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PROGRESSIVE PRACTICES OF IMPLEMENTING PUBLIC-PRIVATE PARTNERSHIP PROJECTS IN CRITICAL INFRASTRUCTURE

ABSTRACT

Private-public partnerships (PPPs) have become one of the leading and most effective models for investing in critical infrastructure, so the use and development of PPP models based on best practices is of particular importance in the current crisis period and during post-war recovery due to high pressure on the state budget and high risks for investment. The purpose of the study is to analyze progressive practices for the implementation of PPP projects for the critical infrastructure sectors and to develop recommendations for formulating a strategy for the usage of PPP projects in the different sectors of Ukrainian critical infrastructure. A detailed analysis of current approaches to the implementation of PPPs in the field of critical infrastructure was conducted, progressive practices of applying digitalization tools in this area were identified, and problems and prospects for their implementation were outlined. The potential factors, barriers and incentives based on regulatory, political, social, and technical factors that affect the implementation and effectiveness of PPPs in creating a modern "smart infrastructure" are highlighted. It is determined that the most important sectors for the execution of PPPs projects in most countries in recent years have been transportation, environment, education, healthcare, and telecommunications. However, the analysis of PPP projects in Ukraine concluded that the main areas of focus were the production and supply of water, gas and heat, while less attention was paid to infrastructure for education and healthcare. The article proposes strategies for the implementation of PPPs and determines the importance of each of their components for the successful implementation of PPPs, which will be relevant for Ukraine, especially at the stage of post-war reconstruction of critical infrastructure. The results of the study provide systematized information that will be useful for civil authorities, potential investors, and the scientific community.

Keywords: critical infrastructure, investment, investment projects, public-private partnership, post-war reconstruction, critical infrastructure sectors, smart infrastructure

JEL Classification: E22, G11, H54

INTRODUCTION

Given the amount of investment in critical infrastructure that is needed in the near future, most governments around the world are seeking to attract additional private funding for its development. Strengthening the significance and functions of the private sector in infrastructure makes it possible to increase investment in more modern, high-quality and safe infrastructure and help to improve efficiency, but it is difficult to achieve this goal. The complex nature of public-private cooperation requires significant attention from public authorities responsible for policy formation and implementation to identify opportunities and incentives to attract private-sector investment, include long-term costs in the budget process, and appropriately allocate project risks between private and public participants.

The topic of public-private partnerships (PPPs) is extremely relevant, as this model of cooperation between the government and private sector representatives has significant market and social potential for the country's socio-economic development. As the cases of many countries show, it can be successfully used to develop public infrastructure and, as a result, has a substantial impact on the competitiveness of the state.

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The growing complexity of economic processes, driven by technological and social progress, requires a higher level of cooperation and pooling of unique resources to achieve a new level of social development. In most cases, the state and individuals are not able to solve complex problems that require significant financial efforts, innovative technologies and skills. In addition, it can be time-consuming. Attracting private investment for the development of "smart infrastructure" based on the PPP model is of particular importance in the current crisis period due to the high pressure on the state budget and the decline in foreign direct investment.

LITERATURE REVIEW

Over the past few years, public-private partnership (PPP) for infrastructure projects have become a topic of considerable attention from both practitioners and academia.

Akomea-Frimpong et al. (2023) aimed to analyze and summarize the existing literature on the use of PPPs to achieve sustainability in infrastructure projects in the country. Their review discovered that there is little research on relevant issues related to PPPs and the Sustainable Development Goals, such as critical resilience, climate measures, clean energy, and sustainable finance.

According to the Sustainable Development Goals declared by the United Nations, access to energy, responsible consumption and sustainable development are critical issues worldwide. To this end, Balcilar et al. (2023) investigated the key role of public-private partnerships (PPPs) for energy investments in Turkey, which is at the moment trying to achieve its energy balance towards energy efficiency. The empirical results from econometric modelling showed a long-term equilibrium relationship between the identified variables, which can be traced using the autoregressive distributed lag (ARDL) limits test. The authors also observed a positive relationship between energy investment through PPPs and the country's energy intensification in both the short and long term. A similar trend could be seen between FDI, GDP growth, and energy intensity. The policy implications of the research suggest effective investment in clean energy (renewable energy) as part of Turkey's efforts to intensify its energy sector to ensure sustainable development. In addition, the involvement of PPPs is a desirable dimension of sustainable economic growth. Such results demonstrate the importance of developing this investment form in order to achieve sustainable infrastructure development.

The study by Gao et al. (2023) empirically investigates the asymmetric relationship between PPPs for energy investments and CO₂ emissions for selected Asian countries from 1990 to 2019. The authors use the econometric approach of nonlinear autoregressive distributed lag (NARDL) modelling for the estimation. The authors argue that the government should encourage PPP investments in the renewable energy sector in selected Asian countries by creating incentives for the maintenance of environmental quality.

The choice of private partners is a vital decision to ensure the success of the project. The selection process is needed to identify, screen and prequalify potential private partners that have the greatest potential to implement the identified PPP projects. To this end, Mohammed Abdelkader et al. (2023) proposed an integrated multi-criteria decision-making model for choosing the best private partners for PPP projects. The proposed model is conceptualized on the basis of two levels of multicriteria decision-making. At the first level, the fuzzy analytical network process is used to carefully examine the relative importance of the priorities of the private partner selection criteria. For this purpose, the PPP selection criteria are categorized into several groups of factors, including safety, environmental, technical, financial, political, and governance. At the second level, a set of 7 multi-criteria decision-making algorithms is used to identify the best private partners for PPP projects.

Four real cases are analyzed to test the feasibility and applicability of the offered integrated model. The results indicate that governance, political, safety and environmental criteria have been assigned different levels of significance depending on the nature of the infrastructure projects. In addition, financial and technical criteria were added as the highest priority criteria for different infrastructure projects. It can be postulated that the proposed model can guide government leaders in assessing the capability of a partner to achieve their strategic goals. The model also sheds light on the strengths, weaknesses, and opportunities of potential private partners in an attempt to neutralize threats and capitalize on opportunities offered by the modern market (Mohammed Abdelkader et al., 2023).

The increasing use of PPPs in the development of infrastructure and delivery of public services has posed various commercial challenges for public sector entities in their ability to initiate, secure and manage PPP projects. Zhang et al. (2023) focus on the importance of project owner capabilities in infrastructure project development and explore how actors learn to develop new enterprising capabilities for procuring infrastructure PPPs, such as the ability to determine project scope and procure and manage suppliers, to fit the PPP context. The authors used a qualitative case study of a state-owned

enterprise in China, which at the time of the study was in the early stages of applying a PPP approach to the procurement for the subway projects.

In theory and in practice, cooperation is the key to effective urban development, which is most often considered through the establishment of PPPs. To systematize the existing practices in the scientific literature, Quan et al. (2023) conducted an in-depth integrative literature review, conducted a content analysis, and identified 4 key areas: locality, stakeholder complexity, tension, and trust building. These 4 areas form the background of their proposed model and describe the key elements that impact the formation of PPPs in smart city projects. The authors argue that the partnerships involved in smart city projects need to be further developed to ensure transparency and participation in different contexts.

