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Trends in the development of the national economy as a medium for the functioning of Ukrainian organizations

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Abstract. The relevance of the research problem is determined by the need to identify perspectives of the functioning of Ukrainian organizations in the conditions of global changes in the world economy and the activation of European integration processes. The purpose of the article was to analyze the trends in the development of the national economy based on the study of the structure of the main indicators, the determination of the degree of their interaction and the assessment of mutual influence on the functioning of Ukrainian organizations. To achieve the goal, the following methods were used: morphological analysis; scientific induction and deduction; dialectical method; system analysis; grouping and comparative analysis; analysis and synthesis, structural-functional approach; content analysis; methods of logical analysis and generalization, descriptive statistics, formalization; graphical and tabular method. The main results of the study are as follows: the need to analyze the causes of the country's economic development, in particular, the dynamics of the nominal and real GDP, its structure and the number and qualification characteristics of the population, which is a stimulating factor of economic development, is substantiated; the expediency of analyzing employment and unemployment indicators, the number of vacancies, the level of entrepreneurial initiative development to assess the economy's ability to provide workers with jobs has been proven; the need to analyze the economic growth of the country in connection with the analysis of the standard of living of the population is indicated, because what reflects positive material changes is an indicator of the development of society; reduction of the population in Ukraine, due to the outflow of its most active part abroad, which negatively affects the quality of the labor and is an obstacle to the growth of production rates; the causes of the outlined trends were identified, such as: the 2014 crisis associated with military operations in the East of Ukraine, political instability, rapid inflation, devaluation of the national currency, and the consequences of the COVID-19 pandemic, which affected the activities of economic entities and individuals due to the growth of unemployment and social restrictions. The practical significance of the obtained results lies in the formation of recommendations for taking into account the development trends of the national economy in the process of identifying prospects and possible problems of the functioning of Ukrainian organizations in the conditions of the country's integration into the European community. Formulated conclusions and recommendations will be useful for managers and business owners seeking to build a competent organization on the way to joining the European economic space

Keywords: functioning of the organization, gross domestic product, organizational efficiency, organizational competence, European integration

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● INTRODUCTION

The need to study the national economy as an environment for the functioning of Ukrainian organizations is explained by its influence on the life of society through a set of elements that, realizing certain functions, cause it to acquire the status of the most complex subject of management. The result of the functioning of the country's economy is measured by the increase in national wealth, the volume

of goods and services necessary for society, the level of political and social stability, as prerequisites for the formation of favorable conditions for organizations [1]. The goal of the country's economic development, which involves a change in the national economy, its transition from one qualitative state to a higher level, is to increase gross income, the well-being of the population with an

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increase in the material security of state members, and the minimization of public expenses [2]. Economic growth is a component of economic development, its quantitative characteristic, the so-called foundation. The impact of these processes on the functioning of Ukrainian organizations, on the acquisition of the status of competent in the European space, requires the study of the development trends of the country's economy with the analysis of relevant indicators, determination of its trajectory, features at the macro- and meso-levels [1].

The outlined problem is the subject of scientific discussions. N.O. Kukhars'ka with co-authors [3] studied the transformation trends of the national economy, determining the conditionality of its competitiveness by economic, social and political factors that affect the stability of the country's position in the domestic and foreign markets, the ability of product manufacturers to work according to international standards, N. Shpak, O.V. Pyroh with colleagues [1], while investigating the conditions of functioning of modern organizations, emphasized the importance of public-private partnership, understanding by it cooperation between the state and business structures of Ukraine and foreign countries. This is considered a condition for successful integration of the country into the European space, activation of innovative activities of Ukrainian organizations, attraction of investments, which will contribute to the solution of socio-economic problems. E.V. Prushkivs'ka and her co-authors [4] emphasized the factors of the socio-economic development of the country in the conditions of European integration, highlighting the economic activity of people in the environment formed by formal and informal institutions as the most influential. Scientists analyzed the value orientations and socio-psychological guidelines of representatives of our country in comparison with representatives of other countries and recognized the dependence of socio-economic development on the socio-cultural component in the form of informal institutions as one of the main determinants of social progress. O.V. Mostipaka [5] studied the structural changes of the national economy, their causes and consequences for the development of Ukrainian society. In formulating recommendations, the author relies on the results of the analysis of nominal and real GDP, the amount of capital investments and their share in GDP, depreciation of fixed assets, considering their level and dynamics as indicators of the activity of innovative processes as a stimulus for the transformation of the national economy. R.V. Lavrov with co-authors [6] tried to identify the factors restraining the economic growth of Ukraine, conducting a study of the impact of the corona crisis on the prospects of economic development. Scientists assessed its short-term and long-term consequences through a SWOT analysis of the current state of the Ukrainian economy, identifying potential risks and taking them into account when outlining the prospects for the functioning of Ukrainian organizations. The results of the analysis of the dynamics of GDP, its industry structure, and the level of the final indicators of Ukraine's foreign trade became the basis for the conclusions regarding the extent of the damage caused to the world economy. A. Korbutyak [7] gave priority to solving the problems of forming the investment and innovation potential of Ukraine in the context of increasing

the level of its competitiveness in the world market. The author investigated the level of development of scientific, technical and innovative activities in Ukraine, carried out a comparative analysis of the share of new technologies and products in the GDP of Ukraine and developed countries of the world, drawing disappointing conclusions about the first. The main goal was to identify opportunities for the development of innovative activity, which requires painstaking work in the direction of improving the investment climate in the country, as well as the volume and structure of investments.

It is necessary to remember the dynamism and extremely high degree of uncertainty of the national economy of Ukraine provoked by the influence of a large number of various factors, especially during the period of military operations and the corresponding economic and political crises, that is the reason for the rapid loss of relevance formulated conclusions. This determines the need for constant monitoring of the state of the national economy and appropriate consideration of existing and probable trends when determining the prospects for the functioning of Ukrainian organizations, in particular, on one of the world's largest markets for goods and services.

The purpose of the article was to analyze the directions of the development of the national economy based on the study of the structure of the main indicators, the determination of the level of interaction between them and the assessment of the mutual influence on the results of the activities of Ukrainian organizations.

● MATERIALS AND METHODS

To solve the tasks outlined in the article, a combination of the following general scientific and special research methods was used:

1) the method of morphological analysis – for substantiating the essence and content of the concepts “economic development” and “economic growth”, identifying their relationship and fundamental differences; disclosure of the essence of the concept of “competency of the organization” to justify the dependence of its general level on the state of the national economy of Ukraine, which forms the environment for the functioning of modern Ukrainian organizations;

2) methods of scientific induction and deduction – to substantiate the expediency of using the results of the analysis of trends in the development of the national economy as an environment for the functioning of modern Ukrainian organizations to identify prospects for their successful activity in the conditions of the intensification of European integration processes;

3) the dialectical method – to substantiate and generalize approaches to the analysis of trends in the development of the national economy and the assessment of the strength of their influence on the conditions of functioning of Ukrainian organizations in order to identify the prospects of their successful activity on the European market of goods and services;

4) the method of system analysis – to study the structure of nominal and real GDP, determine the contribution of various types of economic activity to its total volume, the share of high-tech and science-intensive sectors of the economy, focused on the production of new knowledge and

technologies, in the structure of GDP; to analyze the distribution of GDP by regions of Ukraine, the ratio between the primary, secondary and tertiary sectors of the economy according to the Fisher-Clark model; to determine the size of the existing population of Ukraine, changes in its structure and quality;

5) methods of grouping and comparative analysis – to identify during the analytical period the dynamics of indicators of nominal and real GDP, their growth rates in absolute and relative terms, the volume of GDP per capita, the size of the existing population of Ukraine, the volume of mining and processing industry in the structure of the real GDP of Ukraine, the overall structure of the GDP of Ukraine, shares of the primary, secondary and tertiary sectors of the Ukrainian economy; to analyze the GDP per capita indicator as a characteristic of the quality of life of Ukrainian citizens and an additional tool for comparing the levels of economic development of different countries and, accordingly, the welfare of their population;

6) methods of analysis and synthesis, structural-functional approach – for researching the structure of the national economy of Ukrainian as a basis for analysis, for a detailed description of its components with the aim of clarifying directions for identifying the causes of existing changes in the national economy, assessing the direction and degree of their influence on functioning and development modern Ukrainian organizations, justification of effective methods and tools necessary for this;

7) the method of content analysis – to form a set of indicators for assessing trends in the development of the national economy of Ukrainian, to clarify their essence and content, to identify the difference between the nominal and real GDP of Ukraine and to justify the objective necessity of their combined use for the purpose of analyzing current trends in the national economy of Ukraine;

8) methods of logical analysis and generalization – to determine key indicators for assessing the state of the Ukrainian economy in the context of its influence on the activities of organizations;

9) methods of descriptive statistics – to study the relationship between the level of individual indicators and the general trends of changes in the Ukrainian economy;

10) formalization method and graphic method – for substantiation of formulated conclusions and their visual presentation;

11) tabular method – for systematization of the obtained research results. Modern computer technologies, in particular, the capabilities of the special software and technical tool

MS Excel, were used to process the data, carry out the necessary calculations, and build appropriate diagrams and graphs based on them to present the results of the analysis.

