

Development of the investment and construction sectors of the economy in the context of digitalisation

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<p><i>Article history:</i> Received April 18, 2025 Received in revised form May 24, 2025 Accepted September 16, 2025 Available online December 01, 2025</p> <p><i>Keywords:</i> Artificial intelligence Cloud technologies Construction industry Digital transformation Digitalization Investments Productivity</p> <p>*Corresponding author: Dmytro Komyshev School of Civil Engineering, North Minzu University, Academician of the Engineering Academy of Ukraine, Kharkiv, Ukraine Email: dmytrokomyshev@outlook.com ORCID: https://orcid.org/0009-0002-6162-1532</p>	<p>The construction industry plays a key role in infrastructure development and economic growth, especially in the Asia-Pacific region (APAC), where almost half of the world's construction is expected to be concentrated by 2030. Investment activity in this region, thanks to digitalization, helps to optimize design, construction management, and financing processes, which increases the market's attractiveness to international investors. Given this, digital transformation is a determining factor in improving the efficiency, safety, and environmental friendliness of the industry, which necessitates a study of its impact on businesses. The purpose of this research article is to analyze the level of digitalization of the construction industry, assess the main barriers and prospects for the introduction of digital technologies, and determine their impact on the productivity of enterprises. The study is based on general scientific methods of cognition, including the synthesis of literature sources, methods of generalization and systematization, analysis of statistical data and comparison of the results of regression analysis of the relationship between the level of digitalization and key performance indicators of enterprises for the period 2024-2025. Given that digitalization contributes to increasing productivity, quality of construction, investment attractiveness and economic efficiency of enterprises; it was found that the main trends are the growth of the use of 3D printing (39%), artificial intelligence (37%), the Internet of Things (45%) and cloud software (49%); at the same time, barriers are high costs (54%), lack of digital skills (54%) and low level of staff adaptation to innovation (51%). Digital transformation is a strategic imperative for the construction industry to ensure competitiveness and sustainable development. Successful implementation of digital technologies depends on the elimination of financial, organizational and personnel barriers, as well as on the consistency of digital solutions with the overall strategy of enterprises.</p>

Introduction

The development of the investment and construction industries plays a strategic role in shaping the modern economy, ensuring the growth of production capacity, modernization of infrastructure, and increasing the competitiveness of national economic complexes. In the context of the global digital transformation, the introduction of the latest technologies in construction and investment activities is becoming a prerequisite for increasing efficiency, reducing costs, and improving the quality of implemented projects. This issue is especially relevant for the Asia-Pacific region, where a significant increase in construction volumes is projected, requiring comprehensive modernization of technological processes and adaptation to new digital challenges. Infrastructure development is a key area of activity for governments in the Asia-Pacific region, involving the implementation of significant projects, including transportation networks, urban development initiatives, and utilities (Nitivattananon and Krainara 2025). In particular, the Australian government's goal was for Australia to become a leading digital economy that would contribute to Australia's productivity, maintain global competitiveness, and improve social well-being by 2020 (Leviäkangas, Mok Paik, and Moon 2017), which has been achieved to some extent. In contrast, CBRE's (CBRE 2025) Asia Pacific Investment Intentions Survey revealed an increase in demand for real estate, as more than half of respondents plan to increase investment in the construction industry in 2025. Given the cycle of declining interest rates in most markets, investors are preparing to intensify against the backdrop of digitalization, which is changing the structure and dynamics of construction and investment activities; which allows to optimize management processes, increasing the efficiency and competitiveness of industries in the current economic transformation. China's 14th Five-Year Plan envisages investments of USD 4.2 trillion. The 14th Five-Year Plan of China envisages investments of USD 4.2 trillion focused on transportation and urbanization projects, while India's National Investment Project allocates USD 1.4 trillion for infrastructure. India's National Investment Project allocates USD 1.4 trillion to infrastructure, with a focus on renewable energy and urban infrastructure (Business Wire 2024).

Therefore, the integration of digital technologies into construction and investment activities is now becoming a crucial factor in improving resource management efficiency, optimizing costs, and accelerating the implementation of large-scale projects.