Upgrading infrastructure development through advanced technologies and innovative procurement initiatives is seen as the best way to achieve sustainable development, improved safety and health, and the efficiency and management of built infrastructure. The global COVID-19 pandemic has reinforced these imperatives, emphasizing the global need for smart infrastructure based on modern advances in digitalization. The need to overcome resource constraints indicate an increase in the potential of PPP strategies in procurement worldwide. For example, Jayasena et al. (2023) focus on assessing the potential of successful public-private partnerships in the development and maintenance of smart infrastructure in Hong Kong. To conduct the qualitative research, 10 expert interviews were conducted after a comprehensive review of existing achievements in the scientific literature. The findings revealed potential drivers, barriers, and enablers based on regulatory, social, technical, and political factors that influence the implementation and success of PPPs in building smart infrastructure in Hong Kong. An indicative flowchart was developed to illustrate the main cause-and-effect relationships of these factors. According to the findings, stakeholder management, a citizen-centred approach, and maintaining transparency within the project were identified as relevant for success. The study findings encourage further research along with implementing more evidence-based approaches to obtain enhanced perceived benefits from PPPs under appropriate conditions for smart infrastructure in Hong Kong.

The coronavirus pandemic (COVID-19) has undoubtedly caused unprecedented changes and its impact extends to PPP arrangements. At the same time, PPP agreements have contributed to the fight against the pandemic. However, the literature on the concept of PPPs in the COVID-19 era remains limited. The study by Akomea-Frimpong et al. (2023) aims to review the current literature on PPPs during the COVID-19 pandemic and present main themes, research gaps, and prospective research directions. The research findings offered eight topics, such as major changes in PPP contracts, COVID-19 vaccine development, economic recession, testing, governance, and sustainability of PPPs.

According to the relational contract theory, relational governance has the ability to increase the sustainability of infrastructure PPP projects. The main objective of Tian et al. (2023) is to investigate the relationship between relational governance and the sustainability of infrastructure PPP projects. In addition, this study analyses the mediating effect of managerial innovations and the moderation of public involvement. The analysis uses structural equation modelling (SEM) to test 5 hypotheses. The results indicate a positive correlation between relational governance and the sustainability of an infrastructure PPP project. This relationship is governed by public involvement. Besides, managerial innovations play a mediating role between relational governance and the sustainability of infrastructure PPP projects.

For emerging economies with a lack of resources from public budgets and a need to increase the efficiency of urban wastewater treatment (UWTE), effective public oversight of wastewater treatment infrastructure (WTI) and participation of private capital trying to maximize profits is required. However, it is not clear to what extent this PPP model, which aims to reasonably share the benefits and risks of WTI delivery, can improve UWTE. Cheng et al. (2023) evaluated the impact of the PPP model on UWTE, the author collected data from 1303 urban wastewater treatment PPP projects in 283 prefecture-level cities in China from 2014 to 2019 using data coverage analysis and a Tobit regression model. The UWTE was significantly higher in prefecture-level cities that implemented a PPP model in the construction and operation of WTI, especially in cities with feasibility gap subsidies, competitive procurement, privatized operations, and non-demonstration. In addition, the impact of PPPs on UWTE has been limited by the level of economic development, marketability, and climatic conditions.

One of the effective models was the introduction of public-private partnerships in infrastructure development in Vietnam. This model has been utilized in Vietnam for many years and is designed to help governments improve infrastructure, as it provides an opportunity to reduce public debt profiles. The study by Toan et al. (2023) aims to identify the most important factors that can determine the success of these projects. The regression analysis shows that there are 6 critical success factors, including public sector factors, private sector factors, factors relevant to selected partnership processes, factors relevant to risk management systems, factors relevant to information design, and factors relevant to the natural environ-

ment. The findings showed that the most effective development projects could be implemented through PPPs if the government focused on these important factors during the implementation process. The results of the study will influence the policy development of attitudes towards PPPs and guide partners in the development of PPP projects.

Infrastructure PPP projects around the world have suffered from premature termination, premature change of ownership, cost and time overruns, among others, often as a result of a number of problems, some of which are related to poor dispute resolution. Despite this, the literature has shown that no process-oriented attempt has been made to highlight the critical issues affecting dispute resolution (DR) in infrastructure PPPs. Using Event Sequence Analysis (ESA), the study by Musenero et al. (2023) examined the critical issues affecting DR practices in infrastructure PPP projects, with the motivation of uncovering areas for potential improvement in DR practices. The study clarified the critical issues affecting current infrastructure PPP practices, thereby increasing practitioners' understanding of potential barriers to successful infrastructure PPPs.

PPPs have been implemented in many areas, especially in architecture, engineering and construction. However, PPPs in the field of sustainable critical infrastructure have not received the necessary attention, even though they have been recognized as a panacea for enhancing infrastructure stability. The article by Ampratwum et al. (2023) aims to conduct a systematic review to actively identify risk factors associated with the use of PPPs as a mechanism for enhancing critical infrastructure sustainability through content analysis to obtain 46 risk factors for PPPs in CIR. The results of the systematic study identified the most important risks, such as corruption, natural and unavoidable disasters, wars, terrorism, sabotage, cost overruns, lack of a centralized mechanism for coordinating integrated actions, inconsistent government policies, inadequate oversight, high transaction costs due to unreliable and redundant measures, lack of supporting infrastructure, lack of open and integrated communication, unstable government, political interference, lack of PPP experience, and changes in legislation. A conceptual framework was developed by grouping the identified risks into 13 categories. The results of this study will serve as a guide for decision-makers and stakeholders responsible for building critical infrastructure stability.

Despite the significant achievements in the field of PPPs, the issue of researching and systematizing progressive practices of implementing PPP projects in the field of critical infrastructure requires further development, which is the focus of this article.

AIMS AND OBJECTIVES

The purpose of the study is to research progressive practices of executing PPPs projects in the critical infrastructure sectors and to develop recommendations for the formation of a model of governmental regulation of PPP projects in the critical infrastructure sectors in Ukraine. Achieving this goal involves analyzing modern models of implementing PPP projects in the field of critical infrastructure, the features of implementing smart infrastructure models, as well as studying the progressive practices in Ukraine and other countries, and developing a model of state regulation of PPPs projects for building smart infrastructure.

METHODS

The study uses general and special research methods. In particular, the historical and comparative methods were used to determine the dynamics and reasons for the development of PPPs for critical infrastructure investment, as well as the structure of PPP projects by area. The systematic approach facilitates comprehensively considering the nature and features of the implementation of PPP projects, makes it possible to identify the most important areas of their application, and proposes a mechanism for the development of a smart critical infrastructure on the basis of PPP.

The information base of the study includes data from the Ministry of Economy of Ukraine and as well as the European PPP Expert Center (EPEC). EPEC is an initiative, which involves the European Commission, the European Investment Bank (EIB), states, which are EU members, candidate countries and some other countries.

