

# Management of Adaptation of Organizational and Economic Mechanisms of Construction to Increasing Impact of Digital Technologies on the National Economy

Sergii P. Stetsenko<sup>1</sup>, Viktoriya V. Tytok<sup>2</sup>, Olena M. Emelianova<sup>2</sup>, Olha Yu. Bieliukova<sup>1,\*</sup> and Tetiana Yu. Tsyfra<sup>1</sup>

<sup>1</sup>*Department of Construction Economics, Faculty of Civil Engineering, Kyiv National University of Construction and Architecture (KNUCA), Kyiv, Ukraine*

<sup>2</sup>*Department of Construction Organization and Management, Faculty of Civil Engineering, Kyiv National University of Construction and Architecture (KNUCA), Kyiv, Ukraine*

**Abstract:** *Motivation:* We note significant problems of developing countries, including Ukraine, with the adaptation of organizational and economic mechanisms of the construction industry to increase impact of digital technologies on their economic systems and construction sectors.

*Novelty:* The scientific novelty is a set of management activities for the adaptation of organizational and economic mechanisms of Ukrainian construction companies to the development of digital technologies.

*Methodology and Methods:* The research methods used in this study are a quantitative analysis of statistics on the dynamics of world GDP, the global construction industry, the construction industries of developing countries, including Ukraine, the global digital market, digital markets in developing countries, including Ukraine, for ten years using one-dimensional statistical methods (UT) based on random sampling. The paper also uses the correlation and regression analysis, namely the linear regression model, as well as the statistical verification of the obtained model by calculating the pair correlation coefficient, the coefficient of determination and the Chaddock scale in the study of the impact of digital technology development on the Ukrainian construction industry.

*Data and Empirical Analysis:* To conduct the study, data were collected and an empirical analysis was conducted regarding the dynamics of world GDP, the world construction industry, the construction industries of developing countries, including Ukraine, the global digital market, digital markets in developing countries, including Ukraine, in 2009-2018 according to statistics from Knoema, The World Bank, Deloitte, State Statistics Service of Ukraine, UNCTAD, International Data Corporation, Gartner.

*Policy Considerations:* The economy of the country and the construction sector requires development and implementation of a set of management activities to adapt organizational and economic mechanisms of construction in Ukraine to development of digital technologies.

**Keywords:** Construction, developing countries, organizational and economic mechanisms, digital technology.

## 1. INTRODUCTION

The construction industry, in the context of the transformation of the world and national economies, taking into account the acceleration of globalization processes, occupies one of the key places in economic systems at different levels (Strassman and Wells, 1988; Kniivilä, 2007). The construction industry is actively related to and influences a significant number of related industries, driving their development and the development of the economic system as a whole (UNIDO, 2017). At the same time, construction accounts for up to 10% of the GDP of some countries and the world economic system (Klakegg *et al.*, 2013), stimulating the investment of three additional dollars in

the economy for each dollar invested in the industry (Kane, 2012) and generating the additional employment of four additional workers for each additional person employed in the construction sector (ACIF, 2002).

We note that there are positive forecasts for the development of the construction sector of the world economy for the next 5-12 years (Research and Markets, 2017), where the industry is projected to grow by 85% from the base of 2018 to \$15.5 billion (Robinson, 2019) by 2030.

The construction industry is of great importance for the developing countries, especially in the context of post-crisis recovery of their economy (including Ukraine) (Correa and Kanatsoul, 2018; Chupryna, Kulikov and Ryzhakova, 2018). The revitalization of construction allows those countries to: receive additional investments, including foreign ones; increase the flow of freely convertible currency and have more

\*Address correspondence to this author at the Department of Construction Economics, Faculty of Civil Engineering, Kyiv National University of Construction and Architecture (KNUCA), Kyiv, Ukraine; Tel: 044 248-32-65; Fax: 044 248-32-65; E-mail: olgaromanko111@gmail.com

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opportunities to implement effective monetary policy; solve problems of activation of branches of the national economy; ensure growth of employment as well as revenues of the budget of different levels, business entities and households (Ofori, 2016; Bibik and Dril, 2017).

When describing the construction industry, it must be taken into account that it is low-tech, that is, it is a mature industry where technologies are changing slowly (Kraatz, Hampson and Sanchez, 2014). In this context, construction companies, scholars and government institutions are actively seeking ways to intensify the industry and increase its efficiency, where digital technologies are key (Shibeika and Harty, 2015; Dan, 2017; Build Up, 2019). Thus, according to a survey of the companies in the construction market conducted by Turner & Townsend (2018), digital technologies ranked third among the key drivers of development in the industry. Digital technologies have also been identified within the three important spheres of modern transformation of the construction industry at the World Economic Forum (WEF, 2016). We note considerable attention to the intensification of digital technology implementation in the construction industry in economically developed countries (Furieux et al., 2010; Kraatz, Hampson and Sanchez, 2014), where the UK is among the leaders, which has included the development and implementation of digital technologies in government Construction Development Strategy (HM Government, 2013).

The increasing number of current scientific studies on the use of digital technologies in construction is of particular note. Thus, Kapogiannis and Mlilo (2019) considered strategies for digital construction and the use of BIM technology in the construction of railway tunnels. Dr. Ibrahim (2011) considered the role of integrated digital technologies in construction projects. Shibeika and Harty (2015) investigated the spread of digital construction on the example of British engineering companies. Guo et al. (2017) have reviewed and evaluated the use of digital technologies in construction safety management.

At the same time, we note considerable problems of the use of digital technologies in the construction sector in developing countries and considerable difficulties of their integration and adaptation within the existing organizational and economic mechanisms in those countries, where the following problems may be identified in Ukraine.

Ukraine is actively seeking ways to improve the efficiency of its economy and its individual sectors in the context of accelerated integration processes into the economic space of the European Union. In these conditions, its construction industry has significant prospects for development (Stetsenko, Bielenkova and Lytvynenko, 2017; Izmailova, Bielenkova and Mogolivets, 2019), but the problems, which include the weak implementation of digital technologies, make it impossible to realize the potential of Ukrainian construction sector.