The purpose of this article is to analyze the key trends in the digital transformation of the construction and investment industries, to assess the level of digital technology adoption among enterprises representing these industries, and to identify the main barriers and prospects for their further development of digitalization phenomena in enterprises in the Asia-Pacific region.

Literature review

Digitalization has become an important factor that is significantly transforming the investment and construction industries, providing new opportunities to increase efficiency, reduce costs, and improve management processes (Oesterreich and Teuteberg 2016). Digitalization has fundamentally changed the investment sector by increasing efficiency, enabling real-time data analysis, and expanding market access. The integration of technologies such as blockchain, big data analytics, and fintech solutions has not only optimized transactions, but also created new opportunities and challenges, requiring investors to navigate cybersecurity risks and regulatory complexities (Goa InvestQ Partners 2023). According to Ha, Le, and Nguyen (2025); Tierney (2023), digital technologies, including digital portfolio managers, robo-advisors, investment portfolio software, personalized financial services, digital payments, and RegTech, help optimize the activities of institutional investors, allowing them to clearly define development strategies and adjust economic policies in the context of digital transformation.

According to data collected by Leviäkangas, Mok Paik, and Moon (2017), construction has become one of the most important industries in Australia, investing approximately 1% or less in information and communication technologies (ICT) as its share of GVA; however, it invested about 15% of its total investment (gross fixed capital formation) in ICT. Many researchers attribute the impact of digital technologies on these industries to the increased efficiency and productivity of digital tools, in particular, building information modeling (BIM) and machine learning algorithms optimize resource management and construction processes, leading

to lower costs and time savings (Kapogiannis 2024; ARUTIUNIAN et al. 2024) also emphasize the possibility of continuous monitoring of construction sites through IoT technologies, improving safety and maintenance through immediate detection of problems. According to Leviäkangas et al. (Leviäkangas, Mok Paik, and Moon 2017), the possibilities of the construction industry are almost endless and cover the entire value chain of the construction process, from urban and land use planning to the management of built environment assets. Naji et al. (2024) note that digitalization is causing profound transformations in the construction industry, changing traditional approaches to project management, planning, construction and facility operations, which increases efficiency, reduces costs and contributes to the strategic development of the sector. However, according to Samuelson and Stehn (Samuelson, Olle, and Lars Stehn 2023), the digitalization of the construction industry, while contributing to process efficiency, faces significant challenges due to its fragmented structure, B2B business orientation, and insufficient attention to changes in value creation. Key technologies that will drive the construction industry in the long term include artificial intelligence for predictive analytics, robotics for automation, BIM for design coordination, 3D printing for material fabrication, and digital twins for real-time monitoring (Sacks et al. 2020; Bolpagni et al. 2022; Xiao, Chen, and Yin 2022).

As these industries are traditionally important components of economic development, their modernization through innovative technologies is a prerequisite for achieving sustainable development (Nikonenko et al. 2022; Shevchenko et al. 2023; Švajlenka and Pošiváková 2023), high-quality construction growth by improving technical efficiency and encouraging entrepreneurial innovation (Li et al. 2024), and competitiveness of the construction industry in the global market, which requires strategic implementation to overcome existing challenges (Ali and Hajjar 2024; Kaewunruen et al. 2024; Kubanov, Yashchenko, and Makatora 2024; Tsimoshynska et al. 2021). Despite the benefits, there are differences in the use of digital technologies, as stronger economies use digital tools more effectively than weaker ones, which requires structural reforms to ensure equitable access to digital advances in construction (Kapogiannis 2024). In addition, a study conducted by Revell (2007) among small and

medium-sized construction companies in the UK showed that the financial returns from implementing eco-efficiency measures fully justify the investment of time and resources required to implement them; which indicates the problem of perception of the importance of these investments by the management of such companies, especially in the context of digitalization, innovation and sustainable development.

