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DIGITALIZATION OF PUBLIC-PRIVATE PARTNERSHIP AS A STRATEGIC IMPERATIVE FOR ENSURING THE STATE'S ECONOMIC SECURITY: A BIBLIOMETRIC ANALYSIS AND THE EVOLUTION OF SCIENTIFIC APPROACHES

ABSTRACT

This article is devoted to the timely issues of digitization of public-private partnerships as a strategic tool for ensuring the state's economic security in the context of global instability and war threats. The relevance of the study is determined by the objective need to attract private capital for large-scale post-war economic recovery amidst a critical shortage of budgetary resources. In turn, securing a sufficient level of private investment is only possible through adherence to the principles of transparency, accountability, and algorithmic trust, which is facilitated by the use of digital ecosystems and modern technological solutions. The aim of the research is to provide a comprehensive scientific justification of the role of the digitalization of public-private partnerships as a strategic imperative for strengthening the country's economic security. The study conducted a theoretical and methodological analysis of the transformation of the partnership concept from centralized structures to modern network models such as "Digital PPP" and "4P." Using Google Trends tools, a comparative assessment was carried out of the dynamics and geographical distribution of societal interest in public-private partnerships and digitalization. Based on information from the Scopus database, an in-depth bibliometric analysis was carried out of publication activity, sectoral structure, and the geographical distribution of research devoted to the digitalization of public-private partnerships in the context of ensuring the state's economic security.

Clustering of the scientific landscape using VOSviewer software identified three most common areas of research on the topic: the fundamental principles of public-private partnerships, the technological aspects of digitalization, and public administration and the role of the state. The study paid particular attention to a chronological analysis of the evolution of academic approaches to researching the role of digitalization in public-private partnerships. The article outlines promising aspects of digitalizing the public-private partnership system to ensure economic security and the post-war reconstruction of the state.

Keywords: public-private partnership, digitalisation, innovative digital technologies, digital public-private partnership, national economic security, post-war recovery, bibliometric analysis, public-private partnerships evolution

JEL Classification: H54, O33, G31, M21

INTRODUCTION

In the current conditions of global instability and unpredictable challenges, the issue of ensuring the economic security of the state is of particular importance, which in turn is impossible without the mobilization of domestic resources, and in the current situation, also the attraction of private capital (Hrytsyshen et al., 2025). This issue is of increased relevance in the context of the real economic and political situation in Ukraine: hostilities have caused large-scale destruction on the territory of the country, which in the ten-year perspective are already estimated at hundreds of billions of dollars (Charkina et al., 2026). As of today, such an amount already significantly exceeds the capabilities of the state budget, which means that the question arises of the possibility of attracting

private capital, including on the terms of public-private partnership, which ensures the synergy of financial, technological, and managerial resources of the state and business.

Public-private partnership is one of the areas of modernization of the national economy, which allows the state to redistribute financial and operational risks, transferring them to a private partner more competent in terms of the life cycle of the object (Yefimenko, 2025). Public-private partnership plays a particularly important role in the context of a long-term deficit of budget funds: active attraction of private investments allows the implementation of expensive and socially significant projects in the energy, transport, healthcare, and digital infrastructure (Grytsyshen et al., 2025). In addition, public-private partnership, thanks to state support, as well as investments and expertise of private partners, is a prerequisite for the implementation of the "Build Back Better" principle in the post-war period through the development of such innovative areas as digital technologies, energy-efficient solutions, sustainable infrastructure, etc.

In turn, the greatest efficiency of public-private partnership in modern conditions is achieved only through the broad integration of innovative digital technologies that guarantee accountability, transparency, and sustainability of investment projects in the face of military threats and budget deficits (Zakharkin et al., 2026). The introduction of digital tools creates opportunities for real-time monitoring of investment projects from initiation to evaluation of results (digital ecosystem), predictive analytics and risk management (AI, ML and Big Data), continuous control over the physical state of objects (IoT), integrity and immutability of records in state registers (blockchain and smart contracts) (Charkina et al., 2026).

Thus, the implementation of public-private partnership with the active introduction of innovative digital technologies is currently one of the key drivers of economic security in war and post-war conditions. Such an approach, in our opinion, will allow not only to effectively rebuild the country, but also to form a new sustainable economy on the basis of transparency, trust and shared responsibility. In view of the above, we consider it appropriate to conduct a more thorough consideration of the issue of public-private partnership and integration of digital solutions into its system in the course of a detailed bibliographic analysis.

LITERATURE REVIEW

Considering the outlined topic, it should be noted that the term "state-private partnership" dominated in domestic practice for quite a long time, which reflected the traditional model of management characteristic of the centralized state system. At the same time, a number of scientists, including Yefimenko (2025), emphasize the importance of switching to the model of "public-private partnership", which is more adapted to the real economic situation and widespread in European practice. The fundamental difference between these models appears in the role of the state: if in the first model it acts as a dominant subject in a clear hierarchical system, then the second model includes not only state institutions, but also local self-government bodies or other civil society institutions (Yefimenko, 2025). It should also be noted that in Ukrainian practice, the system is currently being restructured in the direction of public-private partnership, the fundamental principles of which were enshrined by the Law of Ukraine No. 4510-IX "On Public-Private Partnership", 2025, which came into force on 31.10.2025. According to domestic scientists, such changes marked a radically new stage in the development of investment partnerships, creating new approaches to decentralized management, which is especially important in the war and post-war periods.

Returning to the essence of the category fundamental for this study, we emphasize the significant variability of its interpretations from conservative to more modern approaches focused on digital tools. In particular, the World Bank (2017) interprets public-private partnership as "a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance." In other words, this approach emphasizes the fundamental characteristics of public-private partnership – long-term, transfer of significant risks and payment for results. A slightly different approach can be observed in the interpretation of S&P (Standard and Poor's), which considers this category as "any medium- to long-term relationship between the public and private sectors, involving the sharing of risks and rewards of multisector skills, expertise and finance to deliver desired policy outcomes" (OECD, 2008). That is, public-private partnership in this case is perceived as a partnership that allows sharing risks, and not exclusively transferring them to the private sector as in the previous interpretation. In addition, it notes that public-private partnership can be not only long-term, but also medium-term, which is more in line with modern economic realities.

In turn, the OECD (2008), providing an interpretation of public-private partnership, emphasizes the possibility of attracting one or more private partners who can be responsible for both the operational cycle of the project and act as investors. In addition, the approach of this institution highlights an important aspect, namely the need for such agreements that ensure compliance with the goals of the state in terms of providing services and the profit benchmarks of private partners (OECD,

2008). In other words, the fundamental characteristic of public-private partnership according to the OECD approach is the profitability and feasibility of the project for all its participants. Similarly, the European Commission (2003) emphasizes partnership relations in its interpretation, which also emphasizes that the purpose of such cooperation is "to ensure the funding, construction, renovation, management and maintenance of an infrastructure of the provision of a service".

Despite the fundamental nature of the described approaches, the majority of Ukrainian and foreign scientists consider them somewhat outdated and inconsistent with the existing economic situation. Indicative in this context is the approach of Auriol and Saussier (2025), who interpret public-private partnership as one of the important strategic tools of socio-economic development, which in the future will bring benefits, in particular through the pooling of resources, risks and competencies of the parties. In addition, the international environment also has an understanding of public-private partnership as an innovative platform for interaction between the state, business and the public. It is also important to note that most scholars are currently focusing on the importance of society's role in this partnership.