The above issues require the establishment and solution of such research goal as optimizing the management of adaptation of organizational and economic mechanisms of construction to increase the impact of digital technologies on the national economy, on the example of Ukraine, based on the study of global and national trends in developing countries.

Based on the goal, it is important to prove or refute a number of hypotheses, namely:

- the construction sector in the world and in Ukraine has a significant impact on economic systems of the appropriate level and has shown a steady increase over the last decade;
- the development of digital technologies is ahead of the development of the world economy, experiencing disincentivising influence of developing countries in recent years;
- the development and introduction of digital technologies into the Ukrainian economy is slow due to the complex economic and institutional problems;
- digital technologies have a small impact on the development of the Ukrainian construction industry and occupy a secondary place in the organizational and economic mechanisms of construction in the country;
- the economy of the country and the construction sector requires the development and implementation of a set of management activities to adapt the organizational and economic mechanisms of construction in Ukraine to the development of digital technologies.

## 2. MATERIALS AND METHODS

The research methods used in this study are a quantitative analysis of statistics on the dynamics of

world GDP, the global construction industry, the construction industries of developing countries, including Ukraine, the global digital market, digital markets in developing countries, including Ukraine, for ten years using one-dimensional statistical methods (UT) based on random sampling. The paper also uses the correlation and regression analysis, namely the linear regression model, as well as the statistical verification of the obtained model by calculating the pair correlation coefficient, the coefficient of determination and the Chaddock scale in the study of the impact of digital technology on the Ukrainian construction industry. Additionally, based on the use of panel data on a survey of eighty Ukrainian construction firms, which were divided equally into large, medium, small and micro companies, on the importance and use of digital technologies in their activity, we obtained data on the role and place of such technologies in financial and economic activities of these companies. In the course of adaptation of organizational and economic mechanisms of construction in Ukraine to the development of digital technologies, a complex of administrative activities of its implementation was formed based on the "tree of goals" and analytical form of the logical function of Boolean algebra.

An important concept used in this article is the concept of the organizational and economic mechanism, which can be defined as a system of interrelated elements, levers and methods of enterprise management. These elements are functioning to ensure its competitive advantages in the most effective way. Such a mechanism should be flexible, capable of responding to changes in the environment. It should meet the general goals of the enterprise and be guided by modern means and management methods appropriate for a particular enterprise. The tasks set must have quantitative characteristics, as well as criteria for their successful implementation.

The research methodology is based on system and functional, historical and systemic approaches in

identifying and solving problems of improving the efficiency of managing the adaptation of organizational and economic mechanisms of construction to increasing impact of digital technologies on the national economy. At the same time, the system-functional approach allows to reveal the impact of digital technologies on the construction sphere of developing countries, including Ukraine. The historical approach has been used to assess the dynamics of world GDP, the world construction industry, the construction industries of developing countries, including Ukraine, the global digital market, digital markets in developing countries, including Ukraine. The systemic approach allows considering construction companies as components of the economic systems of developing countries.

The paper presents digital technology as one of the key elements of ensuring the growth of the world construction industry and the construction industries of developing countries, including Ukraine. The study is based on the assumption that construction companies from developing countries, including Ukraine, need to manage adaptation of organizational and economic construction mechanisms to increasing impact of digital technologies on the national economy.

### 3. RESULTS

#### 3.1. Analytical Characteristics of the Development of Construction in the World and Ukraine

Construction is one of the key sectors of the world economy that has been actively developing for the last ten years. We note the need to investigate the development of the world construction industry in relation to the GDP of the world economic system (Table 1).

The analysis allows identifying the following:

1. The world economic system for the period under analysis was actively developing despite certain

**Table 1: Analysis of the Dynamics of World GDP, Construction Industry in the World and the Share of Construction in World GDP for 2009-2018**

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Abs. deviation	Growth rates, %
World GDP, \$ billion	60.3	66.1	73.4	75.1	77.2	79.3	75.0	76.1	80.9	85.8	25.5	142.3
World construction industry, \$ billion	3.4	4.5	6.0	6.7	7.8	9.5	10.0	10.5	10.9	11.4	8	335.3
Share of world construction industry in world GDP, %	5.6	6.8	8.2	8.9	10.1	12.0	13.3	13.8	13.5	13.3	7.7	237.5

\*Developed by the author based on: Kosenkov (2018), The World Bank (n./d.), Wang (2019).

problems, and showed a strong upward trend with the exception of 2015-2016. At the same time, for ten years the growth of world GDP amounted to \$25.5 billion or 142.3%.

2. The global construction industry also showed growth from 2009 to 2018. At the same time, during the fall of world GDP, the construction sector grew, which testifies to its considerable potential. We note a faster growth of construction than the world economic system in the period under study (335.3% against 142.3%). At the same time, the following trends are observed:
  - in 2009-2014, the growth of the construction industry was much higher than the growth of the world economy, which was reflected in the growth of the share of construction in the world GDP, and the construction sector was the driver of development of the world economic system;
  - in 2015-2016, the share of the construction industry in the world GDP grew due to the difference in trends, and construction acted as one of the basic sectors of the world economic system, which hindered the growth rate of the world economy;
  - in 2017-2018, despite the positive trend, construction is a deterrent to the development of the global economic system, which is reflected in the reduction of its share in world GDP.

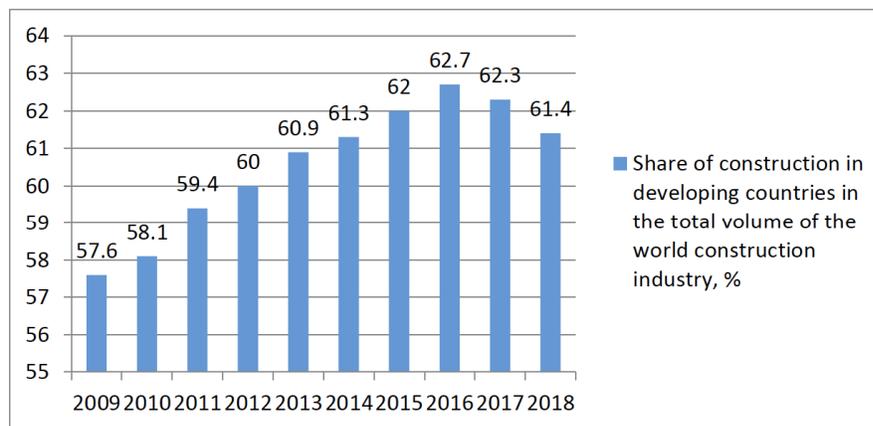
The problems of recent years are quite important for the world economic system, as construction is one of the key sectors of both the world and most national economies.

