



Restoration of the transport infrastructure of Ukraine in the conditions of war: A comparative analysis of economic models and stabilisation mechanisms

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Abstract. The relevance of the study is related to the urgent need to restore the transport infrastructure of Ukraine, which suffered large-scale destruction as a result of the war, taking into account that transport system that plays a key role in ensuring economic stability, logistical continuity and the country's integration into global economic processes. The purpose of the study was to develop a methodological approach that would minimise the level of entropy in transport systems and accelerate the reconstruction process by using elements of a mixed economic model. To achieve the goal and solve the tasks set, a comparative analysis of world models of infrastructure management in crisis recovery was used. The results of the study confirmed the effectiveness of the integration of different approaches to the assessment of economic models, which made it possible to formulate practical recommendations for the restoration of transport infrastructure in crisis conditions. In particular, it was found that the most acceptable model for the restoration of the transport infrastructure of Ukraine is a mixed economic model, which provides a synergistic combination of public and private resources. The study proposed priorities for the reconstruction of key infrastructure nodes that will contribute to the stability of economic processes and improve the orderliness of the transport system. A methodological approach that integrates the best practices of countries with different economic models, adapting them to the specific conditions and needs of Ukraine, has also been developed. The proposed solutions provide a comprehensive approach to infrastructure restoration, taking into account the limited resources and high level of risks. The results obtained are of important practical importance for the development of a state strategy for post-war restoration and infrastructure development of the country, which will reduce costs, optimise the use of resources and increase the speed of implementation of infrastructure projects in the post-war period, ensuring long-term economic stability

Keywords: transport system; economic system; infrastructure projects; post-war restoration; infrastructure development models

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Introduction

The loss or damage of critical transport facilities significantly complicates the supply of goods and services, and also affects the mobility of the population, which in turn leads to economic losses. The restoration of transport infrastructure is one of the main priorities for achieving economic stability and restoring the functioning of key industries in the country. In such conditions, it is necessary to apply modern innovative approaches that will ensure rapid, effective and sustainable development of the transport system. The involvement of international experience, the use of modern technologies and mixed economic models will significantly increase the efficiency of restoration and adaptation to new challenges. Given the strategic importance of transport infrastructure for economic development, the study of this process is important for the formation of optimal policies and strategies for restoration in the context of post-conflict development of the country.

Modern conditions are characterised by a high level of risks. In such conditions, researchers propose to apply centralised management of restoration processes, since it is such approaches that allow to reduce the restoration time (Cherviakova, 2024). T. Charkina *et al.* (2019) in their work focus on the study of transport interchanges as a key element of railway infrastructure. The authors emphasise their role in optimising passenger flows, increasing travel comfort and integrating different modes of transport. They determine that the effectiveness of such nodes depends on rational planning and the implementation of modern technologies. The study demonstrates the importance of international cooperation and harmonisation of standards for creating sustainable and functional hubs. However, the study does not cover the aspects of restoring such nodes in crisis conditions, which is key to our topic, in particular in the context of war and increasing the resilience of Ukraine's transport infrastructure.

Y.C. Xiafei & Y.T. Fujiyama (2022) analyse the impact of transport interchanges on the choice of passenger routes in urban rail transport. The authors concluded that the convenience of transfers significantly affects the routing of passenger flows, increasing the overall efficiency of the system. However, the paper does not consider aspects of transport infrastructure restoration under resource constraints, which is important for our study, in particular for determining strategic approaches to the reconstruction of such nodes in Ukraine. F. Jia *et al.* (2021) investigated the calculation of the capacity of a passenger-oriented metro network. The authors determined that the efficiency of the network depends on the distribution of passenger traffic and the adaptation of the infrastructure to peak loads. Although the study is important for improving transport efficiency, but it does not take into account the specific conditions of infrastructure restoration after significant destruction, which

is key for our study of the transport infrastructure of Ukraine in wartime.

In the international context, it is worth noting studies that assess the impact of different economic models on infrastructure recovery. For example, M. Fedyk (2021) examines the macroeconomic consequences of the COVID-19 pandemic for the global transport system, demonstrating the advantages of mixed economic models. The experience of Sweden and Germany in adapting infrastructure to modern challenges is also valuable for Ukraine, but these countries have stable economic systems that differ significantly from Ukrainian realities. The annexation of Crimea and the war in Donbas have shown the specifics of Ukraine's market economy, where infrastructure projects are heavily dependent on economic support from Western institutions. As researchers T. Luchnikova *et al.* (2023) note, overcoming crisis phenomena in the transport sector is possible only under conditions of strategic investment, while countries with planned economies can use other methods to restore stability. However, the study is limited to the analysis of internal adaptation without sufficient attention to resource coordination models or stabilisation mechanisms on the scale of the national transport system. The study by D. Kotelevets (2022) defines the importance of infrastructure for the development of economic systems, focusing on the relationship between investments in infrastructure facilities and economic growth. The author emphasises the importance of an integrated approach to planning and managing infrastructure projects, but does not sufficiently consider aspects of the restoration of transport infrastructure in times of crisis or war, in particular the integration of stabilisation mechanisms and international experience.

