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DIGITAL-DRIVEN RECONSTRUCTION OF UKRAINE: CONSTRUCTION INNOVATION, MIGRATION AND ECONOMIC RECOVERY

L. HERMAN, I. GLADKYI

Liudmyla Herman[1], Iaroslav Gladkyi[2]
[1] [2] Department of International Economics, West Ukrainian National University, Ukraine
[1] https://orcid.org/0000-0002-4011-9765 E-mail: Laly07260605@gmail.com
[2] E-mail: hladkky@gmail.com

Abstract: *The study is devoted to digitally controlled reconstruction of Ukraine as a strategic mechanism for accelerating reconstruction and economic recovery in the context of migration-induced labour shortages in construction. The aim of the article is to determine the impact of digital innovations (BIM, digital twins, AI planning, e-permits, modular construction and digital procurement) on increasing the productivity of the industry, compensating for staff losses and strengthening the investment capacity of reconstruction. The methodology includes systematisation of scientific approaches to the reconstruction economy, analysis of modern digital solutions in the construction sector, and a comparative review of international practices in post-crisis reconstruction. Key findings show that the digitalisation of construction processes increases productivity, partially compensates for labour shortages, reduces time and cost losses in projects, technological productivity gains partially offset labour shortages, reduce corruption risks and strengthen donor confidence, which contributes to increased investment and accelerated economic recovery in Ukraine.*
Keywords: *digital transformation, construction industry, labour migration, technological compensation, investment capacity, economic recovery*

1 Introduction

Ukraine’s post-war reconstruction is unfolding under conditions of unprecedented infrastructure destruction, demographic losses, and structural economic transformation. The construction sector has become one of the key drivers of recovery because it not only restores physical infrastructure but also generates significant multiplier effects across transport, manufacturing, logistics, finance, and services. At the same time, the sector faces severe labour shortages caused by migration and demographic decline after 2022. According to international estimates, millions of Ukrainians remain abroad, while the domestic construction sector experiences a shortage of qualified workers, particularly in engineering and technical occupations. These labour constraints significantly reduce reconstruction capacity and increase project implementation costs.

In this context, digital transformation is becoming not simply an innovation trend but a strategic mechanism for ensuring reconstruction efficiency. Technologies such as Building Information Modelling, digital twins, artificial intelligence, modular construction, e-permitting systems, and digital procurement platforms enable the optimisation of construction processes, reduction of transaction costs, acceleration of project delivery, and improvement of institutional transparency.

Previous studies have demonstrated the positive impact of digitalisation on construction productivity and project coordination (Abioye et al., 2021; Deng et al., 2021; Nguyen et al., 2023). Research on post-crisis reconstruction also emphasises the importance of institutional transparency and technological modernisation for economic recovery (Myers, 2022). However, despite growing academic attention to construction digitalisation and post-war reconstruction, insufficient attention has been paid to the interaction between labour migration, labour shortages, and digital transformation in reconstruction processes.

Thus, the research gap lies in the limited understanding of how digital technologies can compensate for migration-induced labour shortages and simultaneously strengthen the investment and institutional capacity of reconstruction. The aim of this article is to assess the impact of digital innovations in the construction sector on productivity growth, labour shortage compensation, and investment capacity during Ukraine's post-war reconstruction.

To achieve this aim, the following hypotheses are formulated:

H1: The implementation of digital technologies reduces the construction sector's dependence on labour resources.

H2: Migration-induced labour shortages accelerate digital transformation in the construction sector.

H3: Digitalisation of construction processes increases investment attractiveness and institutional efficiency in reconstruction.

2 Literature Review

Contemporary academic literature increasingly views post-war reconstruction as a process of structural economic transformation rather than merely the restoration of damaged assets. Within this framework, the construction sector is recognised as a key driver of economic recovery due to its strong links with investment activity, infrastructure development, and broader economic modernisation (Myers, 2022). The concept of build back better further emphasises that reconstruction should improve long-term productivity, sustainability, and resilience rather than simply recreate pre-crisis conditions.

A growing body of research highlights the role of digitalisation in improving construction productivity and project efficiency. Artificial intelligence contributes to resource optimisation, planning accuracy, and risk management (Abioye et al., 2021), while Building Information Modelling (BIM) and digital twins enhance coordination, information integration, and lifecycle management of construction projects (Deng et al., 2021; Nguyen et al., 2023). At the same time, modular construction is increasingly recognised as an effective solution for reducing project duration and labour requirements under resource-constrained conditions (Zohourian et al., 2024).

Another important strand of literature focuses on the institutional dimension of digital transformation. Studies demonstrate that e-permitting systems and digital governance tools reduce administrative barriers, improve transparency, and lower corruption risks (World Bank, 2020; Ataíde et al., 2023). Similarly, digital procurement platforms increase accountability and strengthen trust among investors and international donors, thereby improving the investment environment for reconstruction projects (Rysin & Sukh, 2024).

Recent Ukrainian studies emphasise that post-war reconstruction requires not only physical rebuilding but also structural modernisation of the construction sector through innovation and institutional reform. Resource shortages, infrastructure destruction, labour constraints, and increasing donor requirements for transparency have made technological innovation a critical factor in reconstruction effectiveness (Petrov, 2026; Romanova & Grigierman, 2024).

