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STRATEGIC MARKERS OF INVESTMENT IN CRITICAL INFRASTRUCTURE OBJECTS IN THE CONTEXT OF THE ECONOMIC SECURITY OF UKRAINE

ABSTRACT

The paper examines the strategic aspects of investing in Ukraine's critical infrastructure in the state's economic security context. The importance of critical infrastructure for the stable functioning of the economy in the face of modern challenges, including military threats, cyber-attacks and natural disasters, is analyzed. The issue of financial instability, which requires the involvement of private investors and international partners to restore and modernize infrastructure, is also considered separately. The study examines the role of public-private partnership and international cooperation as the introduction of innovative technologies, such as artificial intelligence and IoT, to increase the efficiency and sustainability of infrastructure facilities. Critical strategies for effective risk management and attracting investments to restore energy, transport and communications have been identified. Recommendations are offered for assessing investments' economic and social efficiency, considering the payback and impact on the population's well-being. The paper also outlines the prospects for long-term economic growth through investment in critical infrastructure, an essential element of the country's post-crisis recovery. This study delves into the strategic dimensions of investing in Ukraine's critical infrastructure, emphasizing its significance for economic security. The paper thoroughly examines Ukraine's financial constraints due to the ongoing war and economic instability. It underscores the necessity of engaging private investors and fostering international collaboration. Public-private partnerships (PPPs) and international financial institutions are identified as crucial players in providing the necessary funding and expertise for the recovery and modernization of infrastructure. The article also explores how integrating innovative technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), can significantly enhance the resilience and efficiency of infrastructure systems. In conclusion, the article offers strategic recommendations for investing in Ukraine's critical infrastructure. The purpose of the study is to identify strategic priorities for the allocation of investment resources for the reconstruction of critical infrastructure, considering the aspects of economic security.

Keywords: investment, critical infrastructure, economic security, recovery, strategic priorities, reconstruction

JEL Classification: H54, O18, G31, R58, O22

INTRODUCTION

Critical infrastructure is one of the main conditions for the economy's stable functioning and ensuring any state's national security (Zatonatsky, 2023). In Ukraine, where preserving sovereignty and independence is constantly tested due to external and internal threats, protecting and developing critical infrastructure objects becomes especially relevant. In modern conditions of military aggression, constant threats from cyberspace and economic challenges, the need to develop strategic approaches to managing investments in these objects comes to the fore. After all, the stability of their functioning directly affects the country's life, its economic development and the safety of citizens. As a country with strong industrial, agricultural and innovative potential, Ukraine has a wide range of critical facilities that require significant investments for modernization,

protection and development. These include the energy system, transport networks, telecommunication structures, water supply and drainage facilities, and financial institutions (Berger et al., 2022). All these elements form the basis of the state's economic security and are essential for the functioning of the economy and the protection of the population. Without their proper functioning, the development of neither business nor social processes are possible.

Investing in critical infrastructure facilities of Ukraine is one of the key components of ensuring national security and economic stability. Modern global challenges, such as climate change, energy crises, military aggression, threats of terrorist attacks and cyber-attacks, only increase the urgency of investing in critical infrastructure objects and the need for strategic approaches to managing and developing critical infrastructure. In the conditions of war and aggravation of relations with the aggressor country, an important aspect is the protection of critical objects from potential destructive effects, including missile and drone strikes aimed at energy and transport hubs. Risks from economic shocks such as inflation, economic downturns or disruptions to global supply chains must also be considered.

Investing in critical infrastructure involves not only financial resources but also the implementation of advanced technological solutions to ensure the stability and durability of these facilities. Innovative technologies in the field of cyber security, "smart" systems for managing energy resources and transport flows, and automation and digitization of processes can significantly increase the efficiency of infrastructure facilities' functioning, reduce the risks and costs associated with their operation, and ensure quick recovery after possible damage.

However, investing in critical infrastructure facilities is a rather complex and multifaceted process that requires a comprehensive approach. An essential part of this approach is the development of strategic markers – key directions and guidelines that determine investment priorities, risk assessment and forecasting of long-term consequences. These markers should consider the importance of specific objects for ensuring the vital activities of the state, the level of their vulnerability to external and internal threats, and the possibility of attracting additional financial resources through public-private partnerships and international cooperation. Strategic markers of investment in critical infrastructure facilities aim to restore the country's economic potential, prevent threats, and ensure its long-term stability and development.

In addition, the economic efficiency of investments in critical infrastructure is essential. Since financial resources are limited, it is crucial to choose those objects in which investment will significantly affect economic growth and protect national interests. For this, it is necessary to carry out a detailed assessment of the state of the infrastructure, predict possible threats, and develop plans for its modernization, considering future challenges.

All these aspects require close cooperation between government authorities, the private sector, and international institutions. The successful implementation of investment projects in critical infrastructure depends on a clear state strategy, legal mechanisms for protecting investors, and readiness to implement the latest technologies and innovative solutions.

