ECREG STUDIES
Vol. 18, No. 1, 2025
www.ers.edu.pl
PDF OPEN ACCESS
eISSN 2451-182X

AKADEMIA BIALSKA IM. JANA PAWŁA II

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ECONOMIC AND REGIONAL STUDIES
STUDIA EKONOMICZNE I REGIONALNE

ISSN 2083-3725 Volume 18, No. 2, 2025

ANALYSIS OF THE INFLUENCE OF PUBLIC-PRIVATE PARTNERSHIP ASSETS ON THE STABILIZATION OF THE UKRAINIAN ECONOMY FROM 2014 TO 2023

ANALIZA WPŁYWU AKTYWÓW PARTNERSTWA PUBLICZNO-PRYWATNEGO NA STABILIZACJĘ UKRAIŃSKIEJ GOSPODARKI W LATACH 2014-2023

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Wkład autorów:
A. Study design/ Zaplanowanie badań
B. Data collection/ Zebranie danych
C. Statistical analysis/ Analiza statystyczna
D. Data interpretation/ Interpretacja danych/
E. Manuscript preparation/ Przygotowanie tekstu
F. Literature search/ Opracowanie piśmiennictwa
G. Funds collection/ Pozyskanie funduszy

ORIGINAL ARTICLE
JEL code: H 56, L 30, O 11
Submitted: January 2024
Accepted: May 2025

Tables: 7
Figures: 3
References: 20

ORYGINALNY ARTYKUŁ NAUKOWY
Klasyfikacja JEL: H 56, L 30, O 11
Zgłoszony: styczeń 2024
Zaakceptowany: maj 2025

Tabele: 7
Rysunki: 3
Literatura: 20

Citation: Nemyrovskaya, O. (2025). Analysis of the influence of public-private partnership assets on the stabilization of the ukrainian economy from 2014 to 2023 / Analiza wpływu aktywów partnerstwa publiczno-prywatnego na stabilizację ukraińskiej gospodarki w latach 2014-2023 / E*conomic and Regional Studies / Studia Ekonomiczne i Regionalne, 18*(2), 190-205 https://doi.org/10.2478/ers-2025-0016

Abstract

Subject and purpose of work: This study examines the role of public-private partnerships (PPP) as a management of information flows, defined as long-term agreements between governments and private companies. The purpose is to assess the impact of PPP assets on the stabilisation of the Ukrainian economy during the crisis caused by armed conflict.

Materials and methods: The research is based on reports from Ukrainian ministries, international banks, and organizations. Analytical methods include macroeconomic, econometric, and trend analyses. A linear model for investment in PPP housing construction projects was developed using Python and the least-squares algorithm.

Results: The study shows that PPPs in the housing construction increased during the conflict, with the main driver being industry risk. However, state guarantees of repayment mitigate this risk. The proposed PPP model for Ukraine extends repayment periods and reduces regulatory demands, differing from global practices.

Conclusions: The findings provide a framework for developing PPP strategies in high-risk economies, offering insights for private investors engaging in crisis-affected countries.

Keywords: Sectoral Boundaries, Business Climate, MNC Assessment, Risk Criteria, Insurmountable Factors, Management and Economics

Streszczenie

Przedmiot i cel pracy: Niniejsze opracowanie analizuje rolę partnerstwa publiczno-prywatnego (PPP) jako technologii zarządzania przepływem informacji, definiowanej jako długoterminowe

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Journal included in: SCOPUS; AgEcon Search; AGRO; Arianta; Baidu Scholar; BazEkon; Cabell's Journalytics; CABI; CNKI Scholar; CNPIEC – cnpLINKer; Dimensions; DOAJ; EBSCO; ERIH PLUS; ExLibris; Google Scholar; Index Copernicus International; J-Gate; JournalTOCs; KESLI-NDSL; MIAR; MyScienceWork;Naver Academic; Naviga (Softweco); Po- lish Ministry of Science and Higher Education; QOAM; ReadCube, Research Papers in Economics (RePEc);SCILIT; Scite; Semantic Scholar; Sherpa/RoMEO; TDNet; Ulrich's Periodicals Directory/ulrichsweb; WanFang Data; WorldCat (OCLC); X-MOL.

umowy między rządami i prywatnymi firmami. Celem jest ocena wpływu aktywów PPP na stabilizację ukraińskiej gospodarki w czasie kryzysu spowodowanego konfliktem zbrojnym.
Materiały i metody: Badanie opiera się na raportach ukraińskich ministerstw, międzynarodowych banków i organizacji. Metody analityczne obejmują analizy makroekonomiczne, ekonometryczne i analizy trendów. Liniowy model inwestycji w projekty budownictwa mieszkaniowego PPP został opracowany przy użyciu języka Python i algorytmu najmniejszych kwadratów.
Wyniki: Badanie pokazuje, że PPP w budownictwie mieszkaniowym wzrosło podczas konfliktu, a głównym czynnikiem było ryzyko branżowe. Jednakże państwowe gwarancje spłaty łagodzą to ryzyko. Proponowany model PPP dla Ukrainy wydłuża okresy spłaty i zmniejsza wymagania regulacyjne, różniąc się od praktyk światowych.
Wnioski: Wyniki badania dostarczają ram dla rozwoju strategii PPP w gospodarkach wysokiego ryzyka, oferując wgląd dla prywatnych inwestorów angażujących się w krajach dotkniętych kryzysem.

Słowa kluczowe: granice sektorowe, klimat biznesowy, ocena MNC, kryteria ryzyka, czynniki nie do pokonania, zarządzanie i ekonomia

Introduction

Public-private partnerships (PPPs) were officially introduced in Ukraine with the adoption of the Law of Ukraine 'On Public-Private Partnerships' on 1 July 2010. This law created a legal framework for cooperation between the public and private sectors to improve competitiveness and attract investment in the Ukrainian economy.

During the formation of partnership relations between the state and the subject of private business, the state, depending on the priority directions of development, has the right to consider some elements that, in a certain way, affect the terms of the partnership.

PPPs have several key characteristics, including:

- Joint investment: Both the public and private sectors invest in the project.
- Risk sharing: Risks and rewards are shared between the public and private sectors.
- Long-term commitment: PPPs involve a long-term commitment from both parties, often spanning several decades.
- Innovation: PPPs can encourage innovation by bringing together the expertise and resources of both the public and private sectors.