The informational and factual base of the research, the results of which are presented in the article, was formed on the basis of statistical analysis, generalization and systematization of information from the official websites of the State Statistics Service of Ukraine and the World Bank [8; 9], materials of analytical reviews and periodical publications [10-12], works of Ukrainian scientists, etc.

● RESULTS AND DISCUSSION

According to experts, the dynamics and sectoral structure of the nominal and real GDP, the increase in the number of the population, in particular, the labor resources of the country with the necessary qualification characteristics, which is an important factor of economic development, should be subject to analysis. However, it must be taken into account here that the effect of population growth directly depends on the ability of the economy to provide new employees with workplaces, therefore, the analysis of the levels of employment and unemployment in the country, the number of available vacancies, which, in turn, is related to the development of entrepreneurial initiative, and, therefore, the creation of new organizations and, consequently, new jobs [2]. The importance of analyzing the indicators, determining their level and possible reasons for their decline is explained, first of all, by the fact that their growth creates prerequisites for attracting a larger amount of investment and capital to the country's economy, which, in turn, will ensure a higher level of production.

The nominal and real value of the country's GDP are generalizing indicators of its economic growth and, therefore, economic development. The value of nominal GDP reflects the total volume of production at current prices at the time of production, however, its growth tendency does not always indicate positive trends in the national economy, which makes it necessary to calculate real GDP, that is, the volume of production at constant, basic prices. For countries with a so-called transition economy, characterized by its significant instability, it is most expedient to measure real GDP at the prices of the previous year. The main difference between the indicated indicators is that the real GDP is affected only by production volumes, or, more precisely, their changes, without taking into account the rise in prices, therefore, it can fairly objectively characterize economic activity in the real sector of the national economy (Table 1).

Table 1. Dynamics of nominal and real GDP of Ukraine

Indicators	Nominal GDP (in actual prices), million UAH	Real GDP (in previous year's prices), million UAH	Difference		GDP per capita	
			in absolute terms, million UAH	in relative terms, %	nominal, UAH	real, UAH
Years						
2012	1 404 669,00	1 303 094,00	-101 575,00	-7	30808,7	28580,8
Growth rates (GR), %	8.05	14.5	-	-	8.3	14.8
2013	1 465 198,00	1 404 293,00	-60 905,00	-4	32209,5	30870,6
GR, %	4.3	7.8	-	-	4.6	8.1
2014	1 586 915,00	1 369 190,00	-217 725,00	-14	37050,3	31967,00
GR, %	8.3	-2.5	-	-	15.03	3.6

Table 1, Continued

Indicators	Nominal GDP (in actual prices), million UAH	Real GDP (in previous year's prices), million UAH	Difference		GDP per capita	
			in absolute terms, million UAH	in relative terms, %	nominal, UAH	real, UAH
2015	1 988 544,00	1 431 826,00	-556 718,00	-28	46412,6	33418,8
GR, %	25.3	4.6	-	-	25.3	4.5
2016	2 385 367,00	2 037 084,00	-348 283,00	-15	55899,4	47737,6
GR, %	20.0	42.3	-	-	20.4	41.9
2017	2 983 882,00	2 444 191,00	-539 691,00	-18	70233,0	57530,0
GR, %	25.1	20.0	-	-	25.6	20.5
2018	3 560 596,00	3 085 492,00	-475 104,00	-13	84235,0	72995,2
GR, %	19.3	26.2	-	-	19.9	26.9
2019	3 978 400,00	3 675 300,00	-303 100,00	-8	94661,1	87449,2
GR, %	11.7	19.1	-	-	12.3	19.8
2020	4 222 026,00	3 827 941,00	-394 085,00	-9	101137,6	91697,3
GR, %	6.1	4.1	-	-	6.8	4.9
2021	5 459 574,00	4 363 582,00	-1 095 992,00	-20	131944,4	105457,0
GR, %	29.3	14.0	-	-	30.5	15.0

Source: [8-10]

According to the data provided on the official website of the State Statistics Service of Ukraine [8], Ukrainian's economy has been growing steadily since 2012. Thus, the

nominal GDP during the analyzed period increased by UAH 4,054,905 million; real GDP growth rates were slower – slightly more than 3 times (by UAH 3,060,488 million) (Fig. 1).

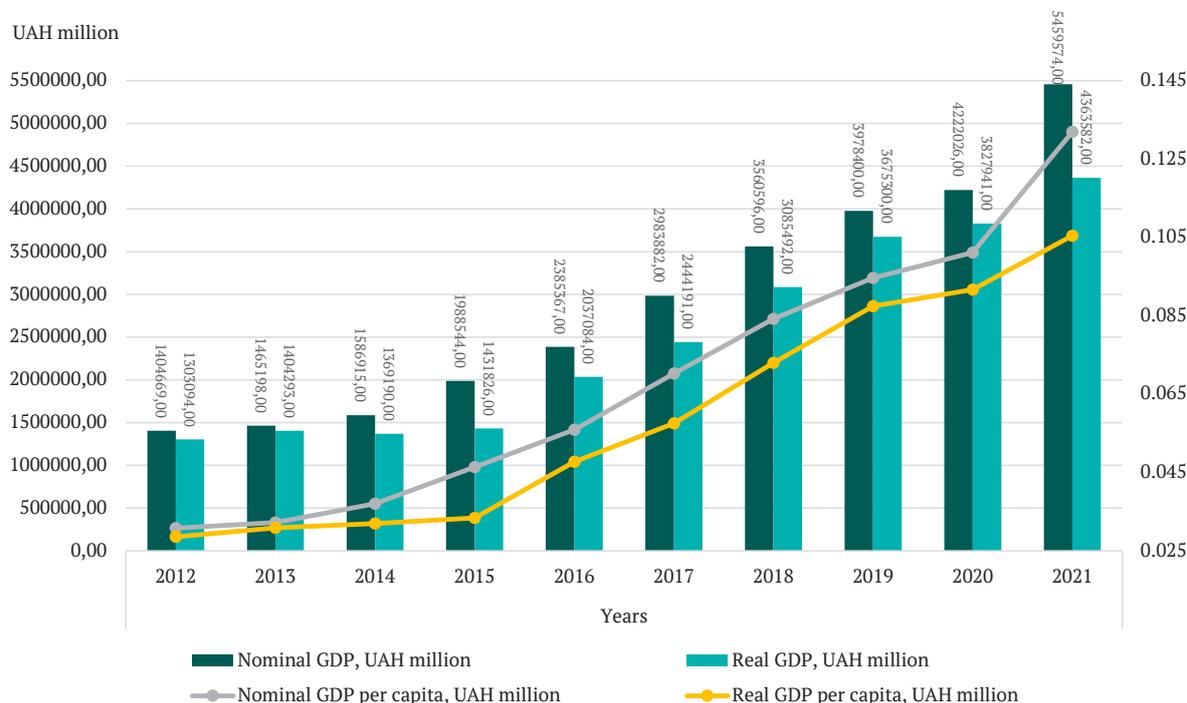


Figure 1. Dynamics of the GDP of Ukraine during 2012-2021

Source: [8-10]

The GDP trend is the main economic indicator traditionally used to characterize the state of national economy, when determining the relative deficit of the state budget, the degree of financial dependence of the country [10]. Taking into account the mentioned trends, it can be said

that there is an improvement in the state of Ukrainian's economy, however, in this case, such unequivocal conclusions cannot be made. The nominal GDP is determined based on current market prices, which reflect the real turnover of the product and determine the incomes of the

participants in the economic process. Such an assessment provides an opportunity to analyze the sectoral structure of the economy, to determine possible disproportions between consumption and accumulation on other, equally important, macroeconomic relationships. However, due to the dependence of such an assessment on the price level, it is not possible to objectively measure the dynamics of the volumes of produced and used goods and services.

