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**Oleksandr Sychov**

PhD Student, Interregional Academy of Personnel Management, Kyiv, Ukraine;  
 e-mail: [sychov09061996@gmail.com](mailto:sychov09061996@gmail.com)  
 ORCID: [0009-0005-7696-955X](https://orcid.org/0009-0005-7696-955X)  
 (Corresponding author)

**Artem Fesun**

Candidate of Economic Sciences,  
 Department of Management in  
 Construction, Kyiv National University  
 of Construction and Architecture, Kyiv,  
 Ukraine;  
 ORCID: [0009-0002-1433-3087](https://orcid.org/0009-0002-1433-3087)

**Galya Ryzhakova**

D.Sc. in Economics, Professor of the  
 Department of Management in  
 Construction, Kyiv National University  
 of Construction and Architecture, Kyiv,  
 Ukraine;  
 ORCID: [0000-0002-7875-9768](https://orcid.org/0000-0002-7875-9768)

**Yurii Chupryna**

D.Sc. in Economics, Professor of the  
 Department of Management in  
 Construction, Kyiv National University  
 of Construction and Architecture, Kyiv,  
 Ukraine;  
 ORCID: [0000-0002-4934-2058](https://orcid.org/0000-0002-4934-2058)

**Svitlana Rubtsova**

PhD in Pedagogical Sciences, Associate  
 Professor of the Department of  
 Language Training and  
 Communication, Kyiv National  
 University of Construction and  
 Architecture, Kyiv, Ukraine;  
 ORCID: [0000-0003-4114-5874](https://orcid.org/0000-0003-4114-5874)

**Natalia Dubyna**

Department of Language Training and  
 Communication, Kyiv National  
 University of Construction and  
 Architecture, Kyiv, Ukraine;  
 ORCID: [0009-0006-3312-0270](https://orcid.org/0009-0006-3312-0270)

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# INVESTMENT SUPPORT FOR DIGITAL CONSTRUCTION IN THE CONTEXT OF POST-WAR RECONSTRUCTION IN UKRAINE

## ABSTRACT

The article thoroughly examines the main problems that hinder the widespread introduction of digital technologies in the construction industry of Ukraine in the context of post-war reconstruction. The authors analyze in detail a set of obstacles, divided into three interrelated groups: financial, human resources, and regulatory. Attention is focused on the high cost of implementing digital solutions, which includes not only the purchase of modern equipment and software but also the costs of their maintenance, updating, and staff training. This creates particular difficulties for small and medium-sized businesses, which often do not have access to cheap financial resources or state support. The authors discuss and justify the acute shortage of qualified specialists capable of working with BIM, IoT, and digital analytics technologies, which is associated with the insufficient development of educational programs and a lack of practical experience in the construction industry. Particular attention is paid to regulatory barriers, which include the absence of uniform state standards, regulations, and clear rules on the legal status of digital project documentation, BIM models, electronic object passports, and digital signatures. This creates significant legal uncertainty and hinders the official introduction of digital technologies in construction. The authors propose a set of measures to overcome the identified obstacles, including the development of national standards for digital construction, the creation of state pilot projects, and tax and financial incentives for innovators. The creation of grant programs, subsidies, and state investment funds is proposed, and the importance of international partnerships and the use of foreign experience is noted, which will contribute to the introduction of best practices in the domestic construction industry. The results obtained are of strategic importance for the effective digitalization of construction, which is a key factor in accelerating the recovery and sustainable development of Ukraine's economy in the post-war period.

**Keywords:** digital construction, investment, financial support, digital transformation, construction industry, construction startups

**JEL Classification:** L74

## INTRODUCTION

In the post-war period, Ukraine faces a massive task – the comprehensive reconstruction of critical infrastructure, housing stock, industrial facilities, and socially important institutions. The implementation of such processes requires significant financial resources, effective strategic planning, and transparent management of investment activities. The ability of the state and business to attract, distribute, and use investments determines not only the speed of physical reconstruction but also the formation of long-term prerequisites for economic growth, social stability, and Ukraine's integration into global markets.

In this context, digital construction is not just a technological innovation, but an important tool for improving investment efficiency. Digital platforms that provide detailed modeling, monitoring, and control over project implementation open up new opportunities for investors, both public and private. The combination of transparency, data reliability, and the ability to respond quickly to changing external conditions creates the

conditions for a stable investment climate, reduced risks, and increased attractiveness of infrastructure projects.

Digital construction is particularly important in terms of mobilizing international financial resources. Grant and loan financing from international organizations, as well as the participation of foreign institutional investors, require transparent project management mechanisms that meet international standards. It is digital technologies in construction that make it possible to ensure such compliance, increase control over the use of funds, improve communication between all participants in the investment process, and significantly reduce inefficient costs.

Thus, digital construction in the investment management system in the context of post-war reconstruction of the country is not only a technical solution, but also a strategic vector for the formation of a new architecture of investment management.

## LITERATURE REVIEW

The issue of investing in the construction sector remains one of the key topics in the research of Ukrainian economists and public policy experts, as this sector is an indicator of the country's overall investment climate and determines the pace of economic growth in the medium term. Among the scholars who have made a significant contribution to the study of theoretical and applied aspects of attracting investment in construction, it is worth highlighting Vozniak, H. (Vozniak, 2019), who argues for the need to develop effective economic mechanisms to stimulate investment activity in the construction industry through in-depth institutional reforms. His approach is distinguished by a holistic view of the relationship between the financial stability of the state, the predictability of fiscal policy, and long-term incentives for investors. In particular, the researcher emphasizes that transparent "rules of the game" in the market, a stable tax environment, and a policy of minimizing administrative barriers should serve as the basis for building investor confidence in the construction sector.