The armed conflict in Ukraine in 2014-2024 had a significant impact on macroeconomic indicators (World Bank, n.d.a). During this period, there was significant damage to infrastructure, which hampers economic recovery and development. For example, Dunayev et al. (2024) note that only after the armed aggression in 2022 did Ukraine's infrastructure suffer damage. As a rule, these are the industrial regions of Ukraine – Donetsk, Luhansk, Kharkiv, Mykolaiv, and Zaporizhzhia regions. These losses amount to hundreds of billion dollars. And recovery is possible only after the war is over. Bun et al. (2024) present the results of a study of the impact of greenhouse gases due to military operations in Ukraine. It is noted that this not only impacts the development of forestry and agricultural enterprises in Ukraine but also has a negative impact on the environment outside of Ukraine. Public-private partnerships (PPPs) are an important tool for attracting investment in a high-risk environment. Significant socio-economic impacts, including increased poverty, migration, and a lower quality of life due to loss of property and destruction of businesses, require modern methods to assess the impact of a range of factors to develop recovery strategies. Studying the impact of PPPs assets on these aspects will help to develop strategies to improve the socio-economic situation, restore housing and infrastructure, which is the basis for planning effective recovery measures.

This topic is relevant not only for Ukraine, but also for other countries facing armed conflicts in order to further overcome economic challenges. For example, after the war in Iraq, the country suffered significant infrastructure damage (Khudhaire, Naji, 2021). PPPs have become an important tool for reconstruction, especially in the energy sector and transport infrastructure. By drawing an analogy with Dunayev et al. (2024), we can emphasise a common feature – the outcomes of such wars are too costly and cannot be resolved by a single state alone. For example, the reconstruction of power plants and the construction of new roads have been carried out with the support of private investors. After a long conflict, Afghanistan

also used PPPs to rebuild its economy in a highly risky environment (Bayat, Noorzai, Golabchi, 2019). Major projects included the construction of roads, bridges and other infrastructure objects. This helped attract foreign investment and create workplaces. After decades of internal conflict, Colombia actively used PPP assets to improve the economic situation in order to avoid default (Zapata Quimbayo, Mejía Vega, 2023). In particular, a number of PPP projects in various sectors of the Colombian economy have contributed to economic growth and stabilization.

The conflict in Ukraine is still ongoing. And this is a significant difference in shaping the development environment for PPP compared to other countries where conflicts have ended or are on the decline. However, at the same time, this situation requires non-trivial solutions that would help improve the living conditions of the population during the armed conflict. In this regard, the Ministry of Infrastructure of Ukraine, together with foreign partners and leading financial institutions, is trying to create an investment climate to restore critical infrastructure and housing that have been damaged by attacks.

The relevance of the topic under study lies in the fact that no studies have been conducted on the impact of public-private partnership assets on the stabilization processes in a country during a prolonged conflict, unlike the impact on growth after the crisis in the country is resolved. The main objective of the study is to be stabilizing the economy with a focus on further recovery during armed conflicts by attracting private investment and improving infrastructure remains open.

The purpose of the study is to assess the impact of PPP assets on stabilizing the economic situation during a prolonged crisis caused by the armed conflict. The objectives of the study are to systematize the factors that have a significant impact on the investment of assets in a crisis economy on the example of Ukraine for the period 2014-2023 and to formally describe the dependencies with the construction of an appropriate model to assess the impact of PPP assets on the country's economic situation. The paper uses macroeconomic, econometric and trend analysis. As a result, a comparative model of the PPP development environment in Ukraine and the world is formed.

Literature review

Public-private partnership is a system of relations between public and private partners, in which the resources of both are combined with an appropriate distribution of risks, responsibilities and rewards. Such a partnership between the state and private institutions is characterised by a long-term relationship and a common goal to create or restore objects requiring investment. Such objects include infrastructure objects that are aimed at ensuring the living conditions of society, as well as housing for citizens.

The formation and development of public-private partnerships in countries around the world is evaluated from two main points of view regarding the state of the environment: the environment with minimal risk and the risky environment. A characteristic feature of the PPP's impact on the infrastructure development is the benefit to society and the state and a constant and stable income for a private investor under state guarantees. There are certain points of conflicting interests on which models of interaction between PPP are based. And the differences in the interaction of PPP in different countries are based on approaches to minimising partnership risks. The study of the impact of PPPs on the economic growth of the state considers both the macro and micro levels, with the corresponding models of interaction on the state and society or the dynamics of influence by a number of factors. For example, the study of the micro-level of the economic system is presented in Biygautane, Clegg, Al-Yahya (2020) through dynamic indicators in the implementation of a PPP project to expand and transform an airport in Saudi Arabia as a low-risk, perspective environment.

A similar modernization and reconstruction project were planned in 2019 at Boryspil Airport in Ukraine (Ministry for Development of Communities and Territories of Ukraine, 2019). However, the Ukrainian project was designed for a potentially high-risk environment, so the introduction of PPP assets is planned after the situation stabilizes. The object was recognised as potentially high-risk before the military intervention. After 24 February 2022, Boryspil Airport's operations were suspended due to the threat of civilian airliners being shot down. The constant shelling of the Kyiv region by cruise missiles makes it impossible to implement the Boryspil Airport's PPP projects. Therefore, Biygautane et al. (2020) draw parallels with the traditional

theoretical framework for the functioning of PPPs for such projects, which are based on five equivalent components: regulation, institutional development, timeliness of repayment, positive business climate and financial interaction. Another benefit of this work is the transition from the structures and organizational spheres of macro- and mezzo-level analysis to individuals – the micro-level – as initiators of new forms of project implementation. However, this view is limited to the economic component. In particular, Biygautane et al. (2020) analysed the tendencies in the country's economic recovery.

Economic growth on the back of the development of PPP projects in the post-crisis Caribbean region is examined by Panadès-Estruch (2021). The focus is on the development of infrastructure projects important for the tourism industry, which is strategic for Bermuda and the Cayman Islands, as well as Jamaica. The analysis is based on a critical assessment of the projects at the macro level, identifying the type of PPP agreement used, the legal and policy framework, financial implications, accountability, and a number of additional data that reveal the overall picture of PPP functioning, also based on the five pillars.