The relationship between labour shortages and technological transformation has also received growing scholarly attention. Empirical evidence suggests that labour shortages stimulate automation and digital innovation, particularly in labour-intensive industries such as construction (Ghodsi et al., 2024; Tverdostup et al., 2025). European studies further indicate that demographic decline and migration accelerate the adoption of digital technologies while increasing demand for highly skilled workers (Bruecker Juricic et al., 2021).

Recent literature also emphasises that digitalisation increasingly performs not only a productivity-enhancing function but also a resilience-building function in post-crisis economies. Digital technologies improve the ability of economic systems to adapt to labour shortages, supply-chain disruptions, and institutional constraints by increasing flexibility and reducing dependence on traditional production factors. In the construction sector, digital tools facilitate real-time project coordination, predictive planning, and more efficient resource allocation, which becomes particularly important under conditions of uncertainty and large-scale reconstruction (Abioye et al., 2021; Deng et al., 2021).

From an institutional perspective, digital transformation is increasingly associated with the improvement of governance quality and investment attractiveness. International experience demonstrates that transparent digital procurement systems, electronic permitting procedures, and data-driven project management strengthen accountability and reduce information asymmetries, thereby increasing investor and donor confidence in reconstruction programmes (World Bank, 2020; Ataíde et al., 2023). Consequently, digitalisation can generate both direct productivity effects and indirect institutional effects that contribute to economic recovery.

Despite the growing literature on construction digitalisation, post-war reconstruction, and labour market transformation, limited attention has been paid to the combined interaction between migration-induced labour shortages, digital transformation, and reconstruction productivity. This gap is particularly evident in the case of Ukraine, where reconstruction is occurring under conditions of large-scale migration and unprecedented infrastructure damage. Therefore, further research is needed to assess how digital technologies can simultaneously compensate for labour shortages and strengthen the efficiency and investment capacity of reconstruction processes.

3 Methodology

The methodological framework of the study combines systemic, institutional and comparative approaches, enabling a comprehensive analysis of the interrelationship between the digitalisation of the construction sector, migration processes and economic recovery. Given the interdisciplinary nature of the subject matter, the study is based on the integration of theoretical generalisations and applied analysis of contemporary digital solutions in construction.

The study employed a method for systematising scientific approaches to the economics of recovery and innovative development in the construction sector, which enabled the authorisation of key theoretical concepts and the assessment of their applicability to the conditions of Ukraine's post-war economic transformation. To identify the role of digital technologies in improving construction efficiency, a structural-functional analysis method was used, which allowed us to identify the main areas of influence of tools such as building information modelling, digital twins, artificial intelligence, electronic permits, modular construction and digital procurement on the processes of planning, implementation and management of construction projects.

To assess the impact of migration processes on the functioning of the construction sector, elements of comparative analysis were applied, involving a comparison of international experience in responding to labour shortages in the context of structural changes in the labour market. This made it possible to identify typical adaptation models, in particular the introduction of technological innovations as an alternative to labour-intensive processes.

3.1 Data Sources

The study also includes an analysis of secondary data from international organisations, analytical reports and academic publications, which has enabled the identification of general trends in the digitalisation of the construction sector and its impact on the sector's productivity and investment attractiveness. Based on a synthesis of the results obtained, an analytical framework for the study has been developed, reflecting the interrelationship between digital innovations, labour shortages and the efficiency of reconstruction processes.

In today's economy, the digitalisation of the construction sector is seen as one of the key factors in boosting productivity, particularly given the sector's traditionally low growth rates. For a long period, labour productivity in construction grew extremely slowly – around 0.4% per year, whilst in industry this figure exceeded 2.5%. This lags significantly behind other sectors of the economy, and in certain periods even showed stagnation (McKinsey Global Institute, 2020). The digitalisation of infrastructure processes can increase resource efficiency in construction by 15–25%, which is critically important for countries with limited labour potential, particularly Ukraine. In this context, the introduction of digital technologies, primarily Building Information Modelling (BIM) and digital twins, serves as a tool for overcoming the sector's structural constraints linked to fragmented processes, information loss and poor coordination between project participants.

As Deng, Menassa and Kamat (2021) demonstrate, the use of BIM helps to reduce design errors by up to 30% and cut rework costs by up to 20%. Furthermore, the implementation of BIM allows project completion times to be reduced by an average of 10–15% (Autodesk, 2023). The further development of digitalisation is linked to the introduction of digital twins, which enable dynamic modelling of objects in real time. The use of digital twins enables a 10–20% reduction in operational costs and improves the accuracy of risk forecasting. Combined with artificial intelligence technologies, this creates the conditions for a transition to predictive management of construction processes (Abioye et al., 2021).

Table 1 summarizes the measurable impact of key digital technologies on construction productivity and clearly demonstrates that digital transformation generates multidimensional efficiency gains across the project lifecycle. The results indicate that BIM technologies primarily influence the design and coordination stages by reducing errors by 20-30% and shortening project duration by 10-15%, which reflects their role in improving information integration and minimizing rework. This confirms that BIM acts as a foundational digital layer that enhances process synchronization and decision-making accuracy at early project stages.

Table 1. *Impact of Digital Technologies on Construction Productivity*

Technology	Effect
Building Information Modeling	-20-30% errors; -10-15% project duration
Digital twins	-10-20% costs
Artificial intelligence	+15-25% efficiency
Modular construction	-20-50% time; -30-40% labour

Source: based on Deng et al. (2021), Autodesk (2023), Nguyen et al. (2023), Abioye et al. (2021), Zohourian et al. (2024).