The data covers different projects, which include:

- projects with secured financial closure in the EU27, Turkey, the UK, and the Western Balkans (Bosnia and Herzegovina, North Macedonia, Albania, Kosovo, Serbia, and Montenegro);
- projects configured as design-build-finance-maintain projects, design-build-finance-operate projects, or concession agreements encompassing construction, public services, and a true public-private risk-sharing arrangement. They may also include regulated assets;

- projects funded through the project finance;
- projects with a minimum value of EUR 10 million.
- The indicated project cost shown in the data refers to the external financing needs for projects at the point of financial closure, encompassing both debt and equity and excludes contributions of public capital. It is worth noting that the external financing requirements of a project may differ substantially from the capital investment cost, as the latter is challenging to consistently secure.

RESULTS

We should take a closer look at the dynamics and areas of PPP project implementation in recent years to summarize the existing practices and create a model for the execution of PPPs projects in Ukraine. In the European market in 2022, the total value of PPP deals that achieved financial closure amounted to EUR 9.8 billion, which is 17% more than in 2021, which reached EUR 8.4 billion (Figure 1).

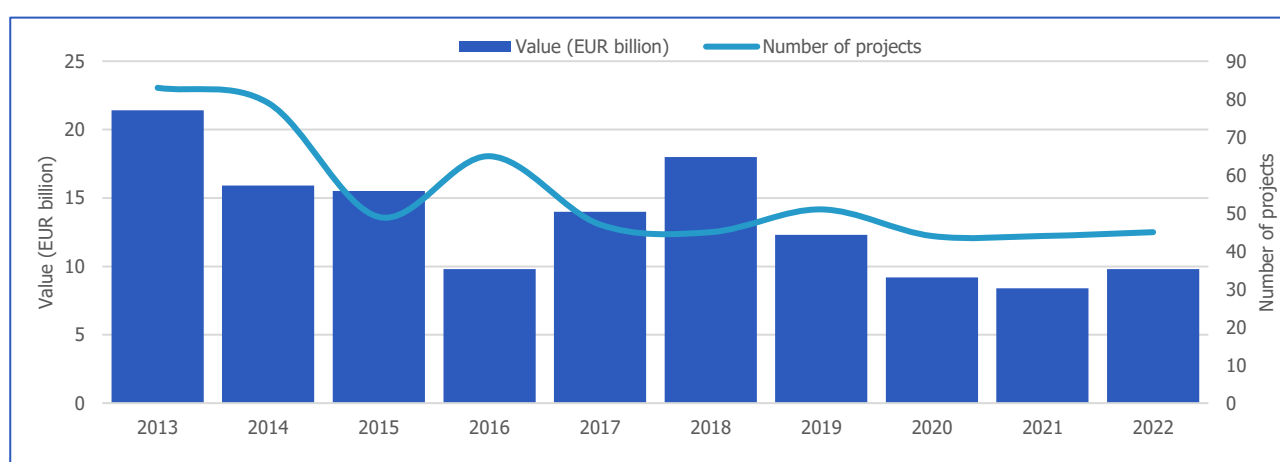


Figure 1. Dynamics of the European PPP market by number of projects and by value in 2013-2022. (Source: European PPP Expert Center (EPEC) data)

The number of PPP transactions that reached financial closure rose to 45, surpassing the 44 transactions recorded in 2021. The average transaction size also saw an increase to EUR 217 million, compared to EUR 190 million in the previous year.

Notably, three big transactions were concluded in 2022, mirroring the same number as in 2021: PPP in Cyprus with EUR 1 billion (Larnaca Port and Marina Reconstruction), in France with EUR 1.4 billion (CEGELOG French Military Accommodation) and in Turkey with EUR 1.8 billion (Antalya Airport Concession).

The total value of these three transactions amounted to EUR 4.25 billion, which is 44% of the total market value. This is a slight decrease compared to the 45% share in 2021 (Figure 2).

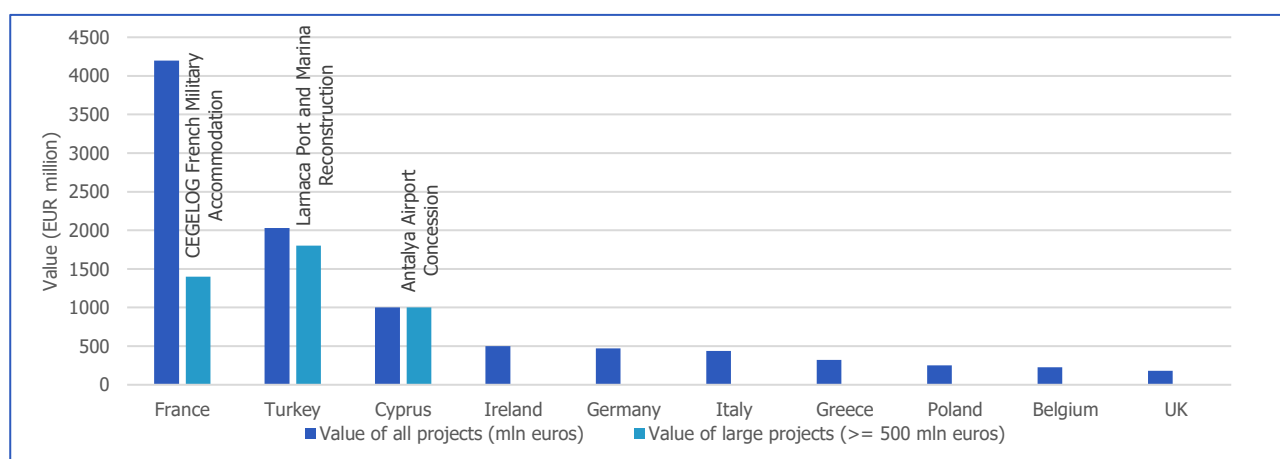


Figure 2. Large PPP projects (over EUR 500 million) in 2022. (Source: European PPP Expert Center (EPEC) data)

In 2022, the share of demand/revenue-based transactions that reached financial closure increased to 70% of the general number of transactions, compared to only 66% in the previous year.

The growth in both the value and quantity of PPP deals in 2022 indicates a recovery in the PPP market despite the uncertainties and volatility of construction prices caused by the shock of the COVID-19 pandemic.

Examining the features of PPPs by European countries (Figure 3), France emerged as the leading PPP market in Europe not only by value with a total volume of EUR 4.2 billion (compared to EUR 1.6 billion in 2021) but also by the number of projects, with 21 projects implemented, which is 3 more than in 2021.