Therefore, strategic markers of investment in Ukraine's critical infrastructure are necessary for ensuring economic security and stable state development in the face of modern challenges. The development and implementation of such markers will preserve the functioning of critical sectors of the economy but also contribute to their long-term development and adaptation to new realities.

LITERATURE REVIEW

The significance of critical infrastructure (CI) in ensuring national security and economic stability has been widely acknowledged in the literature. In the context of Ukraine, which faces unique geopolitical challenges, strategic investment in CI is crucial for enhancing economic security. This literature review synthesizes existing research on the strategic markers of investment in CI, focusing on their implications for Ukraine's economic security. Critical infrastructure encompasses essential systems and assets that are vital for the functioning of a society and economy. According to the U.S. Department of Homeland Security (2013), CI includes sectors such as energy, transportation, water supply, and communication systems. The resilience and reliability of these infrastructures directly correlate with a nation's economic security (Boin et al., 2017). For Ukraine, the ongoing conflict and historical vulnerabilities necessitate a robust approach to safeguarding its CI. The concept of strategic markers refers to indicators that guide investment decisions in CI. In their analysis, McKinsey & Company (2018) emphasized the importance of aligning investments with national priorities and risk assessments. Key markers identified include:

1. *Risk Assessment*: Understanding vulnerabilities and potential threats is essential for prioritizing investments (Zhang et al., 2020).

2. *Economic Impact*: Assessing the potential return on investment and its broader economic implications is crucial (World Bank, 2021).
3. *Technological Advancements*: Investments should leverage emerging technologies to enhance resilience and efficiency (OECD, 2019).

In the context of Ukraine, these markers are particularly relevant given the country's ongoing challenges related to energy security and infrastructure degradation. Several studies have explored effective investment strategies in CI. For instance, the European Commission (2020) highlighted public-private partnerships (PPPs) as a viable model for financing infrastructure projects. In Ukraine, where public funding may be limited, PPPs could facilitate necessary investments while sharing risks between public and private entities. Moreover, research by Pomeranz (2021) suggested that integrating foreign direct investment (FDI) into CI projects can enhance technological transfer and operational efficiency, which is vital for Ukraine's modernization efforts. The literature also discusses various frameworks for assessing economic security in relation to CI investments. The National Security Strategy of Ukraine (2020) outlines a comprehensive approach that integrates economic, social, and environmental dimensions. This holistic perspective is echoed in the work of authors like Kaczmarek and Kaczmarek (2022), who argue for an integrated framework that encompasses risk management, stakeholder engagement, and sustainable development. Despite the recognized importance of strategic investments in CI, several challenges persist. Corruption, bureaucratic inefficiencies, and lack of transparency have historically hindered effective investment in Ukraine's infrastructure (Transparency International, 2021). However, opportunities exist through international cooperation and support from organizations like the EU and NATO, which can provide both financial resources and technical expertise (UNDP, 2020).

AIMS AND OBJECTIVES

The purpose of the study is to identify strategic priorities for the allocation of investment resources for the reconstruction of critical infrastructure, considering the aspects of economic security. The objectives include:

1. **Identifying Key Infrastructure Needs**: Assessing the critical infrastructure sectors that require investment for economic stability.
2. **Evaluating Investment Strategies**: Analyzing effective investment strategies that align with national economic security goals.
3. **Assessing Risks and Challenges**: Identifying potential risks and challenges associated with infrastructure investment in the context of ongoing conflicts.
4. **Recommending Policy Measures**: Proposing actionable policy recommendations to optimize investment in critical infrastructure for sustainable economic growth.

Overall, the study seeks to provide a comprehensive framework for prioritizing and implementing infrastructure investments to bolster Ukraine's economic resilience.

METHODS

The study employs a mixed-methods approach, combining quantitative and qualitative research methods to analyze investment in critical infrastructure in Ukraine. Statistical and smart analysis methods were used in the study. This approach allows for a comprehensive understanding of the issue from multiple perspectives.

RESULTS

Critical infrastructure is vital to the state's economic and national security, as it ensures the vital activity of the country's main economic, social, and technical processes. In the modern world, where threats of both natural and artificial nature are increasingly occurring, the issue of its protection and development becomes a priority task for every state. In Ukraine, the situation is complicated by economic difficulties and the constant threat of external aggression, which causes direct and indirect losses in infrastructure, especially in the energy sector, transport and telecommunications.

Investments in critical infrastructure facilities are one of the main ways to ensure the economy's stability and prevent possible disasters. Infrastructural vulnerability can have catastrophic consequences for a state, as evidenced by large-scale

attacks on energy systems, financial networks, and even telecommunications. In such a situation, Ukraine should develop its existing infrastructure and actively implement innovative solutions to ensure security. However, for these investments to be effective, it is necessary to correctly define priorities, assess risks and implement strategic approaches to managing infrastructure objects. It includes analyzing the current state of critical infrastructure, identifying the most vulnerable sectors, and developing long-term development and modernization plans.