An analysis of the impact of PPPs on economic development through the empirical link between governance and investment in energy is proposed in Ahmed, Musonda, Pretorius (2023). The study is based on a fixed effects model through nonlinear parallel models. The authors conclude that poor control of corruption is the reason for inadequate PPP investments. A linear model for studying the impact of irresistible factors on the development of PPPs in African agriculture (Dumani, Mbangcolo, Mpambani, Mpengesi, Titimani, 2023) allowed to identify ways of improving the agricultural sector in a number of African countries. The limitation of the latter work is that the financial component and the purchasing power of the population are not properly taken into account. It is worth noting that the studies that analyse the impact of PPPs on the economies of African countries (Ahmed et al., 2023; Dumani et al., 2023; Vyas-Doorgapersad, 2022; Nduhura et al., 2022) consider periods when countries have gained their independence, emerged from the acute phase of conflict or crisis and are actively solving problems related to the sequence of economic development policy implementation.

A system dynamics model of India using a causal diagram (Patil, Thounaojam, Laishramc, 2021) analyses different strategies for implementing PPP projects. The model is based on limited data, mainly focused on PPP tendering practices. At the same time, the focus on India, with its limited infrastructure and underdeveloped public-private partnerships, does not allow the model to be applied to other countries without prior modification.

British researchers note that analyzing the impact of PPPs at the macro level provides an interesting result due to the value for money at the micro level (Adamou, Kyriakidou, Connolly, 2021). These results can be used to assess the sustainability of the system at the micro level to ensure the basic components of PPP functioning. However, this study does not fully take into account the challenges of the XXI century with global crises and conflicts and their impact on the components of PPP development and functioning.

The differences between approaches to the causality of procurement and spending through consumer perspectives and the impact of risk on their decisions are explored in Love, Ika, Matthews, Fang (2023). PPP projects are indirectly mentioned in this paper. However, the paper is significant in that such an analysis can give an interesting result in terms of predicting project performance. While the general impression of experts may be situational and biased, the analysis highlights the ambiguity associated with assessing cost-effectiveness in providing PPP development components. The two-stage generalization framework applied to PPP projects (Kaur, Malik, 2020) confirms these findings. For example, institutional imperfections can significantly reduce the impact of PPP assets through consumer biases and risk aversion, which complicate the business climate and financial interactions.

PPP projects based on risk-based criteria that have been implemented worldwide for post-disaster housing reconstruction are examined in Vahdatmanesh, Firouzi, Rotimi (2022). Such projects require significant investment. However, the post-disaster environment leads to uncertainty about potential revenues and the willingness to spend on the part of both the state and the population. This is a high-risk environment. And it is often impossible to determine the risk due to a number of unpredictable factors.

The study developed a methodology based on a combined model of a minimum income guarantee and a maximum income cap. The study was based on real variants of projects that were implemented. On their basis, flexible models were developed to increase the value of investments while reducing investment

losses. The final model proposes a trinomial grid to assess the risk distribution. Each event is considered in terms of income, expenses and risk. The balance between income and expenses is analysed against the risk criterion and a coefficient is calculated which is used to evaluate the investment. The model has been tested in the context of the Australian continent, which has a long history of successful public-private partnerships.

The literature review confirms the relevance of the research topic. In addition, the analysis of research and publications allows identifying the unresolved issue of determining the specifics of the impact of a number of factors on the indicators of PPP development and functioning, which can both hinder the partnership and help stabilize the situation during a deep economic crisis. Identifying the impact of such factors and building a comparative model of PPP development and functioning in risky conditions can contribute to a more efficient use of public-private partnership assets.

Methodology

In this paper, the risks are understood as the risks of losing the investment capital of the PPP. That is, a private investor loses capital and possible profits from this investment. In this paper, the assets of the PPP are understood as the monetary value of the assets. In fact, if the state and a private investor invest their assets in the establishment of an PPP to ensure the PPP operation, there is a risk of losing assets due to various factors. When analysing the activities of the PPP in Ukraine, the main risk factor is military operations and related events, such as destruction of the facilities on which the PPP operates, stoppage of work without destruction, inability to carry out any work due to insurmountable risks, etc.

The research methodology includes a combination of econometric and trend analysis to comprehensively assess the impact of PPP assets on the stabilization of Ukrainian economy in 2014-2023 and the implementation of the country's recovery programs. Given that many public-private partnership programs, such as the development of transport infrastructure and roads, and a number of industrial enterprises with the transition to green energy, were cancelled during this period, the study selected projects aimed at building and restoring destroyed housing for internally displaced persons due to the armed conflict. State assistance for housing reconstruction, inflation index, risk level in the housing and construction industry, and housing price index were selected as the impact factors.

At the initial stage, an extensive literature review was conducted, focusing on the role of PPPs in infrastructure development, economic recovery programmes and national development strategies. The sample for the analysis is based on government reports for the selected period (Ministry of Economy of Ukraine; Ministry of Finance of Ukraine; State Statistics Committee of Ukraine), reports of international financial institutions (World Bank; European Bank for Reconstruction and Development; European Investment Bank) and reports of public organizations (Transparency International Ukraine) on the practical implementation of PPPs. The study then turned to analyzing examples of both successful and unsuccessful housing PPP projects implemented in Ukraine. A sample was created for 2014-2023 according to the selected factors (Table 1).

Table 1. Input parameters of the study by a sample of indicators for 2014-2023 by selected factors (billion USD)

Year	PPP assets in the housing construction sector	State aid for housing restoration	Inflation index, %	Housing price index, %	Risk in the sector
	Y	X_1	X_2	X_3	X_4
2014	1.23	0.2	1.249	1.134	9.3
2015	3.1	0.2	1.433	2.03	5.7
2016	2.2	0.13	1.124	1.021	2.2
2017	2.3	0.13	1.137	1.044	2.1
2018	3.0	0.04	1.098	1.051	2.6
2019	3.2	0.004	1.041	1.079	3.1

Year	PPP assets in the housing construction sector	State aid for housing restoration	Inflation index, %	Housing price index, %	Risk in the sector
	Y	X_1	X_2	X_3	X_4
2020	4.25	0.0005	1.05	1.061	3.2
2021	4.3	0.004	1.1	1.167	3.4
2022	0.15	1.1	1.126	1.127	13.4
2023	42.5	2.0	1.051	1.146	21.8

Source: Independently compiled by the authors.

