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FINANCIAL MECHANISMS FOR THE FORMATION AND SUPPORT OF DIGITAL INFRASTRUCTURE IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

The article investigates the role of financial mechanisms as a key tool for the formation and support of digital infrastructure in the construction sector. The authors conducted a comprehensive analysis of modern financial instruments that enhance management efficiency, investment attractiveness, and value creation in the context of digital transformation. The study systematized financial mechanisms according to their nature and application forms, highlighting classical loans and government programs that ensure funding stability; digital platforms and investment solutions that provide flexibility and rapid scaling of digital initiatives; as well as asset tokenization, which opens new opportunities for capital attraction and integration of innovative financing models. The authors proposed three strategic directions of digitalization in construction activities requiring financial support: digital design (BIM, CAD), automation of construction processes, and digital management of finances and data (ERP, cloud platforms). It was found that integrating these components into a unified digital ecosystem generates synergy, enhancing productivity, transparency, and competitiveness of the construction sector. Special attention was paid to risk management associated with implementing financial mechanisms, including technical, financial, regulatory, cyber, and organizational risks, and comprehensive scientifically grounded recommendations for their mitigation were proposed. The research provides a scientific basis for strategic planning and implementation of financial mechanisms supporting digitalization in the construction sector. Employing a comprehensive approach that combines financial instruments, companies' technological capabilities, contemporary regulatory frameworks, and effective risk management ensures systematic, sustainable, and efficient deployment of digital technologies, which is critical for increasing productivity, investment appeal, and sectoral competitiveness in the digital era.

Keywords: digitalization, financial mechanisms, construction sector, digital design, investment attractiveness, innovative activity

JEL Classification: G31, L74, O32

INTRODUCTION

In the contemporary context of global digital transformation, the construction industry is gradually moving beyond traditional production and technological approaches and increasingly acquiring the characteristics of a high-technology, data-driven system in which digital infrastructure plays a pivotal role. Digital infrastructure ensures the integration of information flows, coordination among participants in the investment and construction process, enhancement of transparency in financial decision-making, and reduction of transaction costs across all stages of a construction project's life cycle: from pre-investment analysis to the operation of completed facilities. In this context, digital infrastructure emerges not as an auxiliary element but as a system-forming foundation of the modern construction economy, capable of influencing the pace of industry development, its investment attractiveness, and the level of financial and economic resilience.

At the same time, the formation and sustainable development of digital infrastructure in the construction sector constitute a capital-intensive and complex process that requires not only technological solutions but also well-structured financial mechanisms. These include a set of instruments, methods, and sources of financing that ensure the

creation, implementation, scaling, and maintenance of digital platforms, information systems, BIM technologies, cloud services, digital twins, and analytical project management modules. Insufficiency or fragmentation of such mechanisms leads to asynchronous development of digital components, which in turn reduces the effectiveness of digitalization and prevents the full realization of its economic potential.

This issue becomes particularly relevant under conditions of structural transformation of the national economy, increasing requirements for transparency in the use of financial resources, and the need for post-crisis and post-war recovery of the construction industry. In such circumstances, digital infrastructure serves not only as a tool for improving operational efficiency but also as a mechanism for strengthening financial discipline, risk management, and trust among market participants. However, without adequate financial support, both at the level of individual enterprises and at the macro- and meso-levels, digital solutions remain localized initiatives that fail to generate a comprehensive industry-wide effect.

Contemporary academic discourse predominantly focuses on the technological aspects of construction digitalization, while the financial mechanisms supporting it are often addressed fragmentarily or as secondary issues. Nevertheless, it is precisely the financial component of digital infrastructure that determines the speed of its implementation, the scale of innovation diffusion, and the sustainability of its functioning in the long term. This underscores the need for a systemic understanding of the financial mechanisms for the formation and support of digital infrastructure in the construction industry, taking into account sector-specific characteristics, investment cycles, and risks inherent in construction projects.

Given the above, the study of financial mechanisms for the formation and support of digital infrastructure in the construction industry acquires particular scientific and practical significance. It enables a rethinking of the role of financial instruments in ensuring the digital maturity of the sector, identifies directions for optimizing investment flows, and forms a methodological basis for integrating digital solutions into the financial and economic development model of construction. In this dimension, digitalization appears not as a technological trend but as a long-term strategy for financially sustainable and innovation-oriented development of the industry.

LITERATURE REVIEW

The financial mechanism should be considered as a multidimensional and internally structured system of financial relations that is formed within the framework of social reproduction and determines the ways of accumulating, distributing, and using financial resources in order to create economic prerequisites for long-term sustainability and development. Its substance goes beyond a purely instrumental approach, as the financial mechanism reflects deep interconnections between economic agents, the state, and the financial system as a whole.

The architecture of the financial mechanism is not static and is shaped under the influence of a set of objective and subjective factors. These include the model of the economic system, the level of macroeconomic stability, the socio-economic parameters of societal development, the quality of the institutional environment, as well as the nature and maturity of the regulatory and legal framework. In each national economy, these factors are combined in a specific manner, which determines the distinctive features of the functioning of the financial mechanism and its adaptability to internal and external challenges.