A similar research paradigm is also characteristic of Ukrainian scientists. In particular, Grytsyshen et al. (2025) interpret public-private partnership as "a successful way of combining financial, technological and managerial resources", which allows you to reconcile the interests of the state, business and society. That is, in addition to the important role of the public, the authors also emphasize the importance of pooling technical resources. A similar opinion is shared by Ponomarev (2026), who interprets public-private partnership as an effective tool for mobilizing private capital and innovative technologies for post-war recovery. In turn, Kot (2025) argues that public-private partnership is a mechanism for creating public value, which combines aspects of economic efficiency and social responsibility.

In turn, Kuznyetsova et al. (2022) interpret public-private partnership as a multicomponent institutional system that is currently undergoing an active transformation from a traditional contract mechanism to a strategic driver of national competitiveness and sustainable economic growth. In other words, the authors rethink the role of public-private partnership in the modern economy, focusing on its prospects not only for the real situation, but also for further sustainable and innovative development. A similar direction is also the study of Kwilinski et al. (2022), which is dedicated to the evolution of public-private partnerships from a narrow industry focus to more comprehensive mechanisms for financing complex projects in various fields. Such transformational trends are especially relevant for the Ukrainian case, where the broad direction of public-private partnership projects, along with their effective management, can become one of the factors of rapid post-war recovery. Along with the study of the evolution and prospects of public-private partnerships, the authors of these works also pay considerable attention to the development of a comprehensive methodological approach to assessing the effectiveness of public-private partnership projects through multifactorial models that would integrate investment, financial, social and environmental indicators to harmonize the fiscal interests of the state, profitability for private partners and the quality of public services (Kuznyetsova et al., 2021).

The issues of coordination of economic interests of the state and business in the course of forming an optimal portfolio of public-private partnership projects are also devoted to the work of Hrytsenko and Boyarko (2015). In general, in the works of Hrytsenko L., the concept of public-private partnership is considered in the context of the financial and investment paradigm, where it is transformed from a classical organizational and legal mechanism into a complex investment architecture focused on innovative development and economic sustainability (Hrytsenko et al., 2021). That is, the author also considers public-private partnership not only as a guarantee of economic sustainability, but also as a factor in the development of innovative areas, which coincides with the real need of society and the state during the war and post-war recovery. In continuation of the innovative component of public-private partnership, it is also worth noting the research of Tverezovska and Hrytsenko (2022). The authors substantiate the role of green project financing as one of the important drivers of sustainable post-war recovery and economic modernization. Thus, researchers define the role of eco-projects in the system of public-private partnership as a tool for increasing national competitiveness and investment attractiveness. This direction is of particular importance today for Ukraine, as it takes into account not only the needs of post-war recovery and economic security, but also focuses on topical environmental issues, which is an important factor in European integration processes.

Thus, most research, as well as official publications on public-private partnership, consider it as an established mechanism of cooperation between the state and business to meet public needs, in particular through infrastructure projects. Despite the gradual development of new areas of study, they are still centered around this idea, but with the direction of implementing innovative and green projects. At the same time, the economic environment is currently actively transforming, including under the influence of digitalization processes, and therefore approaches to the implementation of public-private partnership projects should also be transformed. One of the important and most innovative areas in this context is its digitalization and qualitative renewal in the direction of transparency, accountability, and sustainability. Thus, Maurer (2025) proposes an innovative concept, "Digital Public-Private Partnership (DPPP)", which goes beyond the traditional

implementation of joint projects, and instead turns them into “long-term platform infrastructures”, which integrates economic, social, and institutional dimensions (Maurer, 2025). Another innovative concept is the model “Public-Private-People Partnership (4P)”, proposed in the work of Lyashenko and Petrova (2025). This model is to some extent a combination of modern approaches to public-private partnership, namely the inclusion of society (people) in it and the use of innovative digital tools (Lyashenko and Petrova, 2025). In the context of the Ukrainian situation, such a model of public-private partnership can become one of the effective tools for post-war recovery, which will contribute to “increasing the resilience of the economy and the social sphere through trust, transparency and solidarity participation” (Lyashenko and Petrova, 2025).

A detailed review of the literature allows us to distinguish two main models of public-private partnership – traditional and modern, focused on the introduction of innovative digital technologies. The comparative characteristics of these models are presented in Table 1.

Table 1. Comparative analysis of public-private partnership implementation models in modern conditions. (Source: systematized by the author on the basis of Maurer, 2025; Azhazha et al., 2025; Venger and Kushnirenko, 2025; Chojecka, 2025; Tanveer et al., 2024; Hrytsenko and Boyarko, 2015)

Criterion	Traditional model	Modern innovative model
Object	Physical infrastructure, the creation or renovation of which has a high cost (roads, bridges, infrastructure facilities)	Digital platforms, GovTech solutions, social innovations, etc.
Purpose	Effective financing and management of capital assets	Co-creation of social value, social sustainability
Type of interaction	Vertical, tightly controlled, hierarchical	Horizontal, network, membership
The role of digital technologies	Auxiliary tool for monitoring and transparency	System-forming basis, a means of forming stable trust
Key Resource	Financial capital, technical expertise	Data, social capital, innovation competencies

Thus, one of the main drivers in the context of guaranteeing economic security is precisely the transition from the concept of state-private partnership to public-private partnership, which covers a much wider range of participants, including communities and civil society institutions (Yefimenko, 2025). Developing this idea, Azhazha et al. (2025) offer the concept of GovTech partnerships, in which business acts as a co-founder of innovative solutions, and the state is the architect of ecosystems.

The digitalization of public-private partnerships is also an important tool for ensuring transparency and accountability, and therefore a driver of attracting investments. Thus, digital management systems, such as DREAM (Digital Restoration Ecosystem for Accountable Management), allow creating a single “digital route”, thereby demonstrating all stages of project implementation from idea to completion (Venger et al., 2025). In the current conditions, this aspect is really relevant for Ukraine due to a significant level of distrust on the part of investors – real-time data transparency is a “currency of trust” that allows attracting not only private, but also international capital even in conditions of increased currency risks (Charkina et al., 2026). For the Ukrainian case, the modernization of public-private partnership to the “4P – Public-Private-People Partnership” model, where the role of civil society is of significant importance (Lyashenko and Petrova, 2025), is also important. In this model, digital crowdfunding models play a key role, which allow society to finance socially significant projects through voluntary contributions.

An equally important place in ensuring the economic security of the state is the integration of advanced technologies into public-private partnerships. In particular, technologies such as Artificial Intelligence, Machine Learning, and Big Data are today important risk management tools that allow simulating cash flows and the effect of external shocks in conditions of extreme uncertainty (Zakharkin et al., 2026). In combination with Smart Security and Smart Sustainability approaches, as noted by Omelyanenko et al. (2025), such technologies make it possible to create “smart grids” capable of rapid recovery.

Thus, the digitalization of public-private partnership is a radically new stage in the development of cooperation between the state and business. It is modern progressive technologies and digital ecosystems that make it possible to guarantee accountability, transparency, algorithmic trust, and sustainability of projects, and therefore stimulate investment flows for the implementation of socially significant initiatives. In our opinion, it is the concept of digital public-private partnership that is the most promising in modern conditions.