The main sources are reports from the Ministry of Economy of Ukraine, the European Bank for Reconstruction and Development, the European Investment Bank and the World Bank.
Risk in the sector is defined as the value of destroyed and damaged housing in Ukraine for the period 2014-2023 according to the Ministry of Communities and Territorial Development of Ukraine. The limitation of the study is the generalised amount of destroyed housing. This is due to the fact that part of the territory of Ukraine is occupied and it is not possible to make an accurate assessment of the damage.

If we consider the situation in Ukraine from the moment of relative stability to the present, the risk curve in Ukraine from 2010 to 2024 shows significant fluctuations due to various economic, political and social factors. For example, since the adoption of the Law of Ukraine 'On Public-Private Partnership' in 2010 and the period of improving the regulatory framework until 2013, there has been a period of relative stability in the economy and a gradual increase in risks due to political decisions. No PPP projects were implemented in 2010-2013 due to the fact that Ukraine's legislation in this area was being improved. During this period, various foundations were mainly developing, planning to create a basis for the development of PPP. For example, in 2009-2015, the Ukrainian Centre for Promoting Public-Private Partnerships operated as an institution. It was a non-profit organisation that aimed to create conditions for the implementation of national and state projects on the basis of PPPs. The period of 2014-2015 was characterized by a sharp increase in risks due to the annexation of Crimea and the outbreak of the conflict in eastern Ukraine, with significant financial and property losses. This was followed by a gradual reduction in risks until 2019, due to reforms and international support. The COVID-19 pandemic in the following two years added new risks related to health and economic instability, but these were felt in all countries of the world. In Ukraine, this period was exacerbated in 2022 by full-scale military operations, which led to ultra-high losses in the financial and property sectors and a rapid increase in risks from new destruction and housing. These dynamics continued in 2023.

Based on the available data, a linear model can be built to assess the reliability of the variables, the presence of multicollinearity and the parameters of the linear model.
The analytical form of the linear model is as follows:

$$y = a_0 + a_1x_1 + a_2x_2 + \ldots + a_mx_m + U \quad (1)$$

where a_j – the estimate of the j-th model parameter (j = 1...m);
x_j – model factor;
U – stochastic element;
m – the number of independent variables.

Accordingly, the calculation function for a set of data can be represented as follows:

$$y = a_0 + a_1x_1 + a_2x_2 + \ldots + a_mx_m \quad (2)$$

The factors for model (2) are provided in Table 1. They were selected based on the results of the analysis of reports as having the greatest impact on the implementation of PPP projects in housing construction in Ukraine in 2014-2023. The reliability of the model and factors is assumed to be at least 95% ($\alpha \leq 5\%$).

According to formula (2), the model is specified as follows:

$$Y = \alpha_0 + \alpha_1 \cdot X_1 + \alpha_2 \cdot X_2 + \alpha_3 \cdot X_3 + \alpha_4 \cdot X_4 \quad (3)$$

after which we performed the ANN estimation of the parameters. The implementation was carried out in Python. The model was developed using the traditional least-squares solution algorithm (Harris, 2019). The main block of the algorithm implementation is shown in Figure 1.

```
# Dependent variable
Y = df["Housing PPP assets (U)"]

# Independent variables
X = df[["State aid for housing reconstruction (X1)", "Inflation index
(X2)", "Housing price index (X3)", "Industry risk (X4)"]]

# Adding a constant to the model
X = sm.add_constant(X)

# Building a model using the least squares method
model = sm.OLS(Y, X).fit()

# Displaying the results of the model
print(model.summary())
```

Figure 1. ANN-based model evaluation in Python
Source: Author's work.

The first step is to build a symmetric matrix of pairwise correlation coefficients between the *i*-th and *j*-th factors and between the dependent variable y and the *j*-th factor, taking into account. The reliability of the factors included in the model is determined by the reliability index *μ:*

$$\mu_j = \frac{\left|r_{yx_j}\right| \cdot \sqrt{n-1}}{\sqrt{1-r_{yx_j}^2}} \quad (4)$$

where *n* – number of observations.
The μ indicator is calculated for each factor by which the reliability level is determined. If the reliability level of a factor does not meet the accepted reliability level of 95%, the selected factor is excluded from the model.

The definition of multicollinearity allows us to identify factors in a multivariate regression model that are related to each other by a linear relationship ($\left|r_{x_i x_j}\right| \geq 0.9$). For further study of the model, the following standard statistical coefficients are calculated: determination, correlation. Fisher and Student's criteria are also calculated (Harris, 2019). The model is realized using the Python language. Visualization of results and validation of adequacy are provided in Excel. For the accuracy of the calculations, the data of each year (Table 1) are divided into six-month periods.
As a result, a model of the PPP development environment in Ukraine is formed and compared with the global practice. For this purpose, expert assessments of PPP development from the World Bank are used. The model of the PPP development environment is a market opportunity. In other words, the assessment of parameters is carried out by the investor, who takes into account the scope of his interaction with the state (Table 2).

Table 2. The main parameters on which the investor focuses when establishing a partnership with the state

№	Parameters	Issues considered when establishing a partnership between the government and business
1.	Commodity market	- dimensions of the commodity market; - the main differences of this commodity market from the one on which the business already operates (price level, buyer profile); - structural characteristics of the commodity market;
2.	Analysis of competitors' activities	- the characteristics of competing companies; - the effectiveness of competitors' activities in terms of increasing the volume of sales and the number of profits
3.	Potential target markets	- description of the main segments of the commodity market; - in which segment of the company's market should it be appropriate to sell its products;
4.	Relevant tendencies	- the prospects of the company's activity in this market in the future; - nature of competition; - changes in the efficiency of the competing company;
5.	Success factors	- key success factors in this environment; - weak spots that could lead to absorption.

Source: Author's work.

The study provides a comparative analysis of the annual Doing Business index (World Bank Group, n.d.a) parameters and the central state parameters in their interaction with international business in order to deepen the study of the competition of state interests (Table 3). Also, we considered the parameters on which the international private business is fixed during market research.

Table 3. Parameters of the Doing Business Index

№	Name
1.	Enterprise registration
2.	Obtaining a construction permit
3.	Connection to power grids
4.	Employment of labour force
5.	Property registration
6.	Lending
7.	Investor protection
8.	Taxation
9.	International trade
10.	Enforcement of contracts
11.	Solvency recovery

Source: World Bank Group (n.d.b).