An analysis of the scientific literature demonstrates that, despite a significant number of studies aimed at studying aspects of the development and restoration of transport infrastructure, their results remain fragmentary. Most works focus on general aspects of the development of transport nodes and multimodal systems, but do not sufficiently consider the mechanisms of their restoration in times of war or other crises. Other studies show the advantages of mixed economic models, but do not take into account the specifics of post-conflict restoration, in particular the integration of international standards. To develop a comprehensive strategy for the restoration and development of the transport system of Ukraine, a deeper analysis is needed that would take into account all the key factors affecting the industry. In particular, a comparative analysis of economic models can provide valuable experience for developing an optimal strategy that will contribute to the stable development of Ukraine's transport infrastructure in the face of global challenges. In general, this will allow choosing approaches to reducing the entropy of the system through the adaptation of best practices aimed

at stabilising the infrastructure and improving its functionality, which is critically important for the economic security of Ukraine.

The purpose of this study was to introduce innovative approaches to organising the process of restoring Ukraine's transport infrastructure, focused on integrating the best international practices and stabilisation mechanisms that ensure efficient use of limited resources and increase the system's adaptability to crisis conditions.

Materials and methods

To achieve the goal of the study, a comprehensive approach was used, combining several stages of work, analysis methods and data sources. The main methodology was the concept of comparative analysis of economic models and stabilisation mechanisms in the restoration of transport infrastructure, adapted to the modern conditions of Ukraine. The study was conducted in three main stages:

Preparatory stage. At this stage, scientific sources devoted to the restoration of transport infrastructure in times of crisis were systematised. International scientometric databases (Scopus, Web of Science, JSTOR, Google Scholar) were used to collect materials. The search keywords were: "recovery of transport infrastructure", "economic models of recovery", "mixed economy", "post-conflict infrastructure". The selection was limited to works published from 2018 to 2024.

Analytical stage. At this stage, a comparative analysis of economic models for infrastructure restoration was conducted, including:

- ▲ Market models (USA, Great Britain): the main focus is on the use of private capital and decentralised management.

- ▲ Centralised models (China): emphasis on public financing and centralised project management.

- ▲ Mixed models (Germany, France, Ukraine): study of the synergy of public administration with private investments. The assessment was carried out according to the following criteria: speed of project implementation, financial accessibility, compliance with engineering and environmental standards, as well as socio-economic effect.

Practical stage. At the final stage, an adapted methodological approach to the restoration of Ukraine's transport infrastructure using elements of the mixed economy was developed. This approach includes recommendations for prioritising projects, attracting international investments, and integrating innovative technologies. To implement the research objectives the comparative analysis method was used to compare different economic models (market, command, mixed) and their approaches to the restoration of transport infrastructure. The analysis was carried out according to key criteria, such as the speed of project implementation, financial sustainability, integration of innovations and

environmental compliance. The content analysis method was used to process and systematise information in scientific publications, reports of international organisations and government documents. Special attention was paid to the assessment of specific mechanisms for the restoration of infrastructure in conditions of limited resources. The system analysis method allowed integrating the results of research on various aspects of transport infrastructure (economic, technical, organisational) into a single methodological base, providing a holistic view of the restoration process as an interconnected set of measures. The generalisation method was used to synthesise the best practices and recommendations identified in the international experience of the restoration of transport infrastructure, which allowed formulating approaches to restoration adapted to Ukrainian conditions. The modeling method was applied to develop a methodological approach to reducing the level of chaos in the transport system through prioritisation of key facilities, optimisation of resources, and implementation of stabilisation mechanisms.