At the same time, digital twins extend these benefits into the operational and management phases by enabling real-time monitoring and predictive analytics, resulting in cost reductions of 10-20%. This suggests that their primary contribution lies in lifecycle optimization rather than only design efficiency. In contrast, artificial intelligence demonstrates a broader systemic impact, increasing overall efficiency by 15-25% through automation, resource optimization, and improved planning, indicating its cross-cutting role in enhancing both productivity and decision support mechanisms.

Particularly significant are the effects of modular construction, which exhibits the highest quantitative impact among the technologies considered, reducing project duration by up to 50% and labour requirements by 30-40%. This highlights its importance as a structural innovation capable of addressing labour shortages by shifting production processes from on-site to controlled environments. Overall, the comparative analysis shows that while individual technologies affect different stages of the construction process, their combined implementation creates a cumulative effect that substantially increases productivity, reduces dependency on labour, and enhances the resilience of the construction sector, which is especially relevant in the context of post-war reconstruction.

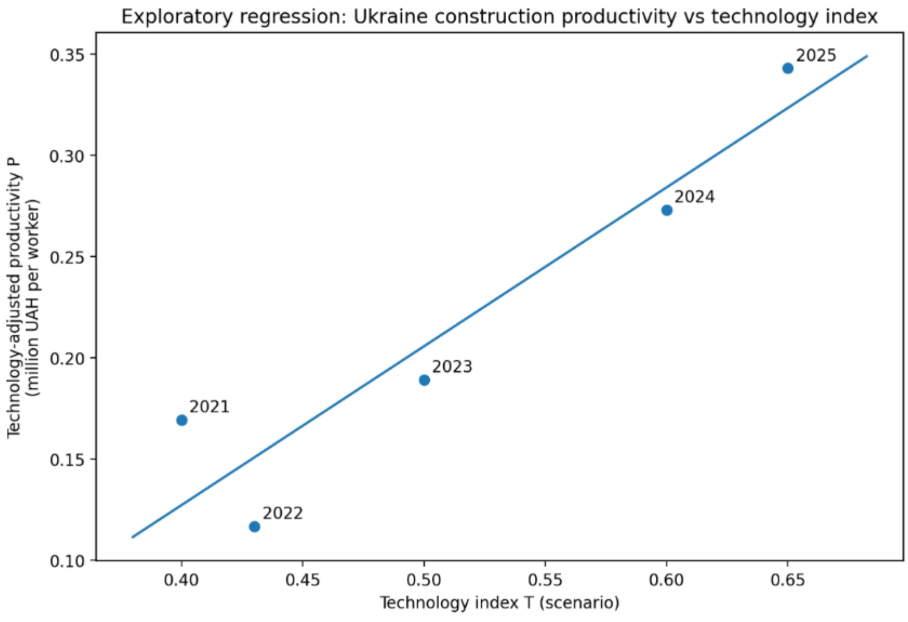
Modular construction is also a key factor in improving productivity, as it allows a significant proportion of production processes to be moved into a controlled environment. According to Zohourian et al. (2024), modular technologies reduce construction times by 20-50% and decrease labour requirements by 30-40%, which is particularly relevant in the context of a labour shortage due to migration.

The synthesis of statistical data enabled the calculation of productivity in Ukraine's construction sector based on the proposed model. In particular, in 2024, the volume of construction work completed amounted to UAH 204.7 billion, indicating a gradual recovery of the sector following a sharp decline in 2022. The construction sector faces an acute labour shortage, which is a consequence of large-scale migration and structural changes in the labour market. Calculations show that, despite a reduction in the labour force of approximately 25%, the sector's productivity has increased by almost 59% due to improvements in technological standards. This confirms that digitalisation acts as a compensatory mechanism, enabling a reduction in reliance on labour and maintaining the sector's operational efficiency under resource constraints.

3.2 Exploratory Productivity Model

To empirically verify the impact of digitalisation on productivity in the construction sector, an exploratory model and corresponding graphical representations were developed. In particular, *Figure 1* shows the relationship between the level of technological development (digitalisation index *T*) and technology-adjusted productivity (*P*), calculated using a formalised model. The results obtained indicate a strong positive correlation between these variables: the regression function takes the form P=0.785T-0.187 with a coefficient of determination R^2=0.884, indicating a high level of explanatory power of the model. This allows us to conclude that an increase in the level of digitalisation is a significant factor in boosting productivity, even in the context of a reduction in the labour force.

Figure 1. *Ukraine productivity regression*



Source: developed by the author.

The analytical significance of the results lies in the fact that digitalisation effectively alters the functional relationship between output and labour costs, reinforcing the role of the technological factor. An increase in the parameter T partially offsets the negative impact of a decrease in L (the labour force), which is particularly relevant in the context of migration losses. Thus, the hypothesis that digital technologies perform a compensatory function, transforming the traditional labour-intensive construction model into a technology-intensive one, is confirmed.