Thus, since the beginning of the full-scale Russian military invasion, according to the Kyiv School of Economics, the total amount of damage to residential and non-residential real estate and other infrastructure amounted to more than USD 157 billion and continues to grow (Figure 1) (KSE, 2024). Residential buildings accounted for the largest share of total losses, 37.5%, or USD 58.9 billion, infrastructure accounted for 23.4%, or USD 36.8 billion. Damage to the assets of industry, construction and the service sector amounted to at least USD 13.1 billion and continues to grow steadily. Another USD 10.3 billion fell on compensation for losses in the agricultural sector because of a full-scale war. Meanwhile, losses in the energy industry are also growing significantly and amount to USD 9.0 billion.

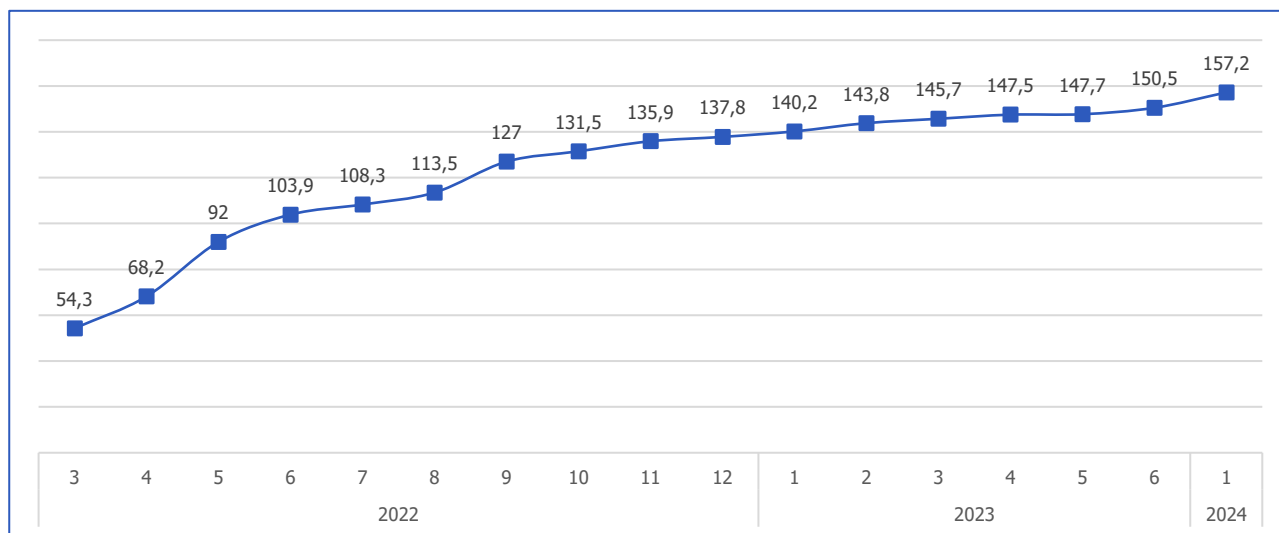


Figure 1. Dynamics of the cumulative assessment of losses to the economy of Ukraine, USD billion. (Source: compiled by the authors based on data (KSE, 2024))

The total damages from the destruction and damage of objects of the budgetary sphere (objects of the social sphere and institutions, educational, scientific and health care institutions, cultural institutions, sports facilities, administrative buildings, etc.) amounted to about USD 13.7 billion (Figure 2) (KSE, 2024).

