Електронний журнал «Ефективна економіка» включено до переліку наукових фахових видань України з питань економіки (Категорія «Б», Наказ Міністерства освіти і науки України № 975 від 11.07.2019). Спеціальності – 051, 071, 072, 073, 075, 076, 292.
Ефективна економіка. 2026. № 4.
ISSN 2307-2105

DOI: http://doi.org/10.32702/2307-2105.2026.4.5
УДК 334.72:004:336.1

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DIGITAL PUBLIC-PRIVATE PARTNERSHIP: EXTERNAL AND INTERNAL INFLUENCING FACTORS AND ROLE IN SHAPING REGIONAL ECONOMIC SECURITY

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ЦИФРОВЕ ПУБЛІЧНО-ПРИВАТНЕ ПАРТНЕРСТВО: ЕКСТЕРНАЛЬНІ ТА ІНТЕРНАЛЬНІ ФАКТОРИ ВПЛИВУ ТА РОЛЬ У ФОРМУВАННІ РЕГІОНАЛЬНОЇ ЕКОНОМІЧНОЇ БЕЗПЕКИ

The article develops a conceptual framework for analysing digital public-private partnership as a mechanism for strengthening regional economic security under conditions of war, post-war recovery, and accelerated digital transformation. The study systematises the external and internal factors that influence digital PPP performance and explains how digital technologies mediate

their impact on project resilience, transparency, and effectiveness. External factors include security threats, macroeconomic instability, legal and regulatory change, compliance restrictions, investment and insurance constraints, and disruptions in logistics and resource supply. Internal factors cover institutional capacity, financial structuring, contract management, technological maturity, human capital, organisational culture, and corruption risks. It is substantiated that digital tools are not merely auxiliary instruments within PPP projects, but act as systemic mediators that transform the architecture of interaction between the state and private partners. Particular attention is paid to digital workflow systems, project management platforms, registers of long-term obligations, BI analytics, KPI and SLA dashboards, e-procurement tools, KYC/KYB systems, open data instruments, red-flag mechanisms, and IoT-based monitoring solutions. The article proposes a matrix "factor → digital tool → effect for PPP and regional economic security", which identifies the channels through which digital technologies reduce transaction costs, improve accountability, support continuity of critical services, and increase investment attractiveness. At the same time, the study demonstrates that digitalisation also creates new vulnerabilities related to cybersecurity, data quality, technological dependence, and possible manipulation of digital procedures. The findings prove that the effectiveness of digital PPP depends on the integration of digital tools into institutional design, contract architecture, and risk management systems. The proposed approach may be used to improve PPP policy, strengthen regional resilience, and support evidence-based decisions in fragile and conflict-affected environments.

У статті розроблено концептуальну основу для аналізу цифрового публічно-приватного партнерства (ППП) як механізму зміцнення регіональної економічної безпеки в умовах війни, післявоєнного відновлення та прискореної цифрової трансформації. У дослідженні систематизовано зовнішні та внутрішні фактори, що впливають на ефективність цифрового ППП, та пояснюється, як цифрові технології опосередковують свій вплив на стійкість,

прозорість та ефективність проєктів. Зовнішні фактори включають загрози безпеці, макроекономічну нестабільність, правові та регуляторні зміни, обмеження щодо дотримання вимог, обмеження інвестицій та страхування, а також перебої в логістиці та постачанні ресурсів. Внутрішні фактори охоплюють інституційний потенціал, фінансове структурування, управління контрактами, технологічну зрілість, людський капітал, організаційну культуру та корупційні ризики. Обґрунтовано, що цифрові інструменти є не просто допоміжними інструментами в рамках проєктів ППП, а діють як системні посередники, що трансформують архітектуру взаємодії між державою та приватними партнерами. Особлива увага приділяється системам цифрових робочих процесів, платформам управління проектами, реєстрам довгострокових зобов'язань, аналітиці бізнес-аналітики, панелям інструментів KPI та SLA, інструментам електронних закупівель, системам KYC/KYB, інструментам відкритих даних, механізмам червоних прапорців та рішенням для моніторингу на основі Інтернету речей. У статті пропонується матриця «фактор → цифровий інструмент → ефект для ДПП та регіональної економічної безпеки», яка визначає канали, через які цифрові технології знижують транзакційні витрати, покращують підзвітність, підтримують безперервність критично важливих послуг та підвищують інвестиційну привабливість. Водночас дослідження демонструє, що цифровізація також створює нові вразливості, пов'язані з кібербезпекою, якістю даних, технологічною залежністю та можливими маніпуляціями цифровими процедурами. Результати дослідження доводять, що ефективність цифрового ППП залежить від інтеграції цифрових інструментів в інституційну структуру, архітектуру контрактів та системи управління ризиками. Запропонований підхід може бути використаний для вдосконалення політики ППП, зміцнення регіональної стійкості та підтримки рішень, заснованих на доказах, у нестабільних та уражених конфліктами середовищах.