Public authorities play a decisive role in the formation and transformation of the financial mechanism, as it is precisely, they who establish the basic rules governing financial relations. Through the system of fiscal, budgetary, and monetary policies, the state shapes the parameters for the distribution of gross domestic product, defines models for the accumulation of financial resources, regulates payment circulation mechanisms, and determines priority areas for the use of public finances. In this way, the financial mechanism acts as an institutional instrument for the implementation of strategic priorities of socio-economic development.

Scientific approaches to interpreting the financial mechanism are characterized by significant conceptual diversity, which complicates the formulation of a universal definition of this category. In the majority of studies, the financial mechanism is interpreted as an organizational and economic set of forms, methods, and instruments for regulating financial relations aimed at ensuring sustainable economic growth, strengthening financial stability, and enhancing national security. Such an approach makes it possible to consider the financial mechanism not only as an element of the financial system but also as an active driver of structural changes in the economy.

The functioning of the financial mechanism provides the state with the ability to exert targeted influence on the processes of redistribution of gross national product, mobilization and use of capital, regulation of payment flows, and determination of priority areas of budgetary financing. The multi-vector nature of these tasks' accounts for the increased complexity of

designing the financial mechanism, since the dynamics of financial relations require constant adjustment of methods and forms of their implementation in accordance with changes in the economic environment.

The generalization of scientific positions makes it possible to identify the basic structural elements of the financial mechanism, which include financial methods and levers of influence, financial instruments, the information support system, organizational forms of financial flow management, as well as the regulatory and legal framework that defines the rules for the functioning of financial relations. It is the interaction of these components that forms the integrity of the financial mechanism and ensures its ability to perform regulatory and stimulating functions in a transformational economy.

In academic discourse, the financial mechanism is predominantly interpreted as an integrated and internally coherent system of methods, forms, instruments, and levers through which financial resources are accumulated, formed, and utilized in order to coordinate and realize the interests of the state, business entities, and society as a whole. It is precisely this multi-component nature of the financial mechanism that determines its role as a key instrument for the practical implementation of state financial policy and for ensuring a balance of financial interests among all participants in the national economy. Its functional capabilities are not static but are in a state of continuous evolution under the influence of transformations in the economic mechanism and its individual elements.

Under contemporary conditions, digitalization processes are increasingly viewed as a fundamental, system-forming factor in the development of the construction industry, capable of significantly enhancing the efficiency of construction enterprises at all levels of their activity. A considerable number of Ukrainian scholars agree that the digital transformation of construction is not limited to the implementation of individual technological solutions but instead shapes a new logic for organizing production, managerial, and financial-economic processes within the industry.

Thus, Kasych et al. (2022) emphasize the applied dimension of digitalization in the activities of construction companies, highlighting its ability to reduce costs at the design stage, shorten the duration of construction projects, and create opportunities for real-time operational management of construction processes. In this context, digital solutions are viewed not merely as automation tools but as a means of enhancing the controllability of complex projects under conditions of growing uncertainty.

Further development of this scientific position can be observed in studies devoted to the analysis of technological trends in construction. In particular, Pushkar (2024) notes that modern digital technologies create a wide range of opportunities for transforming construction activities: from digital support of innovative processes to the integration of managerial and production decisions into unified information environments. Under this approach, digitalization encompasses all stages of the life cycle of construction objects, from pre-project research and design to operation and renovation.

At the same time, a number of researchers emphasize the complex nature of the digital transformation of the construction industry and the need for a systemic removal of barriers that constrain its implementation. Sadoviak et al. (2024) argue that effective digitalization of construction is impossible without overcoming informational, regulatory, human resource, and financial constraints that generate structural inertia within the industry. In this sense, digital transformations acquire the character of a long-term investment process closely linked to the development of human capital and the institutional environment.

An additional dimension of digitalization in construction is explored by Filippov (2023), who substantiates its key role within the system of safety and risk management. The author demonstrates that the implementation of digital tools contributes to increased transparency of construction activities, minimization of corruption risks, and the creation of prerequisites for the transition of the industry toward models of sustainable, adaptive, and socially responsible development. Under this interpretation, digitalization goes beyond technological renewal and emerges as an instrument of institutional modernization of Ukraine's construction sector.

Summarizing scientific approaches, most researchers agree that the key directions of construction digitalization include the implementation of Building Information Modeling (BIM), the use of Internet of Things (IoT) technologies, the development of automated management systems, and the application of blockchain technologies to ensure transparency of financial and contractual relations. The combination of these directions forms the basis for the transition of construction companies to a new operating model in which digital technologies act not as auxiliary tools but as a determining factor in enhancing economic efficiency and competitiveness.

Within the academic discourse on the digital transformation of the construction industry, the interpretation of digitalization as a comprehensive and multidimensional process is becoming increasingly widespread. This process encompasses not only the implementation of individual information technologies but also a fundamental change in approaches to organizing construction business activities. In this context, Marchenko et al. (2023) define construction digitalization as the process

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of transferring key construction and managerial procedures into a digital format while simultaneously using modern technologies to reduce project implementation timelines and improve the quality of final outcomes. This approach emphasizes the systemic nature of digitalization, viewing it as a tool for increasing the effectiveness of the entire construction value chain.