The comparison of physical volumes of macroeconomic indicators of the current period becomes possible under the condition of their revaluation at constant prices that is, by the so-called leveling of the price factor. Turning our attention to the difference between nominal and real GDP (Table 1), it shows an absolute decrease in nominal GDP due to price dynamics, starting from 7% in 2012 and reaching 20% in 2021. The figure 1 clearly shows that the volume of real GDP lags behind its nominal value, which, first of all, indicates the rise in market prices, the deflation of GDP, the excess of the value of the unit price index.

According to scientists, economic growth, which, first of all, reflects positive material and quantitative changes,

is also an indicator of the quality development of society, which determines the relationship between the growth of production levels and the life of the population [3]. This is the improvement of its material well-being, the development of human intelligence, the improvement of its cultural and educational level, the development of social infrastructure sectors, the growth of investments in human capital with the simultaneous creation of safe living and working conditions for people, ensuring the social security of the unemployed and disabled [3]. In view of this, an important indicator of an objective assessment of the functioning of national economy is the growth of GDP per capita, which reflects the quality of life of the country's citizens and, in addition, is a tool for comparing the levels of economic development of different countries and, accordingly, the welfare of their population.

According to the preliminary analysis, it can be said that in Ukraine during 2012-2021 economic growth is observed against the background of a steady trend of reduction in the total population from 45,593.3 thousand people in 2012 to 41,148.9 thousand people in 2021, that is, by almost 5 million people (about 10%) [8; 9] (Fig. 2).



Figure 2. Dynamics of the available population of Ukraine during 2012-2021

Source: [8]

The growth of real GDP per capita varies between 3-5% in 2014-2015 and 2020 and exceeds 40% in 2016. If you analyze the indicator of the size of the existing population of Ukraine, you can understand that such fluctuations are explained not only by the growth of GDP, but also by the decrease in the size of the population: by almost 6% and by about 1.5% in 2014 and 2021, respectively. The exception was 2016, when the population decreased by only 0.4% with a significant increase in real GDP per capita. However, it should be noted about the negative point of reducing the number of the existing population in Ukraine, because it is not always due to the natural consequences of the excess of mortality over birth, very often the explanation lies in the outflow of the most active part of the population abroad, which has an extremely negative effect on the quality of the labor. Active labor migration, which provokes a mass outflow of personnel, is an obstacle to the growth of production rates, first of all, in such critical sectors as construction, industry, agriculture, transport and communication.

This causes a threatening shortage of highly qualified personnel in strategically important areas of the economy in Ukraine.

The value of the GDP per capita indicator in Ukraine, which characterizes the resilience of the national economy to negative internal and external influences, is also significantly lower than its average level in developed countries. So, for example, in 2012, the GDP of Ukraine per capita in terms of US dollars amounted to USD 3.58 thousand, in 2021 its level reached USD 3.89 thousand, that is why it can be noted an insignificant increase while maintaining a lower level than in countries of the European Union, where it reaches almost USD 35 thousand [9].

Additional conclusions about the development or decline of the economy, their rates, about fluctuations in the economic situation, the degree of influence of certain factors on the Ukrainian's economy, can be made by evaluating the dynamics of the growth rates of these indicators (Fig. 3) [11].

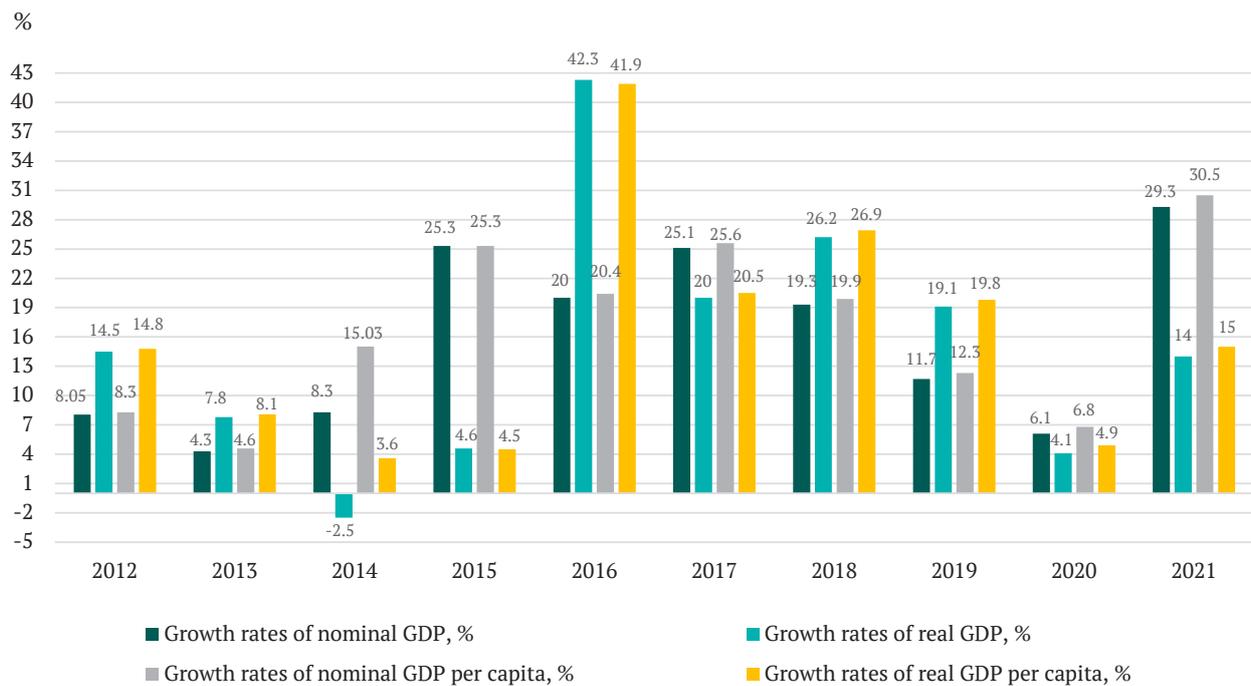


Figure 3. Growth rates of Ukraine's GDP during 2012-2021

Source: [8]

Figure 3 demonstrates the unstable nature of changes in both nominal and real GDP. The nominal GDP growth rate, fluctuating within 10% in 2012-2014 and 2019-2020, reaches 20-30% in 2015-2018 and 2021. As for the volume of real GDP, 2014 showed a negative growth rate of -2.5%, and 2016 showed a maximum growth rate of about 42%. Such trends always have objective reasons [11]. Thus, the crisis of 2014 caused, first of all, by the military actions in the East of Ukraine and the corresponding political instability in the country, which led to an increase in inflation rates, a significant devaluation of the national currency and expected negative sentiments in society [11].

As for the significant decrease in indicators in 2020, this is a consequence of the COVID-19 pandemic, which is still relevant, because the time limits for its solution do not have specific values, and the consequences for the socio-economic sphere are difficult to predict [6; 11]. The pandemic has affected the activities of every business entity, which had to adapt to the new rules, however, the reduction of the number of employees or the complete closure of many organizations could not be avoided. The changes also affected individuals, who felt the increase in unemployment and a number of social restrictions. Due to the instability of national economy and social sphere, the constant deficit of the state budget, the coronavirus pandemic has had a significant impact on Ukraine. Compared to the first wave (spring-summer 2020), which did not result significant negative trends, because unlike European countries, Ukraine had a smaller number of patients and there was no overload of the medical sector, the second

wave of the coronavirus, starting from October 2020, was more dangerous for the economy, based on social attitudes and the previous allocation of budget funds to fight the coronavirus. According to the UN study, 80% of Ukrainian households lost income due to the pandemic, and in more than 40% of households at least one family member lost a job [12]. It is clear that these trends could not help but have an impact on GDP dynamics in Ukraine.

GDP growth in Ukraine, in 2015-2018 and 2021, can be explained by the relative stabilization of the economy of Ukraine compared to previous years, due to the decrease in the activity of military operations in the East, the decrease in the strength of the manifestation of the COVID-19, and, therefore, the gradual recovery of the economy, the development of new sales markets by Ukrainian producers of goods and services, the activation of the country's activities on the international stock market by selling state securities [13].