AIMS AND OBJECTIVES

The purpose of the study is to provide a comprehensive academic justification for the role of the digitalization of public-private partnerships as a strategic imperative for strengthening the state's economic security. This involves, in particular, identifying global trends and analyzing the evolution of scientific paradigms that shape the transformation of public-private partnerships into a digital ecosystem capable of ensuring transparency, institutional stability, and investment attraction amidst the military risks and post-war reconstruction.

The objectives of the study are:

- to assess the dynamics and geographical specifics of societal interest in the categories of "public-private partnership" and "digitalization" in order to identify the impact of global economic shocks on the actualization of search queries;
- to investigate the intensity of scientific activity in the field of digitalization of public-private partnerships as a component of economic security, identifying the key factors of growth of scientific interest;
- to consider the interdisciplinary structure and sectoral focus of research on the digitalization of public-private partnerships;
- to cluster the scientific landscape in order to identify key thematic areas and assess the relationships between them;
- to analyze the chronological evolution of scientific priorities in the study of digitalization of public-private partnerships as a strategic imperative for strengthening the state's economic security.

METHODS

The work is based on the traditional approach to bibliometric analysis, which takes place in several successive stages: determining the goal, forming a data sample, direct analysis, visualization, and interpretation of data.

The first step of the study is to assess the level of societal interest in the issue of public-private partnership and innovative digital technologies in Ukraine and the world. For this purpose, the Google Trends toolkit was used, which allows assessing the popularity of queries in time and geography, and therefore reflects the evolution of concepts under the influence of global challenges and military events. For the study, the queries "public-private partnership" and "digitalization" were used for the regions of Ukraine and the whole world, respectively. Data on societal interest in search queries is displayed on a special scale – Google Trends Scale (GTS) from 0 to 100 points, where 0 reflects the lack of interest and 100 – the peak of popularity. The study also provides for a qualitative assessment of the level of interest, which is divided into low (0 – 30), medium (31 – 70) and high (71 – 100).

In the course of the bibliographic analysis, an in-depth analysis of the scientific landscape on the digitalization of public-private partnerships was carried out using the analytical tools of the Scopus database. The sample was formed according to such a search query as "public-private partnership AND digitalization" in the context of their inclusion in the titles, annotations, and keywords of publications. The analysis of the sample was carried out according to temporal, disciplinary, and geographical characteristics.

For detailed visualization and identification of connections, VOSviewer software was used, which made it possible to group keywords into thematic clusters by area of research. The interpretation of the created maps of relationships is as follows: each point (node) corresponds to a certain term or keyword, and the lines (edges) between the nodes show a common mention of these terms in scientific papers. At the same time, the size of each node reflects the frequency of mentioning the corresponding term in publications, and the colors correspond to different clusters or research patterns. Also, the distance between keywords indicates the close relationship between them. Using this toolkit, a chronological analysis was also carried out to track the transformation of scientific priorities over time.

RESULTS

Today, the issue of implementing public-private partnerships, which is caused in particular by local crises and global instability, is becoming increasingly relevant. Thus, interest in this aspect as one of the effective tools for the implementation of a number of socially significant projects is gradually growing. No less significant is the public's interest in an innovative direction, namely digital technologies, which transform most areas of public life, including public-private partnerships. Upward trends in these areas prevail both in Ukraine and in the global dimension, which can be confirmed by the data in Figure 1.

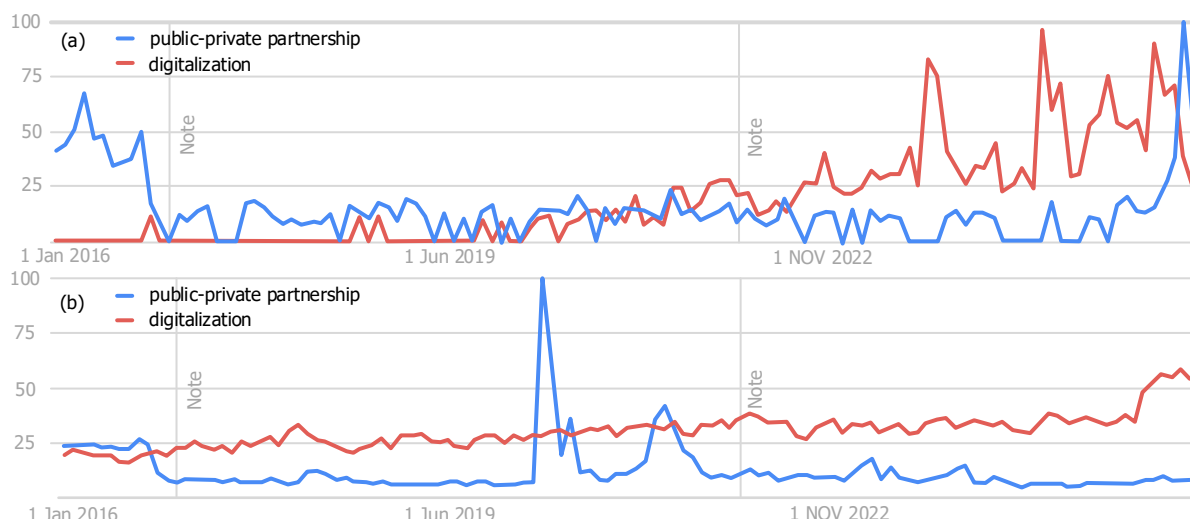


Figure 1. Dynamics of Google search queries for public-private partnerships and digitalization in Ukraine (a) and the world (b) during 2016 – 2025, points. (Source: created by the authors using Google Trends)

The data in Figure 1 primarily highlight the greater volatility of the analyzed queries in Ukraine compared to the global dimension. In general, societal interest in public-private partnerships in the world had fairly stable trends with a peak value in April 2020 and a relatively insignificant increase – up to 41 points in May 2021. That is, we see that the peak of interest in the topic coincided with the beginning of the Covid-19 pandemic, which led to the need to find effective financing tools for the medical sector, in particular in the field of vaccine development. During the analyzed period, interest in this search query on average was low – 14 points. Speaking about the interest in the concept of digitalization in the world, we will determine its upward dynamics with a total increase from 19 points to 58 points for the analyzed period. That is, currently in the global dimension we see a medium level of interest in digitalization and a low level of interest in public-private partnerships. However, in this context, the geographical distribution of requests on these two topics is quite important (Figure 2).