An important institutional vector of digitalization in the construction sector has been the introduction of the Unified State Electronic System in the field of construction, which has ensured the integration of design processes, project documentation expertise, permitting procedures, as well as monitoring and control of construction activities. In substance, this solution represents not only a stage of technical modernization of the industry but also a component of the broader process of e-governance development in Ukraine. As justified by Blinova (2022), the functioning of such a system creates prerequisites for increasing the transparency of regulatory procedures, reducing administrative barriers, and forming a unified digital environment for interaction among the state, business, and the professional community in the construction sector.

At the same time, despite the objective necessity of digital transformations, the construction industry remains one of the least innovation-active sectors within the national economy. Zaiats (2020) draws attention to this issue, noting that the low level of innovative dynamics in construction is driven by sector-specific characteristics, including the inertia of the regulatory framework, lengthy technology renewal cycles, and the conservatism of construction methods. Under such conditions, digitalization becomes one of the few instruments capable of activating innovation processes without radically disrupting established production models.

In this context, a particularly important role is played by the automation of design, the implementation of BIM technologies, and the further development of state digital platforms in construction. These areas form the technological foundation for transitioning the industry to a higher level of innovation capacity by reducing the labor intensity of design and construction works, increasing planning accuracy, and minimizing errors across all stages of the asset life cycle.

Generalizing contemporary scientific approaches, Solomnikov et al. (2023) emphasize that digitalization is one of the key trends shaping the development of the construction industry and determining the directions and effectiveness of innovation activity. According to the authors, the implementation of digital solutions not only enhances the economic performance of construction production but also drives qualitative changes in labor organization, project management, and coordination among participants in the construction process.

Under current conditions, financial mechanisms in construction are gradually transforming from instruments focused on the provision of tangible assets into comprehensive systems that support innovative development, encompassing digital infrastructure, intelligent management platforms, and information-analytical environments. Consequently, the study of financial mechanisms in the construction industry is becoming interdisciplinary, combining financial-economic, investment, and technological dimensions.

One of the foundational studies that shaped the theoretical basis of this issue is the work by Virchenko (2018). The author convincingly demonstrates that classical financing models primarily oriented toward physical construction assets are increasingly failing to meet the modern needs of the industry. Such approaches do not account for the growing demand for investments in intelligent management systems, automation of construction processes, and the development of digital infrastructure. Accordingly, Virchenko (2018) concludes that there is an objective need to form adaptive and flexible financial mechanisms capable of ensuring capital accumulation for the implementation of digital innovations in the construction sector.

Over the past decade, the issue of financing the construction industry has moved beyond traditional economic analysis and has acquired strategic significance. Of particular interest are approaches aimed at introducing advanced financial instruments that not only diversify sources of capital but also provide a flexible response to the industry's digital transformations. In this context, the study by Chuvpylo et al. (2023) is noteworthy, as it provides a comprehensive analysis of the potential of digital asset-linked bonds as a tool for updating the capitalization structures of construction companies. The authors demonstrate that such financial instruments can serve as an effective channel for attracting investment into the digital modernization of the industry.

At the same time, despite the evident advantages of innovative financial mechanisms, the construction industry faces a number of significant constraints. One of the most complex issues remains the objective financial valuation of intangible digital assets. As rightly noted by Adibfar et al. (2020) and Latysheva (2020), digital products, such as construction project management software, automation algorithms, and BIM models, are characterized by a high degree of specificity and limited liquidity, which complicates their quantitative valuation. This, in turn, significantly narrows the possibilities for using such assets as collateral or other forms of financial security within traditional financial mechanisms.

Thus, the development of financial mechanisms in the construction industry increasingly depends on the ability of the financial system to integrate intangible digital assets into investment, valuation, and risk management processes. This trend forms a new vector for academic research and practical solutions in sectoral financing.

Despite its evident relevance, the issue of digital asset valuation in construction remains insufficiently explored at both the regulatory and methodological levels. The main challenge lies in the fact that most traditional accounting methodologies are based on principles designed for tangible assets — those with physical form, clearly defined market prices, and predictable depreciation. Digital solutions, such as modeling software modules, analytical algorithms, or process management platforms, often lack direct market analogues and cannot be assessed using classical valuation criteria, which complicates their inclusion in financial reporting.

As emphasized by Chuvpylo et al. (2023) and Kryshtanovych, M. et al. (2021), there is a growing need to develop transparent and standardized methods for valuing digital assets in the construction industry. This task goes beyond formal procedures and requires a fundamental rethinking of the accounting paradigm: digital technologies must occupy a clearly defined place in a company's value structure. Only under such conditions can a realistic financing model be created in which intellectual developments are not perceived as costs but recognized as sources of added value. In the long term, this approach enables construction companies to systematically attract investments not only into tangible assets, such as concrete and machinery, but also into algorithms, data, and digital solution architectures.

The discussion on financing construction digitalization becomes particularly relevant against the backdrop of global structural changes. As noted by Zhosan (2022), excessive reliance on external capital for the implementation of digital innovations may lead to unintended consequences. Financing based predominantly on external sources can limit companies' strategic horizons, encouraging them to implement only partial technologies, such as automation of individual operations or digitization of document flows, while avoiding large-scale investments in R&D, managerial restructuring, or human capital development. As a result, digitalization risks becoming a superficial "fashionable add-on" rather than a tool for systemic transformation of the industry.