In turn, Shevchuk, T. (Shevchuk, 2009) focuses on the institutional determinants of investment efficiency in construction, emphasizing the critical importance of modernizing the licensing system and deregulating the industry. She rightly notes that excessive administrative burdens, protracted procedures for approving urban planning documentation, and duplication of functions among regulatory bodies create artificial risks for investors, reducing the market's attractiveness for strategic and portfolio investments. These conclusions are particularly important in the context of post-war reconstruction, when the speed and efficiency of project implementation are crucial.

Yurkevych, O. (Yurkevych, 2017) also made a relevant contribution to the study, focusing on the issue of attracting private capital to infrastructure construction through public-private partnership instruments. The author emphasizes that ensuring legal certainty in risk allocation, clearly regulating the responsibilities of the parties, and creating conditions for return on investment are basic prerequisites for the formation of effective models of cooperation between the state and business. Particular attention should be paid to his emphasis on the introduction of digital project management tools, which can significantly increase the transparency, manageability, and attractiveness of such partnerships.

A detailed study of the financial aspects of investing in construction was carried out by Bohdanenko, A. (Bohdanenko, 2019), who, in his works, reveals the importance of modern financial instruments — infrastructure bonds, mutual funds, specialized investment platforms — for mobilizing capital in the industry. His analysis of risk management models in investment projects, covering not only financial but also legal, reputational, and institutional risks, is particularly valuable. His approaches deserve practical implementation, especially in an unstable institutional environment where financial engineering can compensate for some regulatory weaknesses.

A comprehensive approach to studying the legal and organizational aspects of investing in construction is presented in the works of Ohorodnyk, V. et al. (Ohorodnyk, 2023). The researchers emphasize that without harmonizing national legislation with European standards, reducing excessive administrative pressure, and introducing clear procedures for interaction between investors and local authorities, it is impossible to create a favorable environment for capital investment. Their emphasis on the importance of "administrative openness" of municipalities as a prerequisite for the implementation of investment construction projects is particularly relevant in regions where local authorities often determine the fate of a project at the approval stage.

Thus, the results of scientific research by domestic authors form the conceptual basis for further rethinking approaches to investment management in the construction industry. Their work allows us to identify key systemic nodes where reformers' efforts should be focused, in particular: institutional capacity, regulatory stability, tax incentives, modernization of licensing

procedures, and the introduction of digital monitoring and management mechanisms. Together, this creates a methodological basis for building a modern model of investment in construction in the context of the country's reconstruction and integration into the European economic space.

In addition, all of the above-mentioned scholars emphasize that investment activity in construction is closely linked to the political and economic situation in the country. Instability, bureaucratic obstacles, legal uncertainty, and, in recent years, armed aggression against Ukraine have significantly reduced the investment attractiveness of the industry. Therefore, the key tasks at the present stage remain deregulation, institutional strengthening, legal protection of investors, and the formation of a long-term state strategy for the development of construction as one of the priority areas of the economy.

Dykha, M. (Dykha, 2011) has researched a wide range of issues related to investment activity in her publications over the years. She paid particular attention to the organization and improvement of this process, which remains relevant today. Her work examines ways to improve the investment climate and activate investment processes aimed at attracting foreign investment into the Ukrainian economy.

Despite the country's potential, the volume of foreign direct investment during the period of independence remained low due to an unfavorable investment and business climate. This climate was characterized by macroeconomic and political-legal instability, as well as difficult conditions for doing business in Ukraine. Today, the risks associated with the war situation also complicate the situation.

Publication Dykha, M. et al. (Dykha, 2022) analyzes the current state and problems of attracting foreign direct investment into the Ukrainian economy and also identifies the prospects for attracting investment in the post-war period. Khaled M. Aboalganam and Amro Alzghoul (2025) determine how digital marketing practices affect an organization's reputation through quality of service.

Despite the growing interest of the scientific community in investment issues, research into effective mechanisms for attracting investment in the construction sector, particularly with regard to the introduction of digital technologies, remains extremely relevant. This issue is particularly important in the context of the current challenges associated with the large-scale restoration of Ukraine's infrastructure after the armed aggression. Digital construction, as an innovative approach to the organization of the construction process, opens up new opportunities for transforming the investment environment, ensuring transparency, speed, and increased confidence in construction projects.

A comprehensive analysis of existing mechanisms for investing in construction, taking into account digital tools (in particular, BIM technologies, project management platforms, and digital models of objects), reveals a number of shortcomings that investors encounter in the process of implementing capital investments. These include the fragmentation of the regulatory framework, the lack of uniform digital standards in construction, and the low level of digital maturity of individual participants in the investment and construction process. Overcoming these challenges requires systematic improvement of the legislative environment, methodological approaches to the digital transformation of the industry, and intensified cooperation between the state, business, and scientific institutions.

In the current environment, a high level of investment activity in the field of digital construction is seen as one of the key prerequisites for the recovery of Ukraine's economy. Ensuring adequate investment resources and their effective allocation to priority areas of development — infrastructure projects, housing construction, critical infrastructure facilities — makes it possible not only to restore lost capacity, but also to reorient the construction industry toward an innovative, technologically progressive path of development.