The need to understand the objective reasons for modern trends in the development of the national economy requires an analysis of the structure of GDP, because the quality of economic growth is evidenced by the contribution of various types of economic activity to GDP. Ukraine is distinguished by a high and stable level of specialization of basic industries and regions in the national economy, which is characterized by a raw material orientation and, accordingly, a small share of high-tech and knowledge-intensive industries focused on the production of new knowledge and technologies about 3% in the structure of GDP compared to almost 15% of extractive and processing industry (Fig. 4) [11].

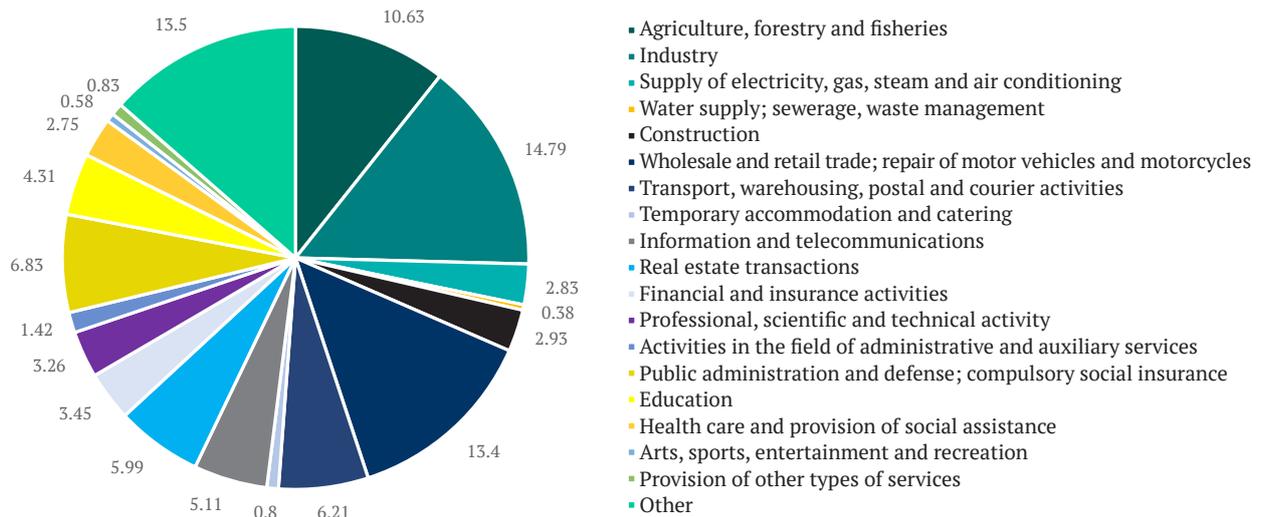


Figure 4. Structural distribution of real GDP of Ukraine in 2021, %

Source: [8]

The majority of experts, considering this a serious restraining factor of economic growth and a precondition for the formation of a regressive sectoral structure of the economy, explain it by the historical features of the development of the regions, not always favourable investment climate and the lack of effective institutional reforms in Ukraine [11]. Therefore, scientists who are engaged in the search for effective ways of developing the national economy insist on the need to increase the share of high-tech industries with high added value, rationalize the sectoral structure of the economy on the basis of this, and accordingly reduce its dependence on raw materials.

For a long time, the high rates of growth of the gross regional product in the leading regions of industrial development, such as the city of Kyiv, Dnipropetrovsk, Kharkiv,

and Zaporizhia regions, were traditionally considered a positive trend and a prerequisite for building up the country's industrial capacity [3]. However, their focus, mainly on the exploitation of mineral resources of local origin, has weak long-term prospects due to their natural limitations and the significant dependence of resource- and energy-intensive industries on chaotic fluctuations of world prices for energy carriers and raw materials. Given this, we can conclude that excessive dependence on raw materials is undesirable for the further development of national economy [4].

In the structure of the real GDP of Ukraine, the share of industry is the largest – about 15%, therefore, its chaotic change during the analyzed period and negative values of growth rates during certain periods practically exclude stable economic growth (Fig. 5).

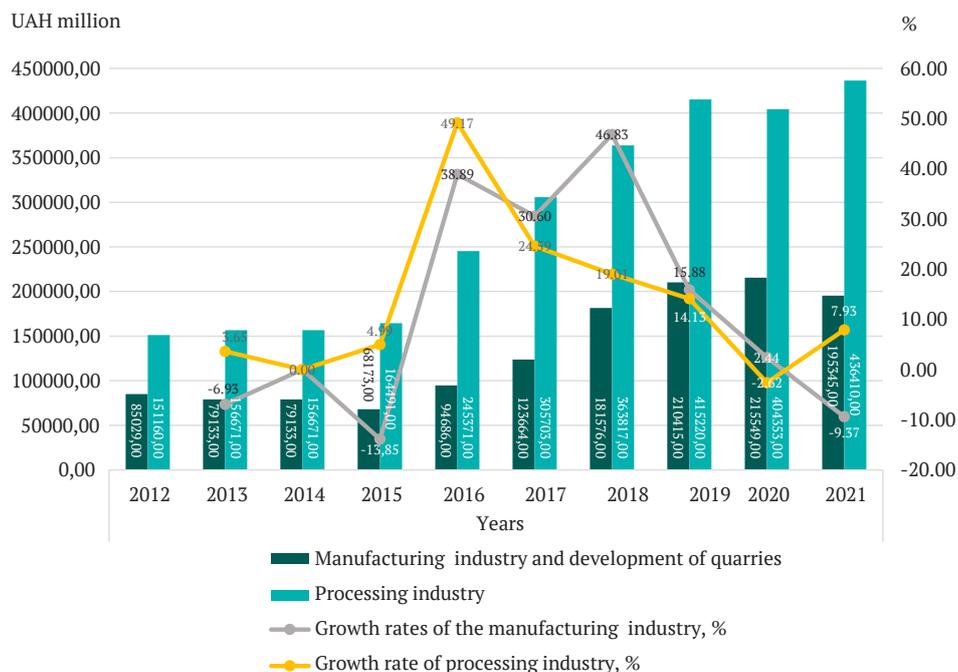


Figure 5. Dynamics of volumes of extractive and processing industry in the structure of real GDP of Ukraine in 2012-2021

Source: [8]

Industrial production, according to experts [3], directly or indirectly shapes the dynamics of the economy as a whole due to its determining influence on other industries (transport, construction). The loss more than 20% of industrial production due to the occupation of the industrial part of Donbas in 2014 led to a decrease in the share of the manufacturing industry in the total volume of GDP by almost 1%. The coronavirus pandemic in 2020 reduced the value added share by a feather 1.15% and the value added share by 0.56%, together with their general focus on energy-intensive, import-dependent energy carriers, negatively affected the efficiency of the economy as a whole due to its significant dependence from the specified sectors of the economy [11].

Experts claim that the gradual slowdown in the rate of growth of the share of industry in the GDP of Ukraine should not be considered exclusively as a negative phenomenon [14]. Changes in the economy of the most developed countries of the world have long been evidence of a gradual transition to the post-industrial stage of their development with a characteristic decrease in the share of industrial and material production against the background of the active development of the information and services sector [11], thereby determining the primacy of the service sector as the main element of the formation of a post-industrial society [10].

It should be noted that the general trends in the structure of GDP of Ukraine, during 2012-2021, also reflect its significant change (Fig. 6) [11].