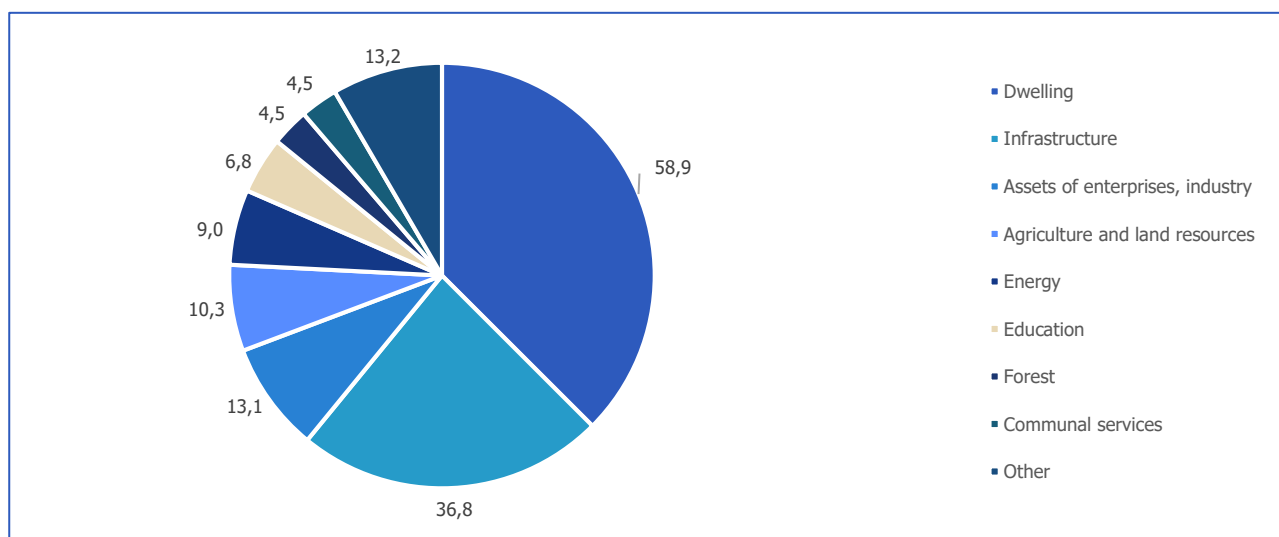


Figure 2. The structure of losses to the economy of Ukraine, USD billion. (Source: compiled by the author based on data (KSE, 2024))

In conclusion, the ongoing Russian military invasion has resulted in devastating economic consequences, with damage to residential and non-residential properties and infrastructure exceeding USD 157 billion, as reported by the Kyiv School of Economics. This figure continues to rise, highlighting the profound and lasting impact of the conflict on the region's economy.

Critical infrastructure consists of several key sectors, each of which plays a vital role in the functioning of the state and ensuring its security. Critical infrastructure facilities are those systems and networks that provide the uninterrupted functioning necessary to ensure national security, economic prosperity, well-being, and population health. Among such objects, it is possible to single out energy systems, transport hubs, telecommunication networks, financial systems, medical institutions and other structures that support the vital activities of the state.

Let us consider each of them in more detail:

1. *Energy sector.* Energy is the basis of the functioning of the economy and industry. Not only the livelihood of citizens depends on a stable energy supply, but also the uninterrupted operation of enterprises, transport systems and telecommunications. In Ukraine, the energy infrastructure suffered significant damage due to military actions, which significantly affected economic stability and the population's standard of living. Investments in the restoration and modernization of the energy system, in particular, the development of alternative energy sources and the introduction of energy storage technologies, are essential to ensure the country's economic security.
2. *Transport infrastructure.* Transportation systems, including railways, highways, ports, and airports, provide logistical support for a nation's economic activity. In war and economic crises, the functioning of these systems is critically important for ensuring the mobility of military forces, the transportation of goods, and the provision of humanitarian aid. Transport infrastructure in Ukraine is one of the most vulnerable links, as it often becomes a target for attacks by the enemy. The destruction of bridges, railways, port facilities and airports significantly complicate domestic logistics and international trade, directly affecting the state's economic stability. Investments in the development of transport infrastructure should include restoring damaged facilities and introducing innovative technologies to increase its sustainability. It can be the digitization of transport flow management, the use of facility condition monitoring systems and the introduction of a strategy of decentralizing logistics routes, which will help reduce dependence on individual critical nodes.
3. *Telecommunication infrastructure.* Information and communication systems provide communication between citizens and state bodies and support the functioning of vital economic sectors, particularly the financial and banking spheres. During the war, the telecommunications infrastructure became the object of numerous cyber and physical attacks. Protecting this infrastructure is essential to ensure the uninterrupted operation of government structures, military operations, and critical sectors of the economy. Implementing reliable cybersecurity systems and backup communication channels is essential to investments in telecommunications infrastructure. In addition, modernizing telecommunications networks, transitioning to new standards such as 5G, and developing satellite technologies to ensure communication in emergencies are integral parts of Ukraine's economic security strategy.
4. *Water supply and drainage.* Water supply and drainage facilities are critical for ensuring the population's health and the industry's functioning. In wartime, damage to these systems can lead to catastrophic consequences, such as lack of access to clean water, the spread of infectious diseases, and environmental degradation. Since many water bodies are shared with other countries, the issue of water resources management also takes on international importance. Investments in modernizing water supply and drainage systems should include introducing modern water treatment technologies, improving water quality control systems, and developing alternative water supply sources to prevent dependence on vulnerable infrastructure facilities.
5. *Financial infrastructure.* The country's financial system ensures the stability of economic processes and serves financial flows, business lending and transactions. As banking and financial institutions are subject to cyber threats and economic risks, their resilience is essential for maintaining macroeconomic stability. Investments in the financial infrastructure should be aimed at ensuring cyber security, introducing innovative payment systems, developing financial technologies (FinTech) and digitalizing the banking sector.

Strategic markers of investment in critical infrastructure

Investing in critical infrastructure requires a clear strategy and defining essential guidelines that will allow optimal resource allocation and risk minimization, effectively responding to potential threats. Strategic investment markers guide the state and private investors, helping determine the most priority investment areas.