The PPP development environment model in Ukraine at the studied stage is not oriented towards income and expenses in the internal market. This is due to the fact that the budget according to the Ministry of Economy of Ukraine does not cover the costs caused by the war. The incomes of both the population and the state as a whole depend on foreign aid. State expenses are oriented to the needs of the population appeared as a result of the military actions' impact. Therefore, the model of PPP development environment in Ukraine is built on the criterion of risk. In particular, it is the risk of investment repayment. This is the main criterion of modern PPP interaction. Based on the above, we can present the main parameters of interaction between the state and private business (Table. 4)

Table 4. The main parameters considered by the state in the case of the partnership establishing

№	Parameters	Issues that are considered when establishing a partnership between the government and businesses
1	Population employment ensuring	- the unemployment rate in the country; - the number of new jobs and social guarantees for employees;
2	National security	- the economy's priority sectors; - economic sectors to which foreign investments are directed; - conditions and infrastructure for the national business stimulation; - the efficiency of anti-dumping measures in the national economy; - the impact of international business projects on the country's development; - economic sectors in which investments are not allowable;
3	Consumer rights protection	- the quality of the goods manufactured for the national market; - the general level of prices; - the level of the population's purchasing power; - the level of salaries and purchasing power;
4	Foreign economic policy	- the allowed forms of foreign economic relations in the country; - the state of the country's foreign trade; - the geography of the state's international trade; - the domestic economic policy methods used in the country;
5	Fiscal policy	- the current taxation system in the state and benefits for investors; - sources of budget replenishment; - customs rates;
	Natural resource potential	- the existing natural resources of the state and their types; - duration of use and depletion of natural potential;
7	Priority sectors of development	- sectors that require investment; - the task of socio-economic development of the state; - deficit sectors of the economy; - goods (raw materials) necessary for local manufacturers;
8	Activity type	- the specialisation of the corporation entering the state market; - experience in implementing investment projects and the sectors in which they were accomplished; - the impact of the production of foreign TNCs on domestic trade turnover;
9	Responsibility of economic entities	- environmental impact of various interaction projects; - ecological safety; - employee social security; - the impact of projects on the lives of the local population;
10	Political stability	- conflict situations in the state; - the political situation in neighbouring states; - form of government; - the attitude of the state's residents to the authorities;
11	Investor countries	- the countries from which investments are coming; - existing trade and economic relations with investor countries; - historical obstacles to investment; - investors' cultural and religious values;
12	Other comparative advantages	- the country's comparative advantages.

Source: Author's work.

In addition to the parameters mentioned above, in establishing a partnership between the state and international private business, depending on the country, the content of the parameters may change. Countries often must thoroughly assess the most important parameters when concluding contracts with foreign partners.

Results

On the basis of Table 1, it is possible to build a graph of the dependence of PPP assets invested in Ukraine on the risk in the industry for the period 2014-2023 (Figure 2). The graph can be supplemented with trend lines with the related equation for each curve. This allows us to trace the general direction of movement of both risk and PPP assets invested over the years. The trend lines show that the trend in housing PPPs is upward, despite the increase in risk. Looking at the R^2 equation, the differences between the trend lines for PPP asset volume and risk are insignificant.

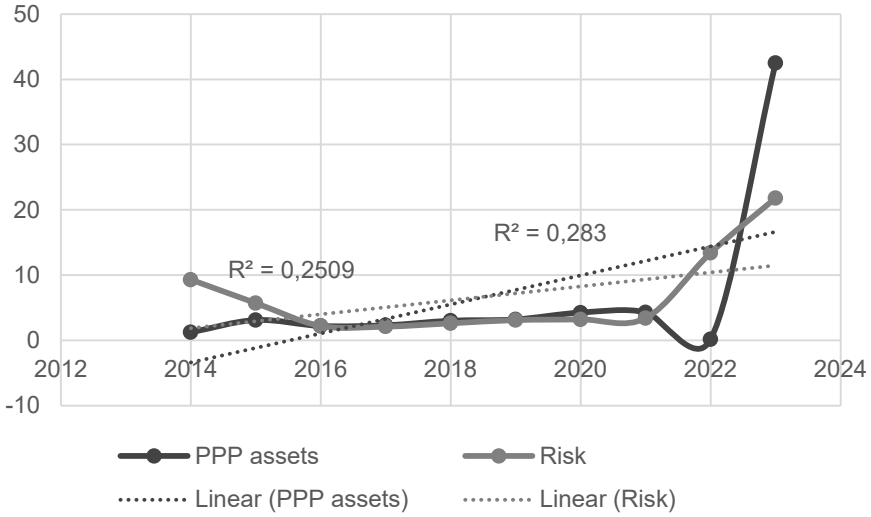

Figure 2. Curves of assets invested and risk in the industry for the period 2014-2023, USD billion and trend lines for selected indicators

Source: Author's work.

The "PPP assets" curve shows trends in investment in the reconstruction and construction of housing for the population. Since 2014, investment fluctuations in housing reconstruction have been insignificant, as the outbreak of hostilities was not as devastating as the period 2022-2024. The 'Risk' curve had a spiking period in 2014, which can be explained by the critical uncertainty of the situation for the European continent. Then, until 2022, the Risk curve almost coincides with the housing investment curve. The linear dependence of the above indicators demonstrates a stable growth of investments in housing construction despite the risk of investment loss.

The graph shows that investments under PPP programs have been growing over the years, despite fluctuations in financial losses due to various risks. This indicates that, despite high risks, Ukraine has been able to attract significant investments for infrastructure and economic development.

The results of the ANN-based estimation of the model of dependence of PPP asset inputs on a number of risk factors in Ukraine in 2014-2023 are provided in Table 5.

Table 5. Results of the ANN model estimation

X_1	X_2	X_3	X_4
0.273	0.796	0.368	0.273

Source: Author's work.

Calculated using the model:

- Index of determination (R-squared): 0.747;
- Correlation coefficient: 0.544;

– Fisher's criteria (F-statistic): 3.687 (probability: 0.0925);
– Student's criteria (t-values): constant: 0.989.

Using model (4), we can calculate the elasticity coefficients that will allow us to determine the degree of sensitivity of PPP assets in housing construction to the factors presented in Table 1. The elasticity coefficients are provided in Table 6.