In this context, it is quite important to study the impact of the development of construction in developing countries on the world construction industry (Figure 1).

Assessing the impact of construction in developing countries on the world construction industry, the following should be noted:

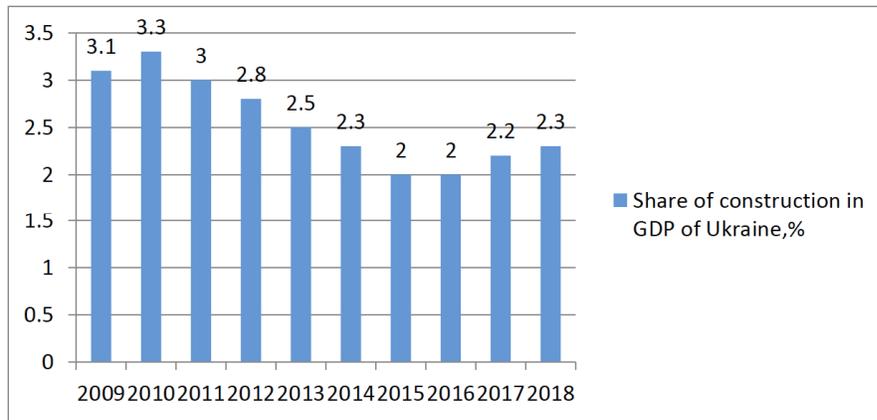
- it is the construction in the developing countries that determined the dynamics of development of the world construction industry in the studied period;
- China made a key contribution to the share of developing countries within the global construction sector;
- the most economically developed countries among the developing ones, such as India, UAE, Mexico, Turkey, Taiwan, Peru, Brazil and Chile, also had a significant impact on the development of world construction;
- the problems of 2017-2018 in the world construction industry have been caused, to a large extent, by problems in the construction sector of developing countries. First of all, this concerns the so-called "second tier" countries, which could not compensate for the declining growth rate in China and the other "first tier" countries listed above among developing countries.

In this context, it is important to investigate the development of construction in the "second tier" countries among developing countries on the example



**Figure 1:** The dynamics of the share of construction in developing countries in the total volume of the world construction industry for 2009-2018, %.

\*Developed by the author based on: Deloitte (2017), Knoema (2019).



**Figure 2:** Dynamics of the share of the construction industry in the GDP of Ukraine for 2009-2018, %.

\*Developed by the author based on: State Statistics Service of Ukraine (2019).

of Ukraine and to identify problems of industry development.

The role and place of the construction industry in the economy of Ukraine will be determined on the basis of the calculation and estimation of the dynamics of the share of construction in the country's GDP for the selected research period (Figure 2).

Assessing the dynamics of the share of the construction industry in the GDP of the country for the selected period, we can note that the impact of construction on the Ukrainian economy was not significant because of the secondary role of the industry. At the same time, three directions of the development trend are clear: 2009-2010 – growth (+ 0.2%); 2011-2016 – decline (-1.3%); 2017-2018 – growth (+0.3%). We note that the construction industry in 2018 did not reach the value for GDP in 2010.

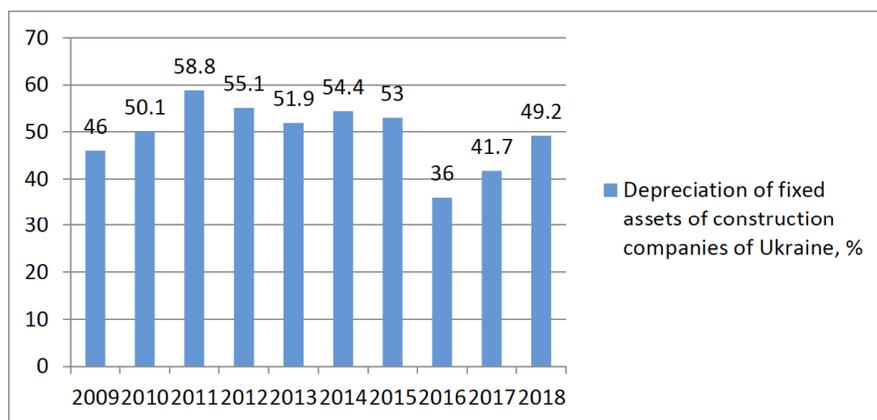
We separately note the lagging of the development of the Ukrainian construction sector behind global

trends (see Table 1), both in terms of GDP and growth trends.

A very important aspect for the development of construction is the availability, depreciation and restoration of fixed assets, which requires research on the construction industry of Ukraine (Figure 3).

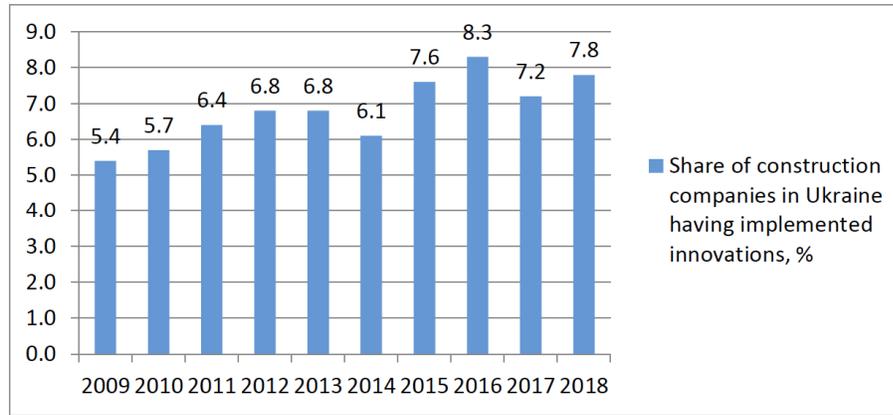
We note a critically high depreciation of fixed assets at Ukrainian construction companies during the study period, despite some positive dynamics in 2011-2018. In the vast majority, positive changes in the depreciation of fixed assets in the construction industry of the country were caused by: bankruptcy of enterprises with the most worn-out fixed assets; artificial reduction of depreciation due to revaluation of obsolete and worn-out fixed assets. Thus, we can note almost complete lack of renovation of fixed assets in Ukrainian construction during the study period.