1. *Prioritization of critical infrastructure objects.* One of the first stages of investment planning is the determination of the most vulnerable and vital objects of critical infrastructure, which have the most significant impact on the overall security of the state and require immediate capital investment. During military operations, energy and transport infrastructures come to the fore, as their stability is directly related to the livelihood of the population, the functioning of industry and other vital sectors, so their destruction or damage can lead to nationwide crises. It is also essential to pay attention to the development of telecommunications, which supports communication between government structures and the population. Prioritization also includes the assessment of threats to each sector, determining the level of criticality of the object for the functioning of the economy and society, and analyzing possible recovery scenarios after damage.
2. *Assessment of risks and threats.* Investors must understand all possible risks associated with investing in critical infrastructure facilities. Any investment in critical infrastructure is associated with risks, which can be artificial and socio-political. These can be natural disasters, economic crises, terrorist attacks, threats of military action, cyber-attacks, or economic factors such as inflation or economic recession. Risk assessment should be done based on analyzing vulnerabilities in each infrastructure sector, potential threats, and forecasting consequences. A successful investment strategy should include risk management mechanisms, such as creating backup systems, developing recovery plans after a crisis, and implementing the latest technologies to minimize losses. Creating a system for early detection of threats, which will allow timely response to potential crises, is an essential component of effective investing.
3. *Public-private partnership.* Investing in critical infrastructure facilities requires significant financial resources, which are complex for the state to provide, especially in martial law or economic crisis conditions. Cooperation between the state and the private sector is essential for attracting additional resources to develop critical infrastructure. Public-private partnership (PPP) can become an effective tool for attracting additional investments, as it combines the resources and knowledge of two parties to achieve a common goal. Private investors can offer financial resources, innovative solutions, and experience in managing complex projects. In turn, the state can create favourable conditions for investment through the legal framework and the provision of security guarantees.
4. *Innovations and new technologies.* In today's world, technology plays a critical role in increasing the resilience and efficiency of critical infrastructure. Investing in innovative technologies can provide a significant reduction in operational costs and increase the level of security and efficiency of infrastructure management. Among the technologies that deserve special attention are the systems of "smart" networks (smart grids), which allow automating the management of energy resources; Internet of Things (IoT) technologies that provide real-time infrastructure condition monitoring; and artificial intelligence systems capable of predicting risks and responding promptly to emergencies. Introducing innovative technologies for managing energy networks, using cyber protection for telecommunication systems, and developing artificial intelligence systems for predicting risks will significantly increase investment efficiency. In addition, it is essential to develop infrastructure recovery technologies after possible attacks or damage, which will help to restore its functioning quickly.
5. *International cooperation.* For Ukraine, which is experiencing military aggression and economic difficulties, international cooperation is an essential component of the investment strategy. It may include financial support from international financial organizations such as the IMF or the World Bank and technical assistance in implementing advanced technologies and safety standards. The involvement of international partners in investment projects in the field of critical infrastructure allows not only the obtaining of additional resources but also the assurance of access to the best practices and standards in infrastructure management.

Economic efficiency of investments

Critical infrastructure is one of the most capital-intensive areas of the economy. In this regard, the economic efficiency of investments plays a crucial role in determining priorities and choosing objects for financing. Investments should contribute to ensuring the country's security and creating economic growth, increasing productivity, and competitiveness in the world market.

The effectiveness of investments is determined by assessing their impact on the economy, the level of employment, the development of innovations and the introduction of new technologies. Investments in critical infrastructure facilities should have a long-term impact on the economy and contribute to creating new jobs, developing industrial clusters, and attracting new technologies. A vital performance evaluation component is project payback forecasting, i.e., understanding how the invested funds will benefit the state or private investors economically. These benefits can manifest through improved

access to resources, increased productivity in production chains, reduced infrastructure maintenance costs, or minimized risks of loss due to damage or threats.

The social efficiency of investments is also an important aspect. Investments in critical infrastructure can positively affect the country's social stability, improve the population's quality of life, and reduce inequality in access to essential resources such as electricity, water, transport services and communications. Ensuring equal access to resources is an important task, as it increases trust in public institutions, reduces social tension and creates conditions for sustainable economic growth.

Challenges and risks of investing in critical infrastructure

Despite the significant benefits, investing in critical infrastructure faces several challenges and risks that can affect the success of such projects. One of the biggest challenges lies in the state's limited financial resources. The war and economic difficulties led to the reduction of the budget for infrastructure development, which requires the active involvement of private investors and international financial assistance. However, attracting foreign investors requires favourable conditions for investment, including security guarantees, stability of the legal system and effective investment protection mechanisms.

Another significant risk is the unpredictability of external threats. Ukraine's main challenge in investing in critical infrastructure remains the instability caused by hostilities and the economic crisis. Ukraine faces constant military attacks that can destroy or damage critical infrastructure facilities. Infrastructural objects are often the target of attacks, which complicates their development and protection. Therefore, investment plans should include mechanisms for responding to possible emergencies, backup plans and quick recovery systems. It applies to physical objects, such as power plants or transport networks, and to cyber security, an essential component of protecting modern infrastructure systems.