Table 6. Elasticity coefficients by the model

α_1	α_2	α_3	α_4
0.025	-0.231	0.002	-0.321

Source: Author's work.

That is, the most significant factor of the studied factors on the volume of PPPs in housing construction is the risk in the industry, but it does not have a controlling effect on the volume of PPP investments in housing construction in Ukraine. This suggests that the risk of losing housing objects is compensated by the state's guarantees of repayment to investors in future periods. Given this and the results obtained, it is possible to create a model of public-private partnership in Ukraine.
Based on the results of the analysis, the criteria provided in Table 2 and Table 3 were selected. These tables allow not only to analyse the possible behaviour of investors, but also to objectively assess the current legislation of Ukraine in the context of the risk of non-return of investments. These criteria are then sorted as those that affect the mechanism of interaction between international private business and the national economy, as presented in Table 6. In the process of comparative analysis, three parameters affecting the interaction between international private business and the state are identified: 1) contentious; 2) reversible; 3) irreversible. The results are provided in Table 7.

Table 7. The classification of the impact parameters of the interaction mechanism between private business and the national economy

№	Impact parameters	Type of parameter
1	Fiscal policy	irreversible
2	Structure and organisational form of business management	irreversible
3	Property registration	irreversible
4	Enterprise registration	reversible
5	Priority development directions	reversible
6	Natural resource provision	irreversible
7	Obtaining loans	reversible
8	Protection of local investors from foreign competitors	reversible
9	The state's foreign economic policy	reversible
10	Protection of foreign investors	reversible
11	The country's international trade situation	reversible
12	National security	controversial
13	Taxation	reversible
14	Ensuring employment of the population	controversial
15	Enforcement of contracts	reversible
16	Responsibility of economic entities	controversial
17	Political stability	irreversible
18	Type of business activity of the company	irreversible
19	Consumer rights protection	reversible
20	Enterprise registration	reversible

Source: Author's work.

On the basis of Table 7 and the World Bank's Doing Business index (World Bank, n.d.a), a comparative model of the PPP development environment in Ukraine and the world can be developed (Figure 3).

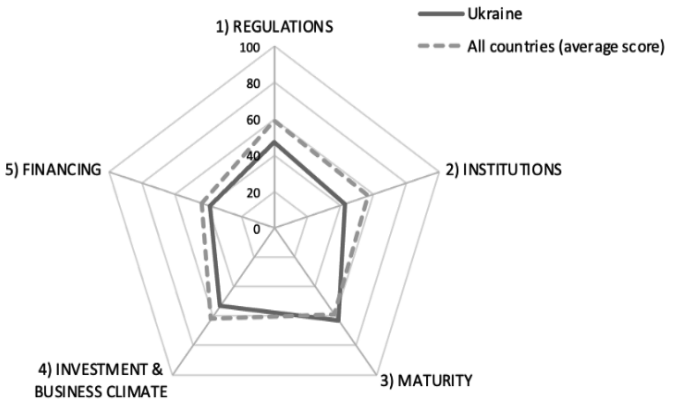

Figure 3. Comparative model of the PPP development environment in Ukraine and in the world
Source: Author's work.

From Figure 3 we can notice an unconventional pentagonal slope of the PPP development environment in Ukraine compared to global examples. In particular, there is a lack of the regulatory and institutional factor with an increase in the maturity factor of PPP relations. According to Table 7, it is important to note that contradictory parameters are aspects of partnerships where the interests of the interacting parties diverge. They are important because they can be crucial for one problem and unimportant for another. Bilateral parameters are adaptive components, as shown in Figure 3. They can take on different meanings depending on the company's business area, the country's development priorities, and global economic policy, as can be seen in the case of Ukraine.

Discussion

Based on the built linear model of PPP asset efficiency using the least squares method (LSM) (3), several important conclusions can be drawn. In particular, the coefficient of determination (R-squared) is 0.747. This means that the model explains approximately 74.7% of the variation in the dependent variable (housing PPP assets). This figure is quite high, which indicates that the model fits the data. But the correlation coefficient shows the average strength of the relationship between the independent variables and the dependent variable. The value of 0.544 indicates a moderate but positive relationship.
Fisher's criterion, which is used to check the significance of the whole model, has a value of 3.687 with a probability of 0.0925. This indicates that the model is significant at the 10% level, but not at more stringent levels.

The t-statistics for each coefficient indicate how significant variables X1 to X4 are in the model. Neither of the independent variables is significant at the 5% level, which may indicate that other factors not included in the model may have an impact on PPP assets. And taking into account the high level of risk and the increase in investment based on this background, this indicates that the main influence is the state guarantees.

A similar conclusion follows from the graph (Figure 2). The key point can be recognised as significant increase in assets in 2023 to 42.5 may indicate a significant change in the development of the crisis or government guarantees. Stable risk reduction over a long period of time is also important. The risk decreased from 2014 to 2017, but started to increase again in 2022, reaching 21.8 in 2023. Taking into account that military operations in Ukraine remain in an active phase and the level of risk is not changing, we can lean towards state guarantees to provide repayment guarantees for PPPs. In addition, Figure 2 shows that in some years, when assets grew, risk decreased, and vice versa. This indicates a certain

correlation between these indicators. The elasticity coefficients show that the growth of PPP assets, albeit slightly, reduces inflation and risk in the industry. That is, there is a positive impact of PPP assets on the stabilization of the country's economy.

The findings of model (3) demonstrate an empirical relationship analogous to that reported by Ahmed et al. (2023). While the latter focused on the corruption component, the present study concentrates on the risk component, yet the analogy can be drawn in terms of excessive expenditure to overcome a state of economic disadvantage. The results indicate that Ukraine has chosen an approach similar to Dumani et al. (2023) as its PPP strategy, where the development of PPP projects is considered by irresistible factors that cannot be directly influenced by the parties to the relationship. This can be explained as follows.

The specific factors of PPP environment existence in Ukraine are the lack of finance with simultaneous instability of investment climate (Figure 3). The state cannot influence this due to the prolonged military operations. That is, it is an insurmountable risk. But in total the mentioned negative is minimised by the maturity of relations, as the guarantees of the Ukrainian state are supported by other European Union states and influential financial institutions.