The application of these methods provided a comprehensive analysis and integration of theoretical and practical aspects necessary for the formation of a strategy for the restoration of Ukraine's transport infrastructure. Information for the analysis was obtained from international databases, such as Scopus, Web of Science, JSTOR, reports and documents of Ukrainian government bodies (Ministry of Infrastructure, Ukrzaliznytsia), analytical materials of international organisations (European Commission, UN), data from studies that covered the assessment of damage to Ukraine's transport infrastructure after 2022. The transport systems of countries such as China, the USA, Germany, France, Sweden and Ukraine were studied, with an emphasis on their economic models, approaches to financing and management of infrastructure projects. The main indicators included: project implementation time, volumes of resources involved, efficiency of restoration of critical facilities and the degree of integration of innovative solutions. Particular attention was paid to problems related to the management of limited resources, the implementation of stabilisation mechanisms and the adaptation of international experience to post-conflict conditions.

Results and Discussion

The war in Ukraine since 2022 has led to large-scale destruction of transport and engineering infrastructure, which is critical for the recovery of the economy. According to Resolution of the Cabinet of Ministers of Ukraine No. 940 (2024) as of December 1, 2023, 1.4 million residential premises were damaged, including 135 thousand individual residential buildings, a significant part of which is located in regions where active hostilities were taking place, such as Donetsk, Luhansk and Kherson regions. As of the end of March

2024, 3,282 educational institutions were damaged, of which 391 were completely destroyed, and in Donetsk region almost all educational institutions were affected. The scale of infrastructure destruction, including damage to 1,675 facilities in 663 healthcare facilities, is unprecedented for modern Europe.

Military conflict significantly increases the level of entropy in the transport infrastructure, the functioning of the infrastructure becomes less orderly, which is manifested in the form of damage to key elements, the complication of logistical routes and the lack of coordination in the recovery processes. For effective management of these processes, special stabilisation mechanisms are required that would allow to reduce recovery times and increase the efficiency of resource use. Firstly, centralised management: for countries with mixed or command economies, centralisation of management of recovery projects helps to establish a clear hierarchy in the coordination process, which contributes to the stability of the transport system. For example, in China, during natural disasters, state authorities quickly mobilise resources for recovery, which allows to reduce the level of disorganisation. Secondly, information monitoring systems: the introduction of digital platforms for monitoring the condition of transport facilities and their damage helps to ensure clear control over the recovery process. In Germany, such a system is used to manage road infrastructure in real time. Third, prioritisation of critical nodes: focusing efforts on the reconstruction of the most important transport nodes for the economy (transport hubs) allows for faster restoration of logistical connections and ensuring economic stability.

The destruction of key infrastructure elements significantly complicates logistics and coordination of restoration work, creating chaos and reducing the efficiency of the transport system. According to preliminary estimates, 25.4 thousand kilometers of roads and 344 bridges were damaged as a result of the fighting. A significant part of the destruction falls on the regions where active fighting took place: Donetsk, Luhansk, Kherson and Zaporizhia regions, which together account for more than 70% of the total damage to the infrastructure. The destruction of the railway infrastructure is also critical: 2862 objects were damaged, and 2891 were destroyed (Resolution of the Cabinet of Ministers of Ukraine No. 940, 2024). Centralised management of recovery processes is important, since in conditions of high risk, such approaches allow for a reduction in recovery times (Chervyakova, 2024). Analysis of damage to the transport sector raises concerns about the limited financial resources available for project implementation (Galushko, 2017; Martseniuk *et al.*, 2021; Shevchenko & Ivashchenko, 2024). Another pressing issue is the integration of international standards, which is one of the main aspects of the country's post-war economic recovery. Transport infrastructure development can be carried out according to several

models: anticipatory, synchronised, catch-up, and combined (Puseva, 2023).

For Ukraine, the most acceptable is the combined model, which integrates both state regulation and market mechanisms. In the post-war period, this model will play an important role, as it provides for significant support from international organisations and investors, which is consistent with the approaches characteristic of open economic systems. The aviation sector has also suffered significant losses, which indicates the need for an adaptive economic strategy to support such sectors in market systems oriented towards a competitive environment. In centralised economic models, stabilisation of air transport could be carried out through direct grants or state subsidies, while market models are forced to look for other instruments, such as foreign investment and partnerships (Chornogor *et al.*, 2024). Therefore, comprehensive mechanisms for the restoration of transport infrastructure in general are needed, in particular, synergies between public and private investments, which could be effective for other transport sectors.

Infrastructure stabilisation is possible through the implementation of managed restoration processes aimed at rebuilding critical nodes of the transport system and reducing the level of entropy. This approach allows creating sustainable development centers around which the process of reconstruction of infrastructure facilities is formed. This process concerns not only the transport network, but also the energy infrastructure, where 47% of facilities were destroyed due to rocket attacks (Resolution of the Cabinet of Ministers of Ukraine No. 940, 2024). In general, clear planning and effective allocation of resources to ensure the functioning of the most important elements of the infrastructure will allow to streamline and accelerate the restoration of economic stability in Ukraine.