Keywords: *digital public-private partnership; GovTech; digital transformation; regional economic security; risk management; institutional capacity; transparency; e-government; post-war recovery.*

Ключові слова: *цифрове публічно-приватне партнерство; GovTech; цифрова трансформація; регіональна економічна безпека; управління ризиками; інституційна спроможність; прозорість; електронне урядування; післявоєнне відновлення.*

Problem statement in general, and its relationship with important scientific or practical tasks. The current paradigm of global economic development demonstrates that no single macroeconomic actor – neither government, nor the private sector, nor international financial institutions – is capable of addressing the challenges of large-scale climate instability, social inequality, rapid technological disruption, and, most critically for Ukraine, the devastating consequences of full-scale war. Public sector budgets are stretched to the limit, while citizens demand better transport infrastructure, more reliable energy supplies, fast connectivity, and secure digital services. In this context, public-private partnerships (PPPs) emerge not simply as an alternative financing tool, but as a basic architecture for building a sustainable, interoperable, and transparent economy. Rather than viewing government and business as competitors for resources, PPPs encourage both parties to co-design solutions that could not be implemented in isolation [1]. By combining national advantages with the private sector's innovative potential, PPPs become a stabilizing force capable of transforming existential uncertainty into an investment opportunity.

Digital technologies in PPP projects act not only as operational tools but also as mediators that modify the impact of external and internal factors. Their implementation can increase transparency, monitoring, and the financial sustainability of projects, but it also adds cyber and technological risks that need to be accounted for in the risk-sharing system of PPP contracts.

Thus, the problem of identifying and systematizing the external and internal factors influencing digital public-private partnerships, as well as understanding the mediating role of digital technologies in this process, becomes critically important both for advancing theoretical approaches and for designing effective practical mechanisms to strengthen regional economic security in conditions of heightened uncertainty and post-war recovery.

Analysis of the latest research and publications in which the solution of this problem was initiated and on which the author relies, selection of previously unsolved parts of the general problem to which the above is devoted article. The theoretical discourse on the nature of public-private partnerships in the era of digitalization is undergoing profound epistemological shifts. Researchers in organizational science and economics are increasingly addressing the question of defining the boundaries between public and private economic activity. There is a gradual but irreversible blurring of these boundaries: public institutions are increasingly adopting the management practices of the corporate sector, and private business is integrated into the performance of traditionally state functions. From the perspective of transaction cost theory, digital platforms, which underpin digital PPP, dramatically reduce the costs of finding partners, negotiating, concluding agreements, and monitoring contract implementation [2].

The introduction of digital PPP tools in e-government is a powerful driver of economic growth, designed to reduce the state's financial constraints while increasing efficiency [3]. The World Bank defines electronic government (e-government) as the systematic use of information and communication technologies (ICT) by government structures to expand the range and improve the quality of information and services provided to citizens, businesses, civil society organizations, and other government institutions. This process should take place in an efficient, cost-effective, and convenient way, making government processes more transparent, accountable, and democratic.

The conceptual core of digital PPP is the formation of a digital public infrastructure (Digital Public Infrastructure, DPI). As noted in research, DPI allows citizens to interact with governments and realize economic opportunities. According to the United Nations Development Programme (UNDP), if DPI principles are fully applied to the financial sector, it could accelerate economic growth in developing countries by 20–33% by 2030. DPI is defined as a set of shared digital systems that are secure, interoperable, built on open standards, and provide access to services for all segments of the population. DPI architecture typically includes components such as digital identification systems (Digital ID), national payment systems, and secure data exchange platforms [4].

Of particular importance has been research on the use of digital tools for transparency and procedural accountability. First, the government procedure for conducting a concession competition and competitive dialogue in the electronic trading system formalizes the digital "selection infrastructure" of the private partner, defining system administrators for different value thresholds and the mechanics of user accounts and electronic forms [5]. Secondly, the procedure for maintaining a register of long-term obligations within the PPP creates an information and communication system for accounting for budget obligations and requires open and free access to certain sets of information [6].