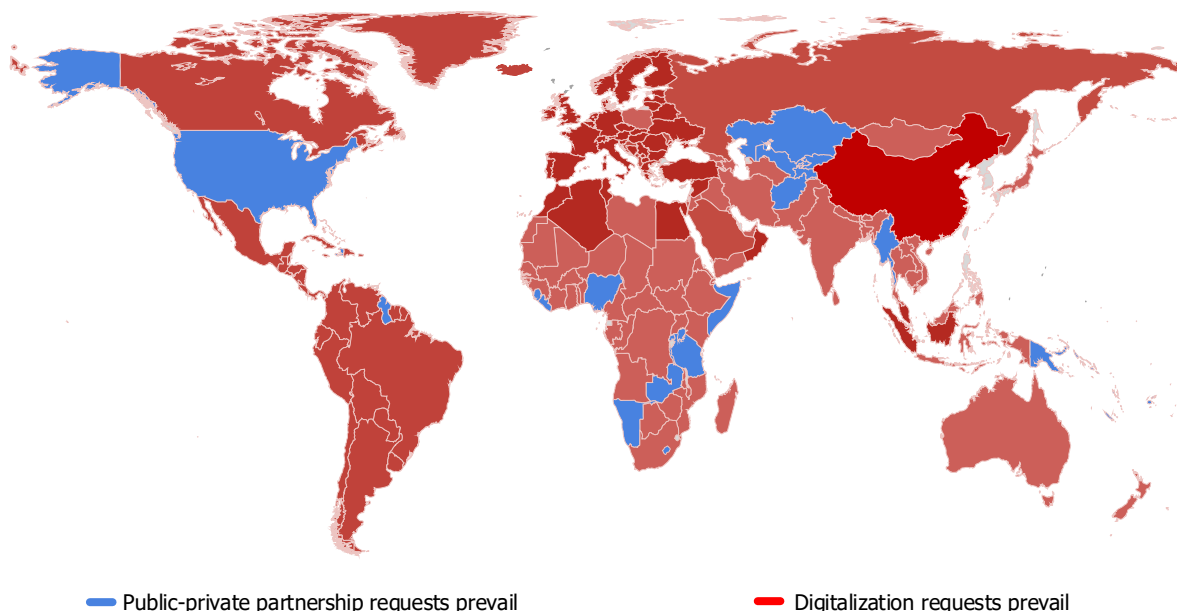


Figure 2. Comparison of the popularity of search queries "public-private partnership" and "digitalisation" in the world for 2016 – 2025, %. (Source: Created by the authors using Google Trends)

The data in Figure 2 generally confirm that most countries in the world are more interested in digitalization than in public-private partnerships. The latter is more popular in countries that currently need significant funding for development – Eritrea, Tanzania, Zambia, Uganda, Kazakhstan, Bangladesh, Kyrgyzstan, Uzbekistan, Kenya, etc. Also, comparing the popularity of the analyzed queries, public-private partnerships have an advantage in the United States – its share is 61 %.

This situation can generally be explained by the search for the most effective financing instruments in the country, which is also one of the world's largest donors. In other words, the issue of implementing public-private partnership is currently becoming more relevant in those countries that have certain economic difficulties and need not only new sources of financing, but first of all, an effective tool for managing investment projects in cooperation between the state and the private sector.

Returning to the dynamics of search queries in Ukraine, it is worth noting in general the similarity of trends with global ones – on average, interest in digitalization (19 points) is higher than interest in public-private partnerships (14 points). However, the overall dynamics are not so stable – in Figure 1, we can observe a sharp increase and fall in the level of interest in both requests, which, in particular, may reflect separate periods of discussion of these aspects in society and the media. In general, we see that the peak popularity of requests for public-private partnership was in December 2025, which emphasizes the relevance of this issue.

Thus, we see that the issues of digitalization and public-private partnership are currently becoming more and more relevant in society, although their level is still relatively low. Long-term economic instability, as well as the need for effective financing instruments in the war and post-war periods, generally increase the importance of studying this aspect. Generally, the analysis based on Google Trends demonstrates purely public interest in the topic, while not indicating the real development of public-private partnership and institutional readiness for its implementation. At the same time, increased public interest together with the advantages and opportunities of this investment instrument may be a prerequisite for intensifying its development. This conclusion can also be drawn from the bibliographic analysis of studies indexed by the Scopus database (Figure 3).

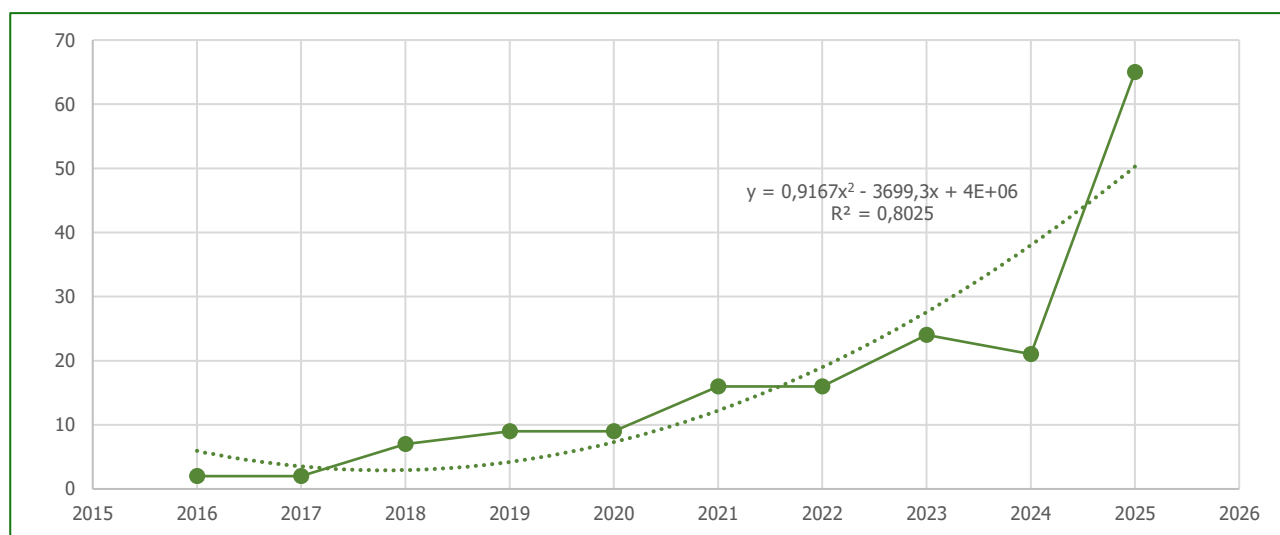


Figure 3. Dynamics of publications indexed in Scopus, whose titles, abstracts and keywords include the terms "public-private partnership" and "digitalization" for the period 2016 – 2025. (Source: built by the author on the basis of the Scopus database)

From the data in Figure 3, first of all, we can determine that the topic of digitalization of the public-private partnership system is relatively new – the first publication in this field in the Scopus database appeared only in 2015. At the same time, this area of scientific research is gradually becoming more and more relevant, as indicated by the upward trend in the number of published works – as of the end of 2025, there were 171 of them. The largest number of studies – 65 – was published during 2025. Also, only in the first quarter of 2026, 17 works have already been published, which means that the positive trend in studying the outlined topic continues. The described growth of scientific interest in recent years can be explained by the following:

1. The consequences of economic instability, the negative impact of the COVID-19 pandemic and subsequently military aggression against Ukraine, which contributed to the search for methods to increase the resilience of the management infrastructure and quickly recover from shocks.
2. The growing importance of the anti-corruption component of digital solutions in public-private partnerships (Charkina et al., 2026).
3. Transition of innovative digital technologies (AI, IoT, ML, Big Data) from the stage of experimental development to the stage of broad integration into infrastructure projects.

4. Development of the concept of Digital-Era Government, which provides for the joint creation of public value, where the state is the moderator of innovation processes, and business is a co-founder of management decisions (Azhazha et al., 2025).

Thus, the digitalization of public-private partnership has now turned from a narrow-tech issue into an interdisciplinary scientific problem that combines aspects of national security, innovative development, and a new theory of public administration. The main areas of research on the digitalization of public-private partnerships are shown in Figure 4.