In contemporary academic and professional literature, the term Digital Construction has acquired a multifaceted meaning, reflecting profound transformational processes within the construction industry. On a global scale, this term does not merely signify the use of digital tools for isolated operations; rather, it encompasses the integration of all stages of the building life cycle into a unified digital environment. According to the definition provided by the European Construction Sector Observatory (2022), digital construction represents a strategic transition from traditional methods to technologies based on artificial intelligence, automation, the Internet of Things (IoT), big data analytics, and cloud services, with Building Information Modeling (BIM) serving as a core component.

In the global context, Digital Construction involves not just the automation of discrete processes but also the creation of so-called Digital Twins — virtual replicas of physical assets that enable real-time modeling, testing, and optimization of both construction and operational phases. This fundamentally changes approaches to project planning, financing, risk management, and infrastructure maintenance.

In the Ukrainian reality, the concept of digital construction is still in its formative stage. It is often equated with the implementation of BIM or the automation of document workflows, which are merely isolated elements of a much broader

process. However, given Ukraine's integration into global markets, it is critically important to define this concept in alignment with international standards. This will help avoid conceptual gaps and ensure the competitiveness of the national construction sector.

Within the framework of this research, Digital Construction is understood as a comprehensive system for organizing construction processes, which includes:

- the integration of digital technologies at all stages of the asset life cycle (from design to operation);
- the use of platform-based solutions for resource, financial, and logistics management;
- the application of big data analytics and predictive financial modeling;
- the automation of financial and production processes through smart contracts and blockchain technologies;
- ensuring transparency and openness for all market participants.

This extended interpretation allows financial innovations to be viewed not as auxiliary instruments but as a fundamental component of the architecture of digital construction, providing its practical implementation.

In global academic discourse, the issue of financing the digitalization of the construction sector is actively explored from multiple perspectives, ranging from risk management to the formation of new financial ecosystems. For instance, works by respected scholar Loosemore, M. (2020) emphasize the necessity of developing adaptive financial strategies for construction companies in the context of digital transformation. Loosemore points out that, in modern conditions, investing in construction can no longer rely solely on traditional banking products, since the risks associated with implementing innovative technologies significantly differ from the conventional risks of construction activities.

Researchers at McKinsey Global Institute, in their report "Reinventing Construction: A Route to Higher Productivity" (MGI, 2017), note that the construction sector remains one of the least digitized branches of the global economy. At the same time, they highlight that combining cutting-edge technologies with financial innovations could boost construction productivity by 50–60%. This requires not only the adoption of technologies but also the development of new financing models, including venture platforms and crowd-investing mechanisms.

Similarly, Deloitte Insights, in their report "The Future of Construction: Technology and Financial Innovations" (Deloitte, 2021), stresses that effective digitalization is feasible only when there is access to flexible financial instruments. Among these, smart contracts, blockchain solutions for construction budget management, and token-based financing of infrastructure projects play a crucial role.

Investments in digital construction create a new quality of production potential based on a modern scientific and technical platform. The introduction of information modeling of buildings, data management at all stages of an object's life cycle, and digital solutions in the field of cost, time, and risk control can significantly increase the competitiveness of the Ukrainian economy. On a global scale, this will contribute to Ukraine's integration into global value chains and strengthen its position in the international capital and innovation market.

## AIMS AND OBJECTIVES

The purpose of this article is to conduct a comprehensive study of investment support for digital construction in the context of Ukraine's post-war reconstruction, taking into account the latest approaches to construction project management.

In line with this purpose, the article aims to analyze the current state of investment activity in construction, explain the concept and advantages of digital construction, compare traditional and digital approaches to managing investments in the construction industry, explore opportunities for investing in digital construction projects, and develop practical measures to overcome obstacles to the implementation of digital solutions in construction in the context of the country's reconstruction.

## METHODS

A number of complementary methods were used in the research process, which ensured a comprehensive approach to the subject. In particular, statistical methods were used for a thorough analysis of investment dynamics in the construction industry of Ukraine, assessment of capital investment volumes, structure of financing sources, and the level of digital technology implementation. Analytical methods made it possible to generalize scientific approaches to defining the essence of digital construction, its role in the transformation of investment processes, and identifying key factors influencing the

effectiveness of investment management. The use of comparative analysis made it possible to compare traditional and digital mechanisms for implementing construction projects across a range of indicators, including speed and planning accuracy. A systematic approach was used to consider digital construction as an integral element of modern investment infrastructure operating in conditions of high technological dynamics. At the same time, inductive and deductive approaches made it possible to build a logical sequence from empirical observations to the formulation of theoretical conclusions and the justification of practical recommendations relevant to the conditions of Ukraine's post-war recovery.

## RESULTS

In the context of the large-scale destruction of infrastructure, housing stock, and social facilities caused by the Russian Federation's armed aggression against Ukraine, investment support for construction is becoming strategically important for national economic recovery. In the post-war period, the construction industry is seen not only as an indicator of economic stabilization, but also as a key driver of structural transformation of the national economy. Accordingly, there is a need for an in-depth analysis of the volume, sources, and dynamics of investment in the construction sector.

According to the State Statistics Service of Ukraine, over the past five years (2019–2023), there has been significant volatility in capital investment in construction. While before the full-scale invasion in 2022, the share of construction in total capital investment fluctuated between 15% and 18%, in 2022, it fell to a critical 8.9% due to the destruction of logistics chains, labor shortages, the curtailment of business activity, and the suspension of infrastructure projects. However, in 2023, thanks to the intensification of international aid programs, the launch of state initiatives to reconstruct critical facilities, and the mobilization of internal resources, the volume of investment in construction began to grow gradually. According to preliminary estimates, the growth rate of capital investments in construction in 2023 was about 12.5% compared to 2022.