Accordingly, digital platforms incorporate scalability properties organically, which can be maximized when the platform is positioned within the PPP network. Platforms act as catalysts for stakeholder interaction, fostering patterns of value co-creation. The interaction of technologies with digital platforms and value chains leads to the formation of "smart" partnerships [7]. This scalability is reflected in the fact that the marginal cost of attracting each subsequent user to the platform approaches zero, making the PPP unprecedentedly cost-effective in the long term.

Moreover, the analysis of modern publications records a shift in the focus of PPP from a narrow infrastructure paradigm (construction of roads, ports, bridges) to a tool for creating complex social value, bordering on the logic of social entrepreneurship. The growing attention to socially oriented business models

within the framework of PPP is driven by the need to address problems such as poverty alleviation, reducing social inequality, implementing environmentally sustainable solutions, and promoting inclusive modernization. Thus, the scientific discourse confirms that public-private partnerships serve as a catalyst for innovative activity, stimulating entire entrepreneurial ecosystems to implement new technologies and organizational models [8].

At the same time, despite the significant development of the theoretical and empirical base of PPPs in the context of digitalisation, the existing literature remains fragmented and does not provide a comprehensive understanding of how external and internal factors interact through digital technologies within PPP systems. In particular, there is a lack of integrative approaches that simultaneously consider risk distribution, institutional capacity, digital maturity, and their combined impact on regional economic security, especially in conditions of war and post-war recovery. Therefore, this article aims to fill this gap by developing a systemic framework for analysing the interaction between environmental factors, digital tools, and PPP performance, which allows not only to deepen the theoretical understanding of digital PPPs but also to offer practical solutions for strengthening the resilience and sustainability of regional economic systems.

Formulation of the goals of the article (setting the task). The purpose of the article is to develop a conceptual and analytical framework for understanding the role of digital technologies in mediating the impact of external and internal factors on public-private partnerships and their contribution to regional economic security. To achieve this goal, the study aims to: (1) systematize external and internal factors influencing PPP development in the context of digital transformation and wartime conditions; (2) identify the key digital tools that modify the effects of these factors on PPP performance; (3) substantiate the interrelationships between digitalisation, risk distribution, and institutional capacity within PPP systems; and (4) develop a matrix-based approach to assess the influence of digital technologies on the resilience and effectiveness of PPP projects in ensuring regional economic security..

Statement of the main research material with full justification of the obtained scientific results. External factors are “environmental parameters” that are mostly beyond the direct control of the parties to the contract but must be incorporated into the contract structure (insurance, guarantees, indexation, force majeure clauses, safety-by-design). In the war and post-war period in Ukraine, their importance increases due to: (a) high probability of shocks; (b) shift in priorities from efficiency to continuity and sustainability; (c) dependence on international assistance and external markets [9].

Key subtypes of external factors:

1) Geopolitical and security: intensity of hostilities, risk of occupation, strikes on energy/transport infrastructure, mining of territories, risks to personnel. RDNA4 records an escalation of hostilities in 2024, the spread of air attacks, and damage to strategic energy, transport, and other infrastructure.

2) Macroeconomic: inflation, interest rates, currency volatility, risks of falling demand/income, budget deficits and forced prioritization of expenditures. NBU forecasts emphasize that inflationary dynamics are constrained by additional business costs associated with maintaining business continuity amid an energy shortage, and that economic growth is moderate due to the effects of the war [10].

3) Legal and regulatory (including European integration requirements): updating the legal framework of PPPs/concessions, specific dates of entry into force of digital procedures, requirements for transparency and budget accounting.

4) International restrictions and compliance: restrictions on participation in PPPs of entities associated with the aggressor state/risky jurisdictions, and requirements for verification of beneficiaries. The new legislation explicitly establishes prohibitions/restrictions on the participation of persons associated with the aggressor state and other specified categories [11].

5) External investment and access to insurance/guarantees: the possibility of involving international development partners/institutions to reduce the risk premium, the use of guarantees and insurance products in situations of high fragility. International approaches to PPPs in fragile/conflict contexts explicitly

indicate that without such mechanisms, long-term models often need to be modified or replaced by shorter forms of participation [12].

6) Supply of resources and logistics: availability of construction materials and equipment, interruptions in supply chains, port/corridor capacity, energy, and water supply. In RDNA4, reconstruction needs to directly take into account “build back better”, changing standards, and inflationary market conditions in construction.