To visualise the relationship between digitalisation and the performance of the construction sector, an exploratory regression model was developed based on the Ukrainian scenario for 2021–2025. It is based on the actual dynamics of the volume of construction work, whilst labour force indicators and technological level were used as scenario variables due to the limited availability of open, fully comparable annual data during the war period. The modelling results demonstrated a positive correlation between growth in the technological index and an increase in technology-adjusted construction productivity ($R^2 = 0.884$), confirming the validity of considering digitalisation as a compensatory mechanism in the context of labour shortages. A comparative benchmark with Poland and the EU also shows that a higher level of digital intensity is associated with higher labour productivity in the construction sector, although for Ukraine such estimates should be treated as preliminary due to wartime statistical constraints.

3.3 Research Limitations

The study has several limitations. Wartime conditions restrict the availability of comprehensive statistical data. Part of the labour and digitalisation indicators are based on scenario modelling. The study focuses primarily on macro-level construction sector dynamics rather than firm-level analysis.

Despite these limitations, the methodology allows identification of key structural relationships between digitalisation, labour shortages, and reconstruction efficiency.

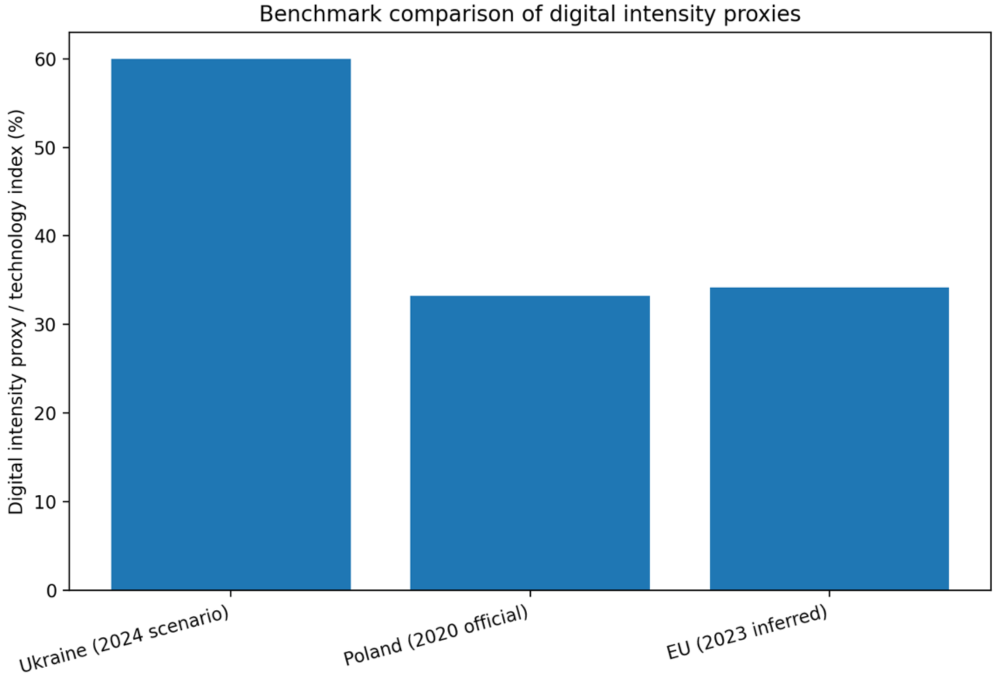
4 Results

4.1. The impact of digitalisation on construction productivity

A comparative analysis demonstrates differences in productivity levels within the construction sector between Ukraine, Poland and European Union countries. Labour productivity in construction in EU countries significantly exceeds the corresponding figure for Ukraine, which is explained by both a higher level of technological equipment and more developed institutional mechanisms for managing the sector. Poland, which serves as a relevant comparative case for Ukraine, occupies an intermediate position, reflecting the transitional nature of its economic structure and the gradual digital transformation of the construction sector.

Figure 2 illustrates the level of digital intensity in the construction sector across the economies under review. The analysis shows that a higher level of digitalisation correlates with higher labour productivity, which is consistent with the results of the regression analysis. Ukraine is characterised by a lower level of digital intensity compared to the EU; however, the positive trend in the adoption of digital tools, particularly in the areas of public procurement and licensing procedures, creates the conditions for improving the sector’s efficiency. Some of the indicators used in the model, notably data on employment and the level of digitalisation in Ukraine, are based on scenarios, due to the limited availability of official statistics during the war. However, even under such conditions, the results obtained allow us to identify general patterns and confirm the key role of digitalisation as a driver of increased productivity in the construction sector.

Figure 2. *Digital intensity benchmark*



Source: developed by the author.

The integration of regression analysis and comparative graphical tools leads to the conclusion that the digitalisation of the construction sector not only improves resource efficiency but also shapes a new model for the industry's operation, in which technological development becomes a key driver of economic recovery.

One of the key challenges facing Ukraine's construction sector during post-war reconstruction is an acute labour shortage, caused by large-scale migration, demographic decline and structural changes in the labour market. Over 6 million Ukrainians remain outside the country, which significantly affects labour-intensive sectors, particularly construction. The shortage of skilled workers in construction after 2022 will reach 20–30%, significantly limiting the pace of infrastructure project implementation (GMK Center, 2025). At the same time, even assuming a partial recovery in construction volumes by 2024 (Interfax-Ukraine, 2025), the sector's labour potential remains below pre-war levels, necessitating the search for alternative mechanisms to ensure productivity.