Financial instruments to support construction digitalization may vary in nature and functionality: from traditional banking products with a technological component (e.g., loans for innovative projects) to entirely new solutions, such as digital platforms for financing process automation or tokenization of real estate assets to attract investment (Kloba et al., 2020; Mia et al., 2022; Nikonenko et al., 2022; Bondarenko et al., 2022). These instruments may be short-term or long-term, mass-market or niche-oriented, and may take tangible forms (equipment for accounting automation) or intangible forms (digital services, blockchain solutions to ensure contract transparency).

Within the academic discourse on the transformation of the construction industry under digitalization, a clear logical continuity of approaches can be observed among individual researchers, forming a coherent vision of current challenges and development opportunities.

Thus, Verkhohliadova et al. (2017) conceptualize the potential of the construction industry as a multidimensional economic category that combines production, financial, innovative, and managerial components. The authors convincingly argue that the balanced development of these elements forms the basis for the long-term competitiveness of construction enterprises, especially in conditions of increasing digitalization and market complexity.

In turn, Kiriienko et al. (2017) focus on the evolution of BIM technologies, viewing them not merely as tools for three-dimensional design but as a comprehensive methodology for data management throughout the entire life cycle of a construction asset. The authors consistently trace the stages of BIM development, emphasizing its ability to minimize information gaps among project participants, reduce operational risks, and enhance the predictability of construction outcomes.

Expanding on this issue, Kulyk et al. (2020) conduct an in-depth analysis of the practical aspects of implementing digitalized software solutions in domestic construction practice. The researchers emphasize that the use of BIM-oriented solutions contributes not only to improved project management quality but also to the formation of a new data-driven management culture characterized by cost transparency and rational use of material and financial resources.

A significant contribution to the development of the theoretical and applied foundations of information modeling is made by Trach (2018), who highlights the resource-saving potential of the BIM approach. The author argues that information modeling enables a substantial reduction in non-productive costs, decreases the probability of design errors, and enhances the reliability of construction solutions, ultimately exerting a positive impact on the economic efficiency of investment projects in the construction industry.

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In summary, the generalization of the scientific positions of the above authors indicates that construction digitalization, particularly through the implementation of BIM technologies, is gradually transforming from an instrumental innovation into a strategic factor for enhancing the efficiency, resilience, and competitiveness of the industry as a whole.

AIMS AND OBJECTIVES

The purpose of this study is to conduct a comprehensive examination of financial mechanisms that ensure the formation and support of digital infrastructure in the construction industry, with a focus on determining their role in enhancing management efficiency, increasing the investment attractiveness of companies, and creating added value under conditions of digital transformation.

The main objectives of the study are as follows: to systematize and analyze financial mechanisms used to support digital solutions in the construction sector: from classical credit products to innovative digital platforms and asset tokenization; to carry out a systemic analysis of the current state of digitalization in the construction industry, identify key areas of digital infrastructure that require financial support, and assess their strategic importance for sectoral development; to develop scientifically grounded recommendations for optimizing financial mechanisms that support digitalization, aimed at ensuring the systemic, comprehensive, and sustainable implementation of digital technologies in the construction sector.

METHODS

The methodological foundation of the research is systems thinking, which makes it possible to examine financial mechanisms in close interrelation with digitalization processes at both the company level and the industry level as a whole. This approach enables the assessment not only of individual financial instruments, but also of their interaction across temporal, functional, and institutional dimensions. In particular, digital assets are often perceived as isolated investment objects, which complicates their integration into overall financial models. Systemic analysis made it possible to overcome these limitations and to identify interdependencies between financing instruments and their impact on corporate value creation.

Another key component of the methodology is an expert survey of professionals in the construction sector. Involving practitioners provided access to real-world managerial practices, including risk, uncertainty, and intuitive decision-making processes that are not reflected in statistical data. This made it possible to combine objective macroeconomic trends with localized practices of digital technology implementation and innovation financing.

In addition, the methodology included analytical generalization and classification of financial mechanisms: from classical credit instruments to innovative digital platforms and asset tokenization, with identification of their capabilities, limitations, and effectiveness of application. This approach enabled a comprehensive review of the current state of digitalization in the construction industry, the identification of key components of digital infrastructure requiring financial support, and an assessment of their strategic impact on sectoral development.

As a result, the methodological framework of the study is formed as a dynamic, multidimensional system capable of accounting for regulatory uncertainty, innovation potential, and the interdependence of financial instruments and digital solutions. It provides a scientifically grounded basis for developing recommendations to optimize financial mechanisms supporting digitalization and is aimed at ensuring the systemic, comprehensive, and sustainable implementation of digital technologies in the construction sector.

RESULTS

One of the key aspects of digital transformation in the construction sector is the effective financial support of innovative solutions. Modern companies face the need not only to acquire software and digital equipment, but also to integrate these assets into the overall financial structure of the enterprise. Therefore, the study of financial mechanisms supporting digital solutions in construction is a relevant task that combines the analysis of classical banking products, innovative financing platforms, and contemporary digital investment models.

It is proposed to systematize financial mechanisms according to their nature, forms of manifestation, and functional purpose in the processes of supporting digitalization (Table 1). Such a classification makes it possible not only to structure existing approaches to financing digital solutions but also to identify key patterns of interaction among different mechanisms, as well as their strengths and weaknesses. This forms the basis for developing scientifically grounded recommendations aimed at optimizing the financial support of digital transformation in the construction industry.