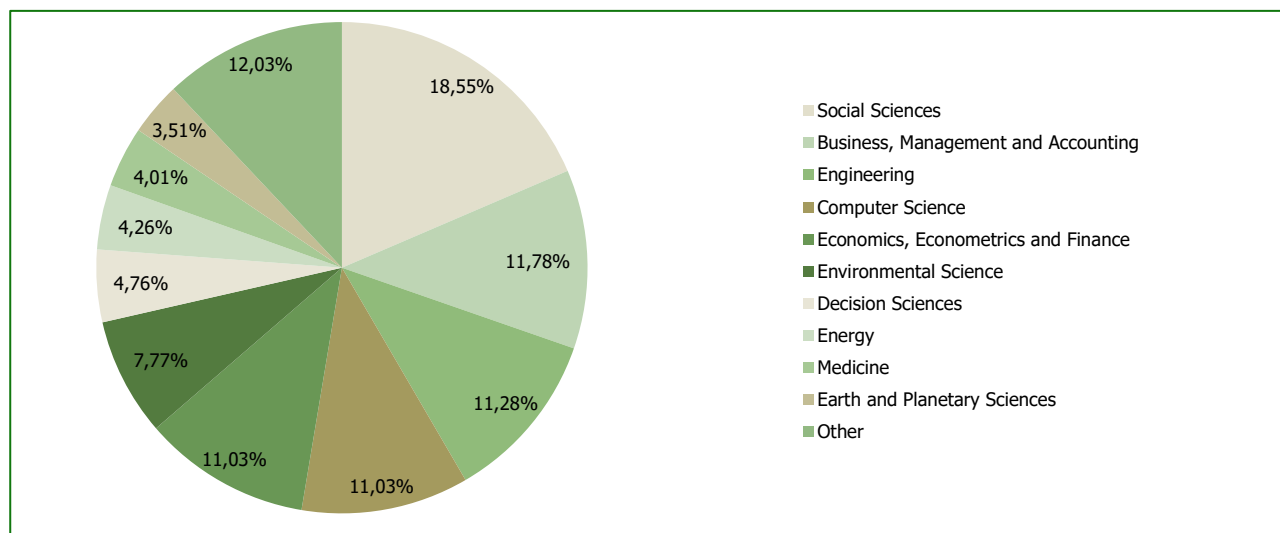


Figure 4. Disciplinary structure of publications indexed in Scopus during 2016 – 2025, whose titles, abstracts, and keywords include the terms "public-private partnership" and "digitalization." (Source: built by the author on the basis of the Scopus database)

Figure 4 shows the largest concentration of research on the digitalization of public-private partnerships in the field of social sciences – 74 publications or 18.55 % of the total number. This situation generally indicates a paradigm shift – digitalization is no longer seen as a technical introduction of digital tools into the system of public-private partnership, but rather as a complex process of transformation of the social contract and relations between citizens, the state and the private sector. In turn, a significant share of research topics in the fields of business, management and accounting (11.78 %), as well as economics, econometrics and finance (11.03 %), indicate the importance of pragmatic aspects of public-private partnership as a tool for financing significant projects. In contrast, a significant number of studies on this aspect in the field of computer science – 44 publications or 11.03 % of the total number – provide the technological basis of research: investigation of the possibilities of using Blockchain and Smart Contracts, the Internet of Things, Artificial Intelligence, etc., for effective project management.

Among other areas of private partnership research, it is worth noting environmental sciences (31 publications or 7.77 %) and energy (17 publications or 4.26 %). In this direction, a significant part of the work is devoted to the concept of Smart Sustainability and the "green" transition, in which digitalized partnerships between the state and business are a catalyst for the development of renewable energy and the circular economy. Also, the outlined topics are currently being actively studied in the context of engineering (11.28 %) – infrastructure solutions and the creation of smart cities; decision science (4.76 %) – development of tools for automation of decision-making during project implementation; medicine (4.01 %) – increasing access to services in conditions of resource shortage; etc. In other words, the digitalization of public-private partnerships is a modern interdisciplinary phenomenon, where a significant concentration of research in the field of social sciences indicates a shift in the focus of attention from the technical side of the issue to social significance.

Taking into account the significant role of public-private partnership for the development of the country, as well as its fundamental importance for its economic security, we consider it appropriate to also consider the geographical structure of publications on the outlined topics (Figure 5). Notably, the largest number of publications on the above-mentioned issue have been produced by researchers from the Russian Federation.

The second-largest share of publications on the digitalization of public-private partnerships in the Scopus database falls on Ukraine – 18. Most of the research is 11 works, published in 2025, and the very first indexed publication dates back to 2020. It should also be noted that the direction of public-private partnership research in Ukraine is quite different – from e-procurement and support for small and medium-sized businesses to medicine or education. In general, a wide range of studies and a significant increase in interest indicate the high relevance of the topic for the country. This is especially

reflected through the study of the possibilities of public-private partnership for post-war recovery, which is discussed in most publications.

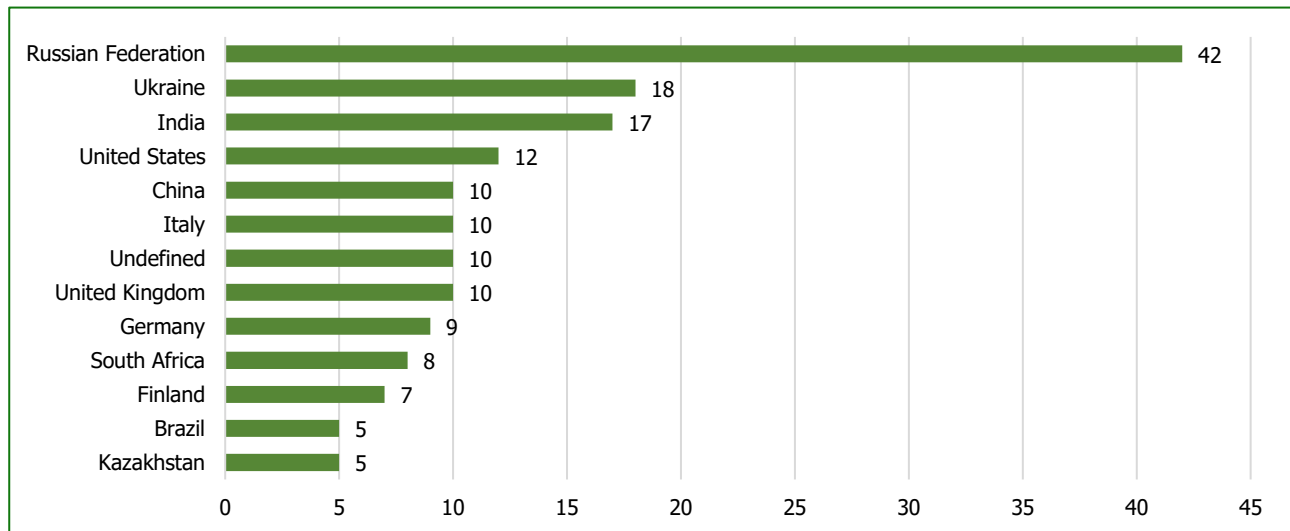


Figure 5. Geographical structure of publications indexed in Scopus during 2016 – 2025, whose titles, abstracts and keywords include the terms “public-private partnership” and “digitalization.” (Source: built by the author on the basis of the Scopus database)

Also, a significant share of research on the digitalization of public-private partnerships was published by Indian scientists – 17 papers since 2020. That is, we can conclude that there is a steady scientific interest in this topic in the country. Similar to Ukraine, the areas of research on the analyzed topics in India are quite wide: medicine, education, railway transport, energy, support for small and medium-sized businesses, etc. At the same time, scientists pay significant attention to the digitalization of public services, circular economy, sustainable development, and smart cities.