We note the efforts of construction companies in the world to intensify their innovation activities (Kraatz,



**Figure 3:** Dynamics of depreciation of fixed assets of construction companies in Ukraine for 2009-2018, %.

\*Developed by the author based on: State Statistics Service of Ukraine (2019).



**Figure 4:** Dynamics of the share of construction companies in Ukraine that have implemented innovations for 2009-2018, %.

\*Developed by the author based on: State Statistics Service of Ukraine (2019).

Hampson and Sanchez, 2014), which requires research and evaluation of the share of construction companies that have implemented innovations in Ukraine (Figure 4).

The assessment of innovation activity in the country's construction industry in the study period indicates a critically low attention of construction companies to innovation, which was due to: lack of understanding by owners and top managers of the importance of innovation in construction; lack of financial resources for development, purchase and implementation of innovations in financial and economic activities; low interest of employees in

development and implementation of innovations; insufficient training of companies' employees on innovation development and implementation.

We note the existence of a set of problems that hinder the development of construction in Ukraine. We consider it advisable to carry out a comparative assessment of construction problems in Ukraine and other developing countries covered by Ofori (2016) in order to identify key ones (Table 2). In doing so, we will rank the problem from 0 (none) to 10 (most critical).

Based on the comparative assessment, we note a similarity of problems in the construction industry in

**Table 2: Comparative Characteristics of Construction Development Problems in Ukraine and other Developing Countries**

Problems	Developing countries	Problem rank	Ukraine	Problem rank
Increased construction costs	yes	7	yes	6
Possibility of attracting credit resources	yes	5	yes	7
Cost of credit resources	yes	7	yes	9
Quality of state regulation	yes	6	yes	7
Solvent demand	yes	7	yes	7
Availability of infrastructure	yes	7	yes	6
Technology	yes	6	yes	5
Shadow market	yes	6	yes	9
Staffing shortage	no	-	yes	8
Staff training	yes	7	yes	5
Low labour productivity growth	yes	7	yes	6
Innovation	yes	9	yes	9
Digital technology	yes	10	yes	10
Quality of construction	yes	8	yes	6

Source: developed by the authors.

developing countries, including Ukraine. The only difference is the rank of the problem and certain national features, for example, for Ukraine - a critically large shadow market in the construction field. At the same time, the tendency is clear that the key problems are the problems of development and implementation of innovations and digital technologies, where the latter are priorities. The priority of digital technologies for construction, including in developing countries, was also confirmed by Kraatz, Hampson and Sanchez (2014), Ofori (2016), the findings of the World Economic Forum (WEF, 2016) and the studies conducted by Turner & Townsend (2018). In this context, it is important to explore the development of digital technologies in the world and the issues that developing countries face on the example of Ukraine.

**3.2. Research on the Development of Digital Technology in the World and in Developing Countries. The Role of Digital Technologies in the Economy of Ukraine and the Problems of their Implementation**

The rapid development of digital technologies is the basis of the modern world and national economies of developed countries, forming: a new sector of economic systems of different levels; a new sphere of business activity; new opportunities for generating income, profits and wealth for countries, individuals and households (UNCTAD, 2019). At the same time, there

are significant risks of widening the gap between developed and developing countries (Trendov, Varas and Zeng, 2019).

We consider it appropriate to reveal and analyze the dynamics of the global digital market and its share in global GDP during the study period (Table 3). At the same time, we will not give the size of world GDP in Table 3, as they are given above (see Table 1).

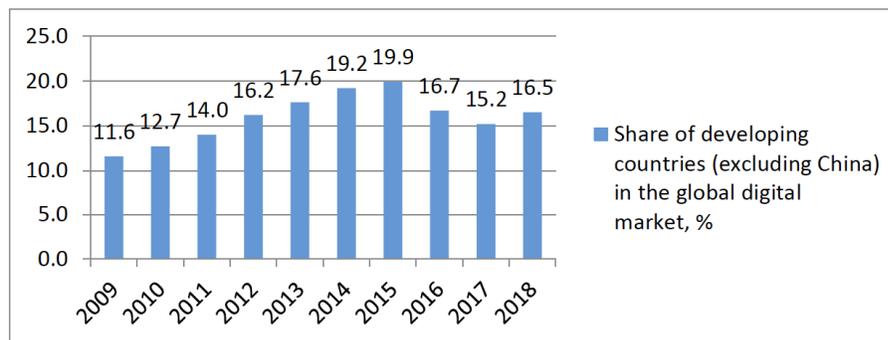
Having studied the data in Tables 1 and 3, we can see that the digital market grew faster in 2009-2018 than the global economy (335.3% versus 142.3%), leading to an increase in its share of global GDP from 2.3% in 2009 to 4.7% in 2018. At the same time, the trend related to market development problems in 2016-2017 and the gradual resumption of growth in 2018 is clear.

The problems with the development of the global digital market in 2016-2017 were due, among other things, to the lack of its growth in developing countries (Trendov, Varas and Zeng, 2019). We note mainly disincentivising impact of such countries on the development of the global digital market. In this context, let us examine the dynamics of the share of developing countries (excluding China) in the global digital market (Figure 5).