Compared to countries with more centralised economies, Ukraine demonstrates limited opportunities for rapid infrastructure reconstruction due to high levels of privatisation and limited state control. Countries such as China or the former Soviet republics can often mobilise significant state resources for strategic reconstruction, while Ukraine faces labor outflows, falling investments, and high defense spending. This situation requires the development of an effective strategy for the reconstruction of transport infrastructure that takes into account limited resources and a high level of destruction. One promising tool for this is the public-private partnership (PPP), which has demonstrated high efficiency in implementing large-scale infrastructure projects in different countries around the world. Comparing PPP models in market, mixed, and centralised economies allows us to identify best practices that can be adapted to the needs of Ukraine. Important aspects of such an analysis are investment incentives, risk sharing between the state and the private sector, and the vector for economic development, which is

especially important for countries with post-conflict challenges, such as Ukraine.

By its nature, PPPs are an important mechanism for attracting private capital for infrastructure development in conditions of limited public resources. PPPs have their own characteristics and effectiveness in different economic systems (Table 1). For example, in the USA, a predominantly market economy, infrastructure projects are financed by private capital through concessions, and their share of implementation is from 1% to 3% of total transport infrastructure spending since 1990 (Congressional Budget Office, 2020). About 60% of large transport projects have been implemented thanks to PPPs, in particular, the construction of highways (Virginia I-495 Express Lanes), where the use of tax breaks and government guarantees contributed to attracting more than \$2 billion in investment (United States Department of Transportation (2024). In Canada, the state actively supports RAP in the transport sector through special agencies. The model involves risk sharing: the state assumes initial financing, and private investors

are responsible for operation. As a result, 40% of new infrastructure facilities in the country were built within the framework of RAP, which provided an annual increase in economic activity of 1.2% of GDP (Government of Canada, 2021). In Germany, where a mixed economic model is used, RAP has also proven its effectiveness, especially in road construction. For example, 35% of autobahns were modernised through RAP. The German government actively uses tax incentive mechanisms that reduce investor costs by 15-20% and provide long-term guarantees of profitability. Thanks to this, the growth rate of investment in the transport sector increased by 8% in 2020-2023 (Statista, 2024). China, with China, a centrally planned economy, has a high level of state intervention in the RAP, which focuses on large strategic projects such as high-speed railways. The state finances more than 50% of the project through state-owned banks, which reduces financial risks for the private sector. As a result, China develops more than 60% of its infrastructure through RAP, providing an annual GDP growth of 1.5% (Export-Import Bank of China, 2022).

Table 1. Comparison of the experience of PPP in different economic systems

Country	Economic model	Key features of PPP
USA	Market	Tax incentives, concessions
Canada	Market	Risk sharing, government support
Germany	Mixed	Tax incentives, long-term guarantees
China	Centralised	State-owned banks, centralised financing

Source: developed by authors based on (OECD, 2023; Asian Development Bank, 2024; Housing, infrastructure and..., 2025)

Based on the analysis of the above models of private-public partnership, it can be argued that their adaptation to the conditions of the Ukrainian economy requires taking into account the high level of risks and limited access to financial resources. In this context, it is advisable to integrate elements of mixed models with the involvement of state guarantees and tax incentives, which can significantly increase the country's investment attractiveness. The introduction of such mechanisms will create conditions for a synergistic combination of public and private sector resources, which will contribute not only to the rapid restoration of transport infrastructure, but also to its sustainable development. The transport infrastructure of Ukraine includes railway and aviation networks, inland waterways, seaports, highways, as well as warehouse and repair facilities and cargo terminals. In 2021, the share of different modes of transport in the total volume of transported goods was distributed as follows: rail transport – 51%, road transport – 32%, water transport – 1%, pipeline transport – 16%, aviation – 0.02% (European Business Association, 2021). To ensure the balanced development of all these modes of transport, a modern and efficient infrastructure is necessary.

The creation, expansion and modernisation of transport infrastructure are necessary conditions for the economic growth of Ukraine. Global trends are

aimed at reducing carbon emissions and switching to more environmentally friendly modes of transport, and Ukraine shares these aspirations. The development of rail and water infrastructure is one of the strategic priorities, which corresponds to the global movement towards sustainable development and decarbonisation. Despite the difficult conditions, rail transport and its infrastructure in Ukraine require constant development. Investments in this sector can contribute to the introduction of high-speed passenger services and increase the efficiency of freight transportation. At the same time, the development of water transport, especially river transport, requires significant state support. The construction of new ports and the expansion of transportation along the Dniester can become an important stimulus for the national economy.