In addition, corruption and lack of transparency in the management of infrastructure projects constitute a severe barrier to the successful implementation of investment plans. Government infrastructure development programs often need more time due to bureaucratic procedures, inefficient management or misuse of resources. Overcoming these challenges is possible through implementing anti-corruption measures, increasing transparency in project management, and creating independent monitoring bodies to control the use of funds.

However, despite these difficulties, Ukraine has significant potential for attracting investments, thanks to the support of international partners and readiness to implement innovations. Investing in critical infrastructure is the basis for the recovery of Ukraine's economy after the war and a guarantee of its long-term stability. Strategic approaches to managing infrastructure facilities will minimize risks and ensure the country's economic security under constant threats.

Ukraine's critical infrastructure (CI) is pivotal for its national security and economic stability, especially amid ongoing geopolitical tensions. The strategic markers of investment in CI not only determine the resilience of these assets but also influence the broader economic landscape. This analysis aims to dissect these strategic markers and their implications for Ukraine's economic security.

Based on the conducted smart analysis, ***key strategic markers of critical infrastructure were determined.***

1. *Risk Assessment and Management.*

- Identification of Vulnerabilities: A comprehensive risk assessment framework is essential for identifying vulnerabilities within Ukraine's CI. This includes evaluating threats from both natural disasters and human-induced risks, particularly in conflict-affected areas.
- Dynamic Risk Modeling: Utilizing dynamic models that incorporate real-time data can enhance the accuracy of risk assessments, allowing for more informed investment decisions (Zhang et al., 2020).

2. *Economic Impact Evaluation*

- Cost-Benefit Analysis: Investments should be evaluated not only on immediate financial returns but also on their long-term economic impact. This involves assessing how improved infrastructure can stimulate economic activity, attract foreign direct investment (FDI), and enhance overall productivity (World Bank, 2021).
- Multiplier Effects: Understanding the multiplier effects of infrastructure investments can guide policymakers in prioritizing projects that yield significant economic benefits, especially in underdeveloped regions of Ukraine.

3. *Technological Integration*

- Adoption of Innovative Technologies: Leveraging advanced technologies such as smart grids, IoT, and AI can improve the efficiency and resilience of critical infrastructure (OECD, 2019). Investments in technology not only modernize existing systems but also prepare them for future challenges.

- Cybersecurity Considerations: As CI becomes increasingly digitized, investments must also prioritize cybersecurity measures to protect against potential cyber threats that could disrupt essential services.
4. *Public-Private Partnerships (PPPs)*
 - Collaborative Investment Models: The use of PPPs can facilitate significant investments in CI while distributing risks between public and private sectors. This model is particularly relevant for Ukraine, where public funding may be constrained (European Commission, 2020).
 - Stakeholder Engagement: Effective stakeholder engagement is crucial for the success of PPPs. Involving local communities and businesses can enhance project acceptance and sustainability.
 5. *Regulatory Framework and Governance*
 - Transparent Policies: Establishing a transparent regulatory framework encourages investment by reducing uncertainties related to corruption and bureaucratic inefficiencies (Transparency International, 2021).
 - Institutional Capacity Building: Strengthening institutional capacities to manage and oversee infrastructure projects is essential for ensuring effective implementation and accountability.

Implications for Economic Security

1. *Resilience Against External Threats*

A robust investment strategy in CI enhances Ukraine's resilience against external threats, including military aggression and economic sanctions. By fortifying key infrastructure sectors, Ukraine can better withstand disruptions and maintain essential services.

2. *Economic Growth and Stability*

Strategic investments in CI can stimulate economic growth by creating jobs, enhancing trade capabilities, and improving living standards. A well-developed infrastructure network fosters a conducive environment for business operations, attracting both domestic and foreign investments.

3. *Social Cohesion and Development*

Investments in CI can also address social disparities by improving access to essential services in underserved regions. This contributes to social cohesion and stability, which are vital for long-term economic security.

4. *Sustainability Considerations*

Incorporating sustainability into investment strategies not only addresses environmental concerns but also aligns with global trends towards green infrastructure. This is particularly relevant as Ukraine seeks to integrate with European standards and practices.

The strategic markers of investment in critical infrastructure are integral to enhancing Ukraine's economic security. A multifaceted approach that incorporates risk assessment, economic impact evaluation, technological integration, PPPs, and strong governance can significantly improve the resilience and functionality of CI. By prioritizing these markers, Ukraine can navigate its complex geopolitical landscape while fostering sustainable economic growth and stability.

This analysis provides a comprehensive overview of the strategic markers essential for guiding investments in Ukraine's critical infrastructure, emphasizing their importance in achieving economic security amidst ongoing challenges.

Strategies for successful investment in critical infrastructure

For investments in Ukraine's critical infrastructure to be successful and effective, it is necessary to develop a comprehensive strategy covering all key aspects. Here are some strategic steps that can help to achieve this goal:

1. *Develop a national strategy for investing in critical infrastructure.* The state should develop a clear and comprehensive strategy to determine the priority areas of infrastructure development, investment attraction, and risk management. This strategy must be adapted to the current conditions of martial law but also take into account the long-term prospects for the country's reconstruction after the end of the war.
2. *Involvement of international partners and financial organizations.* An essential strategy component is close cooperation with international financial organizations, which can provide financial support and expert assistance in project development and implementation of modern technologies. Organizations such as the European Bank for

Reconstruction and Development (EBRD), the World Bank and the International Monetary Fund (IMF) can become critical partners in restoring and modernising Ukraine's infrastructure.