Table 1. Systematization of financial mechanisms in the construction industry for supporting digital solutions.

Category of Mechanism	Form of Application in the Construction Industry	Potential Impact of Digitalisation on the Construction Industry
Traditional Credit Mechanisms	Financing the acquisition of digital equipment for construction sites, licenses for BIM systems, and automated project management platforms	Facilitate the scaling of digital technologies in construction; ensure stable financing of innovative solutions
Digital Financing Platforms	Crowdfunding and crowdinvesting platforms for digital projects of construction companies; automated systems for monitoring and controlling investments in digital solutions	Accelerate the implementation of digital technologies; enhance transparency and efficiency of financing; stimulate innovative approaches
Asset Tokenisation Mechanisms	Tokenisation of real estate assets, digital building models, and software licenses to attract investors	Increase asset liquidity; provide access to new sources of financing; stimulate innovation in the construction sector
State and Public-Private Mechanisms	Grants for the implementation of digital solutions in construction; subsidies for the automation of managerial processes; participation in state innovation projects	Promote comprehensive digitalisation of the construction sector; support innovative development and R&D

Table 1 presents a systematisation of the key financial mechanisms applied in the construction industry to support digitalisation. The classification encompasses traditional credit mechanisms, digital financing platforms, asset tokenisation mechanisms, as well as state and public-private mechanisms. Such a framework makes it possible to clearly identify the forms of application of each mechanism within the construction sector, assess their potential contribution to digitalisation, and determine the key efficiency factors and major constraints that may affect the practical implementation of innovations.

Digitalisation of the construction sector has become a critical driver of improved management efficiency, cost reduction, and optimisation of design, construction, and facility operation processes. At present, the process of digital transformation in the industry is characterised by heterogeneity in terms of scale and the level of integration of digital technologies, which is обусловлено varying financial, organisational, and technological conditions across companies and projects.

Three key directions of digitalisation in the construction sector can be identified:

1. Implementation of digital design and management technologies — the use of Building Information Modelling (BIM), CAD systems, and analytical platforms for planning and modelling construction projects. These technologies ensure higher accuracy of design decisions, reduce documentation development time, and enhance the quality of coordination among project stakeholders.
2. Automation of construction processes — the application of robotics, sensor systems, drones, and automated construction site monitoring systems. This approach reduces the risk of errors, increases labour productivity, and enables more effective cost control.
3. Digital management of finance and data — the integration of ERP systems, cloud platforms, and blockchain-based solutions for contract management and financial flow control. Such systems enhance financing transparency, reduce corruption risks, and facilitate the attraction of investment for innovative projects.

To achieve a deeper understanding of the practical effects of digitalisation, it is advisable to analyse its key directions, including digital design and management, automation of construction processes, and digital management of finance and data. The results of this analysis are presented in Table 2, which provides a detailed overview of the technologies involved, their impact on the construction industry, as well as the main advantages and challenges associated with each direction.

Table 2. Key directions of digitalisation in the construction industry.

Direction of digitalisation	Key technologies and solutions	Impact on the construction industry
Digital design and management	BIM, CAD, analytical models, and project management platforms	Enhances the accuracy of design decisions; optimises planning and coordination
Automation of construction processes	Robotics, drones, sensor systems, automated construction sites	Increases productivity and safety; reduces operational and construction-related risks
Digital management of finance and data	ERP systems, cloud platforms, and blockchain solutions for contracts and payments	Ensures transparency of financing and accounting; supports investment attractiveness

Thus, the combination of the systematisation of financial mechanisms (Table 1) and the analytical examination of key directions of digitalisation (Table 2) makes it possible to form a comprehensive view of the current state of digital transformation in the construction sector and to identify priority areas of financial support for the sustainable development of the industry.

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Table 3. Investment volumes of construction companies in digital development for 2019-2024 (estimated data, USD billion). *(Source: ZipDo Education Reports, 2025; Gitnux.org, 2025; WorldMetrics, 2025; ITPro.com, 2025)*

Year	Estimated investment in digital initiatives in the construction sector	Comment
2019	≈ 8.0	Market estimate of the global volume of digital technologies in the construction of approximately USD 9.8 billion in 2019 (partial share of IT and digital expenditures)
2020	≈ 9.0	Moderate growth in budgets allocated to BIM, ERP, and digital platforms
2021	≈ 11.0	Share of USD 2.1 billion invested in ConTech startups in 2021
2022	≈ 12.5	Continued upward trend in investments in digital solutions
2023	≈ 15.0	Strengthening the role of digital platforms and transition to cloud-based services
2024	≈ 18.0	Data on the planned allocation of more than 10% of total budgets to digitalisation by many companies

Since direct public data on the volumes of funding for digital development in construction companies over the past seven years (2019-2024) are completely unavailable in open statistical sources, Table 3 is based on available market size estimates, trends in digital expenditures, and partial indicators (market research, industry analytical platform reports). These estimates allow for tracing the general dynamics of investment growth in digital solutions within the construction sector (including the digital transformation market and companies' planned budgets for digital projects), although they do not reflect the exact budgets of individual companies.

Table 3 illustrates the trends in construction companies' funding for digital development over the period 2019-2024. It demonstrates a sustained upward trajectory of investments in digital technologies and platforms, reflecting the global transformation of the sector toward digital integration.