Methods

The following methods were used in the research process:

- Synthesis of literature sources was used to analyze theoretical approaches to the digitalization of the construction industry, assess the impact of digital technologies on the economic development of the regions and identify general trends in the industry;
- Comparative analysis was used to assess the level of implementation of digital technologies in different countries of the Asia-Pacific region, as well as to identify the dynamics of the use of certain innovations in construction during 2023-2025;
- Analysis of statistical data was used to assess the size of the construction market on a global scale, determine the level of digital technology adoption, and analyze the key barriers to the digital transformation of the construction industry. The analysis was carried out using data from Deloitte (2023); (2024); (2025) analytical reports, which allowed us to assess the dynamics of the application of innovative solutions and determine their impact on the efficiency of companies;
- Regression analysis was used to assess the statistically significant impact of digital technologies on the main economic indicators of construction companies, including profit growth, revenue, and compliance with project budgets and time frames;
- The method of generalization was used to systematize the main results of the study, to formulate conclusions on the introduction of digital technologies and their impact on construction efficiency;
- The systematization method was used to group information on the level of digital maturity of the construction sector, identify key barriers and

prospects for the use of digital solutions in construction.

Results and discussion

The construction industry currently plays a key role in infrastructure development, providing residential and commercial buildings, roads, energy systems and other facilities. The importance of this industry for the economic growth of the Asia-Pacific region (APAC) is confirmed by forecasts that almost half of the world's construction will be concentrated in this

region by 2030. The global construction market generated a total output of USD 5.11 trillion in 2023. It is expected to grow to USD 8.65 trillion by 2030. US DOLLARS. These dynamics emphasize the need for accelerated implementation of digital technologies that can improve the efficiency, safety and quality of construction work. In this context, the study commissioned by Autodesk analyzes the key trends of digital transformation in construction (figure 1), as well as the level of digital technology adoption in Asia-Pacific countries, including Australia, Japan, Singapore, Hong Kong, Malaysia and India.

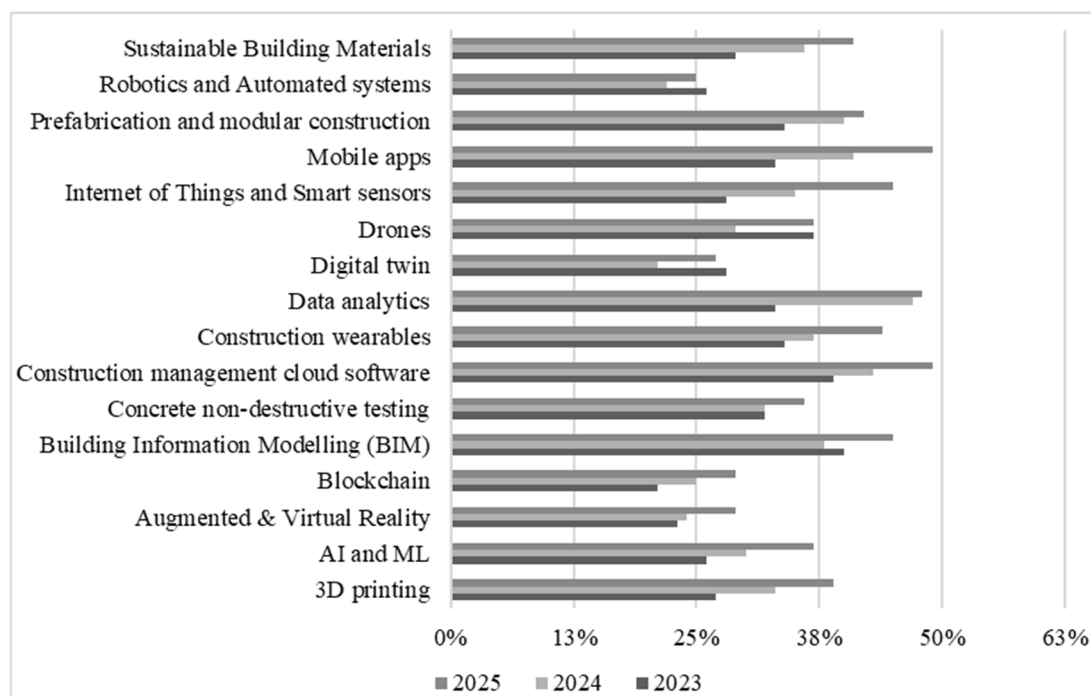


Figure 1. Trends in the use of key digital technologies in the construction industry
 Source: (Deloitte 2023; 2024; 2025)