However, the findings are in complete alignment with Vahdatmanesh et al. (2022). In essence, this suggests that risk necessitates additional investment. It is only within this paradigm that both project performance and economic stabilization can be marginally enhanced. It is important to note that the majority of the model factors are likely to be unpredictable, even in the event that model (1) is made multifactorial and detailed.

The comparative model of the PPP development environment in Ukraine and the rest of the world (Figure 3) demonstrates the main difference between Ukraine and the rest of the world in the development of PPPs: namely, deferred repayment of funds with reduced requirements for regulatory policy and institutional development. The underlying reasons for this phenomenon are outlined in the following section.

The ongoing conflict in Ukraine necessitates a strategic approach to PPP implementation, focusing on flexibility and resilience. Any ongoing or future PPP projects must prioritize designs that can withstand potential damage and facilitate rapid recovery and reconstruction. It is also important to recognise that while PPPs offer significant potential for economic recovery, the current state of Ukraine's infrastructure – under constant threat of destruction-limits the scope for immediate implementation.

A potential escalation in risk during the 2022-2023 period (Figure 2) could yield substantial ramifications, notably an augmentation in the peril associated with protracted hostilities. This is a period of uncertainty about the duration of military operations. The increased risk may have an impact on unemployment and social stability, particularly in regions grappling with prevailing economic difficulties This will have an impact on inflation, which will ultimately lead to changes in the house price index. This will ultimately lead to a further delay in the repayment of investments and require an increase in investment flows (Vahdatmanesh et al., 2022). These consequences could have a long-term impact on the economy and business environment, so it is important to take them into account when planning measures to stabilize the economic situation.

This deepens the results of Biygautane et al. (2020). In particular, the theoretical limits of PPP functioning may not be a classical pentagon, but a figure with different rays. In this case, the components of the model will be compensated according to the priorities of the environment. However, given that we are talking about public-private partnerships, state guarantees will become the basis for project development.

In this paper, the model is limited by four factors that have a risky impact on the final volume of PPP assets. These limitations can be overcome by expanding the influence of the studied factors according to model (1). However, this will increase the number of calculations and require the use of distributed computing.

According to the comparative model (Figure 3), generalization of the factors influencing the final result of repayment does not allow for the study of individual processes. This approach allows us to see the form of implementation of the development environment. Nevertheless, the potential for this study lies in the elaboration of individual processes that exert a controlling influence on the augmentation of PPP assets in Ukraine.

In general, the described approach to assessing the impact of PPP assets on stabilizing the economic situation during the long-term crisis associated with the armed conflict provides a general picture, particularly, in the housing sector. Unfortunately, other areas of PPP implementation projects in Ukraine have been postponed until the end of the acute phase of the conflict.

Conclusions

The formation of PPPs is driven not only by the state's need to secure financial resources from the private sector for achieving socially significant socio-economic development goals but also by the adoption of advanced organizational, management, and production technologies. PPP principles are crucial not only for mobilizing private sector funding but also for employing sophisticated methodologies for organizational efficiency, strategic management, and advanced production processes. The widespread adoption of PPP principles reflects a comprehensive approach to crisis mitigation, encompassing financial considerations and innovative strategies and cooperative frameworks that transcend traditional sectoral boundaries. This multifaceted approach is essential for navigating economic downturns.

The armed conflict in Ukraine from 2014 to the present is a serious challenge not only for the country's economy, but also for public-private partnerships. This paper considers investments in housing construction based on PPP projects. On the one hand, there is a need for such projects, as many people have lost their homes or have remained in the temporarily occupied territories. On the other hand, there is a high risk for construction projects as the conflict continues. Building a linear model led to the conclusion that the most influential factor on PPP investments is the risk in the housing sector. Nevertheless, investment volumes are growing, as the risk of losing housing is offset by government guarantees. Of course, repayment to investors is delayed. This is the main feature of the PPP development environment in Ukraine.

The ongoing conflict in Ukraine necessitates a strategic approach to PPP implementation, focusing on flexibility and resilience. Any ongoing or future PPP projects must prioritize designs that can withstand potential damage and facilitate rapid recovery and reconstruction. Furthermore, it is essential to recognize that while PPPs offer significant potential for economic recovery, the current state of Ukraine's infrastructure – under constant threat of destruction-limits the scope for immediate implementation.
Ukraine's efforts to quickly restore housing and create the most suitable investment environment possible form the basis for economic stabilization during the study period. The Ministry of Infrastructure, with the support of the European Union, the European Bank for Reconstruction and Development, the European Investment Bank, the World Bank, the International Finance Corporation and other international partners, is creating a guarantee pool for international investors involved in the construction industry. And while projects in other areas in Ukraine have been frozen indefinitely, the number of residential construction projects is growing and being realised.

Attracting investment and implementing PPP projects under these conditions require innovative approaches that account for the risks and uncertainties posed by the current crisis. Ukraine's willingness to embrace PPPs is evidenced by the creation of a regulatory and legal framework. However, the ongoing conflict demands a reassessment of this framework to ensure it is robust enough to handle the current challenges. To achieve real success and foster effective state-business partnerships, significant structural changes are necessary in the interaction processes between the state, local authorities, and the population. This involves developing resilient regional strategies, effective communication policies, and strong institutional reinforcement that can withstand the pressures of the ongoing crisis. For example, these could be strategies to compensate the State for part of the cost of housing that is destroyed and/or left in the occupied territories. This compensation could be transferred to a private partner that implements a housing project for the affected population, with the full cost to be paid in instalments over a set period of time. At the regional level, strategies for the construction of modular housing or the repurposing of other structures for housing can be implemented, taking into account the specificity and particularities of the settlements.

PPPs have been used with varying degrees of success in territorial economy management around the world. Successful PPPs require careful planning, robust risk management, and effective stakeholder engagement. Lessons learned include the importance of clear roles and responsibilities, transparency, and effective risk allocation and management. Therefore, Ukraine should continue to develop and implement profound reforms. PPPs are seen as a social innovation, combining state and business resources to address social issues. They serve as an anti-crisis tool for ensuring sustainable economic development in regions. Looking ahead, based on the needs of Ukraine and the analysis of PPP's activities, we can foresee projects of multi-storey and modular housing. Multi-storey construction will be a popular project for cities such as Kyiv, Kharkiv, Dnipro, Zaporizhzhya, Sumy and Kherson. This is due to the small amount of land available and the layout of the area after the ruins of the destroyed buildings have been cleared. Modular construction will be in demand in places where businesses have been relocated from the occupied territories. Rapid reconstruction and satisfactory housing will require construction projects that can be completed in a few months to a year.