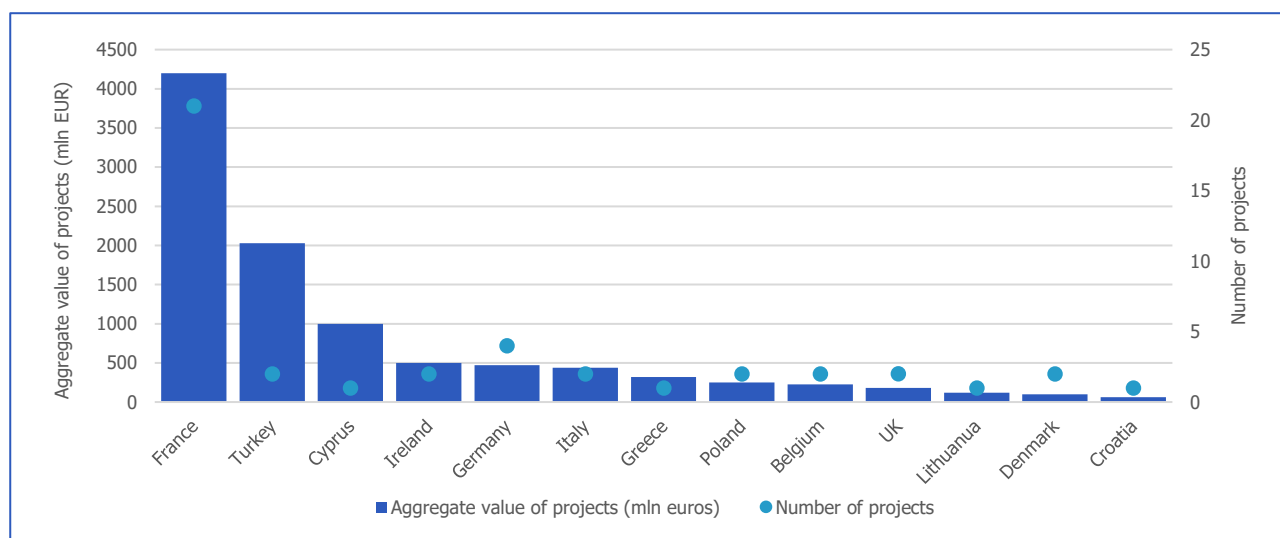


Figure 3. Breakdown of countries by number and value of PPP initiatives in 2022. (Source: European PPP Expert Center (EPEC) data)

Turkey ranked as the second largest PPP market by value, with a cumulative volume of EUR 2.0 billion, up from EUR 1.4 billion in 2021. In 2022, Germany was the first in terms of the number of projects, although it held the second position in terms of the PPP market by value, with four closed deals (compared to 7 deals in the previous year). Additionally, in 2022, 9 states signed 2+ PPP deals compared to only 6 states in 2021, while 15 countries signed 1+ PPP transactions, up from 14 in the previous year).

As depicted in Figure 4, the UK, Germany, and France have consistently been at the forefront of the European PPP market by the general number of deals over the past five years.

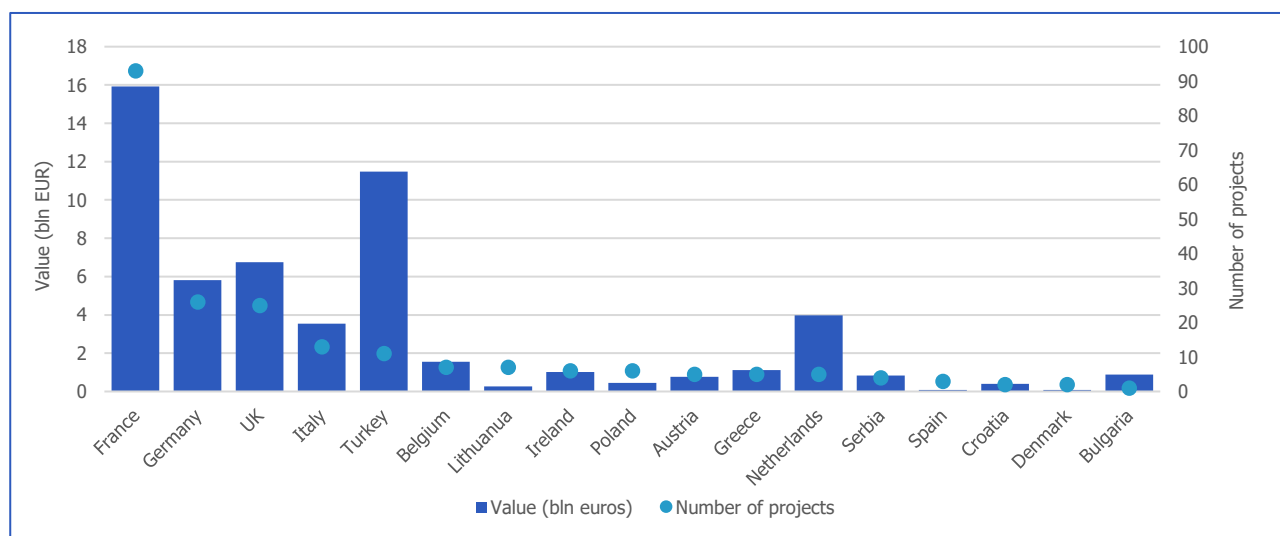


Figure 4. Breakdown of countries in terms of the number and value of PPPs projects implemented in 2018-2022. (Source: European PPP Expert Center (EPEC) data)

In 2022, the transport sector retained its position as the largest sector by value accumulating a total project value of EUR 5.2 billion, slightly lower than in 2021 (EUR 6.0 billion). However, the number of transport projects reaching financial closure rose from 16 in 2021 to 17 in 2022. This includes 4 roads (2 roads in France, one each in Italy and Greece) and 4 ports (2 ports in France, one each in Cyprus and Croatia).

In addition, the environment sector saw the closure of 10 projects, maintaining parity with 2021, with a total value of EUR 1.3 billion vs EUR 1.1 billion in 2021. This sector was the second most active by projects, including 5 district heating projects (all located in France) with a total value of EUR 576 million.

In 2022, the number of the education sector's projects financially closed increased from 5 to 8, and the total value increased to EUR 910 million, compared to only EUR 391 million in the previous year. Six of them were school projects (1 in Belgium, 2 in the UK and 3 in Germany).

The healthcare sector concluded 3 projects in 2022 compared to only 2 in the previous year with a total value of EUR 509 million, almost double the amount of 2021 (EUR 224 million). Two hospitals were completed (one project each in Denmark and in Turkey).

In 2022, 3 projects were closed in the telecommunications sector, which is in line with 2021, with a total value of EUR 231 million, almost half the amount of EUR 427 million in the previous year. All 3 initiatives were French broadband projects (Figure 5, Figure 6).

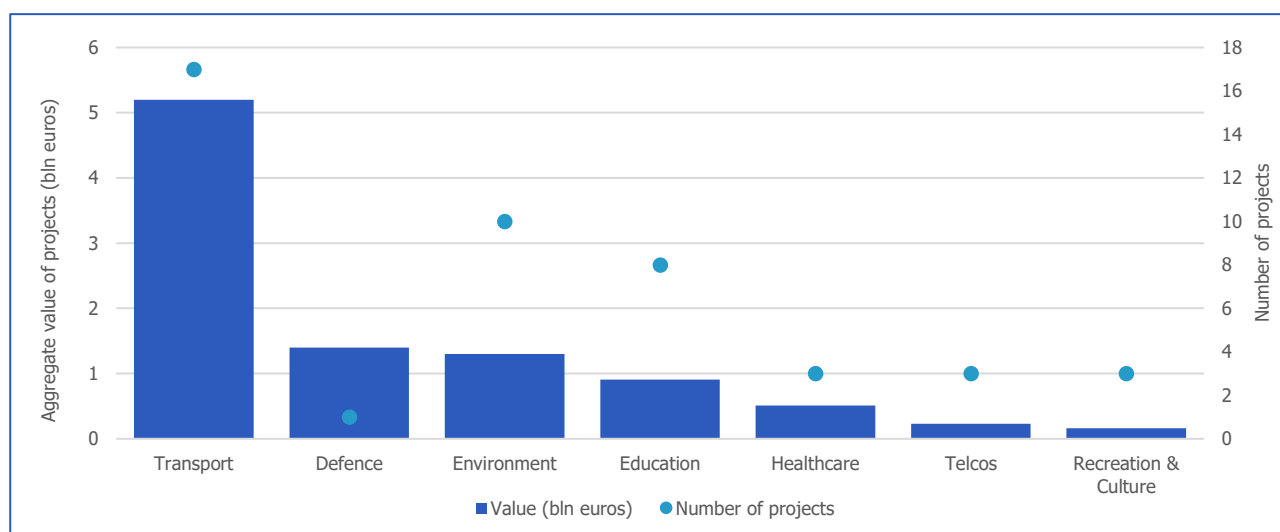


Figure 5. Breakdown of sectors in terms of the number and value of PPP initiatives in 2022. (Source: data from the European PPP Expert Center (EPEC))