The structure of investments deserves special attention. In the post-war period, investments in infrastructure construction (restoration of roads, bridges, railway networks, energy and water supply facilities) dominate. The share of public funding in this category has increased to 52%, while the share of private investors remains relatively low due to high risks and instability of the institutional environment. However, there is a positive trend in the participation of international financial organizations, in particular the World Bank, the European Bank for Reconstruction and Development, and the European Investment Bank, which are expanding financial instruments for the reconstruction of Ukraine.

In the housing sector, investment activity is concentrated mainly in regions far from the combat zone, particularly in Lviv, Ivano-Frankivsk, Zakarpattia, and Vinnytsia regions, where there is increased demand for housing from internally displaced persons. Despite the potential, restrictions on access to financing, increased lending risks, and the lack of adequate insurance hinder the more active involvement of private capital in this segment.

Thus, the current state of investment in construction in Ukraine in the context of post-war reconstruction is characterized by a combination of high demand for financial resources and limited opportunities for domestic capital accumulation. The main task for the near future should be to create a favorable investment environment that includes investor protection guarantees, effective public-private partnership mechanisms, transparency of reconstruction procedures, and the development of an integrated system for prioritizing investment projects in accordance with national and regional needs.

For a more detailed understanding of the structure of sources of financing for construction projects in Ukraine in the period 2019–2023, the distribution of the main forms of investment by year is presented in Table 1. An analysis of these dynamics reveals key trends, including the strengthening role of public financing in the context of post-war reconstruction, fluctuations in private investor participation, and the stable presence of foreign capital. Particular attention should be paid to the still limited but gradually growing role of mixed (public-private) forms of financing, which have the potential to become an effective mechanism for attracting additional resources and reducing investment risks in the construction industry.

The analysis of the structure of construction project financing in Ukraine over the period 2014–2023 reveals a gradual yet significant transformation of the sector's financial landscape. These changes have become particularly pronounced in the years 2019–2023, when the dynamics of investment flows were profoundly influenced by military conflicts, economic turbulence, and a structural reconfiguration of the market.

**Table 1. Structure of sources of financing for construction projects in Ukraine, % of total volume (2019–2023).** (Source: Guryanova, L. et al., 2024); Lelyk, et al., 2022); Vozniak, 2019); State Statistics Service of Ukraine)

Year	Public Funding (%)	Private Investments (%)	Foreign Investments (%)	Public-Private Partnerships (%)
2014	38.5	42.0	15.0	4.5
2015	39.0	41.2	15.5	4.3
2016	39.8	40.1	16.0	4.1
2017	40.5	38.5	16.8	4.2
2018	41.7	36.0	17.5	4.8
2019	43.2	34.7	18.5	3.6
2020	45.1	33.0	19.4	2.5
2021	48.3	30.1	19.8	1.8
2022	56.7	22.5	18.6	2.2
2023	52.4	25.8	20.1	1.7

One of the most striking trends is the sharp increase in the share of public funding in 2022, which reached 56.7%. This reflects not only the state's prioritization of coordinating the reconstruction of critical infrastructure but also its broader role in stabilizing the construction sector under emergency conditions. This surge is a direct consequence of force majeure circumstances and a manifestation of the state's intensified policy of strategic intervention in key sectors.

At the same time, the share of private investments has declined from 34.7% in 2019 to 22.5% in 2022. This trend is driven not so much by a lack of financial resources in the private sector as by heightened uncertainty and a rise in investment risks. For many companies, the potential losses associated with an unstable environment have outweighed the prospects for profit, resulting in a cautious approach to new construction investments.

It is noteworthy that the volume of foreign investments has remained relatively stable, fluctuating between 18% and 20% throughout the analyzed period. This indicates that international partners maintain a sustained interest in the Ukrainian construction market, even amid crisis conditions. For many global investors, financial involvement in the sector is perceived not merely as a commercial venture but as a contribution to Ukraine's reconstruction and its future economic resilience.

As for public-private partnership (PPP) models, their share has remained modest, ranging from 1.7% to 4.5% over the analyzed decade. However, it is essential to emphasize that PPP mechanisms possess the highest potential for development in the coming years. The combination of state and private sector resources provides a viable path to mitigate investment risks and enables the realization of large-scale infrastructure projects. In a post-conflict economy, such projects are often difficult to implement, relying solely on a single source of financing.

For a comprehensive analysis of investment trends in the construction industry in Ukraine in the pre- and post-war periods, it is important to consider not only the total volume of capital investments, but also the specifics of financing digital construction. Table 2 shows the dynamics of total investment in construction and investment in digital technologies (in particular, BIM models and automated control systems) for 2019–2023. These data make it possible to assess the level of technological transformation of the industry against the backdrop of wartime challenges and to determine the potential for innovation to improve the efficiency of reconstruction.

**Table 2. Investment volumes in the construction industry and digital construction in Ukraine (2019–2023).** (Source: Kovalko, et al., 2022; State Statistics Service of Ukraine)

Year	Total Investment in Construction, UAH billion	Including Digital Construction (BIM, Smart Tech), UAH billion	Share of Digital Construction, %
2014	72.5	0.5	0.7%
2015	79.8	0.7	0.9%
2016	85.4	1.0	1.2%
2017	101.2	1.4	1.4%
2018	113.5	1.6	1.4%
2019	127.4	1.8	1.4%
2020	132.9	2.3	1.7%
2021	158.6	3.6	2.3%
2022	94.2	2.9	3.1%
2023	106.0	5.2	4.9%

The analysis of investment trends in Ukraine’s construction sector during the period 2019–2023, with a particular focus on financing digital construction, reveals significant transformational shifts in the industry’s development approaches.