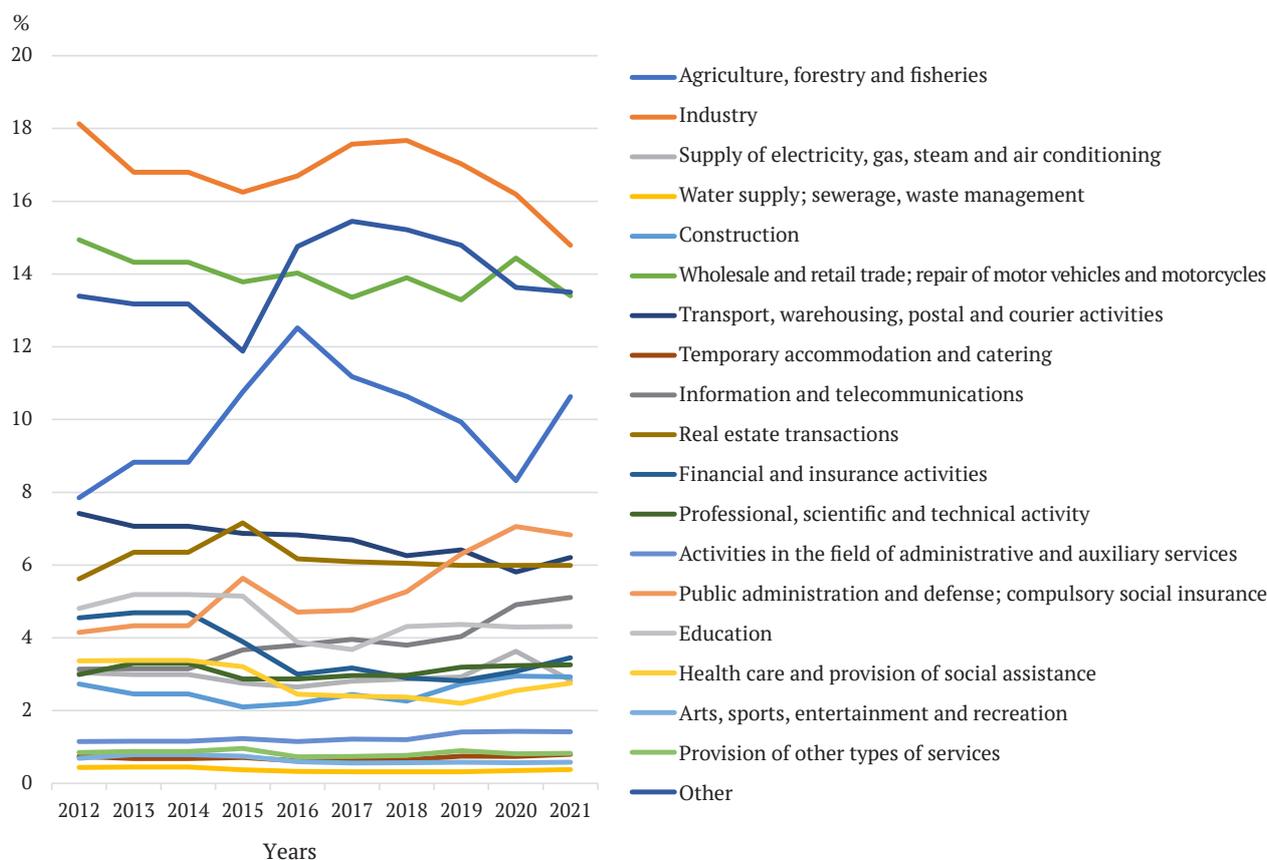


Figure 6. Dynamics of the GDP structure of Ukraine in 2012-2021

Source: [8]

There are an increase in the share of such activities as: agriculture (by 2.46%), public administration and defence is obvious; mandatory social insurance (by 2.68%), information and telecommunications (by almost 2%), real estate transactions (by 0.37%), professional, scientific and technical activities and activities in the field of administrative and auxiliary services (by 0.27%), with a simultaneous decrease in the shares of the manufacturing and processing industry – by 2.05 and 1.6%, respectively, and the almost absence of any positive changes in the construction sector for 10 years – a stable downward trend until 2018 (by 0.47%) with insignificant growth over the next three years (Fig. 6). A similar

trend towards an increase in the share of the service sector in the GDP structure combined with a decrease in the share of industry, which is called in the literature deindustrialization [10], fully corresponds to the trends in the development of the economy of highly developed countries of the world.

The famous scientist A. Fisher and K. Clark, developing a typology of economic sectors, highlighted (Fig. 7) [15]:

- the primary sector, including activities related to obtaining primary resources: agriculture, forestry and fisheries, extractive industry and quarry development;
- the secondary, which unites processing activities, and therefore includes branches of the processing industry;

supply of electricity, gas, steam and air conditioning; water supply; sewerage, waste management;

- the tertiary, covering the sphere of services, construction and certain types of repair activities.

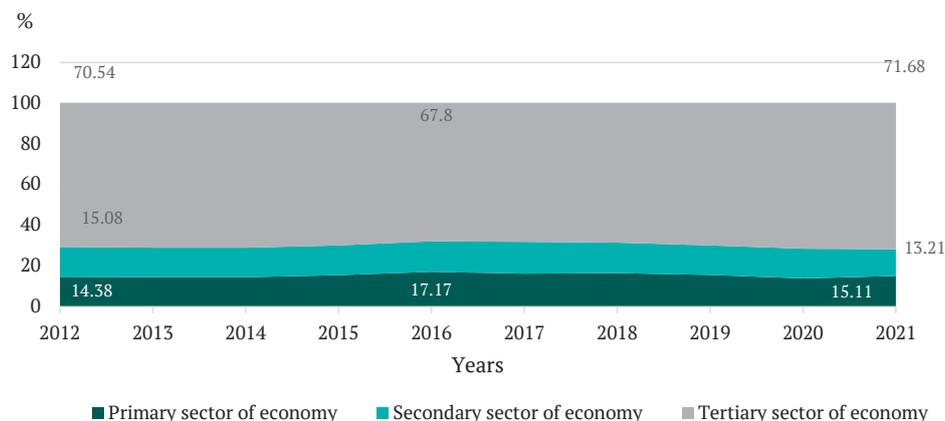


Figure 7. Dynamics of Ukrainian economic sectors according to the Fisher-Clark typology

Source: [8; 15]

Figure 7 generally reflects the structure of the national economy, which corresponds to the trends of the transition of developed countries to a post-industrial society with a characteristic significant advantage of the service sector (more than 70%) [11; 14]. Insignificant growth of the primary sector is mainly explained by positive development trends in agriculture, the secondary sector shows an insignificant but stable tendency to decrease its share in the structure of the real GDP of Ukraine.

The Fisher-Clark typology was formed against the background of the industrial revolution, and subsequent technological and organizational revolutions led to a significant demarcation of the secondary and tertiary sectors and, as a result, the selection of types of services that received the characteristics of the so-called intermediate factors of production and became important components in the production material transformations of the secondary sector – registration of patents, financial services of enterprises, human resources management, advertising, labor organization [16-18]. At the same time, in terms of their essential characteristics, they are closer to the traditional sectors of the tertiary sector aimed at serving the population – trade, education, medicine, especially since some of them are provided to legal entities and individuals by the same organizations (banking and advocacy organizations, etc.).

Under the existing structure of the national economy and the traditional management model, the task of ensuring balanced development and GDP growth at an accelerated pace becomes more difficult. Therefore, it is important, to take into account the potential advantages of Ukraine, the main of which are human capital, geographical location and natural resources, to determine the most powerful factors of the future qualitative leap [11]. Bearing in mind that promising competitive advantages are created in Ukrainian markets, they can become sectors of the economy, types of economic activity and, accordingly, Ukrainian organizations capable of creating innovatively high-quality products and services with a high share of added value and in demand on international markets [11; 19-21].

It would not be an exaggeration to say that the issue of economic development in the context of European

integration has been a concern of scientists in most countries of the world for a long period of time. Scientists such as N.F. Campos, F. Coricelli, L. Moretti [23] tried to investigate the impact of European integration on the economic growth of the country by assessing the state of the countries that joined the EU, choosing for analysis a rather long period of time (1973-2004). Scientists have thoroughly proven the existence of a positive effect of EU membership in almost all countries except Greece, putting forward as an argument the growth of income per capita by an average of 10%. At the same time, only one country, Greece, experienced a smaller decline in GDP and labor productivity. This allowed scientists to justify the need to analyze the cause-and-effect relationships of changes in the state of economies of the world by using the method of synthetic control, which will allow to develop an effective solution to avoid possible problems on the country's path to the EU and during the first ten years after accession. Scientists in [24], having formed a research base from 28 countries of the European Union, tried to analyze the real process of economic convergence in 2004-2018. Assessing the damage caused to it by the financial crisis of 2008-2009, scientists econometrically tested the relationship between the growth rates of GDP per capita and macroeconomic variables and came to a rather unexpected conclusion, the main meaning of which was that the growth rates of poor countries exceeded the rates of similar index of rich countries. The result of the study was also a statement about the positive impact on the economic development of countries seeking EU membership, such factors as the openness of the economy, inflation and the integrity of the government. The authors in [25], trying to understand the factors of GDP growth of EU member states, studied the correlation between state expenditures of various types and the value of GDP. Among the factors of statistically significant, persistent negative impact, scientists singled out expenditures on social protection and general state expenditures, expenditures on public order protection, education, and health care exert a strong positive influence. This made it possible to single out certain types of public expenditures with an accelerating effect on the economic growth of the

country, but with a delayed effect, which can be used in the process of forecasting and achieving the desired level of GDP. In [26], the results of the study of the impact of EU enlargement on the socio-economic development of the member countries are presented. This happens by increasing labor productivity, increasing economic government spending, optimizing the industrial structure, and increasing the population. The conclusion about the heterogeneity of the economic impact of EU expansion has practical significance for determining the future prospects of both participating countries and those that are only on the way to joining the European space, because it is more stimulating for developed countries than for developing countries. Scientists also insisted on the positive role of European integration in promoting regional economic growth, increasing the production efficiency of member countries and releasing their potential. The concept of the siphon effect of developed and central regions on remote and developing regions introduced by the authors [26] determines the feasibility of taking effective measures for new EU member states aimed at avoiding the outflow of labor, capital and other factors of production.