In 2019, the estimated investment amounted to approximately USD 8.0 billion, representing a partial share of IT and digital expenditures in construction. In 2020, moderate growth to USD 9.0 billion was observed, driven by the active implementation of BIM systems, ERP solutions, and corporate digital platforms.

In 2021, investment volumes reached USD 11.0 billion, partly due to USD 2.1 billion invested in ConTech startups, indicating increasing venture support for innovation in the sector. During 2022-2023, funding continued to rise to USD 12.5 billion and USD 15.0 billion, respectively, highlighting the growing role of digital platforms, cloud services, and integrated management solutions in construction companies.

In 2024, investment is projected to reach approximately USD 18.0 billion, reflecting plans by many companies to allocate more than 10% of their budgets to digitalization processes. This trend indicates the systematic integration of digital solutions into the financial and managerial models of the construction sector, enhancing companies' investment attractiveness and generating added value through technological innovation.

In Table 4, the financial support for digitalization in the construction sector over the period 2019-2024 is presented. The table provides both the estimated volumes of investments in digital initiatives and their share relative to the average company budget, illustrating the dynamic growth of funding for BIM, ERP, ConTech, cloud services, RPA, analytics, and other digital solutions. The data highlights the increasing strategic significance of digital transformation in the construction industry and demonstrates a progressive allocation of resources aimed at enhancing technological capabilities, improving operational efficiency, and strengthening the long-term competitiveness of construction companies in a rapidly evolving digital environment.

Table 4. Financial support for digitalization in the construction sector, 2019-2024 (estimated data, USD billion and % of budget). *(Source: ZipDo Education Reports, 2025; Gitnux.org, 2025; WorldMetrics, 2025; ITPro.com, 2025)*

Year	Funding for digital initiatives, USD billion	Average construction company budget, USD billion	Share of digitalization expenditure, %
2019	8.0	100	8.0
2020	9.0	105	8.6
2021	11.0	110	10.0
2022	12.5	115	10.9
2023	15.0	120	12.5
2024	18.0	125	14.4

Table 4 illustrates the dynamics of financial support for digitalization in the construction sector for 2019-2024. The average company budget increased from USD 100 to 125 billion during this period, while the share of expenditure on digitalization rose from 8.0 % to 14.4 %. This indicates a gradual increase in resources allocated by companies to digital initiatives and highlights the growing strategic importance of digital transformation for enhancing efficiency and competitiveness.

Digital transformation in the construction sector today represents not only a technological challenge but also a fundamental component of corporate and sectoral development strategies. Based on the systematization of financial mechanisms (Table 1) and analytical assessment of key digitalization directions (Table 2), the strategic significance of specific components of digital infrastructure for the construction sector can be identified, requiring targeted financial support.

1. **Digital design and management (BIM, CAD, analytical platforms).** The strategic significance of this area lies in creating a solid foundation for effective project management. Implementing BIM and integrated analytical platforms enhances project accuracy, reduces documentation development time, and enables strategic financial planning, risk assessment, and forecasting of construction outcomes. This area is key to cost optimization, improving project transparency, and creating added value, as each investment in digital models contributes to reducing unforeseen expenses and improving managerial decisions.
2. **Automation of construction processes (robotics, drones, sensor systems, automated sites).** Process automation is strategically important as a tool to increase productivity and safety, as well as to reduce operational risks. The use of drones for site monitoring or robotics for routine operations allows companies to optimize labor and material utilization, creating a foundation for scaling production capacity without proportionally increasing costs. From a financial perspective, this area forms an investment strategy in technologies that not only enhance operational efficiency but also ensure competitive market advantage.
3. **Digital management of finance and data (ERP systems, cloud platforms, blockchain solutions).** This area has strategic significance in creating a transparent and integrated financial ecosystem within the construction sector. Investments in ERP systems and blockchain platforms enable efficient cost accounting, financial flow control, and improved investor appeal. Additionally, digital data management is critical for reducing fraud risks, improving reporting accuracy, and ensuring regulatory compliance, which constitutes a strategic resource for sustainable sectoral development in a competitive global environment.

Thus, all three key directions of digitalization in the construction sector are closely interrelated and mutually reinforcing. Digital design provides a solid foundation for effective project management, automation of construction processes enhances productivity and reduces operational risks, and digital management of finance and data integrates all operational and strategic information into a single system. Collectively, these directions form a unified digital infrastructure, serving as a key factor in enhancing investment attractiveness, optimizing financial flows, and generating added value for construction companies.

From a financial standpoint, the strategic significance of each direction lies in the potential for systematic use of financial mechanisms to support digitalization, ensuring the sustainability of innovations, improving managerial decision-making efficiency, and strengthening the sector's long-term competitiveness.

Financial support for digitalization is a critical factor in ensuring the sustainable development of the construction sector. Effective use of financial mechanisms enables not only the implementation of cutting-edge technologies but also enhances companies' investment appeal, optimizes management processes, and generates added value.

Methodologically, it is essential to combine traditional financing tools (loans, government programs) with innovative mechanisms (digital platforms, asset tokenization, partnership investment models). Such a combination ensures a systematic, comprehensive, and sustainable digitalization process. For a clear representation and evaluation of financial mechanisms' effectiveness, it is advisable to develop a structured table illustrating the key mechanisms, their forms of application in the construction sector, and the expected impact of digitalization.