In this context, digital technologies serve not only as a tool for improving efficiency but also as a mechanism for partially replacing human labour. In particular, the automation of construction processes based on artificial intelligence and digital platforms makes it possible to reduce dependence on manual labour and improve the efficiency of resource management. As noted by Abioye et al. (2021), the application of AI in construction facilitates the automation of planning, work supervision and risk analysis, thereby reducing the need for labour resources without compromising the quality of project delivery.

Formally, this can be expressed as a transformation of the productivity function:

$$P=Q/(L-\theta TP)$$

where θ is the technological labour substitution coefficient, reflecting the ability of digital technologies to compensate for labour shortages. This interpretation implies that an increase in the level of digitalisation (T) effectively reduces the demand for labour (L), a finding confirmed by the results of empirical analysis (see Figure 1), which show an increase in productivity even amidst a decline in employment.

4.3 Institutional and Investment Effects of Digitalisation

The key tools for technological compensation are process automation, modular construction and remote project management. In particular, the use of artificial intelligence enables the automation of planning, work progress monitoring and risk management, which significantly reduces the need for manual labour and improves resource efficiency (Abioye et al., 2021). In turn, modular construction brings about a structural transformation of the production process. Unlike traditional approaches, modular technologies involve the manufacture of a significant proportion of structural elements in factories, followed by their assembly on-site, which substantially reduces the need for labour directly at the construction site. According to general estimates, the use of such technologies reduces labour requirements by 30–40% and shortens project completion times by up to 50% (Zohourian et al., 2024), which is critically important in the context of labour shortages caused by migration.

Empirical case studies confirm the effectiveness of this model. In particular, in the UK, rapid housing construction projects based on off-site manufacturing (for example, Homes England initiatives and the use of technologies from companies such as Legal & General Modular Homes) have demonstrated the potential to reduce construction times by 30–50% whilst simultaneously reducing reliance on unskilled labour. In Sweden, where modular construction accounts for a significant share of the housing market, the use of industrialised solutions has helped stabilise costs and mitigate the impact of labour shortages on construction rates, which is particularly relevant in the context of an ageing population.

Similar trends are also observed in Central and Eastern European countries. In Poland, the active introduction of prefabricated technologies in residential and commercial construction helps to compensate for labour shortages by increasing the automation of production processes and requiring fewer staff on construction sites. In Germany, the use of modular solutions in social housing construction, particularly in response to migration challenges, has made it possible to rapidly scale up infrastructure projects despite limited labour resources.

In the context of Ukraine, the potential of modular construction takes on particular significance in the context of post-war reconstruction. Even in the early stages of reconstruction, solutions involving rapidly assembled housing and temporary modular structures are being used, enabling a swift response to the population's needs. In the long term, scaling up such approaches could become one of the key tools for reconstruction, as it allows for combining the speed of project implementation with limited use of labour resources.

Full-scale war has caused significant destruction to Ukraine's housing stock: by the end of 2024, over 236,000 buildings had been damaged or destroyed, with direct losses estimated at approximately $60 billion. In such circumstances, ensuring the rapid and cost-effective restoration of housing has become a key priority, driving the growing role of modular construction as a strategic direction for the sector's development. The efficiency of modular construction is largely determined by the integration of digital technologies, in particular BIM, artificial intelligence, remote monitoring systems and cloud platforms, which ensure the coordination of project participants, optimisation of resource use and cost reduction. A practical example of this innovative approach is the project by WZMH Architects (Canada), which involves the use of concrete modules with built-in engineering systems to restore damaged buildings, thereby reducing reconstruction times to a matter of weeks. (Pro-Consulting, 2025).

In the medium term, modular construction could become a viable alternative to traditional methods, particularly in the areas of social housing and infrastructure regeneration, due to high demand, limited resources and the need to implement energy-efficient solutions.

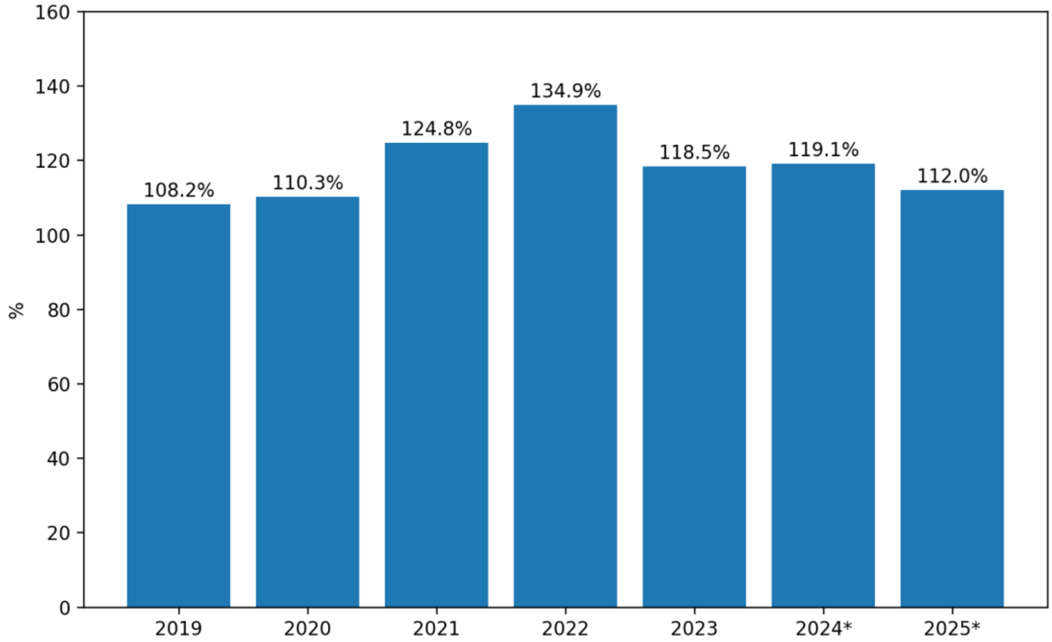
The process of addressing the labour shortage is taking place against a backdrop of profound structural changes in Ukraine's construction and renovation market. Until 2022, the sector demonstrated steady growth, but the full-scale war caused a sharp decline: the volume of construction work fell by more than half in nominal terms, whilst the real decline exceeded