According to the data, the overall volume of investments in construction in Ukraine exhibited unstable dynamics throughout this timeframe, reflecting a complex socio-economic context marked initially by pandemic-related restrictions and subsequently by full-scale military hostilities. In 2019, the construction sector attracted investments totaling UAH 127.4 billion, which increased to UAH 158.6 billion by 2021. This growth can be attributed to the delayed impact of prior investment decisions and the implementation of major infrastructure projects. However, in 2022, due to military aggression, there was a sharp decline in total investment volume, falling to UAH 94.2 billion. This trend was an expected consequence of heightened uncertainty and the physical destruction of portions of the infrastructure.

The increase in the share of digital investments from 1.4% in 2019 to almost 5% in 2023 reflects the priority of implementing BIM and other digital solutions to improve transparency, efficiency, and control over construction processes in Ukraine.

Digital construction is an integrated approach to planning, designing, building, and operating real estate properties with the active use of modern digital technologies that ensure automation, optimization, and transparency at all stages of the investment process. This approach transforms traditional construction management methods, allowing for more accurate planning, reduced risks, effective resource control, and shorter project implementation times.

For a deeper understanding of the role of digital technologies in the transformation of the construction industry, a summary of key innovative solutions used at various stages of construction is provided. Table 3 reflects the main functions, areas of application, and advantages of technologies such as BIM, IoT, 3D printing, and digital project management platforms. This systematic overview allows us to assess the potential of each technology to improve investment management efficiency and optimize construction processes.

**Table 3. Key digital technologies in construction: characteristics and areas of application.**

Technology	Core Function	Application Area	Key Advantages
BIM	Building Information Modeling	Design, coordination, operation	Improved accuracy, transparency, and collaboration
IoT	Data collection and transmission via sensors	Construction site monitoring, technical supervision	Real-time control, risk prevention
3D Printing	Manufacturing of complex structures	Component production, rapid construction	Reduced production time and cost
Digital Platforms	Project management, communication	Planning, budgeting, reporting	Centralized information, increased efficiency

An analysis of key digital technologies shows that they are comprehensively focused on automation, increased transparency, and integration of construction processes. In particular, BIM provides a central information environment for project coordination, IoT provides operational monitoring of the construction site, 3D printing provides innovative methods for manufacturing complex structural elements, and digital platforms provide comprehensive management of project documentation and communications. Together, these technologies form the basis of digital construction, opening up new opportunities to increase productivity, reduce costs, and minimize investment risks in the construction sector.

For a comprehensive analysis of the impact of digital technologies on investment management in the construction industry, it is important to compare traditional methods of organizing investment processes with modern digital approaches. Table 4 shows the key differences between these two management models in a number of critical aspects — from planning and cost control to communication, speed of decision-making, risk management, and quality of project documentation. Such a comparative analysis helps to identify the specific advantages of digital construction and to formulate practical recommendations for the implementation of innovative solutions in the field of investment management of construction projects.

**Table 4. Comparison of traditional and digital approaches to investment management in the construction industry.**

Criterion	Traditional Approach	Digital Approach
Planning	Manual, fragmented	Integrated, based on BIM models
Cost Control	Primarily document-based	Automated, real-time
Communication	Paper documents, in-person meetings	Digital platforms, shared access
Decision-Making Speed	Slow, human-dependent	Accelerated through data and analytics
Risk Management	Retrospective	Predictive, based on models and sensors
Project Documentation Quality	Limited detail	High detail, visualized

The comparison between traditional and digital approaches to investment management in the construction sector clearly demonstrates the transformational impact of digital technologies on all key components of the investment process. The traditional approach, based on manual planning, paper documentation, and fragmented communication, significantly limits management efficiency, causes delays in decision-making, and increases the risks of errors and cost overruns.

In contrast, the digital approach enables integrated planning through BIM modeling, automated and real-time cost control, and centralized communication platforms that enhance transparency and coordination among all project participants. Accelerated decision-making and predictive risk management not only minimize the negative impact of unforeseen factors but also improve the quality of the final outcome through detailed elaboration of project documentation.

Digital construction thus lays the foundation for increased productivity, reduced costs, and the sustainable development of the construction industry in the face of modern challenges, including the post-war reconstruction of the country. In the context of Ukraine's post-war recovery, the application of digital technologies in the field of investment management for construction projects has gained particular relevance. Digital construction is regarded as an innovative model that allows not only for more efficient investment implementation but also ensures transparency, cost control, timely decision-making, and adaptability to changing external conditions.

By utilizing digital tools, all stages of the investment process — from the development of feasibility studies to the commissioning of facilities—are integrated into a single information environment. This approach ensures continuous real-time data updates, visualization, monitoring, and coordination of actions among all project stakeholders. This advantage becomes especially valuable in the context of large-scale reconstruction, where the volume of projects, financial resources, and involved parties grows exponentially.

In reconstruction projects, digital technologies such as 3D scanning and BIM modeling make it possible to accurately assess the extent of damage to existing structures, create their digital twins, and promptly adapt project documentation to the actual condition of the facility. This is particularly important in situations that require rapid response, limited time, and constrained resources.