Similar trends in the study of digitalization of public-private partnership are typical for the following countries: the USA, Italy, the United Kingdom, Germany, etc. In general, we can conclude that the outlined topic is relevant not only for developing countries with a significant shortage of resources, but also for highly developed countries that need expertise and narrow specialists for the implementation of projects. Taking into account the complexity of the topics under study, we consider it appropriate to create maps of the relationships between the keywords of research on the digitalization of public-private partnerships (Figure 6).

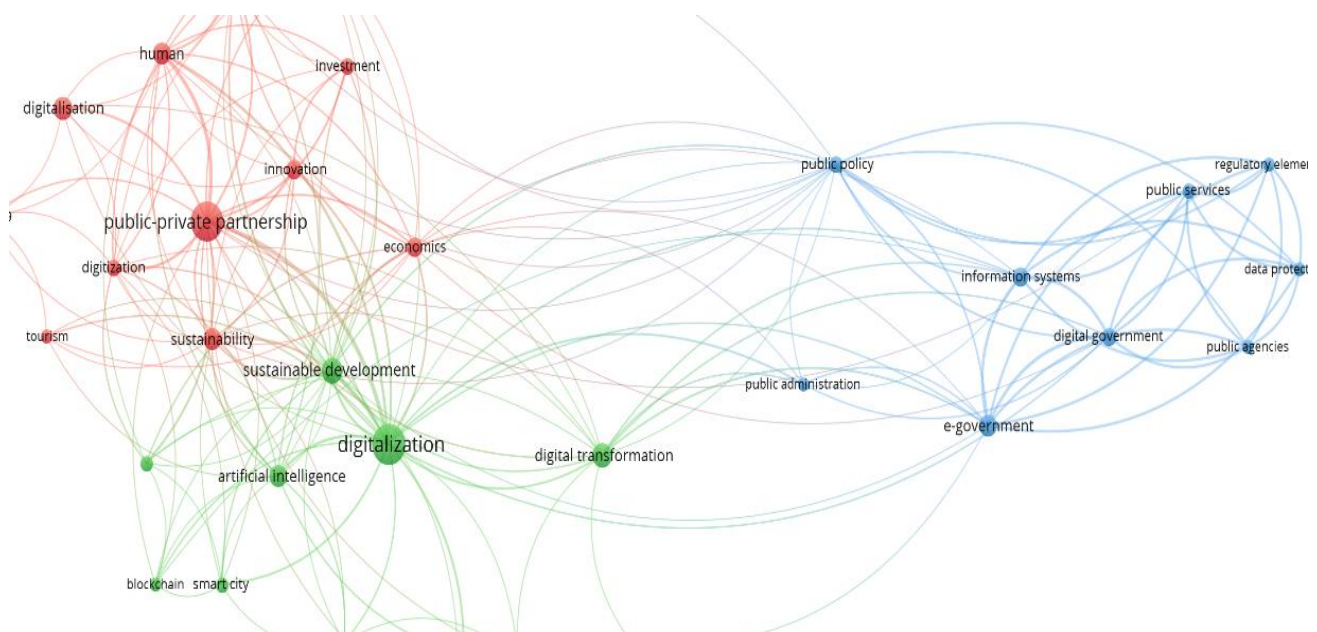


Figure 6. Clustering of scientific papers on the study of issues related to the digitalization of public-private partnerships. (Source: built by the author based on Scopus data using VOSviewer software)

Using VOSviewer software, we mapped the relationships between research keywords indexed by the Scopus database and selected by the query “public-private partnership AND digitalization.” For a more representative analysis, a restriction was set: the keyword must occur at least 5 times to be included in the final sample. Thus, among 1,353 keywords, only 40 have a threshold value. The next step was also to check the keywords for their relevance and, in particular, exclude duplications from the final sample. As a result, 32 terms were selected for further research, presented in Figure 6.

The central place on the created map of keywords belongs to the terms “public-private partnership” and “digitalization”, which emphasizes their fundamental nature in the topic under study. Also, such terms as “sustainable development” and “artificial intelligence”, which are closely related to both key terms, are of significant importance in this context. Quite often mentioned, but weakly related to the key categories for our study, are such terms as “e-government” and “public policy.” In general, the created map of relations proves the wide areas of study of public-private partnership in modern conditions. The selected keywords, in turn, can be formed into 3 clusters:

1. The first cluster (red) is dedicated to the fundamentals of public-private partnership as a tool for the implementation of investment projects, as well as the possibilities of its use both in the context of economic shocks (for example, the COVID-19 pandemic) and for innovative development and sustainability.
2. The second cluster (green) reflects the technological aspects of the analyzed topic, focusing on the use of modern technologies (Blockchain, Artificial Intelligence, Big Data, etc.) for the digital transformation of the economy and sustainable development.
3. The third cluster (blue) focuses more on issues related to the digitalization of public administration, the development of relevant regulatory acts, and the provision of services to society through technological tools, which are components of the e-government concept.

A detailed description of each cluster is given in Table 2.

Table 2. Characteristics of clusters of keywords of scientific research dedicated to the digitalization of public-private partnership.

№	Cluster Color	Cluster Name	The most frequently mentioned term	Number of keywords	Related Keywords
1.	Red	Fundamentals of public-private partnership	public-private partnership	12	public-private partnership, sustainability, COVID-19, economics, human, innovation, investment, public health
2.	Green	Technical aspects of digitalization	digitalization	11	digitalization, digital transformation, digital technologies, digital economy, big data, artificial intelligence, smart city
3.	Blue	Public administration	e-government	9	e-government, digital government, data protection laws, public administration, public policy, public services, regulatory elements

In addition to the direct connections between keywords and research clusters, it is also important to study the evolution of scientific approaches to the study of public-private partnerships and their digitalization. The chronological distribution of key terms is shown in Figure 7.