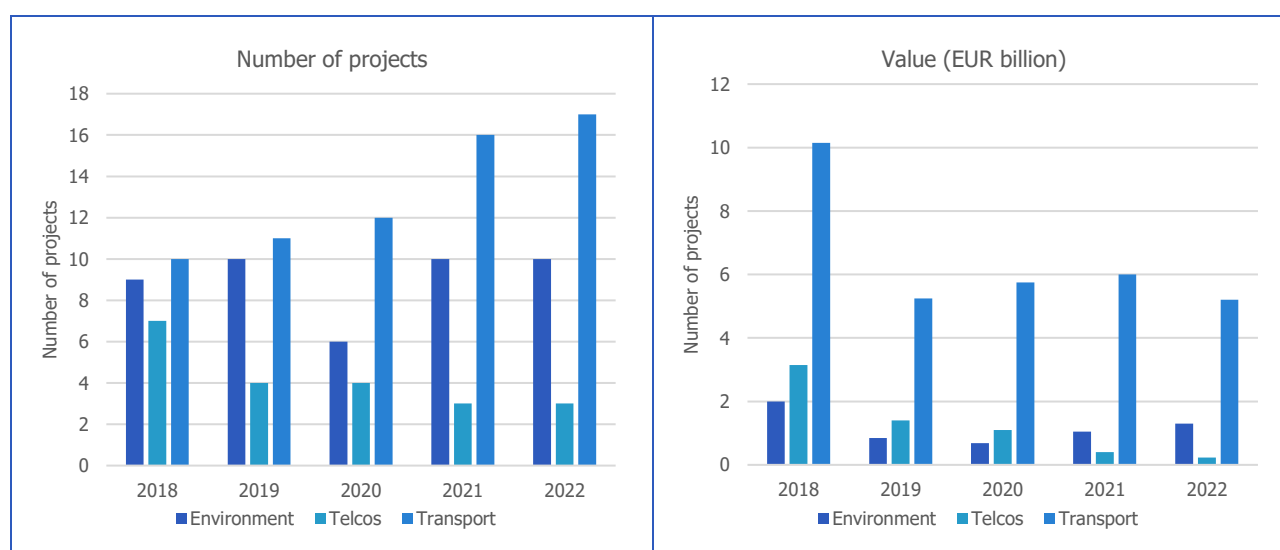


Figure 6. Evolution of key PPP sectors by number and value of projects in 2018-2022. (Source: European PPP Expert Center (EPEC) data)

In 2022, 17 out of 45 projects that were financially closed involved debt from institutional investors, an increase from the 14 out of 44 recorded in the previous year. Various financing models were employed for this purpose and institutional investors include such structures as pension funds and insurance companies. While 7 states completed projects involving institutional investor debt in 2021, in 2022, 8 states (the UK, France, Italy, Denmark, Croatia, Ireland, Cyprus, and Lithuania) benefited from the debt of institutional investors.

The involvement of the national governments, the EU, and public financial institutions (whether supranational or national) remained comparatively limited in 2022. Regarding the European Investment Bank, the 4 PPP projects that were closed during the year received financing from the European Investment Bank with a total loaning volume of EUR 1.0 billion. These projects included the project in France (CEGELOG Affordable Housing & Energy Efficiency), the PPP project in Ireland (Community Nursing), the PPP project in Poland (Krakow Tramway) and the project in Germany and the Netherlands (NeuConnect Interconnector). The last-mentioned project stands out due to its innovative PPP structure and particularly high value of EUR 3.3 billion.

Other important PPP projects that reached financial completion in 2022 include:

1. The PPP in Cyprus for the reconstruction of the Larnaca Port and Marina, reaching financial closure with a total value of EUR 1.0 billion. This marks the second PPP project in Cyprus worth more than EUR 500 million since the European PPP Expertise Centre began collecting data for the European PPP market.
2. The EUR 245 million PPP project Irish Community Nursing Units successfully reached financial closure in 2022. It marks the second healthcare PPP in Ireland and the first community nursing PPP in the country since 2016.
3. The EUR 300 million Thessaloniki Ring Road PPP (Greece) has achieved financial close. Notably, this is the first road accessibility PPP in Greece, and it stands out as the first road projects in the country since the financially closed projects in 2007.
4. Krakow Tram. This EUR 186 million PPP project has achieved financial closure in Poland. This marks a significant milestone as the first PPP-based tram in Polish urban transport.

Moreover, when considering the top 3 countries with the largest number of projects under development, France leads with 50 projects, followed by Italy with 32 projects, and Greece with 28 projects (Figure 7). Over the past 3 years, Greece has notably established a robust project pipeline that demonstrates its ongoing success in procuring PPP projects and its competence to combine EU and public financing.