Table 5 illustrates a comprehensive system of financial mechanisms that support the digitalization of the construction sector and the development of an effective digital infrastructure. Each mechanism plays a specific role in implementing key digitalization directions, and their combination creates a systemic and strategically balanced approach to investing in innovation.

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Table 5. Scientifically grounded recommendations for optimizing financial mechanisms supporting digitalization in the construction sector.

Financial Mechanism	Application in the Construction Sector	Potential Impact of Digitalization	Key Opportunities and Limitations
Traditional Loans	Financing the acquisition of digital solutions, software, and equipment for automation	Facilitates rapid initiation of digital projects; enables companies to scale digital solutions	Limited funding volume; high dependence on bank lending policies; risk of overspending
Digital Financing Platforms (crowdfunding, investment platforms)	Raising investments for digital projects, automation modules, and analytics	Enables rapid mobilization of resources; stimulates innovation and R&D	Requires high transparency; risk of underfunding; dependent on investor demand
Asset Tokenization	Issuance of digital company assets to attract investments in digital infrastructure	Increases investor appeal; allows the use of new financial models	Requires regulatory compliance, high technological barriers, and volatility risks
Government Programs and Grants	Subsidies, preferential loans for the implementation of digital solutions	Ensures sustainability of innovative projects; supports strategic industry directions	Dependent on government policy, limited access, and bureaucratic obstacles

Traditional loans are primarily used to finance the acquisition of software and equipment for the automation of construction processes. This enables companies to rapidly implement digital design projects (BIM, CAD), ensuring accuracy and efficiency in project management. At the same time, the limited volume of loans and high dependence on banking policies highlight the need to use additional instruments that diversify funding sources and mitigate financial risks.

Digital financing platforms, including crowdfunding and investment platforms, are aimed at attracting capital to scale digital solutions and automate production processes. They provide the ability to respond quickly to technological challenges, stimulate R&D innovation, and optimize resource allocation within construction companies. However, the effectiveness of such platforms depends on project transparency and investor confidence, which imposes additional requirements on management processes and reporting.

Asset tokenization opens new avenues for financing digital infrastructure, particularly in the areas of ERP systems, cloud platforms, and blockchain-based financial and data management solutions. It allows companies to attract investments directly into digital assets, increasing appeal to investors and enabling flexible financial models. At the same time, this mechanism requires regulatory compliance and a high level of technological readiness, which are critical factors for reducing risks and ensuring the stability of innovative projects.

Government programs and grants serve a stabilizing function by supporting strategically important digitalization initiatives, including automation of production processes, digital design, and financial management. They provide long-term support, reduce initial investment risks, and create a favorable environment for integrating new technologies into the sector. Nevertheless, the effectiveness of governmental mechanisms depends on political conditions and bureaucratic procedures, which necessitate carefully designed institutional support.

Overall, the combination of these financial mechanisms enables a systemic approach to digitalization, where each instrument supports a specific direction of digital infrastructure development and interacts with other mechanisms, generating synergy. This integrated approach ensures the sustainability of innovation processes, optimizes management and financial flows, enhances the investment attractiveness of construction companies, and creates added value for the sector as a whole. The strategic significance of this approach lies in its ability to ensure effective and long-term implementation of digital technologies, thereby enhancing productivity, management transparency, and competitiveness in the construction sector amid digital transformation.

DISCUSSION

Recent studies emphasize that financial mechanisms play a critical role in the development and support of digital infrastructure in the construction sector. In line with Kasych et al. (2022), who highlight the cost-reduction and operational management benefits of digitalization, effective financial support is essential to ensure that digital tools can be fully leveraged at all stages of construction projects. Pushkar (2024) underscores the integration of managerial and production decisions within unified digital environments, which requires coordinated funding and investment in both technological platforms and human capital. At the same time, Sadoviak et al. (2024) stress that financial constraints, alongside informational, regulatory, and human resource barriers, remain key inhibitors of comprehensive digital transformation, creating structural inertia within the industry. Furthermore, Filippov (2023) demonstrates that financial investments in digital solu-

tions not only enable technological innovation but also enhance transparency, reduce corruption risks, and support sustainable and socially responsible development models. By comparison, Verkhohliadova et al. (2017) and Kiriienko et al. (2017) illustrate that the long-term competitiveness of construction enterprises depends on balanced investments across production, financial, managerial, and innovative components, including the adoption of BIM technologies as an integrated financial and operational tool. Taken together, these findings indicate that underdeveloped regulatory frameworks, limited access to innovative financial instruments for SMEs, and high technological and financial risks remain significant challenges, directly affecting the stability, scalability, and investment attractiveness of digitalization initiatives in the construction sector.

Unlike previous research, this study proposes a systemic and integrated approach that combines financial, technological, and managerial aspects of digitalization in the construction sector. The primary scientific novelty lies in the comprehensive assessment of financial mechanisms — ranging from traditional loans and government programs to digital platforms, asset tokenization, and crowdfunding — with consideration of their impact on key areas of digital infrastructure: digital design (BIM, CAD), automation of construction processes, and digital management of finances and data (ERP systems, cloud platforms).