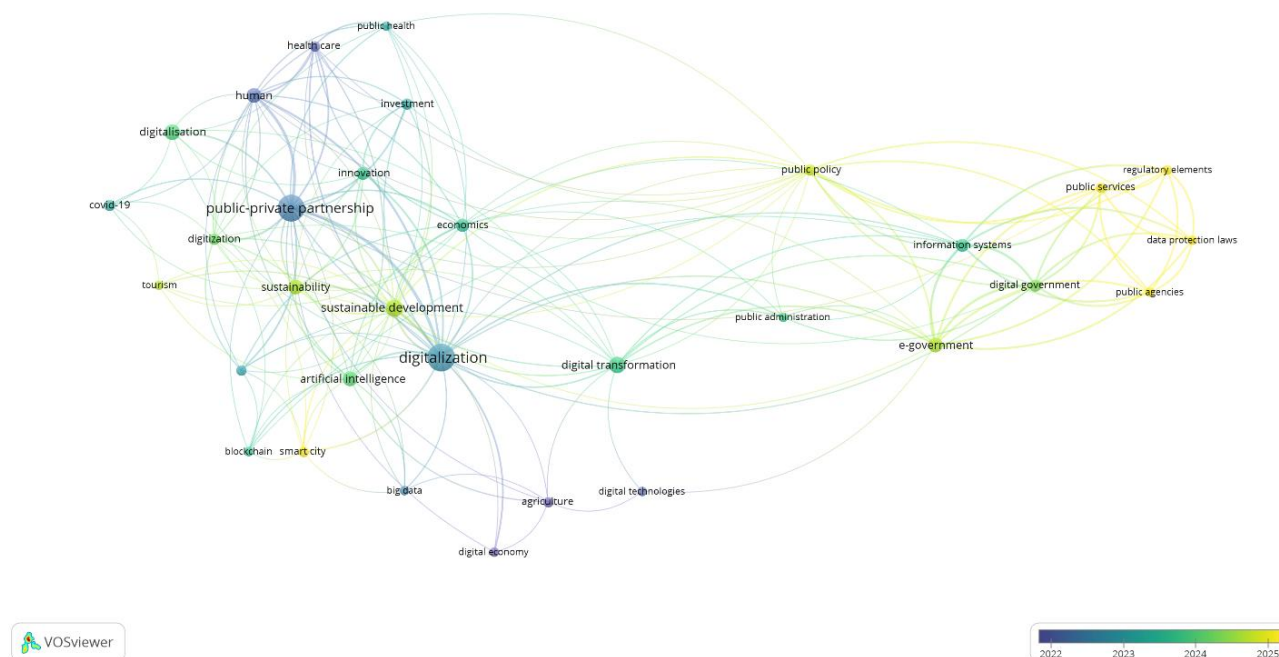


Figure 7. Chronological distribution of clusters of scientific papers on the study of issues related to the digitalization of public-private partnerships. (Source: built by the author based on Scopus data using VOSviewer software)

The data in Figure 7 primarily indicate a significant growth and transformation of the areas of research on the digitalization of public-private partnership in the period 2022–2025. Thus, at the beginning of this period, the topic was considered to a greater extent in the context of the implementation of public-private partnerships, in particular in the areas of healthcare, the agricultural sector, or building a digital economy. In other words, this is the initial stage where digital technologies were considered only as an auxiliary tool in cooperation between business and the state. The next stage can be called the intensification of the study of aspects of digitalization and the integration of modern technologies into the system of public-private partnership (turquoise knots). At the same time, the study of the possibilities of integrating Artificial Intelligence and Blockchain is one of the newest areas of study of the outlined topic, which is typical for 2024 – 2025. Also, the most pressing issues today include the use of public-private partnership to ensure sustainable development

The most modern and new direction of studying the digitalization of public-private partnership is the development of the concept of e-government and the creation of appropriate regulation of this aspect (yellow knots). In other words, the scientific focus has now shifted from the study of the advantages and possibilities of integrating innovative digital technologies to the identification and prevention of threats at the state level. This is confirmed in particular by terms such as “data protection laws” and “regulatory elements”, which are typical for publications at the end of 2025. In general, the concept of digital government in this context can be considered from two sides: as one of the goals of implementing cooperation projects between the state and private companies to attract expertise and technical resources, and as a key driver for the development of public-private partnerships for the implementation of socially significant projects. In general, we see that scientists currently have a fairly comprehensive approach to the study of public-private partnership and consider the integration of innovative digital technologies into its system not as a purely technical update, but as a radically new approach that contributes to sustainable development and economic security.

In general, the described evolution of scientific approaches to public-private partnership reflects a fundamental transformation of managerial logic from the traditional contract form, focused on the implementation of large-scale infrastructure facilities, to the creation of permanent digital infrastructure. Thus, the scientific discourse has changed the orientation from the institutional and functional approach to public-private partnership, where digitalization is considered only as a tool for automating internal processes, to the concept of GovTech. The latter, in turn, leads to radical changes in the role of the state – from a hierarchically supreme controller to a participant in an inclusive model working on the basis of the joint creation of public value and social solidarity.

The transition to digital ecosystems is also accompanied by a shift in focus from the purely technical side of this aspect to the formation of an “algorithmic trust” architecture, where digital data and automated ledgers replace bureaucratic confirmations. The central topics of modern research are predictive risk management based on AI and Big Data, the use of

blockchain and smart contracts to guarantee the immutability of data, as well as the introduction of IoT technologies for constant monitoring of physical objects. At that time, the peripheral areas of study of public-private partnership also remain the possibilities of its use for the implementation of single-directional, large-scale investment projects, including infrastructure projects or aimed at economic recovery.

The described transformation processes are of particular importance in the context of the economic security of the state, because the digitalization of public-private partnership radically changes the institutional architecture of interaction through the mechanism of algorithmic trust and platform management processes. Thus, the integration of innovative digital tools, including the DREAM ecosystem and OCDS standards, guarantees end-to-end transparency of the digital route of investment projects from the initiation stage to the moment of commissioning/completion of work (Venger et al., 2025). In turn, this minimizes information asymmetry, reduces transaction costs, and neutralizes corruption risks through continuous monitoring and automated detection of anomalies in estimates. In our opinion, such a digital infrastructure of public-private partnership is a critical prerequisite for capital mobilization for the recovery of Ukraine in the post-war period, including data openness and electronic accountability forming a base of trust for international donors and financial organizations.

In addition, the digitalization of public-private partnerships has a positive impact on increasing the resilience of partnership objects, especially if it is a project for the construction or rehabilitation of critical infrastructure facilities (Zakharkin et al., 2026). Thus, the use of the Internet of Things (IoT), Artificial Intelligence, and Big Data allows remote monitoring of objects in real time, forming a real evidence base for the implementation of KPIs and implementing strategies for predictive management of fiscal risks. The transition from traditional contracts to Digital Public-Private Partnership (DPPP) models, as well as the establishment of a common logic of shared value in general, transforms one-time infrastructure facilities into digital ecosystems that are able to adapt, operate efficiently, and scale even in conditions of instability and external shocks. Thus, the digitalization of public-private partnership acts as a systemic driver of the state's economic security, which increases the transparency of projects, reduces the risks of corruption, and contributes to the attraction of additional investment capital through a positive impact on investor confidence, sustainability of the recovery process, and effective project management.

DISCUSSION

The traditional approach to partnerships, which prevailed in scientific research until 2020, considered public-private partnerships as a financial instrument for the construction of physical infrastructure. At the same time, the study revealed a gradual shift in emphasis to the 4P model "Public-Private-People Partnership", where society itself plays a significant role. At the same time, we cannot fully agree with the approach of Liashenko and Petrova (2025), who emphasize social solidarity through crowdfunding tools. In particular, the mapping of the scientific landscape proves that this process is not purely social; an important role belongs primarily to the institutional segment. Modern scientific discourse is increasingly gravitating towards the concept of GovTech partnerships, where the state is turning from a controller into a key architect of public-private partnership ecosystems. In contrast to the approach of Azhazha et al. (2025), who consider GovTech as a service model, our study shows the promise of GovTech as a foundation of algorithmic trust, where digital data replaces bureaucratic procedures.

An important aspect of the study is also the role of innovative digital technologies in public-private partnership and the prospects of the DPP model "Digital Public-Private Partnership." Thus, the work of Zakharkin et al., 2026 offers a map of the risks of integrating digital technologies into the PPP system, focusing on the technological side of this aspect. At the same time, our research indicates that a significant part of scientific publications belongs to the social sciences, and therefore we can put forward the thesis that the digitalization of public-private partnership is not purely the integration of modern technologies (AI, Big Data, Internet of Things, crowdfunding, etc.) into its system, as Venger and Kushnirenko, 2025 believe, but primarily a tool for transforming the social contract.