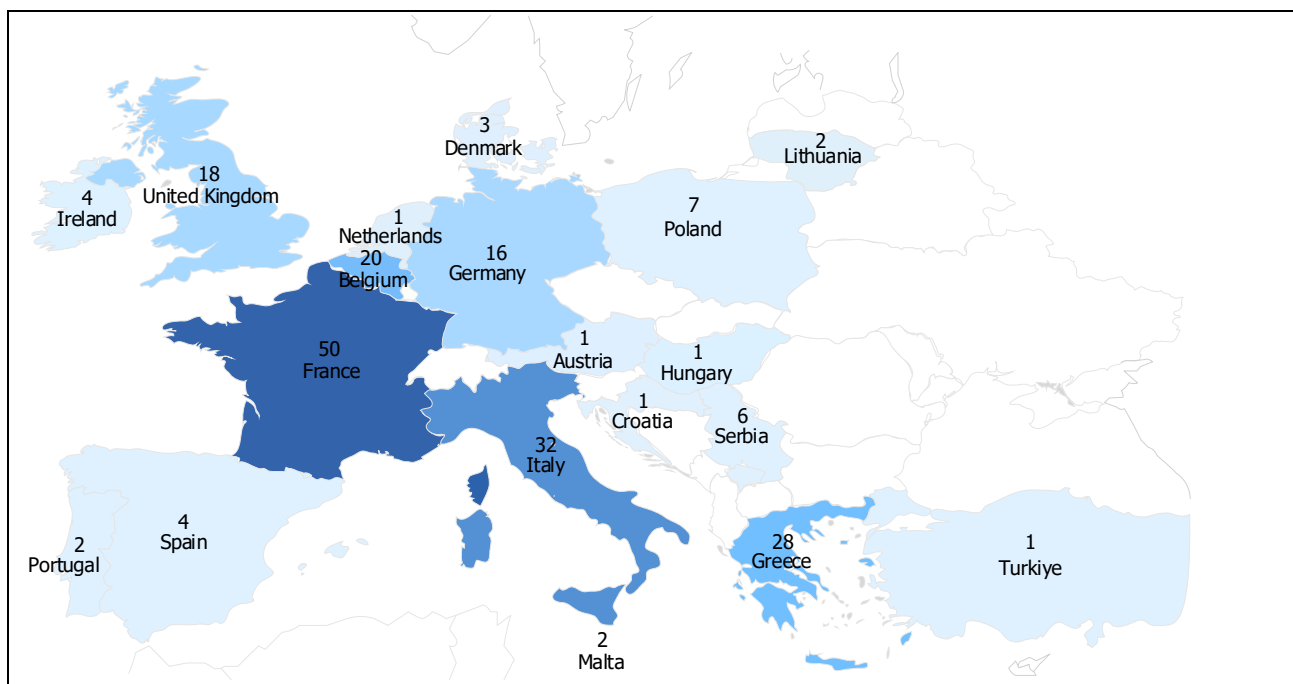


Figure 7. Quantity of projects under development by country in 2022. (Source: data from the European PPP Expert Center (EPEC))

In the project development pipeline, the transportation sector maintains its dominance in terms of the number of projects, with the environment and education sectors following closely (Figure 8). Environment and transportation account for 80% of the French project portfolio. Of the 22 environmental projects, 14 are specifically district heating initiatives, while the 18 transport projects include 5 railways and 4 ports. In Greece, half of the projects are focused on the environment and education sectors. Among the 9 environmental initiatives, 5 are related to water management. Of the 5 education projects, 3 are focused on student housing and one centers around schools.

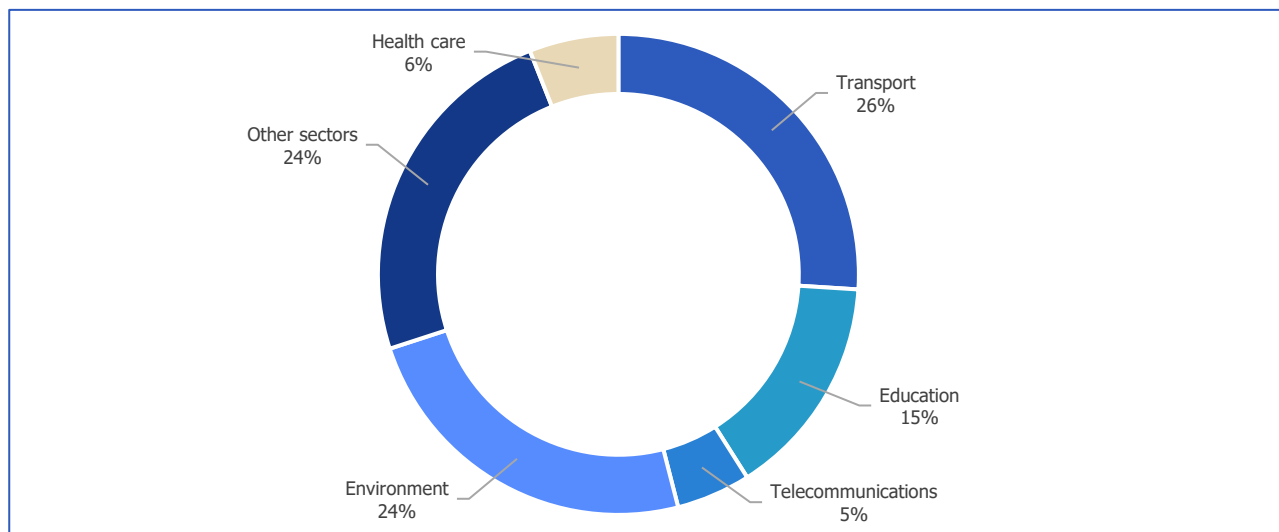


Figure 8. Main areas of projects under development in 2022. (Source: data from the EPEC)

The state of PPP execution in Ukraine is dynamic: in Ukraine, PPPs are also actively developing. Thus, based on information from central and local executive authorities as of January 01, 2023, there have been 193 PPP agreements concluded. Among these, 18 agreements are currently in progress (including 5 joint venture agreements, 9 concession agreements, and 4 other agreements), while 162 agreements are not currently being executed (116 are not being implemented, 46 are terminated/expired), 13 are suspended due to the full-scale armed invasion of the Russian Federation.

The main areas of PPP implementation in Ukraine are the production, transportation, distribution and supply of natural gas and heat, as well as the collection, treatment and distribution of water (Figure 9). Undoubtedly, a full-scale invasion and war require even greater intensification of PPP processes. Another progressive direction is the formation of smart infrastructure and the transition to a more technological basis for the development of infrastructural projects. Smart infrastructure is an infrastructure governed by an intelligent system employing a feedback loop of data to enhance the process of decision-making on a particular problem or process. Smart infrastructure can track, evaluate, analyze, report, and react to received sensors' data. Smart infrastructure is the basis for the future transition to the smart city concept.

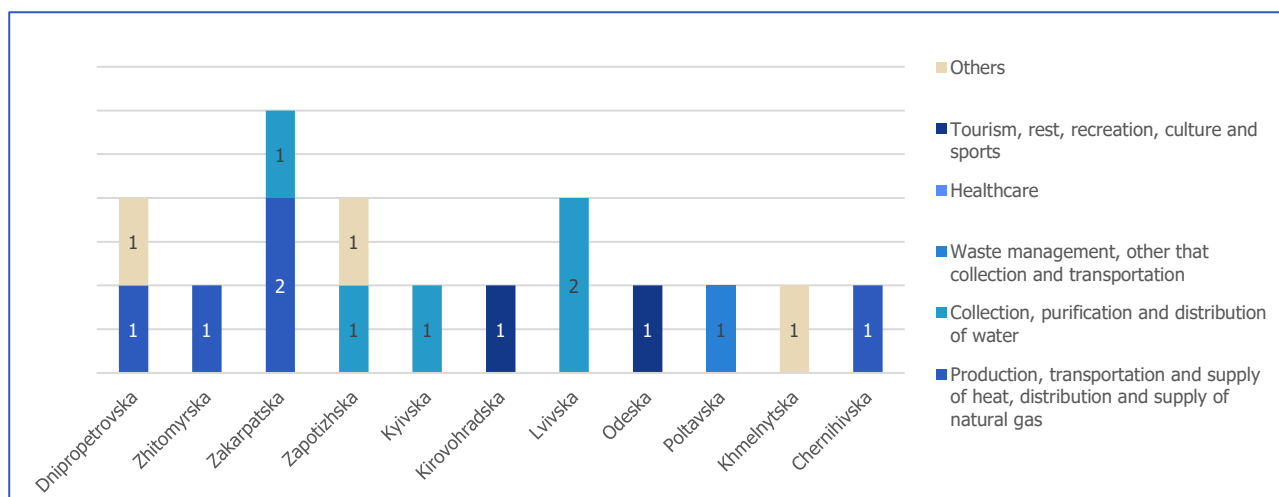


Figure 9. PPP agreements in progress as of January 01, 2023. (Source: data of the Ministry of Economy of Ukraine)