65%. Despite this, a gradual recovery has been observed since 2023; in the first quarter of 2024, the market volume grew by 57% compared to the same period of the previous year, indicating the emergence of positive growth dynamics in the sector.

Structurally, the construction sector remains dominated by the civil engineering segment, which exceeds the share of residential and non-residential construction. This structure is characteristic of a recovery period, when the main focus shifts to infrastructure reconstruction, particularly transport, energy and utilities. The geographical structure of construction activity has undergone significant changes, with new projects concentrated mainly in the western regions of the country, whilst in the central and eastern regions, work on the restoration of damaged facilities dominates.

The investment side of the market has also undergone a transformation. Private investment has fallen significantly, whilst public funds and international aid – in the form of grants, loans and targeted programmes – have come to play a key role in financing construction. This means that the efficient use of resources is becoming a critical factor, further reinforcing the importance of digitalisation and industrialisation of construction processes as tools for cost optimisation.

Figure 3. *GDP deflator, % (2019–2025)*



Source: author's elaboration based on World Bank data.

It is advisable to analyse the performance of the construction sector within a broader macroeconomic context, particularly taking into account inflationary trends, which directly affect the cost of implementing infrastructure projects and the sector's investment attractiveness. As shown in *Figure 3*, the trend in the GDP deflator for 2019–2025 reflects significant fluctuations in price levels in the Ukrainian economy. During 2019–2021, a moderate increase in the indicator is observed, from 108.2% to 124.8%, indicating a gradual intensification of inflationary pressure against the backdrop of economic growth. The deflator reaches its highest value in 2022 – 134.9% – reflecting a sharp acceleration in inflationary processes due to full-scale war, disruptions to production and logistics chains, as well as devaluation and resource shocks. In subsequent years, a partial stabilisation of the indicator is observed: in 2023, it falls to 118.5%, and in 2024, it shows a slight increase to 119.1%, which may indicate the economy's gradual adaptation to new operating conditions. The figure for 2025 (112%) indicates a trend towards a further reduction in inflationary pressure, which is an important signal of macroeconomic stabilisation. At the same time, the deflator remains higher than pre-crisis levels, reflecting the incomplete nature of economic recovery processes. The dynamics of the GDP deflator suggest that the economy is undergoing a transition from a shock inflationary surge to gradual stabilisation, creating more favourable conditions for investment activity and the implementation of large-scale reconstruction projects, particularly in the construction sector.

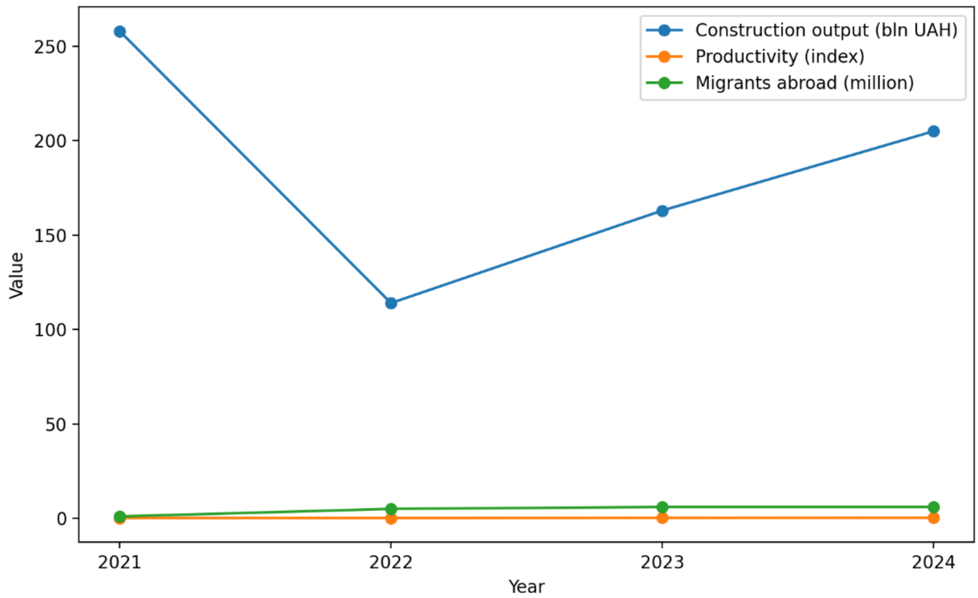
In the context of this study, this is of fundamental importance, as high inflation reinforces the need to adopt digital technologies and industrialised solutions, particularly modular construction, which enable cost optimisation and improved resource efficiency. Macroeconomic instability, reflected in the dynamics of the GDP deflator, acts as an additional factor stimulating the transition to a technology-compensated model of development in the construction sector, where productivity is achieved not through increased labour input but through the intensive use of digital tools.