In general, the scientific novelty of our study lies in the systematic bibliometric justification of digitalization as a strategic imperative for the evolution of public-private partnership. Thus, we proved that starting from 2024, the dominant issues of scientific research in the context of a given topic are "data protection laws" and "regulatory elements", which, in particular, shifts the focus from the technical advantages of integrating innovative and digital technologies into public-private partnerships to the issue of legal resilience of such partnerships in a dynamic macro environment. In general, this allows us to consider the digitalization of public-private partnerships not as an additional option, but as a strategic tool for the survival of the national economy in the context of hostilities and post-war recovery.

Despite the described novelty of the study, the results obtained have certain limitations. Thus, bibliometric analysis revealed a significant concentration of scientific publications in countries with a high level of military or/and economic risks (Ukraine and India). Such division can distort the global picture, because in highly developed countries, in particular among EU members, the focus shifts more to the sustainable approach, rather than the digitalization of public-private partnerships as a tool for ensuring economic security. In addition, in the course of the study, the Scopus database was used as the main source of bibliographic data, which limits the sample to works with a high citation index. Under this condition, certain local developments and niche research, which are less integrated into the global system, are potentially left out of attention.

Summing up, we can state that the integration of innovative and digital technologies into the system of public-private partnership is becoming a strategic driver of Ukraine's economic security and its post-war recovery. It is the synergy of smart technologies and institutional transparency, as well as the active participation of society, that contributes to the creation of a new adaptive management model capable of withstanding global and unpredictable shocks.

CONCLUSIONS

Thus, in the context of global instability, the digitalization of public-private partnership appears not just as a technological update, but as a strategic tool for ensuring the economic security of the state. The integration of digital systems and modern technologies (AI, Machine Learning, IoT, Blockchain, etc.) provides the necessary level of accountability, transparency, and institutional sustainability of investment projects, which, in particular, is critical in the context of budget deficits and wartime risks. In general, the results of the study allow us to draw the following conclusions.

The theoretical and methodological analysis demonstrated the transformation of the concept of partnership from "state-private" to "public-private", which provides for a much wider range of stakeholders. Modern scientific approaches are generally guided by the concepts of "Digital Public-Private Partnership (DPPP)" and "Public-Private-People Partnership (4P)", where digital systems become a basis for building trust between participants and creating public value.

Based on the analysis of the dynamics of societal interest using the Google Trends toolkit, the correlation of the growth of public interest in public-private partnerships with periods of global shocks and instability (for example, the COVID-19 pandemic) has been established. It has been proven that in the global dimension, the level of interest in digitalization is much higher than in public-private partnerships. At the same time, for countries that need significant resources for development (for example, Ukraine, India, the USA), the topic of public-private partnership remains in the focus of public attention.

Bibliometric analysis based on the Scopus database confirmed the rapid growth of scientific interest in the digitalization of public-private partnerships since 2015, with a peak value in 2025. An interdisciplinary paradigm of studying the analyzed issue with a significant predominance of social sciences (18.55 %) has been revealed, which indicates an active study of public-private partnership as a driver of social resistance in the face of external shocks. The geographical distribution also identified Ukraine as one of the world leaders in the number of publications on the digitalization of public-private partnerships, which is explained by the critical need of the state to develop innovative models of post-war recovery on the basis of transparency and security.

The clustering of the scientific landscape carried out with the help of VOSviewer made it possible to identify three areas of research on the topic: the fundamental basis of public-private partnerships, technological aspects of digitalization of public-private partnerships, and public governance and regulation of public-private partnerships. The chronological evolution of the key terms demonstrated the shift of the scientific focus from considering digital technologies as an auxiliary monitoring tool to a system-forming factor and direction of fundamental transformation of public-private partnership.

Summarizing the results of the study, the formation of digital ecosystems of public-private partnership is a promising driver of economic security of the state in the war and post-war periods. Considering all the above, promising areas of research in the field may include the development of a comprehensive methodological framework for the quantitative assessment of the level of digital maturity and the innovative contribution of projects, as indicators of their resilience to external shocks in the current conditions.

Furthermore, in this context, it is important to continue exploring the potential for creating prognostic models based on Artificial Intelligence, Machine Learning and Big Data analytics, which would enable predictive risk management – a critical factor for ensuring the country's economic security in conditions of uncertainty. Looking specifically at the Ukrainian case, it is also relevant to examine the development and role of crowdfunding as a key element of the "4P" model, which is actively developing in the current conditions and has great potential for post-war recovery.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ЦИФРОВІЗАЦІЯ ПУБЛІЧНО-ПРИВАТНОГО ПАРТНЕРСТВА ЯК СТРАТЕГІЧНИЙ ІМПЕРАТИВ ЗАБЕЗПЕЧЕННЯ ЕКОНОМІЧНОЇ БЕЗПЕКИ ДЕРЖАВИ: БІБЛІОМЕТРИЧНИЙ АНАЛІЗ ТА ЕВОЛЮЦІЯ НАУКОВИХ ПІДХОДІВ

Стаття присвячена актуальним питанням цифровізації публічно-приватного партнерства як стратегічного інструмента забезпечення економічної безпеки держави в умовах глобальної нестабільності й воєнних ризиків. Актуальність дослідження зумовлена об'єктивною потребою залучення приватного капіталу для масштабного повоєнного економічного відновлення в умовах критичного дефіциту бюджетних ресурсів. У свою чергу, отримання достатнього рівня

приватних інвестицій можливе лише за рахунок дотримання принципів прозорості, підзвітності й алгоритмічної довіри, що стає можливим за рахунок використання цифрових екосистем і сучасних технологічних рішень. Мета дослідження полягає в комплексному науковому обґрунтуванні ролі цифровізації публічно-приватного партнерства як стратегічного імперативу зміцнення економічної безпеки держави. У ході дослідження здійснено теоретико-методологічний аналіз трансформації концепції партнерства від централізованих структур до сучасних мережевих моделей «Digital PPP» та «4P». За допомогою інструментарію Google Trends проведено компаративну оцінку динаміки та географічного розподілу суспільного інтересу до питань публічно-приватного партнерства та цифровізації. На основі інформації бази даних Scopus здійснено поглиблений бібліометричний аналіз публікаційної активності, галузевої структури та географії досліджень, присвячених цифровізації публічно-приватного партнерства в контексті забезпечення економічної безпеки держави.

Кластеризація наукового ландшафту з використанням програмного забезпечення VOSviewer виявила три найбільш поширені напрями вивчення тематики: фундаментальні основи публічно-приватного партнерства, технологічні аспекти цифровізації та публічне управління й роль держави. Особливу увагу в ході дослідження приділено хронологічному аналізу еволюції наукових підходів до дослідження ролі цифровізації в публічно-приватному партнерстві. У статті також окреслено перспективні аспекти цифровізації системи публічно-приватного партнерства для забезпечення економічної безпеки та повоєнного відновлення держави.

Ключові слова: публічно-приватне партнерство, цифровізація, інноваційно-цифрові технології, цифрове публічно-приватне партнерство, економічна безпека держави, повоєнне відновлення, бібліометричний аналіз, еволюція публічно-приватного партнерства

JEL Класифікація: H54, O33, G31, M21