Despite the increased attention among foreign scientists to the level of macroeconomic indicators as indicators of the economic development of European countries, almost none of their representatives connected the achieved level of indicators directly with the effectiveness of the functioning of organizations and internal organizational factors of its growth. Analysis of the state and development trends of the national economy in the context of its influence on the formation of a high level of competence of Ukrainian organizations is almost absent in the scientific literature. In addition, the use of the formulated conclusions in the practice of Ukrainian organizations is associated with serious methodological difficulties, mainly due to the heterogeneity of countries, significant differences between them, specific features of management, and the mentality of citizens.

Summing up, it can be noted that the relevance and expediency of an objective assessment of the prospects of the functioning of Ukrainian organizations in today's conditions, their acquisition of a high level of competence on the European market in close relationship with the assessment of the current state of the national economy. The intensification of globalization processes and the formation of a single information space, providing many opportunities to Ukrainian organizations, simultaneously threaten the loss of the stability of their competitive advantages. The ability of the organization to form a permanent competitive advantage on the market through the effective use of acquired knowledge and skills is becoming extremely important today. This is achieved through the formation and development of general organizational competence, which significantly complicates the task of managers, because, firstly, despite the presence of a sufficiently developed theoretical basis for the study of the competence of both managers and work executors, almost no attention is paid in scientific circles to the formation and development of competence at the level of the organization as a whole; secondly, the presence of the first problem reduces the probability of correctly determining the current composition of the organization's competence due to the lack of relevant

knowledge and abilities; thirdly, managers must clearly understand the basis for building a strategy for future activities, and this, in turn, requires an analysis of the environment, forecasting its changes in order to flexibly respond to the influence of dynamic environmental factors. In addition, the described research results are incomplete without an attempt to determine the possible consequences of the shock state in which the economy of Ukraine found itself today due to the full-scale military invasion of the Russian Federation, which inflicted a blow that was difficult to predict in terms of impact on all the links of the country's economic system without exception. According to the Center for the Development of Innovations, together with the Office for the Development of Entrepreneurship and Export, as well as the National Project for the Development of Entrepreneurship and Export Diia. Business [22], it is almost impossible to estimate the amount of damage caused during the continuation of hostilities, but they unanimously state a significantly greater loss of Ukrainian business in the months of the war than in the two years of the pandemic. Considering the fact that Ukrainian organizations adapt quite quickly, which is confirmed by the analysis of publicly available information on the registration of new businesses in Ukraine, the study of the environment of their operation to identify opportunities or potential threats is extremely important and timely, moreover, it needs to be continued due to its exceptional relevance.

● CONCLUSIONS

Organizations of various levels, including sectoral and inter-sectoral complexes, enterprises, households, entrepreneurial structures and the state, united by means of certain economic relations in the form of single system, participating in the social division of labor through the performance of separate functions for production of goods and services, form the basis of the national economy, they are the main subjects with inherent self-interests subordinated to the state-wide interests of national security.

An equally important catalyst for a qualitative jump of the national economy is human capital, that is, highly educated employees of organizations with their own list of necessary knowledge and skills, united by the realization of a common goal and effective management, which contribute to the transformation of Ukraine into a country of balanced development.

Promoting the development of entrepreneurial activity, which successfully solves a range of complex tasks in rather difficult conditions, ensures the formation of an effective market national economic system. Acting as the basis of structural economic shifts, entrepreneurial activity creates an environment for the development of effective competition, ensures the rational use of resources and the emergence of effective incentives for productive work. Taking into account the interpretation of entrepreneurship and its special function in the economy, which aims to renew the economic system through the rational transformation of traditional structures, and thus create an innovative environment, entrepreneurship can be considered as the main factor in accelerating the movement of the economy on the path of efficiency, rationalization, frugality and continuous renewal in the conditions of the modern globalization system.

Determining the prerequisites and possible problems on the way to the formation and ensuring the functioning of organizations competent in European markets, which are an important factor in increasing Ukraine's competitiveness and strengthening its position in the world, requires a thorough study of the current state, existing trends

and future prospects for the development of Ukrainian organizations in the context of integration into of the European community, tracking the dynamics of their regional and sectoral distribution, evaluating the financial results of activities on the Ukrainian and foreign markets, which acquires the status of a priority task of future research.

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Тенденції розвитку національної економіки як середовища функціонування українських організацій

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Анотація. Актуальність проблеми дослідження обумовлена необхідністю виявлення перспектив функціонування українських організацій в умовах глобальних змін світового господарства та активізації євроінтеграційних процесів. Метою статті було проведення аналізу тенденцій розвитку національної економіки на підставі дослідження структури основних показників, визначення ступеня їх взаємодії та оцінки взаємного впливу на функціонування українських організацій. Для досягнення мети використано методи: морфологічного аналізу; наукової індукції та дедукції; діалектичного методу; системного аналізу; групування та порівняльного аналізу; аналізу та синтезу, структурно-функціональний підхід; контент-аналізу; методів логічного аналізу й узагальнення, описової статистики, формалізації; графічний та табличний метод. Основні результати дослідження полягають у такому: обґрунтовано необхідність аналізу причин економічного розвитку країни, зокрема, динаміки номінального і реального ВВП, його структури; кількості та кваліфікаційних характеристик населення, що є стимулюючим чинником економічного розвитку; доведено доцільність аналізу показників зайнятості та безробіття, кількості вакансій, рівня розвитку підприємницької ініціативи для оцінки спроможності економіки забезпечити працівників робочими місцями; зазначено про необхідність аналізу економічного зростання країни у зв'язку із аналізом рівня життя населення, адже те, що відображує позитивні матеріально-речові зміни, є індикатором розвитку суспільства; виявлено скорочення чисельності населення в Україні, спровоковане відтоком найактивнішої його частини за кордон, що негативно позначається на якості робочої сили, є перешкодою зростанню темпів виробництва; виявлено причини окреслених тенденцій, як то: криза 2014 р., пов'язана з військовими діями на Сході України, політичною нестабільністю, стрімкою інфляцією, девальвацією національної валюти, та наслідки пандемії вірусу Covid-19, що відбилася на діяльності суб'єктів господарювання й фізичних осіб через зростання безробіття й соціальних обмежень. Практична значущість отриманих результатів полягає у формуванні рекомендацій щодо врахування тенденцій розвитку національної економіки у процесі виявлення перспектив та можливих проблем функціонування українських організацій в умовах інтеграції країни до європейського співтовариства. Сформульовані висновки та рекомендації будуть корисними для керівників та власників бізнесу, що прагнуть до побудови організації, компетентної на шляху приєднання до європейського економічного простору

Ключові слова: функціонування організації, валовий внутрішній продукт, організаційна ефективність, організаційна компетентність, євроінтеграція

Methodology for developing an information site with Workflow support for publishing articles

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Abstract. The Workflow system is an effective solution to the task of optimizing information flow in the electronic publishing system, which can reduce the number of errors and optimize the process of publishing articles. The purpose of this article was to create a methodology for developing an information site for web publishing. To achieve the goal of the research, scientific methods of generalization, classification, deduction and analysis were used. A problem-solving tree has also been created. The ultimate goal of overcoming this problem is the development of an information site with Workflow support. The study outlines the general structure of sections and subdivisions of the information site. In the context of this article, a methodology was developed to support the process of publishing articles on an information site based on the use of a modern content management system. For this purpose, the key criteria for a basic decision-making model for choosing a content management system were proposed and a rating of free content management systems was given. As a result of the analysis of the proposed criteria, it was concluded that the Joomla tool environment should be used to support web publishing processes. The paper compares the components of the work flow organization on the information site. An algorithm for selecting a component for organizing the workflow has been created. In order to create a site with Workflow support for publishing articles, the stages of development were planned, a list of criteria, based on which the development should be carried out, was proposed and a structural diagram for creating such site was given. The limitations of the created methodology for the development of an information site, which may arise in the process of practical implementation and adoption of relevant management decisions, are considered. The practical result of the work is recommendations for web developers to create an information site with Workflow support for publishing articles

Keywords: algorithm, problem-solving tree, interface, basic decision-making model, content management system

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● INTRODUCTION

In order to provide users with interesting and relevant information in a convenient and attractive form, a modern web publishing house cannot do without the joint cooperation of specialists. The coherence of their work is not possible without modern means of managing work processes. The process approach forces the management of the publishing house to focus on the rules and interactions of the process participants since these aspects are the main centres of losses due to their blurring and uncertainty. Within the automation of individual functions, the need to have tools for automatically tracking the sequence and time of their execution, document routes, hiring of employees at various stages of the process, etc., led to the idea of creating Workflow class systems. Implementation of Workflow can reduce the number of errors and optimize the process of publishing articles on the information

site of a web publisher. Given that the main channel for publishing articles is the site, Workflow should be quite closely integrated with it, and preferably be an integral part of it.