To deepen the analysis of the relationship between labour shortages, productivity and the dynamics of the construction sector, an integrated graphical model (Figure 4) was constructed, reflecting the simultaneous changes in construction volumes, productivity levels and migration processes in 2021–2024.

After 2022, there is a sharp increase in the scale of labour migration, accompanied by a significant reduction in construction volumes. However, despite the reduction in the labour force, the sector's productivity shows positive dynamics in 2023–2024. This indicates that the construction sector is adapting to new operating conditions by intensifying the use of technology and optimising production processes.

The rise in productivity against a backdrop of a shrinking labour force supports the hypothesis that there is a technologically compensated labour economy model, within which digitalisation partially replaces human labour. Even in the face of a significant outflow of labour, the sector retains its capacity for recovery, which is attributable to improvements in the technological level of production and the implementation of innovative solutions.

Figure 4. *Construction output, productivity and migration trends (2021–2024)*



Source: compiled by the author based on World Bank data and industry estimates.

In the context of Ukraine's post-war recovery, the digitalisation of the construction sector has not only operational implications but also significant institutional and investment implications that determine the overall efficiency of the sector's functioning. Of particular importance is the introduction of electronic permitting systems and digital public procurement platforms, which transform the mechanisms of interaction between the state, business and international partners.

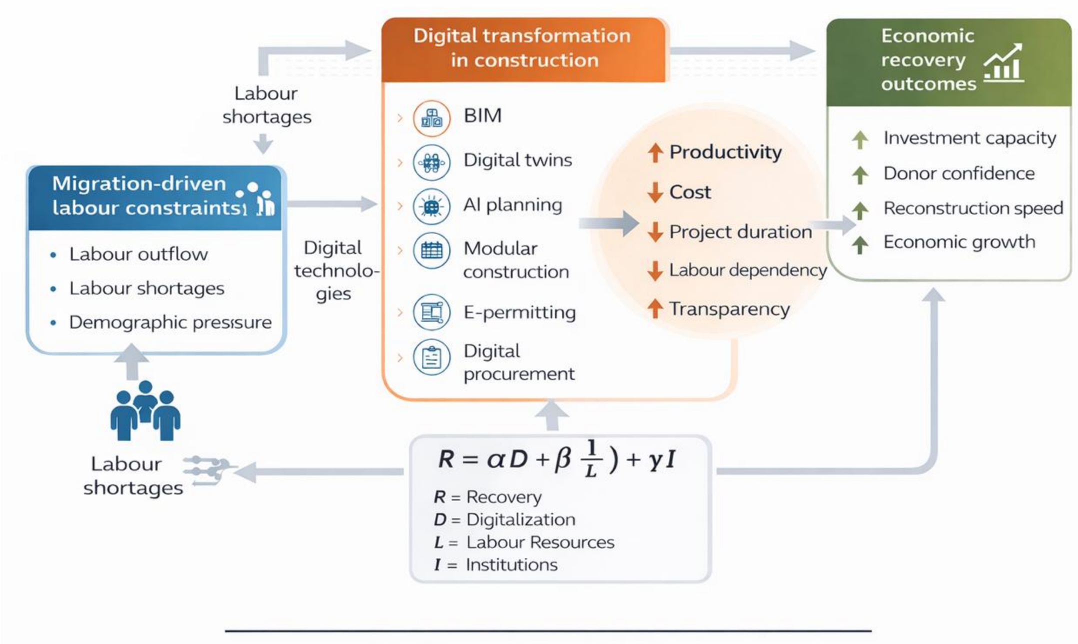
The digitalisation of permitting procedures, including the introduction of electronic permits (e-permitting), makes it possible to significantly reduce administrative barriers and improve the efficiency of regulatory processes. As research by international organisations shows, moving permitting procedures to a digital format reduces corruption risks by minimising the human factor and limiting opportunities for informal practices. In this context, digital tools serve as a mechanism for improving institutional quality, which is critically important for economies in transition.

This is of critical importance, as the scale of reconstruction is unprecedented: according to estimates by international organisations, the total cost of economic recovery already exceeds US$500–580 billion, whilst direct infrastructure losses amount to over US$190 billion (Shalal, 2026). Under such conditions, effective project management and transparent procedures become key factors in the use of financial resources.

The Prozorro electronic public procurement system plays a vital role in ensuring transparency, functioning as an open digital platform for conducting tenders. The system ensures competition among suppliers, open access to information and the ability to automatically detect violations through analytical tools, which significantly reduces corruption risks. In particular, the introduction of 'red-flag' mechanisms allows potential violations in the procurement process to be identified in real time, which boosts confidence in the system among both the business community and international donors.

Institutional transformation driven by digitalisation has a direct impact on the investment attractiveness of the construction sector. Under current conditions, a significant portion of the funding for Ukraine's reconstruction comes from international aid, including grants, loans and investment programmes (OECD, 2025). Ukraine's economic recovery depends to a large extent on the stability of public finances, the efficiency of public spending and the support of international partners. In this context, digital tools serve as a guarantee of greater transparency in the use of funds and a reduction in the risks of their misuse.