Internal factors are those that PPP parties can change (or at least significantly improve) through organizational decisions, contract design, and digitalization. In wartime, they should be treated as “manageable resilience factors” rather than secondary management details [13].

Key subtypes of internal factors:

1) Institutional: the public partner’s ability to build a pipeline of projects, conduct feasibility studies, conduct tender procedures, manage contracts and changes, and coordinate with regulators. International principles emphasize the roles of PPP units, budget authorities, and audit institutions.

2) Financial: the structure of revenues and payments (user-pay vs. government-pay), indexation, currency clauses, demand/price risk sharing mechanisms, and fiscal constraints. In Ukraine, this is covered by a digital register of long-term budget commitments with the requirement for open access to key parameters.

3) Management: quality of project management, KPI/SLA performance, reporting discipline, ability to negotiate and resolve disputes, “anti-renegotiation” design. International principles directly warn about the risks of the operation phase and the need for transparent rules for changes/negotiations.

4) Technological: digital maturity, data quality, integration of registries/platforms, cyber hygiene, access architecture, ability to work in degradation (fallback) mode. The regulatory framework provides for digital selection platforms in concessions and digital submission forms/user cabinets.

5) Human resources: competencies in PPP structuring, financial modeling, cybersecurity, and data analytics for monitoring assets and contracts.

6) Cultural: trust between the government and business, willingness to share data, risk-taking and innovation, “public mandate” for PPP. The international recommendation emphasizes the need to inform society and involve stakeholders.

7) Corruption risks: manipulation of the competition, conflicts of interest, “regulator capture”, and shadow payments. Empirical evidence on e-GP indicates the potential of digital procurement and institutional reforms to increase transparency and accountability [14].

The generalization of the interaction of external and internal factors with digital tools in the public-private partnership system is presented in the matrix format “factor → digital tool → effect for PPP and regional economic security” (Table 1). This approach allows us to systematize the channels of influence of factors of different natures and determine how digital technologies modify their impact on the functioning and sustainability of PPP projects.

The analysis shows that in the case of external factors, digital tools act as adaptive mechanisms that reduce the sensitivity of PPP projects to macroeconomic, security, and institutional shocks. In particular, the use of IoT-based asset-monitoring systems, remote management technologies, and business continuity tools can enhance the resilience of infrastructure facilities against physical damage and operational disruptions. In the context of a war economy, this is particularly important, as digital monitoring systems enable rapid detection of damage, prioritize restoration work, and support the functioning of critical services. Similarly, digital financial models, business analytics tools, and budget commitment registers increase transparency and predictability of the state’s fiscal obligations, reducing macro-financial uncertainty and enhancing the investment attractiveness of PPP projects. At the same time, digital solutions play an important role in reducing transaction costs and information asymmetry between partnership participants. Digital identification tools, counterparty verification systems (KYC/KYB), electronic document management, and beneficial owner registers form an institutional infrastructure of trust that ensures partnerships comply with regulatory and sanction requirements. In this sense, digital platforms perform not

only a technological but also an institutional function, as they increase transparency in interactions among the state, businesses, and other stakeholders.

Table 1. Matrix "Factor → digital tool → effect for PPP and regional economic security"

Factor	Channel of influence on PPP	Digital tools	Positive effect	Potential risk
External factors				
Security (war, destruction of infrastructure)	Interruptions in the functioning of facilities, risk of loss of assets	IoT - asset monitoring, remote management, BC/DR systems	Rapid damage detection, priority recovery, support for service continuity	Cyberattacks on digital infrastructure, dependence on IT systems
Macroeconomic (inflation, currency fluctuations, budget constraints)	Rising project costs, financial instability	Digital financial models, BI analytics, digital registers of budget obligations	Better control of fiscal risks, scenario forecasting	Model errors or inaccurate data
Legal and sanction restrictions	Counterparty verification, compliance risks	KYC/KYB systems, beneficiary registers, electronic document management	Fast partner verification, reduced transaction costs	Risks of data leakage, identification errors
Logistical and resource constraints	Disruptions in the supply of materials and equipment	Digital logistics platforms, supply chain management systems	Logistics optimization, increased supply transparency	Dependence on digital operators
Internal factors				
Institutional capacity	Quality of preparation and implementation of the PPP	Digital workflow systems, project management platforms	Transparency of processes, control of deadlines and decisions	Formalization of processes without real quality improvement
Financial management	Control of budget commitments and payments	Digital registers of PPP obligations, financial dashboards	Fiscal risk transparency, accountability	Technical errors in systems
Contract management	Monitoring of KPI and SLA performance	Digital monitoring systems, KPI dashboards	Improving contract management efficiency	Data manipulation
Technological maturity	Data and digital systems integration	Integrated state registers, data platforms	Faster information exchange, improved manageability	Cyber risks
Corruption risks	Manipulation of competitions and decisions	E - procurement , open data, red-flag systems	Increasing competition and transparency	Attempts to bypass digital procedures
Personnel competencies	Quality of PPP management	Digital analytical tools, learning platforms	Increasing professional capacity	Dependence on IT experts