Given that a significant part of the projects executed through the PPP mechanism are concession agreements, it is crucial to highlight that the implementation practices of PPP projects in the infrastructure sector cannot be considered fully successful due to:

- general unpopularity of the PPP mechanism as a result of the unclear distinction between PPP and concession procedures, the complexity of the procedure for concluding a concession agreement, which led to a much greater popularity of mechanisms familiar to private market participants, such as joint venture or lease;
- inability of private partners to provide financing for the works envisaged by concession agreements;
- inability to replace the private partner in case of its incapability to ensure the implementation of the activities envisaged by the project;
- inadequacy of the mechanism for determining the amount of concession payments, which, given the depreciation of fixed assets of state-owned enterprises in the industry at the level of about 80-96%, does not allow to ensure revenues to the state budget;
- inability to provide for an availability fee;
- the problem of state guarantees and the impossibility of long-term budget planning.

At the same time, the PPP mechanism is gaining popularity among local communities as part of the new regional policy in Ukraine, which aims to strengthen the capacity of local communities to independently and effectively use available resources to satisfy the immediate needs of the population of a particular territory. For example, some local governments already have positive experience in the execution of PPP projects, in particular in the area of heat energy production and supply. One example of such a partnership is a joint venture agreement concluded between the community of Malyn and a private investor in 2014 under the PPP mechanism, which provides for the replacement of gas boilers with those that will run on alternative fuels (pressed wood, straw pellets); ensuring the installation of a boiler with a capacity that would allow heating two schools and one sports school; providing the private partner with financing and equipment; the private partner selling heat energy to the city at a discount. The contract is valid for 15 years (Spilno, 2017).

Ukraine is gradually developing the PPP mechanism, as the regulatory framework for PPPs has already been formulated and implemented, with ongoing enhancements of concession legislation. These improvements aim to align with the best international standards for project preparation with the involvement of collaboration with international organizations and representatives from the business community.

Successful execution of PPP projects that will satisfy the requirements of both parties is possible only if PPP projects are prepared in a quality manner, including reasonable evaluations and fair allocation of risks between the participants. At the same time, proper performance analysis and professional preparation of an open and transparent tender for the private partner's selection are equally important for the effectiveness of the project. Given the imperfection of the institutional system of public administration in Ukraine, the organization and conduct of open tenders may require the involvement of advisors and international consultants who could provide the public partner with the necessary expert support, including at the stage of project structuring and negotiations with potential investors, laying the foundation for long-term mutually beneficial collaboration between the private investor and the state.

Based on the progressive practices of the European countries, as well as the results of PPP projects in Ukraine, it is worth outlining a modern mechanism for successful financing of projects based on PPP principles, which will be relevant for Ukraine, especially at the stage of post-war reconstruction of critical infrastructure.

The main stages of the recommended mechanism are as follows:

1. Project selection and preparation.
 - Needs analysis in accordance with existing short- and long-term plans and development priorities.
 - Selection of a suitable project according to available internal and external resources.
 - Project preparation: planning, design review and evaluation of the financing plan.
2. Selection of participants. In this case, when selecting private partners, it is appropriate to use the scheme presented in Figure 10, which involves taking into account a number of factors, including financial, technical, security and management, as well as political (Mohammed Abdelkader et al., 2023).
3. Implementation of PPPs in accordance with the existing legal and regulatory regime and public policy.
4. Project and contract management.

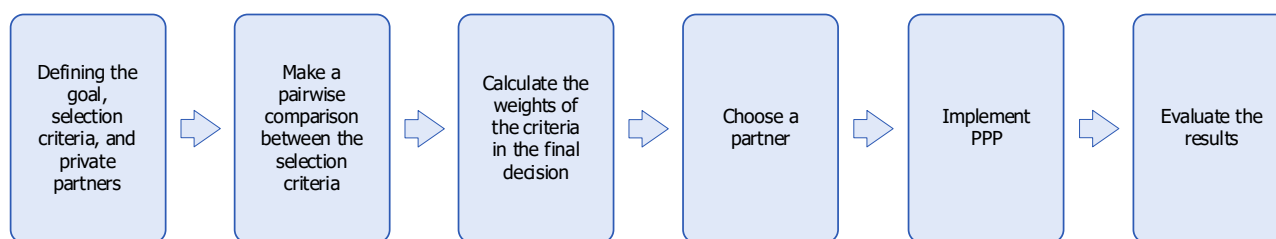


Figure 10. Key stages of selection of PPP and private partners for its implementation.

In general, a number of factors should be considered in evaluating the possible success of PPP projects. Thus, for smart critical infrastructure development projects, the following opportunities and factors that facilitate the use of PPPs are noteworthy:

- a commitment to lowering public sector costs;
- government's active participation in the process;
- effective project implementation and administration;
- the private sector's innovation in smart technologies;
- elevated risk associated with smart infrastructure development;
- the necessity for advanced technology programs in projects of smart infrastructure development;
- greater experience in PPPs projects from both the public and private sectors.

At the same time, the primary obstacles to the execution of PPPs in smart critical infrastructure development projects should be outlined as follows:

- public reluctance to embrace private sector participation in infrastructure development initiatives;
- unfavourable financial structures;
- absence of comprehensive policies and regulations;
- political instability or undue political influence;
- lack of public awareness of the benefits and importance of PPPs.

Taking into account the influencing factors that determine the choice of PPPs in the critical infrastructure sector, the results of the analysis showed that the most influential factors in the choice of PPPs and private partners are financial and technical aspects with a relative weight of 27% and 23%, respectively. Additionally, previous research has also found that equity or debt, the availability of a construction program and the ability to achieve the planned outcome, and compliance with the legal and regulatory frame are critical to the successful implementation of PPPs, which can likewise significantly complicate the selection of PPPs and private partners. These factors weigh in the PPP decision-making process at 37.4%, 55.3% and 35.8%, respectively (Mohammed Abdelkader et al., 2023).

Based on the experience of PPP implementation and the possible influence of the above factors, the recommended model for formulating strategies for the development and execution of PPPs, especially for the evolution to smart critical infrastructure, includes effective procedures for managing PPP projects, raising public awareness of projects, and close monitoring and supervision over the execution of the PPP project. Each of the components of such a strategy has an impact on the success of PPPs in between 60% and 100% of projects (Figure 11).

Such a strategy is recommended for implementation in Ukraine in order to form a smart critical infrastructure. In addition, it is worth noting that for Ukraine, the most priority areas for attracting PPPs to rebuild critical infrastructure are: the transport sector, and educational and healthcare projects due to the destruction of a large number of educational and medical institutions, which are also priorities in European countries. It is the involvement of private investment in public funding that will allow the entire critical infrastructure system to resume functioning in the shortest possible time.