The integration of new technologies is an important aspect of the modernisation of transport infrastructure. The introduction of modern navigation systems and autopilots into vehicles can significantly reduce the number of accidents and increase the overall efficiency of the transport system. This technological evolution reflects global trends towards digitalisation and automation, demonstrating the adaptation of economies to modern challenges. The restoration of transport infrastructure occurs in synergy with other sectors of the economy, such as energy and technology. Combining public and

private investments in transport with investments in energy efficiency and renewable energy sources is necessary for sustainable development and is in line with global economic trends. Despite the ongoing armed conflict, the strategic directions of Ukraine's infrastructure development remain consistent, although achieving the set goals is becoming a more difficult task. Strategic priorities are determined based on the functions performed by transport infrastructure, including:

- ▲ ensuring the basic needs of society;
- ▲ increasing economic productivity;
- ▲ supporting national security;
- ▲ regulating economic processes;

- ▲ stimulating economic activity;
- ▲ social integration and development;
- ▲ development of foreign economic relations.

In defining the main strategic directions, Ukraine should focus on the restoration and development of transport infrastructure to meet domestic needs and meet international standards. This includes adaptation to modern economic challenges and trends, such as environmental sustainability and technological innovation, which are critical for the country's economic stability and growth. The development of transport infrastructure should include the following priority areas (Fig. 1).

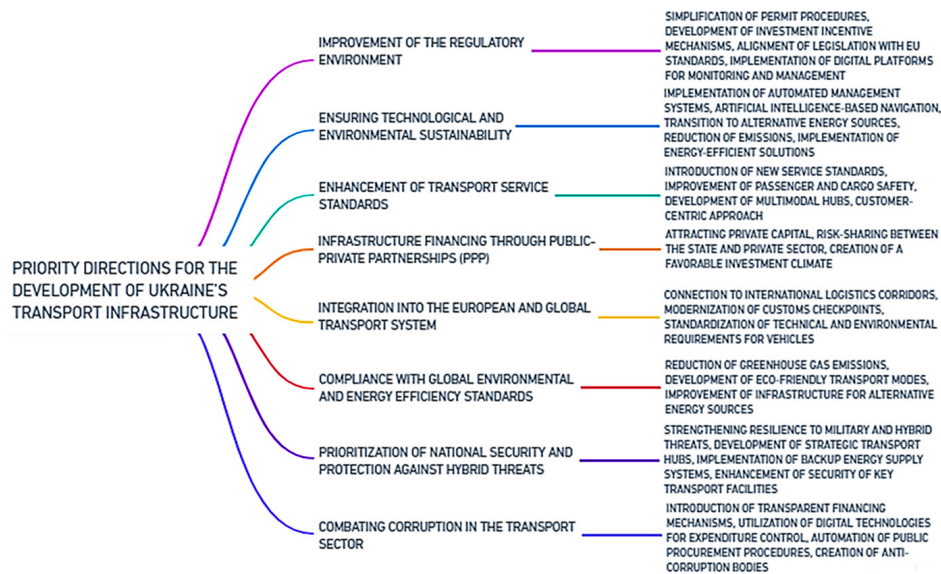


Figure 1. Priority areas for the development of Ukraine's transport infrastructure

Source: developed by the authors based on (Mekh, 2023; Resolution of Cabinet of Ministers of Ukraine No. 940, 2024; European Business Association, 2021)

In the context of global economic trends and their impact on the restoration of Ukraine's transport infrastructure, it is worth considering different models of infrastructure project development and opportunities for attracting international cooperation. Each of the types of economic systems – market, command, mixed, traditional – offers its own approaches to the

implementation of infrastructure projects, which are reflected in the degree of state intervention, levels of private investment and integration with other sectors of the economy. Currently, the development of Ukraine's transport infrastructure is focused on strategic directions that correspond to global trends in greening and digitalization (Table 2).