Source: compiled by the authors

Regarding internal factors, digital tools primarily serve as catalysts for increasing institutional capacity and the quality of PPP project management. The use of digital project management systems, workflow platforms, and analytical panels (dashboards) enables greater coordination among partnership participants, greater control over the implementation of contract terms and conditions, and more effective risk management throughout the project life cycle. Of particular importance is the use of digital KPI and SLA monitoring systems, which provide continuous feedback between the project's operational results and management decisions, reducing the risk of opportunistic behavior by the parties.

In addition, the digitalization of the selection and implementation processes for PPP projects creates additional mechanisms to prevent corruption risks. The use of electronic procurement systems, open data, and anomaly-detection algorithms (red-flag systems) increases competition, accountability, and public control over the use of public resources. In a broader institutional context, this creates a more transparent environment for attracting private capital to the development of regional infrastructure.

At the same time, the results of the matrix analysis confirm that digital technologies not only reduce risks but also create new cybersecurity challenges, increased dependence on digital infrastructure, and challenges related to data quality. Therefore, the effectiveness of digital PPP largely depends on the ability of the state and private partners to form comprehensive digital risk management systems.

In conclusion, the proposed matrix demonstrates that digital technologies act as a key mediator of the interaction between environmental factors and PPP performance, changing the nature of risk distribution, increasing management transparency, and contributing to strengthening regional economic security. It is the integration of digital tools into the institutional design of partnerships that creates the prerequisites for increasing the resilience of infrastructure systems, more efficient use of public resources, and the formation of long-term investment opportunities in the regions.

Conclusions from this study and prospects for further research in this direction. The conducted research confirms that digital public-private partnerships represent a qualitatively new stage in the evolution of PPP mechanisms, in which digital technologies act not only as auxiliary instruments but as systemic mediators of interaction between external and internal factors. It has been substantiated that in conditions of war and post-war recovery, the role of external factors–security, macroeconomic instability, regulatory constraints, and resource disruptions–significantly increases, requiring their formal integration into PPP design through adaptive contractual and digital solutions. At the same time, internal factors–particularly institutional capacity, financial structuring, technological maturity, and human capital–become critical determinants of the resilience and effectiveness of PPP projects.

The proposed matrix "factor → digital tool → effect" allows to systematize the channels through which digital technologies transform the impact of environmental factors on PPP performance and regional economic security. It has been proven that digital tools contribute to increasing transparency, reducing transaction costs, improving monitoring and accountability, and strengthening trust between stakeholders. However, digitalisation simultaneously generates new risks related to cybersecurity, data quality, and technological dependence, which necessitates the development of integrated digital risk management systems within PPP frameworks.

From a practical perspective, the results of the study can be used to improve the institutional design of PPP projects, develop digital infrastructure for partnership management, and enhance policy approaches to ensuring regional economic security under conditions of heightened uncertainty.

Prospects for further research are related to the development of quantitative methods for assessing the impact of digitalisation on PPP efficiency, including the construction of composite indices and econometric models that capture the interaction between digital maturity, institutional quality, and fiscal sustainability. In addition, future studies should focus on empirical testing of the proposed

framework using cross-country data, as well as on the analysis of specific sectoral cases (transport, energy, social infrastructure) to identify best practices for implementing digital PPPs in fragile and conflict-affected environments.

Acknowledgment. This research was supported by the Ministry of Education and Science of Ukraine (project № 0126U000543 “Digitalization of the public-private partnership system as a driver of the state's economic security in the war and post-war periods”).

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Отримано редакцією журналу / Received: 28.03.26

Прорецензовано / Revised: 08.04.26

Дата публікації / Published: 23.04.26