An important role in the modern information space is assigned to the search for information. Today, there is an increase in the desire of people not only to perceive information, but also to express their opinion about what they have read or seen.

That is why publishing houses offer their clients an alternative to classic printed publications – electronic ones. These can be analogues of books but in electronic format, sites with paid and free access to texts, images, video and audio, and so on. An alternative to newspapers and magazines is information sites. Information on them can be available both for free and as part of a subscription.

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In contrast to the years 2000-2005, when authors' blogs were rapidly developing on the Internet [1], now it is very difficult to quickly provide information in a user-friendly form. Such task requires the work of several authors and other specialists, for example, an editor, a photographer and a specialist in search engine optimization. The quality and speed of publication of articles on the site depends on their coordinated work. For the medium or large publishing houses, implementing a workflow is a must. Such publishing houses have the funds and dedicated specialists to implement and maintain the workflow. A small online publisher may not have the funds for such task.

That is why, using a content management system that would support the workflow or have special modules for its organization is an important task. Such system can reduce costs and time for implementation and increase the coherence of the work of all the participants in the publishing process.

The specified aspects determine the relevance of the issues of developing an information site with Workflow support for publishing articles.

In studies [2-4], recommendations are provided regarding the visualization of components of information sites and electronic publications and the factors influencing the use of the interface based on mobile applications are proposed. But these studies lack a list and analysis of criteria for a basic decision-making model regarding the choice of a content management system for an information site with Workflow support for publishing articles.

Scientific works [5-7] are devoted to the problems of creating web-based components of information sites. Large-scale model-driven engineering of web user interaction and the specifics of content marketing for information sites and electronic publications are considered. However, these works do not take into account the concepts and capabilities of the main components for the organization of the work process.

Some issues of quality assessment of the development of information sites and optimization of the interface are raised in works [8-10]. However, in these works there are no criteria for evaluating the effectiveness of the process of developing an information site with Workflow support.

The analysis of the main technological aspects of improving the process of developing information sites is given in scientific works [11-13]. At the same time, these works do not provide recommendations regarding possible options for creating an aggregated technological scheme, according to which it was possible to develop a site with support for Workflow for publishing articles.

Studies [14-16] contain methodological principles for optimizing site loading speed which, at the same time, do not take into account the basic principles and features of optimizing components for organizing the workflow of information sites.

Studies [17-19] describe algorithms for optimizing workflows for solving certain production tasks. However, the research data does not provide insight into the directions of optimization of workflows for the publication of articles.

The scientific article [20] proposes a method of developing an information site for creating 3D advertising, which, however, does not take into account the components of the organization of the work flow on the information site.

The purpose of the article was to design a methodology for developing an information site with Workflow support for publishing articles.

The tasks of the research were as follows: 1) justification of the main criteria for the basic decision-making model regarding the choice of a content management system; 2) development of a component selection algorithm for the organization of the work process; 3) development of a structural diagram of the website creation technology with Workflow support for publishing articles.

● MATERIALS AND METHODS

In accordance with the objectives of the research, the main stages of the scientific work were: 1) formation of the general structure of sections and subdivisions of the information site; 2) studying the rating of free content management systems; 3) selection and justification of the main criteria of the basic decision-making model regarding the choice of the content management system; 4) creation of a basic decision-making model regarding the choice of a content management system; 5) comparison of the components of the work process organization on the information site; 6) creating an algorithm for selecting components for organizing the work process; 7) allocation of stages of development of an information site with Workflow support for publication of articles; 8) formation of a criterion base for the development of an information site with Workflow support for the publication of articles; 9) development of a structural diagram of the website creation technology with Workflow support for publishing articles.

The following research methods were used in this article to implement the set scientific tasks: 1. generalization. With the help of this method, the general structure of sections and subdivisions of the information site were formed and a basic model was created for making a decision on the choice of a content management system and for developing a structural diagram of the website creation technology with Workflow support for publishing articles; 2. classification. This method was used to highlight and substantiate the main criteria of the basic decision-making model regarding the choice of a content management system and the formation of a criteria base for the development of an information site with Workflow support for publishing articles; 3. deduction. With the help of this method, the creation of an algorithm for selecting components for the organization of the work process, as well as the selection of the stages of the development of an information site with Workflow support for the publication of articles, were carried out; 4. analysis. This method made it possible to study the rating of free content management systems and to compare the components of the work process organization on the information site.

● RESULTS

Study of the ways to create sites

All methods of creating sites can be conditionally subdivided into 2 main groups. The first group of methods of creating sites are methods of manually writing sites in one or more web programming languages, while the work can be carried out both in simple (text) and visual HTML and CSS editors, as well as in program writing (used in the absence of web skills – programming).

In the case of creating a static site, the use of HTML and CSS “links” with the possible inclusion of Javascript will be quite sufficient for manual writing [6]. To create a dynamic site is not possible without server programming languages, such as PHP, ASP.NET, etc.

When using “manual” methods of creating a site, the site design (graphic design) is also created manually. For these purposes, any graphic editors are used as desired. Ready-made design templates, both paid and free, can be manually edited.

The second group of site creation methods includes automated site creation methods such as using special site builders or content management systems (CMS). The most popular content management systems are Joomla and WordPress.

In addition to content management systems, there are online site builders. Site builders are systems that allow you to “assemble” a site from a ready-made standard set of modules and components and immediately place it on the Internet.

The manual site creation method has an undeniable advantage: by creating a site manually, you can always get the desired result. But manual site creation methods are quite complex because they require a wide range of knowledge in the field of web programming and site design.

The development of an information site with Workflow support for the publication of articles should be carried out on the basis of generally accepted practice, which allows considering the creation of the site as a sequence of a number of stages [4; 5; 10]:

1. definition of project goals and objectives;
2. positioning of the project, definition of its role and audience;
3. development of the overall web strategy of the project;
4. development of a technical task for the object, its final estimate and work schedule;
5. development of the design concept of the site;
6. choice of website creation technology;
7. development of the layout (sketch) of the main page;
8. development of layouts (sketches) of internal pages;
9. development of design elements (logos, flash, fonts, etc.);
10. HTML version of the site;

11. development of additional functionality (scripts, “engines” and the like);
12. site content;
13. launching a trial version of the site, testing it and eliminating errors;
14. transferring the site to hosting, testing it and opening the site.

The goals and objectives of the project are formulated during work with the customer, this stage is informal and very responsible.

In the course of positioning, an analysis of the customer’s activity is carried out, the audience is determined (for whom it is intended), analogues are selected and analyzed (their analytics are carried out). If there are resources (funds) to determine the possible audience (circle of users), it is advisable to conduct a sociological study.

The web strategy should contain information about the goals and objectives of the resource, analysis of competitors, developed recommendations for the structure and functional content of the site, as well as an exemplary plan for further promotion of the resource (analysis of competitors’ actions, advertising, promotion, exemplary activities and budgets). The development of such strategy significantly helps at all stages of the project life cycle.

Structuring the process of creating an information site with Workflow support

There are various ready-made systems for the implementation of the workflow in the publishing house, which, at the same time, are designed for medium and large publishing houses. It is not advisable for a small web publishing house, which only has a website and consists of 5-10 employees to implement such systems. Developing your system will also cost quite a lot. The best option is to choose a content management system with built-in workflow support. This provides an opportunity to significantly reduce costs and time to implement the workflow.