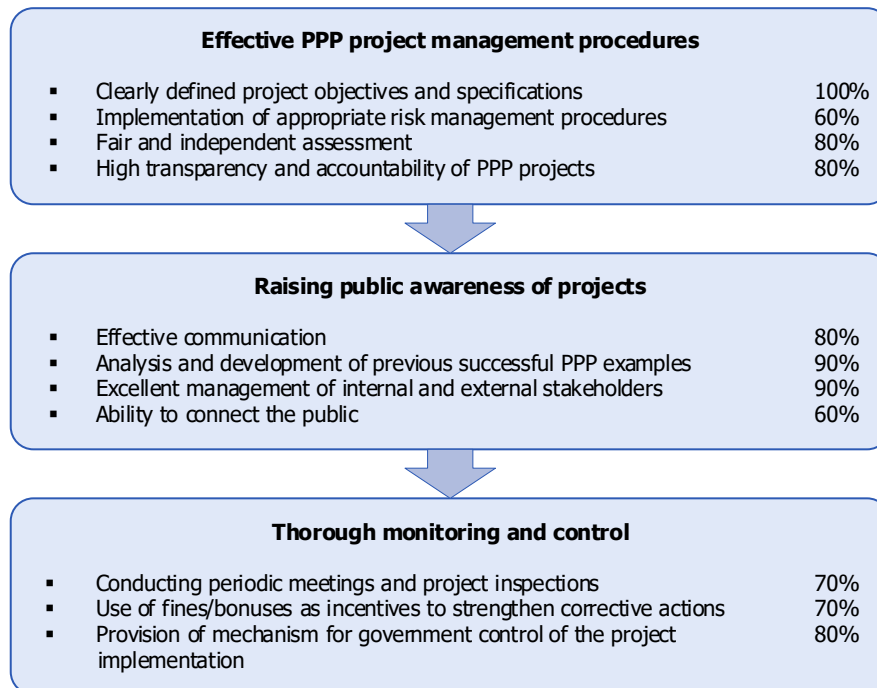


Figure 11. Recommended components of a PPP implementation strategy and their importance for the successful implementation of a PPP for smart critical infrastructure.

DISCUSSION AND CONCLUSIONS

The research results prove the effectiveness of PPPs as a model of cooperation, which is confirmed by thousands of successfully implemented projects in countries that are both developed and developing. As the legislative and institutional framework is being developed, the effective planning and execution of pilot PPP projects in various sectors of the economy, including infrastructure, will create new prospects for potential consultants, banks, and investors.

Based on the analysis of PPP projects in the field of critical infrastructure in European countries, the author proves that the execution of pilot projects supported by international financial organizations is essential. This is deemed necessary for developing successful practices in the implementation of PPP's projects by drawing upon the best international experiences and tailoring them to accommodate the distinctive features of Ukraine. The outcomes derived from the execution of specific projects at both the national and regional levels should serve as the foundation for ongoing efforts to enhance regulatory procedures in initiating, developing and approving projects.

The study shows that leading countries such as France, the UK, and Germany are actively using the PPP mechanism to finance critical infrastructure and are leaders in the market. At the same time, the most important sectors for the realization of PPP projects are transportation, environment, education, healthcare, and telecommunications. However, based on the analysis of PPP projects in Ukraine at the moment, it was concluded that the focus is on the production and supply of water, gas, and heat, while the infrastructure in the fields of education and healthcare attracts less attention. Accordingly, it is necessary to increase funding for these areas of critical infrastructure.

Ukraine, with its considerable economic development potential, is currently taking important steps towards investors, including improving its PPP legal framework and using the support of international financial institutions for implementing pilot projects. The establishment of effective PPP mechanisms opens up new opportunities for investment in Ukraine's promising market.

This study provides an overview of key trends and progressive practices of PPP implementation both in the international arena among European countries and in Ukraine, confirming the prospects of this industry, which is of great interest to the scientific community. The article proposes a modern mechanism for successful financing of projects based on PPP principles, which will be relevant for Ukraine, especially at the stage of post-war reconstruction of critical infrastructure. This mechanism includes 4 key stages from project planning to implementation. We also propose strategies for implementing PPPs and determine the importance of each of their components for the successful implementation of smart critical infrastructure PPPs.

The article is a continuation of our previous research, presented in particular in the monograph chapter (Zatonatska et al., 2022), but it is certainly not without limitations. The limitations of the current study include the focus on 2022 indicators, as the data for 2023 have not yet been consolidated, but further study of the structure of the Ukrainian and international PPP is a direction for further research. In addition, the analysis of the regulatory framework for PPP implementation in European countries to introduce advanced achievements into Ukrainian practice should be noted as an area for further research.

The results of the study will be of interest to financiers interested in the PPPs' development in order to immerse themselves in current trends in the public-private partnership market.

ADDITIONAL INFORMATION

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ПРОГРЕСИВНІ ПРАКТИКИ РЕАЛІЗАЦІЇ ПРОЄКТІВ ДЕРЖАВНО-ПРИВАТНОГО ПАРТНЕРСТВА В ЦАРИНІ КРИТИЧНОЇ ІНФРАСТРУКТУРИ

Державно-приватне партнерство (ДПП) стало однією з провідних і найефективніших моделей інвестування в критичну інфраструктуру, тому використання та розвиток моделей ДПП на основі найкращих практик набувають особливого значення в кризовий період та під час післявоєнного відновлення через високий тиск на державний бюджет і високі ризики для інвестування. Метою дослідження є аналіз прогресивних практик реалізації проєктів ДПП для секторів критичної інфраструктури та розробка рекомендацій щодо формування стратегії використання проєктів ДПП в різних секторах критичної інфраструктури України.

У статті проведено детальний аналіз сучасних підходів до реалізації ДПП в царині критичної інфраструктури, визначено прогресивні практики застосування інструментів диджиталізації в цій сфері, окреслено проблеми та перспективи їх упровадження.

Висвітлено потенційні фактори, бар'єри та стимули, що базуються на регуляторних, політичних, соціальних і технічних чинниках, які впливають на реалізацію та ефективність ДПП у створенні сучасної «розумної інфраструктури». Визначено, що найбільш важливими секторами для реалізації проєктів ДПП в більшості країн упродовж останніх років були транспорт, екологія, освіта, охорона здоров'я й телекомунікації. Водночас аналіз проєктів ДПП в Україні показав, що основними сферами, на яких зосереджувалася увага, були виробництво та постачання води, газу й тепла, тоді як інфраструктурі освіти та охорони здоров'я приділяли менше уваги. У статті запропоновані стратегії реалізації ДПП та визначена важливість кожної з їхніх складових для успішної реалізації ДПП, що буде актуальним для України, особливо на етапі післявоєнної відбудови об'єктів критичної інфраструктури. Результати дослідження містять систематизовану інформацію, яка буде корисною й для органів державної влади, і для потенційних інвесторів і наукової спільноти.

Ключові слова: критична інфраструктура, інвестиції, інвестиційні проєкти, державно-приватне партнерство, післявоєнна відбудова, сектори критичної інфраструктури, розумна інфраструктура

JEL Класифікація: E22, G11, H54