The analysis of trends in the use of digital technologies in the construction sector in 2023-2025 shows a steady increase in the introduction of key innovations. In particular, a significant spread of technologies such as 3D printing (growth from 27% in 2023 to 39% in 2025), artificial intelligence and machine learning (from 26% to 37%), as well as the Internet of Things and smart sensors (from 28% to 45%) is forecasted. There has also been a significant increase in the use of mobile applications (from 33% to 49%) and cloud-based construction management software (from 39% to 49%). Particular attention should be

paid to the spread of sustainable building materials, the use of which increased from 29% to 41% in 2025, which emphasizes the importance of the environmental component in the development of the construction industry. At the same time, there are fluctuations in the adoption of technologies such as digital twins (down from 28% in 2023 to 21% in 2024, with a further recovery to 27% in 2025) and robotic and automated systems (down to 22% in 2024 with a slight increase to 25% in 2025). These trends indicate a differentiated speed of adaptation of

technological innovations depending on their level of complexity and economic feasibility.

The significance of digitalization for the construction industry is justified by its impact on increasing productivity and improving the quality of final products, as well as ensuring the safety of employees. In this context, special attention is paid to the aspects of change management that are crucial for the effective implementation of technological innovations. The study surveyed 894 companies, which provided comprehensive data on the level of digital maturity of the construction sector and the challenges faced by companies in implementing the latest technologies. Consequently, construction companies that actively implement digital technologies demonstrate higher levels of productivity, reduce costs, and improve the quality of construction. At the same time, the effectiveness of digitalization largely depends on the consistency of the implemented solutions with the overall development strategy of companies and the ability of managers to adapt business processes to new conditions. Thus, digital transformation is a strategic imperative for the sustainable development of the construction and investment industry in the face of current challenges.

One of the key current challenges is the high level of costs, which is the result of steadily rising prices for raw materials and supplies, as well as a significant burden on the payroll, as illustrated in [figure 2](#). According to analytical data, 38% of companies consider material costs to be one of the three main challenges, while 31% face the problem of high personnel costs. This is complemented by economic uncertainty, which is noted by 27% of respondents, and growing competition (25%).

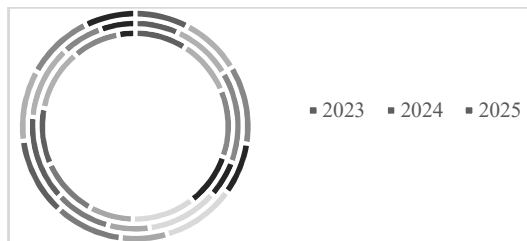


Figure 2. Barriers and challenges to the development of construction companies
Source: (Deloitte 2023; 2024; 2025)

However, one of the main ways to minimize these risks is to effectively integrate digital

technologies into business processes, as shown in [figure 3](#). Despite the significant benefits of digitalization, its implementation is constrained by a number of factors. In particular, 54% of businesses expect a shortage of digital skills among employees in 2025, which is 10% more than in 2023. At the same time, 42% of organizations face the reluctance of staff to adapt to new technologies, and 37% face the problem of staff turnover, which makes it difficult to steadily build digital competencies. The financial aspect also remains a significant barrier: 54% of companies point to the excessive cost of technological solutions, and 49% point to insufficient budget allocations.

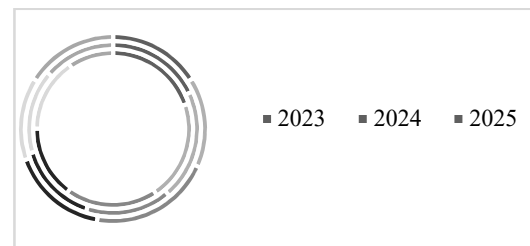


Figure 3. Perspective ways to remove barriers to investment and development of construction companies
Source: (Deloitte 2023; 2024; 2025)

Despite these barriers, the key sources of growth in the investment and construction industry in the future lie in the expansion of markets and the use of digital tools. In particular, 50% of companies plan to increase the volume of projects by attracting new orders of similar complexity, while 37% are focused on larger and more technically complex projects. At the same time, technologies for project work and internal processes remain an important driver of development, with their role estimated at 50% and 40%, respectively. Access to new international markets, which 38% of companies plan to expand in 2025, is also a significant driver of economic growth. Therefore, removing barriers to digitalization, in particular by developing employees' digital competencies and increasing investment in technological innovation, is a prerequisite for the long-term development of the construction industry in the context of global digital transformation.