Table 2. Comparative analysis of strategic areas for the development of transport infrastructure in different economic systems

Strategic directions	Description	Example of implementation in economic systems
Development of multimodal transport and interchanges	Integration of different modes of transport into the logistics system to support international trade	In market economies: private capital is used to create interchanges and logistics centers
Expanding international transport corridors	Improving logistics connections or cross-border trade, which is important for open economies	In open economies: the EU is developing the TEN-T network to facilitate transport corridors
Attracting investment from public and private sources	Ensuring the sustainable infrastructure development with the support of international financial institutions and funds	In mixed economies: public support for strategic projects together with private investments

Table 2. Continued

Strategic directions	Description	Example of implementation in economic systems
Optimisation of tariff policy	Increasing competitiveness through effective pricing to attract international carriers	In market economies: flexible tariff policy attracts new carriers and investors
Implementation of information systems and digital technologies	Automation of processes and integration with global digital networks to reduce costs	In mixed economies: government digitalisation programs supported by private IT companies
Modernisation of border crossing points	Increasing capacity and efficiency at borders to facilitate international trade	In EU countries: financing of border crossing point modernisation through European development funds

Source: developed by the authors based on S. Dominguez-Amarillo & O. Mykhailovska (2024), Y.V. Pichuhina *et al.* (2024), K. Bagatska (2024)

A comparative analysis of global approaches shows that in developed market economies (e.g., the United States, Great Britain), infrastructure projects are mainly financed by private capital, which allows for the rapid implementation of projects. The private sector provides flexibility and adaptation to market conditions, while the state performs a regulatory function, attracting investors through favorable tariffs and concessions. In such economies, the main criteria are financial stability and competitiveness. Command economies (e.g., China) use centralised planning, which provides the ability to quickly mobilise state resources for the development of strategic facilities – high-speed railways and seaports. This approach allows you to concentrate resources on key projects, but limits the participation of the private sector, which can reduce flexibility. In command economies, strategic importance and centralised management are the priority criteria. For Ukraine, which is moving towards integration with the EU, a mixed approach is optimal, combining state support and investments from international organisations and the private sector, in particular in strategic sectors: rail and water transport. Such an approach ensures resilience in responding to economic challenges, adapting the best practices of other economic systems for post-war recovery. For the successful development of transport infrastructure, it is important to apply a comprehensive strategy that takes into account risks and opportunities and is based on detailed analysis. Using the synergy of international investments, modern technologies and best practices will reduce the risks of infrastructure projects and ensure adaptation to global challenges, in particular in the field of environmental sustainability and technological innovation.

Given the numerous global macroeconomic challenges, strategic infrastructure development is becoming even more relevant. Transport infrastructure is a fundamental part of the economic policy of countries, allowing them to maintain competitiveness in the world economy. Modern trends, such as globalisation and digitalisation, stimulate states to optimise transport systems. In their study, H. Seng *et al.* (2019) propose to

include the following in the main models of transport infrastructure development:

1. Market model

In market economies, private capital plays a major role in financing large infrastructure projects, such as the development of ports, airports, highways and multimodal hubs. The USA and the UK are examples of countries where private investment is the main source of financing, and the role of the state is reduced to regulation and stimulation of competition.

2. Command model

Command economies, such as China, use centralised planning and public financing to develop strategically important projects. The central role belongs to state-owned companies, which allows for the implementation of large-scale infrastructure initiatives quickly and purposefully, in particular high-speed railways and ports.

3. Mixed model

Mixed economies (France, Germany, Ukraine) develop infrastructure through a synergy of public and private resources, which provides a balance between flexibility and sustainability. This approach allows the state to finance strategic facilities by involving the private sector in the development of logistics, ports and transport networks. For example, in France, railway and air connections are actively developing through public-private partnerships.

To optimise project selection, it is recommended to consider the following criteria (Pichuhina *et al.*, 2024):

▲ strategic relevance: priority of projects for the restoration of economic activity, especially in combat zones;

▲ financial capabilities: availability of financing from state and international sources;

▲ engineering characteristics: simplification of design to accelerate implementation and ensure the functionality of the infrastructure.

These criteria allow creating a transparent mechanism for making decisions on the selection and prioritisation of infrastructure projects, which is especially relevant in conditions of limited resources and the urgency of restoration work (Fig. 2).