In new construction, digital solutions enable comprehensive optimization of the entire project cycle—from concept to implementation. They help reduce design errors, mitigate the risks of cost overruns, and ensure adherence to deadlines. Moreover, project investment attractiveness is significantly enhanced through transparent procedures, accurate budgeting, and the ability to forecast economic outcomes.

An examination of investment patterns in Ukraine's construction industry over the last ten years reveals a gradual yet insufficiently dynamic increase in the share allocated to digital construction. Comparing these indicators with experiences from other countries provides a deeper understanding of structural challenges and helps identify potential avenues for development.

According to data from the McKinsey Global Institute (2022), in the United States, investments in digital technologies within construction have reached approximately 12% of the total construction investment volume. Priority is given to areas such as Building Information Modeling (BIM) systems, 3D printing of construction components, digital platforms for supply chain management, and blockchain-based smart contracts. Digitalization has emerged as a key driver in cost optimization and shortening project completion timelines.

In the European Union countries — particularly Germany, France, and the Netherlands—the share of investments in “smart construction” averages between 8% and 10%. This trend is underpinned by comprehensive government policies supporting green building initiatives, the transition to digital building passports, the use of digital twins for infrastructure assets, and the development of innovative financial instruments such as green bonds aimed at funding energy-efficient projects.

China demonstrates even more aggressive digitalization momentum in its construction sector. According to analytical reports by the China Construction Industry Association (2023), about 15% of construction investments are directed toward digital solutions, including platforms for automated project management, deployment of artificial intelligence technologies for managing construction activities, and lifecycle monitoring of buildings through IoT systems. The government actively promotes such investments through subsidy programs and tax incentives.

Despite the significant potential of digital technologies, their large-scale implementation in Ukraine faces a number of serious challenges. These challenges are complex in nature and can be broadly categorized into three key groups: financial, human resource, and regulatory-legal.

First, one of the main reasons for the low level of digitalization is the high cost of implementing digital technologies. This includes not only the purchase of modern software or equipment (such as 3D scanners, drones, server solutions), but also

the expenses related to their maintenance, updates, and personnel training. These issues are especially acute for small and medium-sized enterprises, which often lack access to affordable financial resources or government support programs.

Second, the adoption of digital solutions requires qualified specialists — specifically BIM managers, data analysts, project coordinators, digital technology operators, and others. Currently, Ukraine experiences a significant shortage of professionals with the necessary competencies, caused both by the insufficient availability of relevant educational programs and the lack of practical experience among construction sector specialists.

Third, another serious challenge is the underdevelopment of the appropriate regulatory framework. Ukrainian legislation has yet to adapt to digital formats of project documentation; there are no unified standards for exchanging digital data, nor clear regulations regarding the legal status of BIM models, electronic object passports, digital signatures, and similar matters. The absence of such norms slows the official adoption of digital tools and creates legal uncertainty for market participants.

Furthermore, Ukraine still lacks a comprehensive national digital construction strategy to coordinate the actions of government agencies, educational institutions, the private sector, and donor communities. Fragmented initiatives introduced at the level of individual projects or ministries do not establish a sustainable digital infrastructure and therefore fail to provide investors with confidence in the sector’s long-term stability and predictability.

Additionally, a certain investment caution driven by the ongoing war has translated into reluctance toward high-risk innovations. Investors who previously were willing to invest in technologically complex solutions now prefer simple, fast, and proven options. Combined with the low digital literacy of a significant portion of managerial personnel, this creates an atmosphere of mistrust toward new tools and methods in construction project implementation.

The digitalization process in Ukraine’s construction sector is thus challenged not only by technical or resource limitations but, above all, by deeper systemic issues. Overcoming these requires not only investments but primarily a coordinated transformation of managerial, institutional, and educational approaches that will shape the future of construction in Ukraine’s emerging economy.

Modern realities demand a systematic approach to creating conditions for the implementation of innovations. State policy must not only declare digital transformation as a priority but also ensure its practical realization through financial instruments, legislative reforms, human capital development, and institutional support. In this context, it is critically important to consider the international experience of countries that have achieved significant progress in digital construction, including the United Kingdom, Germany, Singapore, and South Korea. Their successful practices can be adapted to Ukrainian realities, taking into account the scale of post-war reconstruction, limited resources, and strong interest from international partners.

The table below (Table 5) summarizes the key areas of action necessary to overcome barriers to digitalization, indicating possible implementation tools, examples of effective foreign experience, and an assessment of their implementation potential in the Ukrainian context. This approach enables the development of a well-grounded vision for transforming the investment and construction environment toward innovation, transparency, and strategic resilience.

<b>Table 5. Proposed measures to overcome barriers to the implementation of digital solutions in construction.</b>			
<b>Area of Impact</b>	<b>Proposed Measures</b>	<b>International Experience</b>	<b>Implementation Potential in Ukraine</b>
State Policy	Development of national digital construction standards; implementation of state pilot projects; tax incentives for innovators.	In the UK, the mandatory use of BIM Level 2 for public procurement has been in place since 2016.	High, provided there is political will and support from the Ministry of Infrastructure and the Ministry of Economy.
Education and Workforce	Integration of BIM, IoT, and digital analytics into curricula; professional certification; promotion of internships at real projects.	Germany and the Netherlands have state-funded programs for BIM specialist training.	Medium requires reforms in educational standards and cooperation with the private sector.
Financing	Introduction of grant programs for SMEs; subsidies for software licenses; public-private investment funds.	In South Korea, digitalization is supported through concessional government loans and subsidies.	Feasible, with support from international donors and recovery programs (e.g., USAID, EBRD).
International Partnership	Attracting donor assistance; import of digital technologies; establishment of knowledge exchange centers; participation in global initiatives.	The EU funds the “Horizon Europe” programs to develop digital infrastructure in Eastern European countries.	High, considering Ukraine’s status as an EU accession candidate.