Obviously, Ukraine should be the main investor in such projects, thus contributing to the development of its own industry, in particular the construction sector. In partnership, foreign investors will be expected to provide not only financing, but also new technologies for the production of building materials, recycling of resources for project implementation, and development of opportunities for the use of clean energy sources.

References:

1. Adamou, M., Kyriakidou, N., Connolly, J. (2021). Evolution of public-private partnership: the UK perspective through a case study approach. *International Journal of Organizational Analysis, 29*(6), 1455-1466. https://doi.org/10.1108/IJOA-08-2020-2397
2. Ahmed, A. B., Musonda, I., Pretorius, J. H. C. (2023). Dynamics of PPP investment in energy and country governance: evidence from Sub-Saharan Africa. *Built Environment Project and Asset Management, 13*(1), 172-184. https://doi.org/10.1108/BEPAM-12-2021-0141
3. Bayat, F., Noorzai, E., Golabchi, M. (2019). Identifying the most important public-private partnership risks in Afghanistan's infrastructure projects. *Journal of Financial Management of Property and Construction, 24*(3), 309-337. https://doi.org/10.1108/JFMPC-08-2018-0045
4. Biygautane, M., Clegg, S., Al-Yahya, K. (2020). Institutional work and infrastructure public–private partnerships (PPPs): the roles of religious symbolic work and power in implementing PPP projects. *Accounting, Auditing & Accountability Journal, 33*(5), 1077-1112. https://doi.org/10.1108/AAAJ-04-2019-3982
5. Bun, R., Marland, G., Oda, T., See, L., Puliafito, E., Nahorski, Z., Jonas, M., Kovalyshyn, V., Ialongo, I., Yashchun, O., Romanchuk, Z. (2024). Tracking unaccounted greenhouse gas emissions due to the war in Ukraine since 2022. *Science of the Total Environment*, *914,* 169879. https://doi.org/10.1016/j.scitotenv.2024.169879
6. Dumani, A., Mbangcolo, M. M., Mpambani, B., Mpengesi, X., Titimani, M. (2023). Impact of a multi--stakeholder approach on rural livelihood and socioeconomic status of the farming community at Zanyokwe Irrigation Scheme, Amahlathi Local Municipality, Eastern Cape. *South African Journal of Agricultural Extension, 51*(1), 1-12. https://doi.org/10.17159/2413-3221/2023/v51n1a14956
7. Dunayev, I., Kuchma, M., Byelova, L., Jatkiewicz, P., Bilichenko, O., Poberezhets, H. (2024). Wartime destruction: regional assessment of damage to Ukraine's infrastructure. *International Journal of Environmental Studies*, *81*(1), 8-17. https://doi.org/10.1080/00207233.2024.2314862
8. Harris, J. K. (2019). *Statistics With R: Solving Problems Using Real-World Data*. Thousand Oaks, CA: SAGE Publications.
9. Khudhaire, H. Y., Naji, H. I. (2021). Adoption PPP model as an alternative method of government for funding abandoned construction projects in Iraq. *IOP Conference Series: Materials Science and Engineering, 1076*, 012115. https://doi.org/10.1088/1757-899X/1076/1/012115

10. Kaur, S., Malik, S. (2020). Determinants of public–private partnerships: a state-level empirical analysis of India. *Property Management, 38*(4), 597-611. https://doi.org/10.1108/PM-10-2019-0063
11. Love, P. E. D., Ika, L. A., Matthews, J., Fang, W. (2023). Large-scale transport infrastructure project performance: generating a narrative of context and meaning. *IEEE Transactions on Engineering Management, 70*(10). https://doi.org/10.1109/TEM.2021.3094511
12. Ministry for Development of Communities and Territories of Ukraine. (2019). *Announcement on competitive tender for determination of the private partner for implementation of the public-private partnership for the project: Reconstruction of the Existing and Construction of the New Cargo Terminal at Boryspil Airport*. Downloaded from: https://mtu.gov.ua/en/news/31022.html (accessed on January 16, 2025).
13. Nduhura, A., Molokwane, T., Lukamba, M., Mugerwa, B., Nuwagaba, I., Twinomuhwezi, I., Kadondi, F., Mbabazi, M. (2022). Food security: The application of public-private partnerships to feed the hungry and prosper Africa. *African Journal of Public Administration and Environmental Studies, 1*(1), 65–94. https://hdl.handle.net/10520/ejc-aa_ajopaes_v1_n1_a4
14. Panadès-Estruch, L. (2021). Public-private partnerships in transport: A critical assessment of the Caribbean. *Public Administration and Policy, 24*(1), 61-75. https://doi.org/10.1108/PAP-02-2021-0004
15. Patil, N. A., Thounaojam, N., Laishram, B. (2021). Enhancing sustainability of Indian PPP procurement process using system dynamics model. *Journal of Public Procurement, 21*(4), 345-369. https://doi.org/10.1108/JOPP-01-2019-0002
16. Vahdatmanesh, M., Firouzi, A., Rotimi, J. O. B. (2022). Real options analysis of revenue risk sharing in post-disaster housing reconstruction. *Journal of Financial Management of Property and Construction, 27*(3), 281–305. https://doi.org/10.1108/JFMPC-02-2021-0018
17. Vyas-Doorgapersad, S. (2022). An assessment of economic policies in Zimbabwe in compliance with SMART principles. *Journal of Contemporary Management, 19*(1), 107-131. https://doi.org/10.35683/jcm20137.140
18. World Bank Group. (n.d.a). *Ease of Doing Business rankings*. Downloaded from: https://archive.doingbusiness.org/en/rankings (accessed on January 16, 2025).
19. World Bank Group. (n.d.b). *Doing Business*. Downloaded from: https://archive.doingbusiness.org/en/doingbusiness (accessed on January 16, 2025).
20. Zapata Quimbayo, C. A., Mejía Vega, C. A. (2023). Credit risk in infrastructure PPP projects under the real options approach. *Construction Management and Economics, 41*(4), 293-306. https://doi.org/10.1080/01446193.2022.2151023