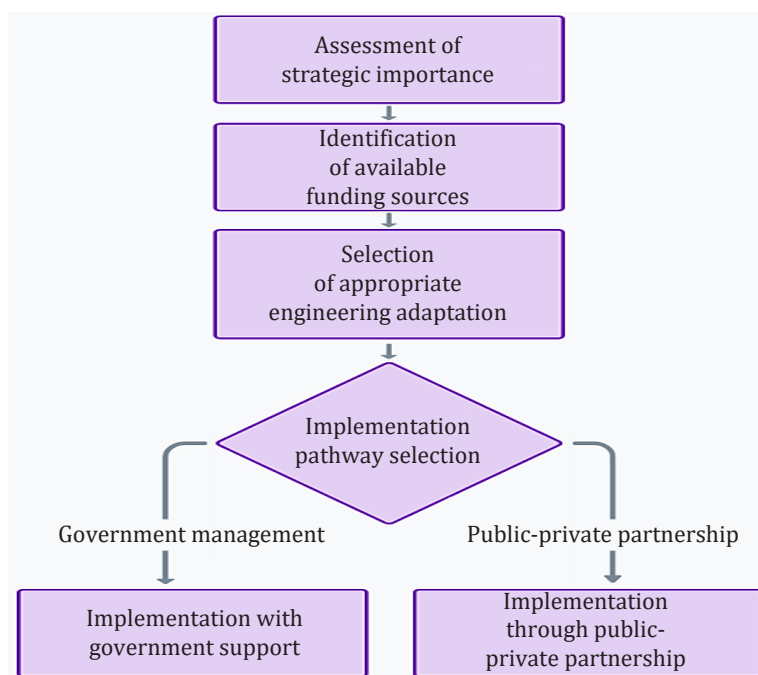


Figure 2. Scheme for selection and prioritisation of transport infrastructure projects

Source: developed by the authors

Analysis of transport infrastructure development models indicates differences in approaches inherent in market, command and mixed economic systems (Table 3). Mixed models, similar to the model used in Ukraine, provide high stability by integrating public administration with private capital. This approach

becomes important for the country's post-war recovery, since the involvement of international financial institutions, the adaptation of best practices, as in Germany and France, allows to strengthen the stability and competitiveness of the Ukrainian economy in the context of global challenges.

Table 3. Models of transport infrastructure development in different economic systems and stabilisation mechanisms

Country	Infrastructure development model	Key characteristics	Examples of projects and stabilisation mechanisms
USA	Market	Private financing, competition in attracting investors	Construction of airports by private companies, implementation of digital monitoring systems
UK	Market	Predomination of private capital, emphasis on competition among investors	Investments in multimodal hubs, automation of transport processes
China	Command	centralised management and rapid mobilisation of public resources	Development of high-speed railways, centralised management of restoration works
France	Mixed	Public-private partnership for strategic projects	Development of railway connections through a partnership between the state and the private sector
Germany	Mixed	Integration of public and private resources	Expansion of transport corridors, automation of processes
Ukraine	Mixed	Public financing of critical facilities, involvement of international partners	Modernisation of border infrastructure, integration of digital monitoring systems

Source: developed by authors based on M.O. Volodovska (2020), H. Unnikrishnan & T.P. Kattukaran (2024), O. Suntsova (2024)

To achieve successful infrastructure restoration in Ukraine, it is recommended to implement a mixed development model, attracting international investments and best practices. The use of criteria of strategic importance, financial accessibility and simplified

engineering solutions will help optimise the restoration process. A comprehensive approach based on global standards will allow Ukraine to reduce infrastructure risks, adapt to new technologies and maintain economic stability in the long term. The article proposes a new

approach to assessing and comparing economic models used for the restoration of transport infrastructure in the context of crisis recovery, with a special focus on the post-war development of the national economy of Ukraine. The innovation of the study lies in the development and implementation of a comprehensive set of criteria that take into account the specific challenges of restoration, in particular, resource constraints, the complexity of process management and the need for international coordination. The study also emphasises the value of mixed economic models that create synergy between public and private resources, increasing the efficiency of infrastructure restoration. These criteria provide a universal basis for prioritising infrastructure projects and ensuring their compliance with post-conflict recovery requirements and conditions. The main criteria include:

1. Speed of project implementation. This criterion determines the ability of the economic model to quickly implement large-scale infrastructure projects, which is a critical factor in crisis conditions.

2. Financial sustainability and availability of resources. It is possible to assess the sources of financing for projects, including public, international and private investments.

3. Engineering and environmental standards. The integration of innovative solutions allows for shorter project duration and lower costs, while meeting modern environmental standards.

4. Socio-economic impact. The contribution of projects to the socio-economic development of the region and their strategic relevance are assessed.

The selected criteria allow for a detailed comparative analysis of economic models, focusing on the advantages and limitations of each model in recovery conditions. The proposed methodological approach has universal significance and can be used to assess and prioritise infrastructure projects in different countries with different economic structures, for example:

- ▲ India is an example of the successful use of private-public partnerships in the transport sector, in particular in the expansion of the railway network and the construction of airports, which contributes to the growth of investment potential and international competitiveness (Unnikrishnan & Kattukaran, 2024).