*(continued on next page)*

**Table 5.** Continued.

Area of Impact	Proposed Measures	International Experience	Implementation Potential in Ukraine
Digital Infrastructure	Creation of a unified national digital construction platform; cloud-based collaboration systems; digital project registries.	Singapore operates a national BIM platform with automated submission of documents to government agencies.	Medium requires investments in cyber infrastructure and data standardization.
Innovation Ecosystem and Support for Digital Construction Startups	Establishment of innovation hubs and accelerators for startups; mentoring programs; funding R&D through grants and venture funds; pilot projects to test new digital technologies.	The USA, Israel, and Finland have specialized startup ecosystems and government platforms supporting digital innovations in construction.	Ukraine has the potential to build similar ecosystems in cooperation with international partners, fostering innovation and attracting investment.

The analysis of the directions and instruments outlined in the table for overcoming barriers to digitalization in the construction sector highlights the necessity of a comprehensive, multi-level approach to implementing digital technologies in reconstruction project management. None of the proposed measures alone can ensure sustainable impact — effective digital transformation is achievable only through coordinated action among governmental, educational, financial, and technical institutions.

Table 5 demonstrates that the adoption of digital solutions in construction is a multifaceted process requiring an integrated approach and cooperation at various levels. First and foremost, state policy plays a pivotal role, as it establishes the frameworks and incentives for the development of digital technologies. The experience of the United Kingdom illustrates that when the government mandates standards and supports innovation through tax incentives, it creates a strong impetus for the entire sector.

Equally important is the development of human capital. Integrating modern digital technologies into educational curricula and providing practical training for specialists lays the foundation for qualitative changes in construction. The examples of Germany and the Netherlands show that government support for education and professional development significantly accelerates digital transformation.

Financing remains a critical factor, especially for small and medium-sized enterprises that often face limited resources for technology adoption. Support in the form of grants, subsidies, and investment funds — as practiced in South Korea — can serve as a catalyst for change. Ukraine has realistic prospects for such support, particularly through international donor programs.

International partnerships provide access to advanced technologies, expertise, and financial resources. As a candidate country for EU accession, Ukraine is well-positioned to integrate into European programs supporting digital infrastructure, which opens additional opportunities for sector development.

Regarding digital infrastructure, establishing a unified national platform and digital registries is a mandatory condition for effective coordination and automation of construction processes. Singapore’s example, where government services are fully automated and integrated, indicates the direction to pursue. However, this requires substantial investments and meticulous planning.

Perhaps the most promising and dynamic area is the creation of an innovation ecosystem and support for startups in digital construction. This approach remains underdeveloped in Ukraine but holds tremendous potential. Innovation hubs, accelerators, mentoring programs, and funding for R&D can become the driving forces enabling faster implementation of new digital solutions and attracting investments.

Considering this, Ukraine should actively focus on developing such an ecosystem by leveraging support from international partners and its own innovation potential. This will not only help overcome existing challenges but also establish a stable platform for the continued advancement of digital construction.

In summary, for digital transformation in construction to become a reality, systemic collaboration among the government, educational institutions, business, financial entities, and international organizations is essential. Only the combination of these components will pave the way for a modern, competitive, and innovative construction sector in Ukraine.

Thus, the proposed measures to overcome barriers to the implementation of digital solutions in construction represent a strategic roadmap intended to guide the development of effective state and industry policies in digital investment for construction. Their implementation has the potential not only to eliminate current constraints but also to transform the sector towards sustainability, innovation, and transparency — a critical necessity during the national recovery period.

## DISCUSSION

The research results demonstrate that the implementation of digital technologies in the investment management system within Ukraine's construction sector holds significant transformational potential. It is capable of reshaping both the technical and managerial architecture of the industry, establishing a new decision-making infrastructure, reducing costs, mitigating risks, enhancing monitoring, and ensuring transparency at every stage of the investment cycle. At the same time, the practical application of this model faces a number of contradictions arising from both internal factors and the external environment.

One of the key aspects is the necessity for a harmonious integration of digital solutions with the existing construction management practices. Currently, a substantial portion of enterprises, especially at the regional level, continue to rely on traditional project implementation mechanisms based on paper documentation, fragmented accounting, and low integration among process participants. Digital transformation in such an environment requires an adaptive implementation model that involves gradual updating of practices, workforce upskilling, and modernization of the technical base.

Digitalization is perceived not only as a tool for technological renewal but also as a means to overcome systemic inefficiencies and minimize corruption risks in capital construction. The transparency, automation, and controllability offered by digital platforms create conditions that prevent abuses, improve accountability among stakeholders, and ensure objective quality control. However, under weak institutional conditions and without adequate regulatory support, even the most advanced technologies may prove to be ineffective.

The financial aspect of digital transformation also demands careful consideration within the context of the market participants' resource capabilities. Despite the prospect of long-term return on digital investments, the high initial costs of software, equipment, and personnel training remain significant barriers, particularly for small and medium-sized enterprises. Consequently, the role of the state and international partners in compensation, subsidy, and grant programs becomes crucial in stimulating demand for digital solutions in construction.