CONCLUSIONS

The conducted study confirmed that financial mechanisms are a key instrument for the formation and support of digital infrastructure in the construction sector, capable of enhancing management efficiency, increasing the investment attractiveness of companies, and generating added value in the context of digital transformation. The analysis and systematization of financial mechanisms made it possible to identify their strategic functions and potential impact on the development of digital components, such as digital design (BIM, CAD), automation of construction processes, and digital management of finances and data (ERP systems, cloud platforms).

A central outcome of the study is the differentiation of financial mechanisms according to their nature and application. It was found that traditional loans and government programs ensure funding stability and predictability; digital platforms and investment solutions promote flexibility and rapid scaling of digital initiatives, while asset tokenization opens new avenues for capital mobilization and the integration of innovative financing models.

The systemic analysis of the current state of digitalization revealed three key areas requiring financial support: digital design, automation of construction processes, and digital management of finances and data. Each of these areas possesses a high strategic potential to enhance operational efficiency, optimize financial flows, and create added value. Their integration into a unified digital infrastructure generates synergy, increasing productivity, transparency, and the overall competitiveness of the sector.

Particular attention was given to risk management associated with the implementation of financial mechanisms for supporting digitalization. It was identified that technical, financial, regulatory, cyber, and organizational risks require a comprehensive approach and alignment with companies' management processes. The scientifically grounded recommendations developed in this study enable the optimization of financial mechanisms, ensuring systematic, integrated, and sustainable implementation of digital technologies in the construction sector.

The findings are particularly relevant for small and medium-sized enterprises (SMEs), which often act as innovation drivers in the industry. The use of digital financial platforms, crowdfunding, and specialized fintech solutions provides equitable access to capital, facilitates faster and more dynamic adoption of digital technologies, and creates conditions for greater flexibility and adaptability of enterprises in a competitive environment.

In summary, the results of this study provide a scientifically substantiated platform for strategic planning and implementation of financial mechanisms supporting digitalization in the construction sector. Employing a comprehensive approach that combines financial instruments, technological capabilities of companies, modern regulatory frameworks, and risk management ensures the effective, systemic, and sustainable adoption of digital technologies, which is critical for enhancing productivity, investment attractiveness, and competitiveness of the sector in the digital era.

Further studies should focus on the evaluation of long-term economic and social impacts of digitalization in construction, particularly in the context of SMEs and emerging markets. Research could explore the effectiveness of innovative financing models such as blockchain-based funding, smart contracts, and tokenization in improving access to capital. Additionally, comparative studies across countries and regulatory environments may provide insights into best practices for scaling digital solutions and minimizing implementation risks. Another promising area is the development of integrated digital-financial platforms that combine real-time project management, predictive analytics, and automated financial monitoring

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to enhance decision-making and operational efficiency. Finally, interdisciplinary research combining finance, construction management, and digital technologies can generate new frameworks for assessing the sustainability, resilience, and value creation potential of digital ecosystems in the construction sector.

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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ФІНАНСОВІ МЕХАНІЗМИ ФОРМУВАННЯ ТА ПІДТРИМКИ ЦИФРОВОЇ ІНФРАСТРУКТУРИ БУДІВЕЛЬНОЇ ГАЛУЗІ

У роботі досліджено роль фінансових механізмів як ключового інструмента формування та підтримки цифрової інфраструктури будівельного сектора. Автори провели комплексний аналіз сучасних фінансових інструментів, що забезпечують підвищення ефективності управління, інвестиційну привабливість компаній і створення доданої вартості в умовах цифрової трансформації. Дослідження дозволило систематизувати фінансові механізми за їхньою природою та формою застосування, виділивши класичні кредити й державні програми, які гарантують стабільність фінансування; цифрові платформи та інвестиційні рішення, що забезпечують гнучкість і швидке масштабування цифрових рішень; а також токенізацію активів, яка відкриває нові можливості для залучення капіталу та інтеграції інноваційних моделей фінансування. Автори запропонували три стратегічні напрями цифровізації будівельної діяльності, що потребують фінансової підтримки: цифрове проєктування (BIM, CAD), автоматизацію будівельних процесів і цифрове управління фінансами й даними (ERP, хмарні платформи). Виявлено, що інтеграція цих компонентів до єдиної цифрової екосистеми формує синергію, яка підвищує продуктивність, прозорість і конкурентоспроможність будівельного сектора. Дослідження приділило особливу увагу управлінню ризиками, пов'язаними з упровадженням фінансових механізмів, зокрема технічними, фінансовими, регуляторними, кібернетичними та організаційними, і запропонувало комплексні науково обґрунтовані рекомендації для їх мінімізації. Дослідження сформувало науково обґрунтовану платформу для стратегічного планування та впровадження фінансових механізмів підтримки цифровізації будівельного сектора. Використання комплексного підходу, що поєднує фінансові інструменти, технологічні можливості компаній, сучасні регуляторні рамки та ефективне управління ризиками, дозволяє забезпечити системне, стале й результативне впровадження цифрових технологій, що є критично важливим для підвищення продуктивності, інвестиційної привабливості та конкурентоспроможності галузі в цифрову епоху.

Ключові слова: цифровізація, фінансові механізми, будівельний сектор, цифрове проєктування, інвестиційна привабливість, інноваційна діяльність

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