**Table 3: Analysis of the Dynamics of the Digital Market in the World and its Share in the Global GDP for 2009-2018**

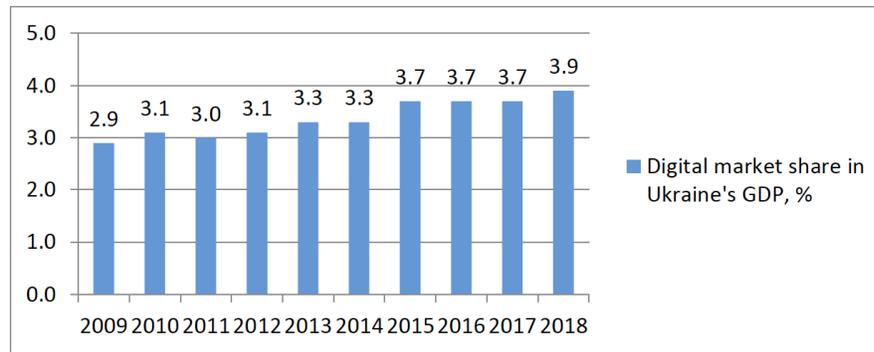
Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Abs. deviation	Growth rates, %
Digital market, \$ billion	1.4	1.5	1.6	2.1	3.8	4	4.2	4.1	3.5	4	2.6	285.7
Digital market share in global GDP, %	2.3	2.3	2.2	2.8	4.9	5.0	5.6	5.4	4.3	4.7	2.3	200.8

\*Developed by the author based on: ICI (2019), Gartner (2019).



**Figure 5: Dynamics of the share of developing countries (excluding China) in the global digital market for 2009-2018, %.**

\*Developed by the author based on: ICI (2019), Gartner (2019).



**Figure 6:** Dynamics of the digital market share in Ukraine's GDP for 2009-2018.

\*Developed by the author based on: State Statistics Service of Ukraine (2019).

Having examined data in Figure 5 and comparing it with the information in Table 3, it can be noted that problems with the development of national digital markets in developing countries have had a negative impact on the global digital market in 2016-2017. At the same time, digital markets are slowly developing due to a set of problems. In this context, we consider it appropriate to explore one national digital market (Ukrainian market) and identify its problems.

Let us estimate the dynamics of the digital market share in the economy (GDP) of Ukraine for the selected study period (Figure 6).

Having examined the data in Figure 6 and comparing it with the information in Table 3, it can be noted that the digital market in Ukraine: had a positive trend even during the two successive crises in the country; has demonstrated global trends, except for the period of 2016-2017, but has lagged far behind the share of digital technology in the global economy; showed lower growth rates than the world market (134.5% against 200.8%); grew more nominally due to the devaluation of the national currency.

We note that despite the growth, the national digital market has a set of problems, which include:

- insufficient level of state support;
- underdevelopment of legislative and regulatory framework of the market;
- lack of sufficient understanding on the part of businesses regarding the place of digital technologies in their organizational and economic mechanisms of functioning;
- insufficient funding for the development, procurement and implementation of digital technologies;

- emphasis on developing digital technologies for companies from developed countries;
- the constant outflow of digital technology developers, digital technology professionals and companies into developed and more wealthy developing countries.

Taking into account the above regarding the construction industry and digital technologies at the world level, the levels of developing economies and the economic system of Ukraine, we consider it appropriate to investigate in greater detail the role of digital technologies in the Ukrainian construction industry and their place in the organizational and economic mechanisms of the country's construction.

### **3.3. The Role of Digital Technologies in the Ukrainian Construction Industry and their Place in Organizational and Economic Mechanisms of Construction**

In today's environment, digital technologies are becoming increasingly important for the construction industry and its individual businesses. They are used for building information modeling (BIM technology), reducing the number of errors in design and construction management, improving working time accounting, improving the quality of communication between employees (Jackson, 2016), room design (Merschbrock, Tollnesa and Nordahl-Rolfsen, 2015), improving quality of safety management (Guo *et al.*, 2017), and in many other areas of construction companies.

Surveys of eighty Ukrainian construction firms, which were divided equally into large, medium, small and micro companies, on the importance and use of digital technologies in their activities provided the data summarized in Table 4.

**Table 4: The Role of Digital Technologies in Financial and Economic Activity of Ukrainian Construction Companies**

Questions	Large companies	Medium companies	Small companies	Microcompanies
Are digital technologies key to your business?	Yes (5); No (15)	No (20)	No (20)	No (20)
Does your company use digital technology?	Yes (20)	Yes (20)	Yes (20)	Yes (20)
Does your company use digital technology in management?	Yes (20)	Yes (20)	Yes (20)	Yes (20)
Does your company use digital technology in its financial activities?	Yes (20)	Yes (20)	Yes (20)	Yes (20)
Does your company use digital technology in manufacturing activities?	Yes (6) No (14)	Yes (4) No (16)	No (20)	No (20)
Does your company use digital technology in marketing?	Yes (8) No (12)	Yes (6) No (14)	No (20)	No (20)
Does your company use digital technology in HR management?	Yes (4) No (16)	Yes (1) No (19)	No (20)	No (20)
Does your company develop digital technology?	No (20)	No (20)	No (20)	No (20)
Does your company buy digital technology?	Yes (7) No (13)	Yes (2) No (18)	No (20)	No (20)
The main problem of developing and increasing the use of digital technology in your company is:				
Resistance of owners	No (20)	No (20)	No (20)	No (20)
Resistance of top managers	No (20)	No (20)	No (20)	No (20)
Resistance of employees	Yes (10) No (10)	Yes (14) No (6)	Yes (20)	Yes (20)
The cost of technologies	Yes (20)	Yes (20)	Yes (20)	Yes (20)
Deficit of funds	Yes (20)	Yes (20)	Yes (20)	Yes (20)
Staff training	Yes (9) No (11)	Yes (17) No (3)	Yes (20)	Yes (20)
Lack of state support	Yes (20)	Yes (20)	Yes (20)	Yes (20)
Ineffective state regulation	Yes (20)	Yes (20)	Yes (20)	Yes (20)
Unwillingness of consumers	Yes (15) No (5)	Yes (18) No (2)	Yes (20)	Yes (20)
Access to digital technologies	Yes (14) No (6)	Yes (19) No (1)	Yes (20)	Yes (20)

Source: developed by authors.