Equally important is the regulatory and legal framework supporting digital construction. To date, Ukraine lacks unified standards regulating the application of BIM models, data formats, and digital signatures in construction documentation. The legislative framework adapted to the digital paradigm is still under development. This slows down the legitimization of digital approaches and restricts their use in official procedures related to design, approval, financing, and operation of facilities.

In the context of post-war reconstruction, international cooperation acquires special significance. Technical assistance programs, the experience of digital transformation in EU countries, and international standards for infrastructure project management all create prerequisites for qualitative industry renewal. However, the effectiveness of such cooperation depends on Ukraine's ability to establish a transparent environment, build effective institutions for the implementation of digital initiatives, and ensure the sustainability of political priorities.

Thus, digitalization of investment management in construction is not merely a technical upgrade but a profound managerial and institutional reform. It requires the consolidation of efforts among all stakeholders — government, business, academia, educational, and civil society institutions — around a long-term vision of a sustainable, innovative, and transparent construction sector. Only through a strategic approach to digital transformation can a new quality of the investment environment be created, capable of ensuring efficient, rapid, and responsible reconstruction of the country.

## CONCLUSIONS

The conducted research substantiates the strategic importance of digital construction as a key driver in transforming the investment management system within Ukraine's construction sector amid post-war reconstruction. An analysis of the current state of investment provision revealed structural imbalances, unstable capital inflows, and the dominance of traditional financing methods, which collectively reduce flexibility and efficiency in implementing large-scale infrastructure projects.

Against this backdrop, digital technologies — primarily BIM modeling, the Internet of Things, cloud-based project management platforms, and data analytics — acquire functional significance not only as tools for technical enhancement but also as mechanisms for optimizing investment processes. Digital construction enables data integration across all stages of an asset's lifecycle, enhances accountability, and accelerates decision-making.

The study identified key advantages of the digital approach compared to traditional methods, including improved planning accuracy, reduction of transaction costs, prevention of duplicated work, automated cost control, and increased transparency of financial flows. At the same time, systemic challenges related to digitalization were identified — financial, human resource, and regulatory — that require targeted government actions and strengthened cross-sectoral cooperation.

It is substantiated that effective implementation of digital solutions in the construction industry requires a comprehensive approach — combining state digital transformation policies, development of digital competencies among market participants, establishment of a modern regulatory framework, and engagement of foreign technical and financial assistance. In this context, priority areas include the creation of public electronic registries, mandatory use of BIM in state-funded projects, development of educational programs in digital engineering, and expansion of grant and credit programs for small businesses operating within digital construction.

Thus, digital construction emerges not only as a response to technological challenges but as a new managerial paradigm that lays the foundation for a transparent, efficient, and inclusive model of investment development. Its widescale adoption has the potential to significantly accelerate infrastructure reconstruction, restore investor confidence, and ensure a qualitative leap in the development of Ukraine's construction sector based on sustainability, innovation, and openness to global standards.

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## ADDITIONAL INFORMATION

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### AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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The Authors declare that there is no conflict of interest.

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Сичов О., Фесун А., Рижаківа Г., Чуприна Ю., Рубцова С., Дубина Н.

## ІНВЕСТИЦІЙНЕ ЗАБЕЗПЕЧЕННЯ ЦИФРОВОГО БУДІВНИЦТВА В УМОВАХ ПІСЛЯВОЄННОЇ ВІДБУДОВИ УКРАЇНИ

У роботі ґрунтовно досліджені основні проблеми, які перешкоджають широкому впровадженню цифрових технологій у будівельній галузі України в умовах післявоєнної відбудови. Автори детально проаналізували комплекс перешкод, поділених на три взаємопов'язані групи: фінансові, кадрові та нормативно-правові. Акцентували увагу на високій вартості впровадження цифрових рішень, що включає не лише закупівлю сучасного обладнання та програмного забезпечення, а й витрати на їх обслуговування, оновлення, а також підготовку персоналу. Це створює особливі труднощі для малого та середнього бізнесу, який часто не має доступу до дешевих фінансових ресурсів або державної підтримки. Автори розглянули та обґрунтували гостру нестачу кваліфікованих фахівців, здатних працювати з технологіями BIM, IoT й цифрової аналітики, що пов'язано з недостатнім розвитком освітніх програм і браком практичного досвіду в будівельній галузі. Особливу увагу приділено нормативно-правовим перешкодам, які включають відсутність єдиних державних стандартів, нормативних актів, а також чітких правил правового статусу цифрової проєктної документації, BIM-моделей, електронних паспортів об'єктів і цифрових підписів. Це створює значну правову невизначеність і гальмує офіційне впровадження цифрових технологій у будівництві. Автори запропонували комплекс заходів для подолання виявлених перешкод, серед яких розробка національних стандартів цифрового будівництва, створення державних пілотних проєктів, а також податкові та фінансові стимули для інноваторів. Запропонували створення грантових програм, субсидій і державних інвестиційних фондів і відзначили значення міжнародного партнерства й використання зарубіжного досвіду, що сприятиме впровадженню найкращих практик у вітчизняну будівельну галузь. Отримані результати мають стратегічне значення для ефективної цифровізації будівництва, яка є ключовим чинником прискорення відновлення й сталого розвитку економіки України в післявоєнний період.

**Ключові слова:** цифрове будівництво, інвестиції, фінансове забезпечення, цифрова трансформація, будівельна галузь, стартапи в будівництві

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