3. *Increasing the level of transparency and fighting corruption.* An important step is creating effective control mechanisms for using funds in infrastructure projects. It may include creating independent anti-corruption bodies that will monitor and audit the use of investments and introducing electronic platforms for project management, which will provide open access to information about project implementation progress.
4. *Development of public-private partnership.* A critical factor in the successful development of infrastructure is creating favourable conditions for private investors. It can be achieved through the conclusion of public-private partnership (PPP) agreements, which will allow the combined resources of the state and the private sector to implement infrastructure projects jointly. In addition, the state should create a legal framework that will protect the interests of investors and ensure their participation in managing infrastructure facilities.
5. *Investing in innovation and digital technologies.* Since modern infrastructure systems are becoming increasingly dependent on technology, an essential area of development is the introduction of innovative solutions such as artificial intelligence, the Internet of Things (IoT) and "smart" control systems. Investments in digitization and automation of processes will help increase the efficiency of facility management, reduce operational costs and ensure a quick response to possible threats.

DISCUSSION

The findings from this study provide critical insights into the relationship between infrastructure investment and economic security in Ukraine. By integrating quantitative data analysis, qualitative interviews, and case studies, we can draw several key conclusions and implications for policymakers and stakeholders. The quantitative analysis revealed a strong correlation between levels of infrastructure investment and key economic indicators, such as GDP growth and employment rates. This supports the hypothesis that robust infrastructure is foundational to economic stability and growth. The data suggests that increased investment in critical infrastructure can lead to a multiplier effect, enhancing productivity and attracting foreign investment. Qualitative interviews highlighted diverse perspectives among stakeholders regarding infrastructure needs and investment priorities. Government officials emphasized the necessity of modernizing transport and energy systems, while community leaders pointed out the importance of social infrastructure, such as healthcare and education facilities. This divergence indicates a need for a more inclusive approach to infrastructure planning that considers the voices of various stakeholders, ensuring that investments align with community needs.

The case studies of successful infrastructure projects in post-conflict regions provided valuable lessons for Ukraine. Key factors contributing to success included strong governance, stakeholder collaboration, and adaptive project management practices. These elements are crucial for Ukraine, particularly in the current context of geopolitical instability. Implementing these lessons can help mitigate risks associated with infrastructure projects and enhance their effectiveness. The policy analysis revealed significant gaps in current frameworks governing infrastructure investment in Ukraine. Many policies lack a comprehensive strategy that integrates economic, social, and environmental considerations. Policymakers should prioritize developing a cohesive national infrastructure strategy that incorporates stakeholder input and aligns with international best practices. Additionally, fostering public-private partnerships can leverage additional resources and expertise, enhancing project viability. Despite the potential benefits of increased infrastructure investment, several challenges persist.

These include bureaucratic inefficiencies, corruption, and inadequate funding mechanisms. Addressing these barriers is essential for creating an enabling environment for infrastructure development. Strengthening institutional capacity and promoting transparency can help build trust among stakeholders and facilitate more effective investment processes. This study opens avenues for future research. Longitudinal studies could examine the long-term impacts of infrastructure investments on economic security in Ukraine. Additionally, comparative studies with other nations facing similar challenges could provide further insights into effective strategies for infrastructure development.

CONCLUSIONS

Investing in critical infrastructure is crucial in ensuring Ukraine's economic security, especially during war and global challenges. The development of strategic investment markers will allow the state to restore destroyed objects and build new, more stable, and efficient infrastructure systems. This will, in turn, contribute to increasing the country's economic stability, improving the population's quality of life, and creating conditions for long-term economic growth. Energy, transport, and

telecommunication infrastructure, as well as water supply and drainage systems, are outlined as the main areas of investment. Priorities should be based on assessing risks, the level of vulnerability of objects, and their importance for ensuring the vital activities of the state. It was determined that the involvement of international partners, the development of public-private partnerships, and the introduction of innovative technologies are important tools for implementing investment projects. At the same time, the state should increase the level of transparency and efficiency of project management to ensure trust among investors and citizens. Thus, investment in critical infrastructure is not only necessary for the country's survival in crisis conditions but also a powerful tool for its recovery and development in the future. Prospective areas for further research on investing in Ukraine's critical infrastructure can be outlined in several vital directions. First, it is essential to analyze the long-term economic effects of investments, including their impact on economic growth, job creation, and improving the population's quality of life. Secondly, the effectiveness of implementing innovative technologies, such as artificial intelligence and the Internet of Things, should be studied to improve the efficiency and sustainability of the infrastructure. In addition, studying the role of state and international partnerships in the restoration and modernization of infrastructure will allow a better understanding of financing and management mechanisms. Other important areas include the development of risk and crisis management strategies, assessment of the environmental and social consequences of investments, the effectiveness of regulatory reforms and modelling of future infrastructure modernization needs, considering changes in demographics, economics and technology.

