transport systems	Development of systems that allow easy switching between different types of transport (rail, road, water, air).
Organizational measures	
Strategic planning	Development of long-term strategies for the transport and logistics system, taking into account possible risks and scenarios of crisis situations.
Coordination and cooperation	Establishing close cooperation between various participants in the logistics chain – carriers, operators, suppliers and government organizations.
Risk management system	Implementation of methods and tools for identification, assessment and management of risks in the logistics chain.
Technological measures	
Use of modern technologies	Implementation of innovative technologies, such as the Internet of Things (IoT), blockchain and big data, to increase the efficiency and transparency of logistics processes.
Automation and robotics	Use of automated systems and robots for warehousing, cargo handling and transport management.
Management information systems	Use of modern software solutions for monitoring, planning and management of logistics operations.
Economic measures	
Financing and investments	Attracting financing for infrastructure development and modernization, introduction of new technologies and innovations.
Cost optimization	Reduction of operating costs due to improved process efficiency and the use of modern technologies.
Reserve funds	Creation of reserve funds to cover expenses in case of emergencies.

Source: compiled by authors.

The resilience of transport logistics under shock impacts depends on a comprehensive approach to implementing infrastructural, organizational, technological, and economic measures. As shown in *Table 4*, infrastructural measures such as the modernization and expansion of existing networks and the diversification of transport routes contribute to increasing the reliability and efficiency of transportation. The integration of multimodal systems ensures flexibility and rapid response to changes in the logistics environment.

Organizational measures, such as strategic planning and risk management systems, allow for advanced preparation for potential crisis situations and ensure effective coordination among logistics chain participants. Technological innovations, such as the use of modern information systems and process automation, improve the accuracy and speed of transport logistics operations management, which is crucial for maintaining the system's competitiveness. Economic measures, such as cost optimization and the creation of reserve funds, support financial stability and the system's ability to adapt to changes in the economic environment. Thus, these directions collectively form a comprehensive approach to ensuring the resilience of transport logistics and are essential for the successful operation of transport and logistics systems in changing conditions.

In April 2021, the Cabinet of Ministers of Ukraine approved the National Transport Strategy of Ukraine until 2030 (hereinafter referred to as the Strategy). This is the main program document that outlines development of the transport sector in Ukraine and specifies concrete stages and timelines for implementing measures necessary for the comprehensive development of the sector as a whole. The document was developed with the support of the European Union Delegation to Ukraine and reflects the implementation of Ukraine's European integration commitments in the transport sector, including the introduction of the European Green Deal, the replacement of public transport with more modern and environmentally friendly options, improvement of passenger transport services, and the development of cycling infrastructure, among others.

Among the key measures provided by the Strategy are the following (National Transport Strategy of Ukraine until 2030, 2021):

- strengthening the institutional capacity of executive authorities in the transport sector;
- designing and developing a model of the future transport and logistics system, conducting a quality diagnosis, and identifying effective development directions;
- improving the conditions for passenger and freight transportation, ensuring the balanced development of all types of transport;
- modernizing existing and constructing new transport and logistics infrastructure and rolling stock to meet the needs of the economy, taking into account resource and environmental constraints;
- participating in international transport and logistics projects to attract additional transit flows through Ukraine;
- developing a digitalization program for the Ukrainian transport sector, adopting new digital business models;
- preparing highly qualified personnel through the development of higher education and business qualification improvement programs;
- enhancing state management of transport safety and its environmental component in accordance with international standards.

For the EU in 2020 Transport Strategy on Smart and Sustainable Mobility was developed that aims to modernise the European transport sector with regard to sustainability and the digital transformation. In the strategy three areas for action have been identified (Transport strategy of the European Commission, 2024):

Climate change mitigation: the strategies currently in place to reduce greenhouse gas emissions in the transport sector need to be enhanced for greater effectiveness. This involves decarbonizing the sector, shifting transport services from road to more environmentally friendly modes, and modernizing the infrastructure.

Digital transformation: the strategy views digital transformation as a key tool to achieve a climate-sensitive vision for EU mobility.

Lessons learned from the corona crisis / resilience: While the COVID-19 pandemic has caused significant challenges for the transport sector, it is also seen as an opportunity to foster a green economic recovery and promote more sustainable and clean mobility.

In line with climate change mitigation efforts, the Commission is continuing the direction set by the comprehensive "European Green Deal" introduced a year ago, which aims to make the EU climate neutral by 2050. Ukraine, with its aspirations for European integration, also adheres to the principles of sustainable green development in its National Transport Strategy for the period up to 2030, emphasizing the use of digital measures to accelerate development.