Having studied the use and importance of digital technologies for construction industry in Ukraine, we note:

- their secondary role for companies in the industry where they are mainly used by large business entities;
- the predominance of the use of digital technologies in management and financial activities, almost without their use in manufacturing activities;
- lack of development of digital technologies by construction companies and low purchasing activity (mainly large companies);
- given the use of digital technologies by Ukrainian construction companies, regardless of their size, and low activity in their development and purchase, we emphasize the problems of using non-licensed digital technologies;
- the main problems in the use of digital technologies by Ukrainian construction

companies are their cost, difficulties with access to them, lack of funds, poor quality of state support, resistance and training of personnel.

At the same time, given that the survey was conducted among owners and top managers, we note their subjectivity in the answer to the question regarding their resistance to the introduction of digital technologies in construction companies.

In view of the above we consider it appropriate to build a model of dependence of the development of the Ukrainian construction industry on the use of digital technologies, applying a correlation and regression analysis, namely a linear regression model, as well as to carry out a statistical verification of the obtained model by calculating the pair correlation coefficient, the coefficient of determination and Chaddock scale (Baraz, 2005). At the same time, to calculate the linear regression model, we will use statistics on the scope of construction in Ukraine during the study period, as well as the share of digital technologies in the country's GDP (Table 5).

Using the Excel tools for the data presented (Table 5), we obtained the formula of the linear regression model:

$$y = 2726x + 28177, \quad (1)$$

where  $y$  is the scope of the construction industry in Ukraine, UAH mln.,  $x$  - expenditures for use of digital technologies in construction, UAH mln.

Now, it is necessary to carry out a statistical verification in order to provide a qualitative and

quantitative assessment of the closeness of the relation between the two selected indicators. For that purpose, it is proposed to use the achievements of Baraz (2005) by three areas of verification:

1. Calculating the correlation coefficient using Excel and performing a qualitative assessment of the relationship between the two selected indicators using the Chaddock scale.
2. By comparing the calculated correlation coefficient ( $r_{calc}$ ) with the critical correlation coefficient ( $r_{crit}$ ), which will be taken from the table with consideration of  $\alpha = 0.05$  and  $f = 9$ .
3. By calculating the coefficient of determination  $R^2$  and estimating its approximation to one.

Given the above, we will conduct a statistical test of the close relationship between the scope of the construction industry in Ukraine and the expenditures for use of digital technologies in construction (Table 6).

Based on the statistical verification (Table 6), we can state:

1. Comparing the calculated value of the correlation coefficient ( $r_{calc}$ ) by the Chaddock scale (Baraz, 2005), we can say that the relation between the two selected indicators is very strong.
2. Comparing the obtained value of the calculated coefficient of correlation ( $r_{calc}$ ) with the critical value of the correlation coefficient ( $r_{crit}$ ) obtained from the table (Baraz, 2005), we note the inequality  $|r_{calc}| \geq |r_{crit}|$ , which indicates that the

**Table 5: Dynamics of the Scope of Construction Industry and Expenditures for Use of Digital Technologies in Construction in Ukraine for 2009-2018, UAH mln**

Years	Scope of the construction sector	Expenditures for use of digital technologies in construction
2009	34,123	990
2010	35,366	1,096
2011	39,575	1,187
2012	39,049	1,211
2013	36,902	1,218
2014	36,876	1,217
2015	38,928	1,440
2016	47,457	1,756
2017	64,431	2,384
2018	82,924	3,234

\*Developed by the author based on: State Statistics Service of Ukraine (2019).

**Table 6: Statistical Verification of the Closeness of the Relation between the Scope of the Construction Industry in Ukraine and the Expenditures for Use of Digital Technologies in Construction**

Factor	$r_{calc}$	$\alpha$	f	$r_{crit}$	Correlation of $r_{calc}$ and $r_{crit}$	$R^2$
Expenditures for use of digital technologies in construction	0.993	0.05	9	0.602	>	0.986

Source: developed by authors.

hypothesis of significance of linear relation is not rejected and the indicator can be included in the above model (see Formula 1).

- The value of the coefficient of determination  $R^2$  is close to one, indicating a high dependence of the scope of the construction industry in Ukraine on the amount of expenditures incurred for the use digital technologies in construction.

Taking into account that all three components of the statistical verification point to the high close relation between the two selected indicators, we note that digital technologies are a key factor in influencing the development of the construction industry in Ukraine.

At the same time, it is important to identify the place of digital technologies in organizational and economic mechanisms (OEM) of construction in Ukraine (Figure 7).

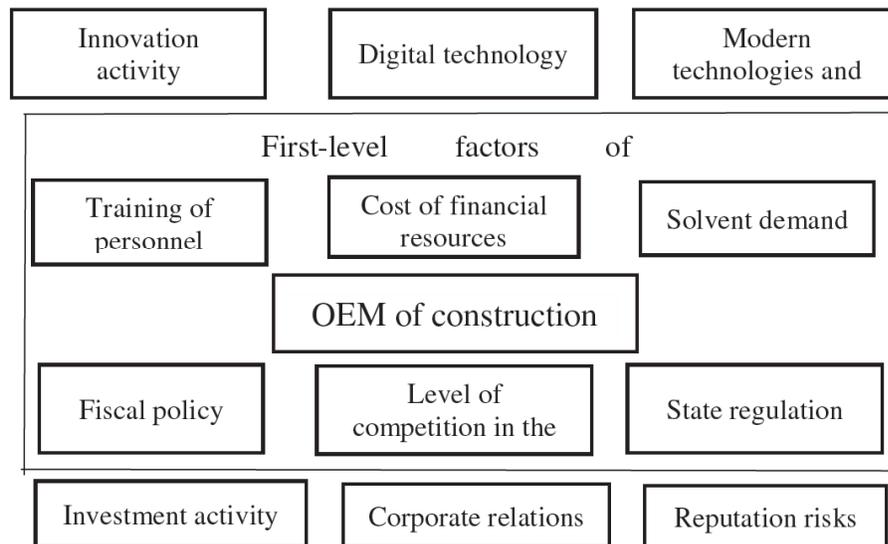
We note that digital technologies, like most other modern factors, are secondary factors influencing the functioning of organizational and economic

mechanisms of construction in Ukraine, which, given the correlation and regression analysis, does not correspond to reality and requires intensification of management influences on the adaptation of OEMs of construction companies to digital technologies.