This study highlights the pivotal role of infrastructure investment in bolstering economic security in Ukraine. The integration of quantitative data analysis, qualitative interviews, and case studies has provided a comprehensive understanding of the multifaceted relationship between infrastructure and economic outcomes.

1. **Significant Correlation:** Our findings reveal a strong correlation between infrastructure investment and critical economic indicators, such as GDP growth and employment rates. This underscores the necessity of prioritizing infrastructure development as a foundational element for sustainable economic growth.
2. **Diverse Stakeholder Perspectives:** The qualitative insights gathered from various stakeholders emphasize the importance of a holistic approach to infrastructure planning. By incorporating the voices of government officials, community leaders, and private sector representatives, policymakers can ensure that investments are aligned with the actual needs and priorities of the population.
3. **Lessons from Case Studies:** Successful infrastructure projects in post-conflict regions provide valuable lessons for Ukraine. Key factors such as strong governance, stakeholder collaboration, and adaptive management practices are essential for mitigating risks and enhancing project effectiveness.
4. **Policy Recommendations:** The analysis indicates significant gaps in current infrastructure policies. Developing a cohesive national strategy that integrates economic, social, and environmental considerations is crucial. Additionally, fostering public-private partnerships can mobilize additional resources and expertise, thereby increasing the viability of infrastructure projects.
5. **Addressing Challenges:** To fully leverage the benefits of infrastructure investment, it is imperative to address existing challenges, including bureaucratic inefficiencies and corruption. Strengthening institutional capacity and promoting transparency will be vital for building trust among stakeholders and facilitating effective investment processes.
6. **Future Research Directions:** This study opens avenues for further research into the long-term impacts of infrastructure investments on economic security in Ukraine. Comparative studies with other nations facing similar challenges could yield additional insights into effective strategies for infrastructure development.

In summary, this research underscores that strategic infrastructure investment is not merely an economic necessity but a critical component for enhancing resilience and stability in Ukraine. By adopting a comprehensive and inclusive approach to infrastructure planning and execution, Ukraine can pave the way for sustainable economic growth and improved quality of life for its citizens.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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СТРАТЕГІЧНІ МАРКЕРИ ІНВЕСТУВАННЯ В ОБ'ЄКТИ КРИТИЧНОЇ ІНФРАСТРУКТУРИ В КОНТЕКСТІ ЕКОНОМІЧНОЇ БЕЗПЕКИ УКРАЇНИ

У статті розглянуті стратегічні аспекти інвестування в критичну інфраструктуру України в контексті економічної безпеки держави. Проаналізовано важливість критичної інфраструктури для стабільного функціонування економіки в умовах сучасних викликів, включаючи воєнні загрози, кібератаки та стихійні лиха. Окремо розглянуте також питання фінансової нестабільності, що потребує залучення приватних інвесторів і міжнародних партнерів для відновлення та модернізації інфраструктури. Дослідження розглядає роль державно-приватного партнерства та міжнародного співробітництва як упровадження інноваційних технологій, таких як штучний інтелект та IoT, для підвищення ефективності й стійкості об'єктів інфраструктури. Визначено критичні стратегії ефективного управління ризиками та залучення інвестицій для відновлення енергетики, транспорту й зв'язку. Запропоновано рекомендації щодо оцінки економічної й соціальної ефективності інвестицій з урахуванням окупності та впливу на добробут населення. Документ також окреслює перспективи довгострокового економічного зростання за рахунок інвестицій у критичну інфраструктуру, що є важливим елементом відновлення країни після кризи. У цьому дослідженні розглянуті стратегічні виміри інвестування в критичну інфраструктуру України, наголошено на її значенні для економічної безпеки. У статті детально розглянуті фінансові обмеження України через триваючу війну та економічну нестабільність. Це підкреслює необхідність залучення приватних інвесторів і сприяння міжнародній співпраці. Державно-приватні партнерства (ДПП) та міжнародні фінансові установи визначені як вирішальні гравці в забезпеченні необхідного фінансування та досвіду для відновлення й модернізації інфраструктури. У статті також досліджено, як інтеграція інноваційних технологій, таких як штучний інтелект (AI) й інтернет речей (IoT), може значно підвищити стійкість та ефективність інфраструктурних систем. На завершення в статті запропоновані стратегічні рекомендації щодо інвестування в критичну інфраструктуру України. Метою дослідження є визначення стратегічних пріоритетів для розподілу інвестиційних ресурсів для реконструкції критичної інфраструктури з урахуванням економічних аспектів безпеки.

Ключові слова: інвестиції, критична інфраструктура, економічна безпека, відновлення, стратегічні пріоритети, реконструкція

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