- ▲ South Korea demonstrates a centralised approach to infrastructure development, integrating digital technologies and safety standards in high-speed rail. This contributes to the innovativeness of projects and ensures high environmental efficiency (Suntsova, 2024).

- ▲ Sweden pays significant attention to environmental standards in water and rail transport, actively developing green technologies and electrified networks, which meets the requirements of sustainable development and can become an example for Ukraine in the context of integration into the European Union (Volodovska, 2020).

The examples of these countries show how it is possible to adapt their economic models to modern challenges, such as globalisation, digitalisation and environmental sustainability. Ukraine can effectively use this experience by developing a post-war recovery strategy that combines the adaptability of market models with the strategic advantage of centralised management to ensure long-term economic stability.

Conclusions

Restoration of Ukraine's transport infrastructure is a necessary condition for ensuring economic stability and creating a basis for the country's sustainable development. The conducted research allowed us to establish that the most effective approach in modern conditions is to use a mixed model that combines state regulation with private investments. Such a model ensures a rational distribution of financial and material resources, rapid restoration of priority facilities and the introduction of innovative technologies.

The results of the analysis of international experience indicate the feasibility of attracting private-public partnerships for the implementation of large-scale infrastructure projects. In particular, the examples of Germany and Canada demonstrate the effectiveness of combining state guarantees with private investments to achieve high socio-economic results. In addition, the use of digital platforms for monitoring and managing restoration processes allows for transparency and control in the implementation of projects, which is an important factor in conditions of limited resources. It is advisable for Ukraine to adapt these approaches to the realities of the national economy, taking into account the scale of destruction, limited finances and the need to integrate into international standards. The proposed approach involves the creation of a balanced strategy that will contribute to attracting investment, modernising transport infrastructure and ensuring the effectiveness of the country's post-war development.

Further research should focus on the development of mechanisms for private-public partnerships that will contribute to attracting foreign investment. Attention should also be paid to the integration of digital platforms for monitoring the state of infrastructure and managing recovery processes. These aspects are critically important for the effective implementation of infrastructure projects and ensuring Ukraine's competitiveness in the global economic environment.

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Conflict of interest

The authors declare that no conflict of interest arose in the process of writing this scientific article. All stages

of the study were carried out independently, and the results obtained are objective and were not subject to influence by third parties or organisations.

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Відновлення транспортної інфраструктури України в умовах війни: порівняльний аналіз економічних моделей та стабілізаційних механізмів

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Анотація. Актуальність дослідження зумовлена нагальною потребою у відновленні транспортної інфраструктури України, яка зазнала масштабних руйнувань внаслідок війни, оскільки саме транспортна система відіграє ключову роль у забезпеченні економічної стабільності, логістичної безперервності та інтеграції країни у глобальні економічні процеси. Метою дослідження стала розробка методичного підходу, що дозволить мінімізувати рівень ентропії в транспортних системах та пришвидшити процес відбудови шляхом використання елементів змішаної економічної моделі. Для досягнення мети і вирішення поставлених завдань використано порівняльний аналіз світових моделей управління інфраструктурою в умовах кризового відновлення. Результати дослідження підтвердили ефективність інтеграції різних підходів до оцінки економічних моделей, що дозволило сформулювати практичні рекомендації для відновлення транспортної інфраструктури в кризових умовах. Зокрема, було встановлено, що найбільш прийнятною моделлю для відновлення транспортної інфраструктури України є змішана економічна модель, яка забезпечує синергічне поєднання державних та приватних ресурсів. У рамках дослідження запропоновано пріоритети відбудови ключових вузлів інфраструктури, які сприятимуть стабільності економічних процесів і підвищенню упорядкованості транспортної системи. Також розроблено методичний підхід, що інтегрує найкращі практики країн із різними економічними моделями, адаптуючи їх до специфічних умов і потреб України. Запропоновані рішення забезпечують комплексний підхід до інфраструктурного відновлення, враховуючи обмеженість ресурсів та високий рівень ризиків. Отримані результати мають важливе практичне значення для розробки державної стратегії повоєнного відновлення й розбудови інфраструктури країни, що дозволить знизити витрати, оптимізувати використання ресурсів та підвищити швидкість реалізації інфраструктурних проєктів у післявоєнний період, забезпечуючи довготривалу економічну стабільність.

Ключові слова: транспортна система; економічна система; інфраструктурні проєкти; повоєнне відновлення; моделі розвитку інфраструктури