Cooperation between Ukraine and the EU in the transport sector is regulated by the Association Agreement between Ukraine and the European Union and aims to promote the development of stable transport systems; to carry out efficient and safe transport operations by eliminating administrative, technical, border, and other obstacles; and to improve the transport network and modernize transport infrastructure. This process is based on contractual relations with the European Union, which involves the gradual implementation of common international transport rules, the strengthening of European safety and environmental standards on its territory.

Currently, cooperation between the EU and Ukraine in the field of transport logistics includes several important areas: harmonization of legislation, financing of infrastructure projects, and exchange of experience and technologies. Ukraine is adapting its legislation to EU standards within the framework of the Association Agreement, which includes regulations on transport safety, environmental norms, and customs control. The EU also provides financial support for the modernization of Ukraine's transport infrastructure, particularly through the Investment Plan for Europe (EFSI) and other financial instruments. European companies and organizations share their experience and technologies with Ukrainian partners through personnel training, seminars, and the implementation of joint projects.

In countries of EU, government regulation in the transport sector is among the priority functions of the state, as creating legal incentives for the development of the transport system is one of the main reserves for increasing societal well-being and economic potential. EU member states have common rules regarding technical, safety, and social standards, state aid, and market liberalization in the fields of road transport, railways, inland waterways, aviation, and maritime transport. Accordingly, under the Association Agreement, Ukraine needs to implement the EU's priority transport rules aimed at facilitating the restructuring and modernization of the transport sector and gradually aligning with existing EU standards. In this context, Ukraine's transport sector should gradually become more resilient, safe, and efficient.

Conclusions

Transport logistics resilience is determined by three attributes: the ability to withstand shock impacts, the ability to adapt to shock impacts, and

the ability to recover after shock impacts. Causes of these shock impacts can include natural disasters, financial-economic crises, military actions, technological accidents, and others. Due to Russia's military aggression, Ukraine's transport infrastructure has suffered significant damage. This includes the destruction of roads, bridges, railways, airports, and ports, which has significantly affected domestic transport connectivity and logistics.

Key challenges for doing business in Ukraine due to damaged transport infrastructure and logistics include: reduced inventory levels due to high risk of losses and frozen finances, shortage of warehouse space; complicated logistics operations due to checkpoints; difficulties with transport flows; overload of European infrastructure unable to cope with the large volume of Ukrainian goods. These problems cannot be solved without intergovernmental coordination and cooperation in route planning, infrastructure modernization, including through EU grant assistance, financing, and adaptation of regulatory frameworks that correspond to the realities of wartime, thus confirming the hypothesis of the article.

In wartime conditions, the following measures are crucial for ensuring the resilience of transport logistics in Ukraine that accordingly should be promoted within governmental policies: transparency in transport logistics system; availability of alternative delivery routes; cooperation and building reliable relationships with partners; measures for monitoring and evaluating the system's effectiveness.

Factors influencing the resilience of transport logistics in EU and Ukraine include challenges and opportunities related to the efficiency of customs and border procedures; quality of trade and transport infrastructure; ease of organizing international shipments at competitive prices; competence and quality of logistics services; ability to track shipments; timeliness of delivery to destination.

Ukraine's Logistics Performance Index (LPI) has averaged between 2.5 and 3 over the past 15 years, peaking at 3 in 2014 but declining due to wartime activities. The EU's LPI fluctuates within a narrower range but at a generally higher level of 3.4–3.6, indicating greater resilience.

Ukraine's LPI score was notably lower at 2.7 in 2023 compared to EU countries. The weakest aspects of the country's score are customs and infrastructure, while international shipments and timeliness are among the highest-rated. Strategies to enhance Ukraine's transport system resilience include improving border service operations and developing efficient transport infrastructure, which suffered significantly during wartime.

The resilience of transport logistics in the face of shock impacts depends on a comprehensive approach that includes infrastructure, organizational, technological, and economic measures. Modernization and expansion of networks, diversification of routes, integration of multimodal systems, strategic planning, risk management, technological innovations, and economic optimization ensure the reliability, efficiency, and competitiveness of the logistics system. In the context of Russia's large-scale war against Ukraine,

ensuring the resilience of transport logistics will largely depend on restoring its integrity: passenger and freight route restoration considering demand for transport services and security needs, organizing multimodal interactions, improving logistical connectivity for domestic and international transport, restoring unhindered movement of road transport in conflict-affected regions. The process of further restoring the transport and logistics system based on principles of sustainability and digitalization as ones of the main directions in European development in the nearest future and a guarantee of integration of Ukraine within the EU, will be the subject of our future scientific research.

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