In particular, the economic downturn in the Asia-Pacific market indicates a 38% drop in venture capital investment in new startup projects in 2023, reaching its lowest point since 2015. The amount raised totaled US\$78.1 billion, down from

US\$125.2 billion raised in 2022 and an even more significant decline from the peak of US\$187.4 billion in 2021. However, in 2024, large technology companies from around the world made significant investments in the Asian market. In particular, Southeast Asia is beginning to be recognized as one of the fastest growing online markets, thanks to the daily influx of new internet users. This has made the region attractive to foreign technology investors. For example, Indonesia launched the Bitera Data Center, which aims to support the country's digital economy by providing reliable data storage and processing capabilities. Adding to this, EDGE DC, a Digital Edge company, is setting new standards for sustainable data center design with low-latency connectivity services in Southeast Asia, further supporting the region's digital growth (Telecom Review Asia 2024).

Instead, the case of Australia demonstrates significant potential for the investment industry, with the construction and real estate sectors being the top priority for investment, which is an important segment of the country's economy, given the high level of urbanization and growing demand for infrastructure. Investments in the construction industry in Australia provide a wide range of opportunities for portfolio diversification, with the sector offering a variety of options for capital investment, from residential properties to commercial buildings and infrastructure projects. Major Australian cities, including Sydney, Melbourne and Brisbane, remain key locations for construction investment and are characterized by strong economic

development, high levels of urbanization and sustainable demand for housing, creating attractive conditions for construction investment. In particular, Melbourne is experiencing rapid growth in the multifamily residential sector, and Brisbane is actively developing infrastructure projects, focusing on the development of new housing and commercial space to meet the needs of a rapidly growing population. Rental rates for these properties provide investors with a stable income, and this sector is attractive for long-term investment (Finexia 2024). The digitalization of construction processes, including the use of BIM (Building Information Modeling) and the Internet of Things (IoT), can reduce costs and increase construction efficiency. Technologies that integrate energy-saving solutions and intelligent energy management systems reduce the environmental impact and help reduce the cost of operating buildings. Thus, digital technologies in construction not only help to save resources but also become an important component of investment projects focused on sustainable development.

In the context of digitalization, the investment and construction sectors of the economy demonstrate the evolution of the identified trends, which is confirmed by the results of the regression analysis for 2024-2025 (table 1). The use of digital technologies in these areas has a statistically significant positive impact on key performance indicators, including profit growth, revenue, and compliance with budget and project implementation timeframes.

Table 1. Results of regression analysis of the impact of digital technologies on performance in the investment and construction industries (2024-2025)

	Profit growth		Revenue growth		% of projects under budget		% of projects on time	
	2024	2025	2024	2025	2024	2025	2024	2025
count_techs	0,11 (0,003)	0,11 (0,005)	0,014 (0,003)	0,014 (0,005)	0,005 (0,002)	0,008 (0,002)	0,007 (0,002)	0,006 (0,002)
num_employees	0,00000 (0,00000)	0,00000 (0,00000)	-0,00000 (0,00000)	-0,00000 (0,00000)	0,00000 (0,00000)	0,00000 (0,00000)	0,00000 (0,00000)	-0,00000 (0,00000)
Hong Kong	-0,027 (0,050)	-0,135 (0,075)	-0,004 (0,040)	-0,157 (0,082)	0,029 (0,031)	-0,044 (2,738)	0,036 (0,026)	-0,053 (0,029)
India	0,046 (0,038)	0,034 (0,056)	0,104 (0,031)	0,072 (0,061)	0,033 (0,025)	0,025 (0,021)	0,004 (0,020)	0,008 (0,022)
Japan	-0,071 (0,038)	0,045 (0,068)	-0,022 (0,031)	0,064 (0,074)	0,089 (0,025)	-0,008 (0,025)	0,00004 (0,024)	-0,091 (0,021)
Malaysia	0,008 (0,047)	-0,084 (0,068)	0,053 (0,038)	-0,070 (0,074)	-0,018 (0,029)	-0,013 (0,025)	-0,008 (0,024)	-0,021 (0,021)
Singapore	0,065 (0,046)	-0,083 (0,066)	0,029 (0,037)	-0,108 (0,072)	0,034 (0,028)	0,033 (0,025)	0,009 (0,023)	0,008 (0,026)