Figure 5. *Conceptual Model of Digital-Driven Reconstruction in Ukraine*



Source: author's own elaboration.

Figure 5 illustrates a conceptual framework linking labour constraints, digital transformation in the construction sector, and economic recovery outcomes. The model demonstrates that migration-driven labour shortages act as a primary structural constraint affecting the construction industry. In response, digital transformation encompassing technologies such as BIM, modular construction, e-permitting, and data-driven management, serves as a central mediating mechanism that reduces labour dependency and enhances operational efficiency.

The framework further highlights that the integration of digital technologies generates a set of interconnected effects, including improved resource optimization, reduced project timelines, and increased transparency of institutional processes. These effects collectively contribute to strengthening investment capacity and accelerating economic recovery. Importantly, the model emphasizes the role of institutions in supporting this transformation, indicating that the effectiveness of digitalization depends not only on technological adoption but also on the quality of governance and regulatory frameworks. The figure conceptualizes the transition from a labour-intensive to a technology-driven model of construction development, in which digitalization acts as a key driver of productivity growth and structural economic recovery.

Digitalisation helps to create a more effective institutional environment that encourages the mobilisation of private capital. It is estimated that up to 40% of the funding required for reconstruction could potentially be met through private investment, provided that the necessary reforms are implemented and the transparency of economic processes is improved. This underscores the importance of digital platforms as tools for reducing information asymmetry and boosting investor confidence. Given the massive scale of reconstruction needs, digitalisation is one of the key factors determining the economy’s ability to effectively mobilise and utilise investment resources.

5. Discussion

The findings support previous studies that identify digitalisation as a major driver of productivity growth and efficiency improvement in the construction sector. Consistent with the work of Abioye et al. (2021), Deng et al. (2021), and Nguyen et al. (2023), the results indicate that digital technologies improve resource allocation, project coordination, and overall operational performance. Similarly, the findings confirm the conclusions of Zohourian et al. (2024), who emphasise the role of modular construction in reducing labour requirements and accelerating project delivery.

The study also supports previous research linking labour shortages to technological transformation. In line with the findings of Ghodsi et al. (2024) and Tverdostup et al. (2025), the results suggest that labour constraints act as a catalyst for digital innovation. However, unlike previous studies that primarily focus on automation at the firm level, this research demonstrates the importance of digitalisation at the sectoral level within a post-war reconstruction environment.

A further contribution of the study concerns the institutional dimension of digital transformation. The results are consistent with findings by the World Bank (2020), Ataíde et al. (2023), and Rysin and Sukh (2024), which show that digital governance tools improve transparency and accountability. However, this study extends existing research by demonstrating that digitalisation not only improves administrative efficiency but also strengthens investment capacity by increasing donor and investor confidence in reconstruction programmes.

An important finding is the emergence of a technology-intensive reconstruction model. While previous studies have generally examined digitalisation, migration, and reconstruction separately, the present research integrates these dimensions into a unified analytical framework. The results suggest that digital technologies perform not only a productivity-enhancing function but also a compensatory function by partially offsetting migration-induced labour shortages. This finding contributes to a better understanding of how post-war economies adapt to structural labour constraints.

The study additionally highlights the potential role of digital platforms in facilitating hybrid forms of labour participation. Through remote coordination and digital project management tools, highly skilled professionals located abroad may contribute to reconstruction processes without physical relocation. This expands the traditional understanding of labour mobility and opens new opportunities for engaging the Ukrainian diaspora in economic recovery.

Overall, the findings confirm hypotheses H1-H3 and demonstrate that digitalisation has a multidimensional impact on reconstruction processes through productivity improvements, labour compensation mechanisms, and institutional strengthening. These results suggest that digital transformation should be considered a central component of Ukraine's long-term reconstruction strategy.

6. Conclusions

The findings of this study demonstrate that digitalisation has become a strategic component of Ukraine's post-war reconstruction process. Under conditions of infrastructure destruction, labour shortages, and resource constraints, digital technologies contribute to higher productivity, more efficient resource allocation, and improved implementation of reconstruction projects.

The analysis confirms that technologies such as Building Information Modelling (BIM), digital twins, artificial intelligence, modular construction, e-permitting systems, and digital procurement platforms help partially compensate for migration-induced labour shortages while enhancing the operational efficiency of the construction sector. The results additionally indicate that digitalisation strengthens institutional transparency and accountability, thereby improving the investment attractiveness of reconstruction programmes.

The study contributes to the literature by integrating technological, migration, and institutional dimensions into a unified framework of digitally driven reconstruction. The findings suggest that post-war recovery increasingly depends on the transition from a labour-intensive to a technology-intensive development model, in which digitalisation functions not only as a productivity-enhancing factor but also as a mechanism for economic resilience and adaptation.

From a policy perspective, the results highlight the importance of accelerating digital transformation within Ukraine's reconstruction strategy. Expanding the use of digital construction technologies, improving digital governance instruments, and strengthening institutional transparency may contribute to more effective mobilisation of domestic and international investment resources.

Future research should focus on firm-level evidence, regional differences in reconstruction processes, and quantitative assessment of the long-term economic effects of digital technologies in the construction sector.

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