We can distinguish the following promising areas of digitalization in the construction industry of Ukraine, which, according to the author, will significantly contribute to the development of the construction industry as a whole and increase the operational efficiency of construction companies in which changes will be introduced, in particular:

- Visualization (the most promising direction), in particular - 3-D - modeling.
- Automation of construction business management systems (control of procurement and expenditure of materials, use of equipment and working time, etc.).
- The use of construction robots (demolition of buildings in conditions that pose a danger to humans, self-propelled carts, air drones, etc.).

Second-level impact factors



**Figure 7: The place of digital technologies in organizational and economic mechanisms of construction in Ukraine.**

Source: developed by authors.

4. 3D printing ("printers" that allow "printing" buildings or parts of buildings, etc.) is the most promising for low-rise construction.
5. Building condition sensors (energy efficiency, infrastructure condition, etc.).

### 3.4. Set of Management Activities for Adaptation of Organizational and Economic Mechanisms of Construction in Ukraine to the Development of Digital Technologies

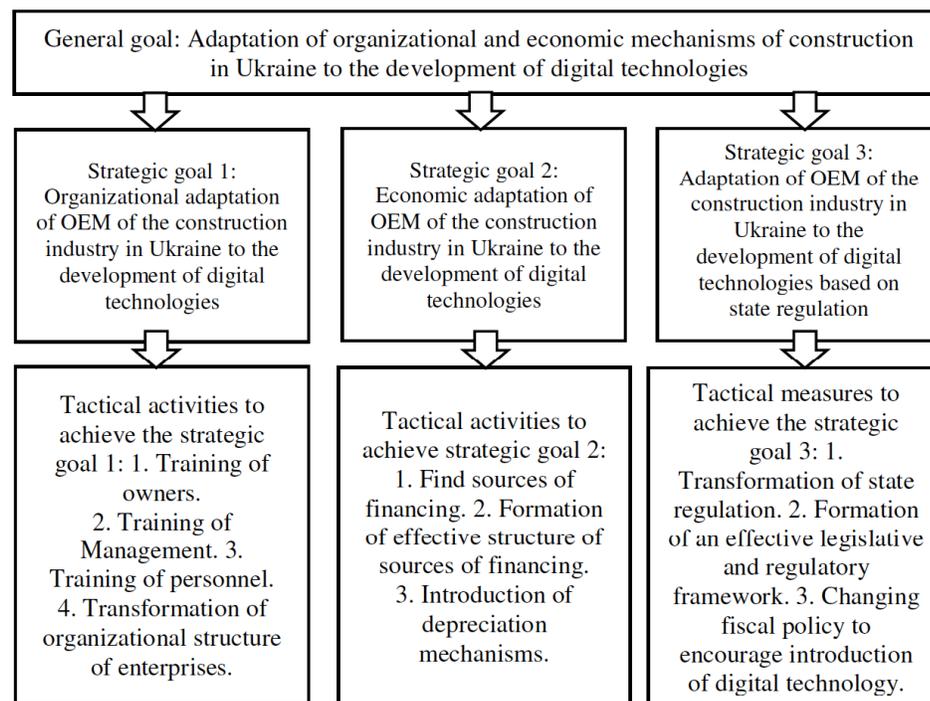
Digital technologies have one of the key influences on the development of the Ukrainian construction industry, but they are not perceived as such by business entities in national construction, which requires appropriate adaptation of the organizational and economic mechanisms of construction companies of Ukraine (Tytok, 2019). In this context, we consider it appropriate to develop and apply a set of management measures based on the methodology of Kozina and Frolina (2018).

Within the framework of managing the adaptation of OEM of the construction industry in Ukraine to the development of digital technologies, it is necessary to establish the general goal, strategic goals and tactical measures for their achievement (Figure 8).

We note that the strategic objectives 1 and 2, as well as the tactical measures to achieve them, are achieved within the internal management influences in relation to construction companies, while the strategic goal 3 and its tactical measures are achieved within the external management influences in relation to the construction companies.

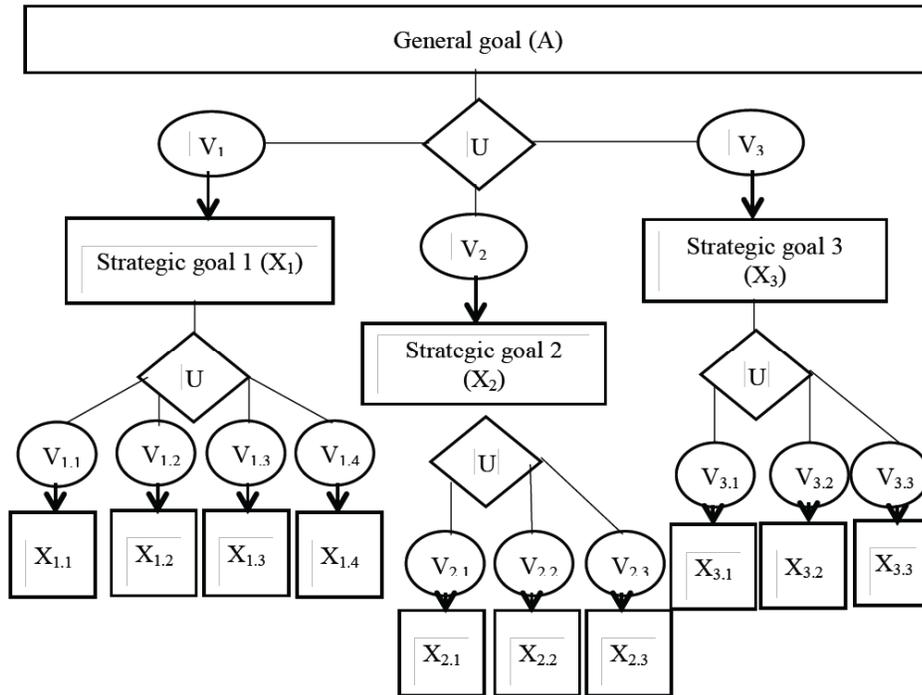
To increase the efficiency and effectiveness of the implementation of the proposed set of management activities (see Figure 8), it is proposed to use the "tree of goals". However, in the context of achieving the general goal, the following limitations should be taken into account when building and implementing the "tree of goals" in our case:

- is used for hierarchical ordering of activities within the achievement of strategic goals and general goal;
- the management process has no cycles and a goal (objective) closed in a cycle;
- synchronization of terms of implementation of activities, strategic goals and general goal;
- coherence of the general goal, strategic goals and tactical activities;



**Figure 8:** A set of management activities to adapt organizational and economic mechanisms of the construction industry in Ukraine to the development of digital technologies.

Source: developed by authors.



**Figure 9:** The “tree of goals” as part of adaptation of organizational and economic mechanisms of the construction industry in Ukraine to the development of digital technologies.

Source: developed by authors.

- concreteness of the general goal, strategic goals and tactical activities, as well as resource support for their implementation.

Given these limitations, we will build the “tree of goals” to achieve the general managerial goal (Figure 9).

We note that in Figure 9: A is the general goal of building and implementing the “tree of goals”;  $V_i$  is the coefficient of significance of strategic goals in relation to the general goal;  $V_{ij}$  is the coefficient of significance of tactical activities in relation to strategic goals;  $X_i$  - strategic goals;  $X_{ij}$  - tactical activities; U is a disjunction.

Achievement of the general goal (A) can be represented relying on the “tree of goals” (Figure 9) by linking strategic goals ( $X_i$ ) and tactical activities ( $X_{ij}$ ) as an analytic form of the logical function of Boolean algebra:

$$A = X_1 U X_2 U X_3 = (X_{1.1} U X_{1.2} U X_{1.3} U X_{1.4}) U (X_{2.1} U X_{2.2} U X_{2.3}) U (X_{3.1} U X_{3.2} U X_{3.3}), \tag{2}$$

Thus, as part of adaptation of organizational and economic mechanisms of the construction industry in Ukraine to the development of digital technologies, a set of management activities for its implementation was formed based on the “tree of goals” and analytical form

of the logical function of Boolean algebra, which will allow increasing the role and efficiency of digital technologies in the construction industry of Ukraine in the context of global trends.

#### 4. DISCUSSION

The construction industry is one of the key to the development of the world economic system and individual economies. It is of great importance to developing countries, enabling significant opportunities to stimulate the growth of their economic systems. At the same time, digital technologies are becoming increasingly important for the construction industry, which allows increasing its efficiency and competitiveness in the world and national markets of construction services. In this context, it is necessary to improve the management of adaptation of organizational and economic mechanisms of the construction industry to the development of digital technologies in developing countries, including in Ukraine, which requires testing a number of hypotheses.

The hypothesis that the construction sector in the world and in Ukraine has a significant impact on economic systems of the appropriate level and shows a steady increase in the last decade has been confirmed

in part and only for the world market of construction services.

The hypothesis that the development of digital technologies is ahead of the development of the world economy, experiencing disincentivising influence of the developing countries in recent years, has been fully confirmed.

The hypothesis that the development and introduction of digital technologies into the Ukrainian economy is slow due to a set of economic and institutional problems has also been confirmed.

An assessment of the development of digital technologies in Ukraine has shown that they have little impact on the development of the Ukrainian construction industry and occupy a secondary place in the organizational and economic mechanisms of the national construction industry. At the same time, the correlation and regression analysis identified the key importance of digital technologies for the national construction sector.

The hypothesis that the economy of the country and of the construction sector needs development and implementation of a set of management activities to adapt the organizational and economic mechanisms of the construction industry in Ukraine to the development of digital technologies has been confirmed. As part of this hypothesis, an appropriate set of management activities based on the “tree of goals” and an analytical form of the logical function of Boolean algebra were developed.

In view of the above, it can be noted that the objective of the study, which was set at the beginning of the research, was achieved. A key value of the research paper is the development of a set of management activities for the adaptation of organizational and economic mechanisms of the construction industry in Ukraine to the development of digital technologies. In this regard, some limitations can be identified in the application of the results of this research paper, namely: the need to review the proposed activities in practice; spread of the set to developing countries taking into account the individual characteristics of the development of their national economies and construction industries. At the same time, the stated limitations do not diminish the scientific and practical value of this research paper and describe, to a greater extent, the prospects of further scientific research.

## 5. CONCLUSION

Digital technologies are increasingly important for all sectors of the economy, including construction sector. At the same time, the construction industries of developing countries, including Ukraine, are mostly not adapted for the active introduction of digital technologies into the organizational and economic mechanisms of their business entities. This situation needs to be solved by optimizing the management of adaptation of OEM of national construction companies to the development of digital technologies on the example of a separate state (Ukraine in this study).

The conducted research revealed the trends and problems of development of the construction industry and digital technologies in the world, in developing countries and Ukraine. On this basis, a set of management activities was developed for the adaptation of the organizational and economic mechanisms of Ukrainian construction companies to the development of digital technologies.

The practical implementation of the suggestions and conclusions of this research paper should be considered in the context of their importance for improving the efficiency of the construction sector of developing countries, including Ukraine, through the active introduction of digital technologies.

Prospects for further research based on the scientific results of the conducted research are to finalize the developed set of management activities for developing countries taking into account the individual features of the development of their national economies and construction industries.

Despite the fact that this research makes the most important contribution to the scientific base of the construction industry, the results of this research can be used not only in the construction industry, but also in other areas of the economy, since it uses the methodology and principles that can be applied to other objects of study. In this case, it is necessary to take into account the specifics of the activities of enterprises in a particular area and focus on solving specific problems in this area.

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