	Profit growth		Revenue growth		% of projects under budget		% of projects on time	
	2024	2025	2024	2025	2024	2025	2024	2025
More than 1 year, up to 3 years	-0,303 (0,232)	-0,055 (0,346)	-0,303 (0,194)	-0,218 (0,377)	0,245 (0,158)	-0,037 (0,181)	-0,051 (0,107)	-0,101 (0,191)
More than 10 years, up to 20 years	-0,380 (0,227)	-0,185 (0,334)	-0,216 (0,191)	- 0,310 (0,364)	0,159 (0,155)	-0,105 (0,177)	-0,106 (0,104)	-0,070 (0,187)
More than 20 years	-0,367 (0,227)	-0,231 (0,334)	-0,256 (0,191)	-0,360 (0,364)	0,122 (0,155)	-0,085 (0,177)	-0,143 (0,104)	-0,072 (0,187)
More than 3 years, up to 10 years	-0,361 (0,227)	-0,149 (0,335)	-0,235 (0,191)	-0,268 (0,365)	0,206 (0,155)	-0,072 (0,177)	-0,089 (0,104)	-0,032 (0,187)
R ²	0,059	0,036	0,111	0,044	0,048	0,078	0,058	0,105
Adjusted R ²	0,043	0,019	0,097	0,027	0,033	0,061	0,044	0,089

The results of regression modeling indicate that the impact of the number of implemented technologies on financial indicators is stable: the regression coefficient for profit growth remains unchanged (0.11 at $p < 0.005$), which confirms the stability of the digital impact trend. For revenue growth, this coefficient is 0.014 (at $p < 0.005$) in both years, which indicates a similar impact of digital technologies in the long run. Regarding the effectiveness of cost and project management, there is a slight increase in the coefficients: the share of projects completed within budget increases from 0.005 (at $p < 0.002$) in 2024 to 0.008 (at $p < 0.002$) in 2025, and the rate of compliance with deadlines increases from 0.007 (at $p < 0.002$) to 0.006 (at $p < 0.002$), respectively.

In addition, taking into account regional factors shows some differences. For example, Hong Kong is expected to see a decline in profits and revenues in 2025, while Japan, on the contrary, will see an improvement in terms of revenue growth; this is due to different levels of digitalization and market specifics. Similar trends can be observed in other regions, such as India and Singapore, which indicates the heterogeneity of the impact of digitalization depending on national economic conditions. The analysis also demonstrates the impact of the age of enterprises on the results: young companies (up to 3 years old) show a more positive effect of digital technologies, while enterprises with more than 20 years of history have less pronounced benefits; this is due to organizational inertia and the complexity of adapting to digital changes. Thus, the trends in the development of the investment and construction industry in the context of digitalization indicate a positive impact of digital technologies on the efficiency of companies.

However, regional peculiarities and the age of enterprises remain important factors that determine the degree of realization of this potential. Given these results, we can predict further integration of digital technologies into these industries, which will help to increase the competitiveness and financial stability of enterprises.

Discussion

The further development of the investment and construction sectors of the economy in the context of digitalization requires a comprehensive approach to improving the digital maturity of enterprises, including the implementation of five strategic priorities. The first step is to eliminate outdated IT systems that pose risks of data fragmentation and increase staff training costs. Gonzalez et al. note that optimizing the technology stack will reduce the time spent on data management and increase the efficiency of work processes (Gonzalez, Rodriguez, and Manzanares 2024). Instead, Ogundipe et al. suggest optimizing the construction materials supply chain using artificial intelligence based on real-time data analytics, automation of procurement workflows, and integration of intelligent logistics management systems, which will reduce costs by minimizing waste and optimizing logistics, increasing the efficiency of procurement processes, and improving project timelines (Olorunshogo Benjamin Ogundipe, Azubuiki Chukwudi Okwandu, and Sanni Ayinde Abdulwaheed 2024).

The second important area involves implementing effective change management, which includes communicating the benefits of digital solutions to staff, testing new technologies,

and implementing them in stages. Studies by Eyieyien et al. show that companies that implement planned change management activities can significantly increase the expected return on digital investments (Osemeike Gloria Eyieyien et al. 2024; Leong et al. 2024; Kala Kamdjoug 2024; Zhong et al. 2025).

The third aspect of development is related to the assessment of subcontractors' digital maturity and the integration of digital solutions into joint production activities. As 58% of companies have a higher level of digital maturity than their partners, there is a need to standardize technological requirements and introduce common digital platforms. An example of such an approach is the development of a digital readiness index for contractors in Alnaser et al., which allows to increase the level of digital integration of the entire industry (Alnaser et al. 2024).

The fourth key task is to build a reliable digital ecosystem through cooperation with technology partners and educational institutions. Given the significant shortage of digital skills in the construction industry, companies should more actively engage external experts to develop specialized solutions and train staff (Rocha et al. 2025), encourage construction companies to participate in specialized training (Nwaogu et al. 2024; Nyqvist et al. 2025), and invite university professors and training providers to expand opportunities for the development of skilled workers in the construction industry (Zhou and Cheng 2024).

The last priority is to develop internal expertise in artificial intelligence and machine learning. Given the rapid growth in the adoption of these technologies, the formation of internal training programs will create a qualified team capable of using AI solutions to optimize management and production processes (Ali and Hajjar 2024; ARUTIUNIAN et al. 2024; Kapogiannis 2024; Olorunshogo Benjamin Ogundipe, Azubuike Chukwudi Okwandu, and Sanni Ayinde Abdulwaheed 2024). Thus, the consistent implementation of these strategies will ensure the sustainable development of the investment and construction industry in the context of global digital transformation.

Conclusions

The results of the study confirm that digitalization is a key factor in improving the efficiency of the construction and investment industry, contributing to productivity growth, cost reduction, and project quality improvement. Regression modeling has shown a stable positive impact of digital technologies on financial performance, including profit growth (coefficient of 0.11 at $p < 0.005$) and revenue (0.014 at $p < 0.005$) in the long term, as well as improved cost management (increase from 0.005 ($p < 0.002$) in 2024 to 0.008 ($p < 0.002$) in 2025) and project timelines (increase from 0.007 ($p < 0.002$) in 2024 to 0.006 ($p < 0.002$) in 2025). At the same time, there is a regional differentiation in the impact of digitalization: in Hong Kong, profit and revenue indicators are declining in 2025, while Japan is showing improvement, due to the level of digitalization. Similar differences are typical for India and Singapore, which emphasizes the importance of taking into account national economic conditions. In addition, the analysis showed that young companies (up to 3 years old) benefit more from digital technologies, while companies with more than 20 years of history show less effect due to organizational inertia and difficulty in adapting.

Therefore, special attention should be paid to the growing importance of digital, innovative, and environmental technologies, including sustainable building materials, which are becoming increasingly popular due to the growing demands for sustainable development. At the same time, there are a number of challenges that limit the pace of digital transformation in the construction industry. The main barriers include high costs of technology implementation, insufficient digital competencies of employees, and low readiness of organizations for change. In addition, there are certain fluctuations in the use of certain technologies, which is due to both economic and organizational factors. Despite these difficulties, the prospects for the development of the construction and investment industry are inextricably linked to further digitalization. Companies that actively integrate digital technologies into their business processes demonstrate higher levels of productivity, cost reduction, and increased profitability. In addition, the expansion of international markets, the use of advanced project management technologies, and

increased investment in digital innovations are important strategic directions for the industry. Accordingly, the formation of a comprehensive digital transformation policy at the level of government regulation and the business environment should be a key task to ensure sustainable economic growth in the construction sector.

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Author(s) contribution

Oleksandr Zavora contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Nina Petrukha contribute to methodology, supervision, and validation.

Dmytro Komyshev contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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