Figure 1 displays a problem resolution tree. The ultimate goal is to develop an informational website with Workflow support for publishing articles. The general structure of sections and subdivisions of the information site is as follows (Fig. 2).

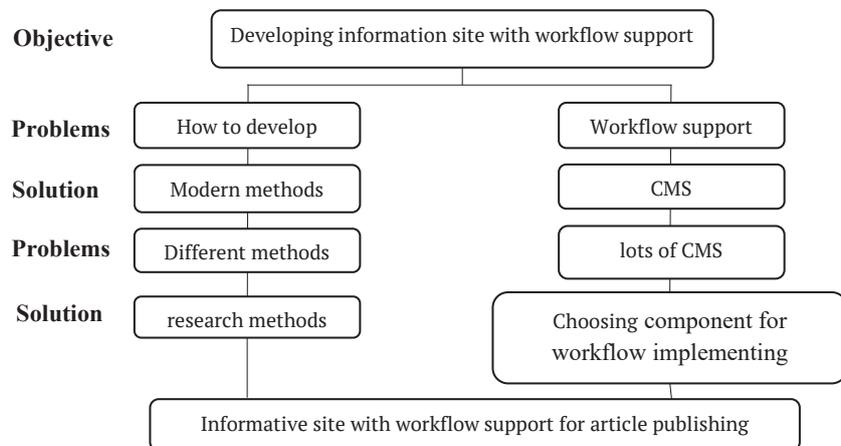


Figure 1. Problem-solving tree

Source: the authors’ development

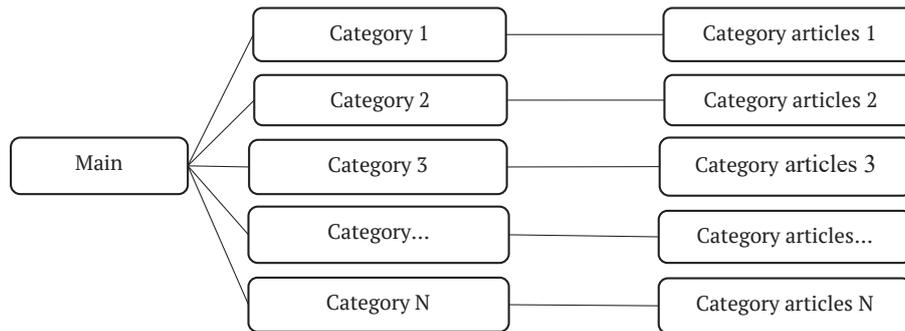


Figure 2. General structure of sections and subsections of the information site

Source: the authors' development

It should be noted that the structure is designed in such a way that it can be easily expanded “in all directions”.

Analysis of content management systems for creating an information site

Development of an information site with Workflow support for publishing articles should be based on the use of a modern content management system (CMS). Research should choose a modern distributed content management system that can meet the needs of creating an information site and has built-in workflow support. It is advisable to research the popular free content management systems and find the

most suitable one among them. Free content management systems provide all the necessary tools to create an informative site that is adapted for different devices. The analysis of specialized literature [1; 3; 7], which contains the functionality of these systems, made it possible to formulate the following criteria for the basic decision-making model: security; support; ease of use; productivity; manageability; possibility of interaction; customization options; built-in extensions; commerce.

A criterion for the presence of workflow support was also added. Information about the rating of free content management systems is presented in Figure 3.

FREE CMS RATING

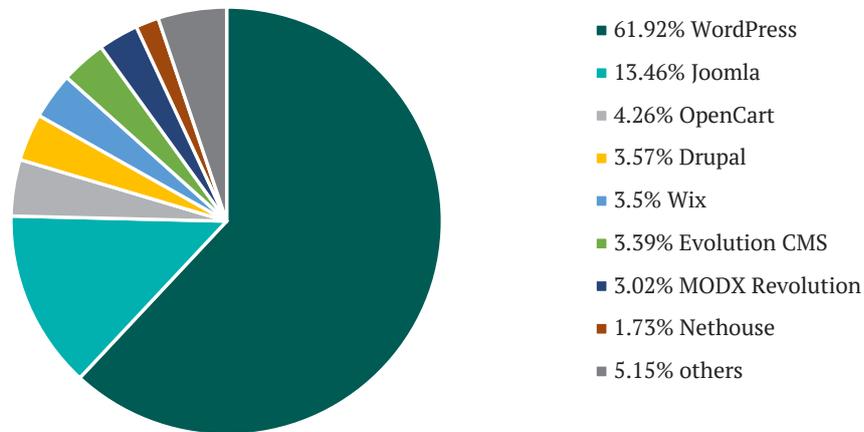


Figure 3. Ranking of free content management systems

Source: [1; 3; 7]

To make a decision, Table 1 was formed, for which all selected criteria for dermal CMS were analyzed and ranked

(on a scale of 1 to 3, where 1 is low implementation, 2 is average, 3 is high).

Table 1. A basic decision-making model for choosing a content management system

Criteria\Systems		Drupal	Joomla	WordPress
Nº	the name of the criterion			
1	security	2	3	2
2	support	1	2	3
3	ease of use	2	3	2
4	productivity	2	3	1
5	manageability	3	3	3

Table 1, Continued

Criteria\Systems		Drupal	Joomla	WordPress
Nº	the name of the criterion			
6	possibility of interaction	2	2	2
7	customization options	2	3	3
8	built-in extensions	2	3	2
9	commerce	1	3	3
10	workflow support	2	3	2
Total:		19	28	23

Source: [1; 3; 7]

Based on the data obtained in Table 1, it can be concluded that we should use the Joomla tool environment to create an information site with Workflow support for

publishing articles. Table 2 shows the comparison of the components of the work flow organization on the information site.

Table 2. Comparison of basic features of software products

Software products Basic signs	Component “Processes”	My Content & Workflow	Joomflows
Cost	Free	2260 UAH	12675 UAH
Joomla 4 support	+	-	-
Materials component support	+	+	+
Translated into Ukrainian	+	-	-
Technical support from the developer	-	+	+
Sending letters when the status changes	+	+	+
Create multiple workflows	+	+	+
Creating multiple object statuses	+	+	+
Expansion of functional capabilities due to plugins	+	+	+
Demarcation of access rights	+	+	+
Total benefits	8	7	7

Source: [10]

Based on the preliminary review of content management systems and components for organizing the workflow,

the authors presented the algorithm for selecting the appropriate component (Fig. 4).

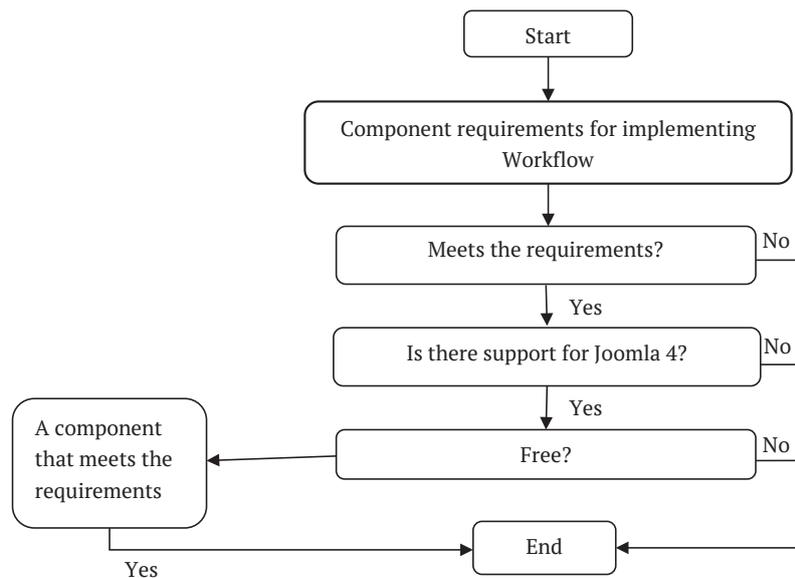


Figure 4. Algorithm for selecting a component for organizing the workflow

Source: the authors' development

Based on the results of research and algorithm work, the optimal component for the development of an information site with Workflow support – “Processes” – was chosen.

Methodical principles of developing an information site with Workflow support for publishing articles

After choosing a content management system, additional extensions and a workflow component, it is advisable to move on to planning the stages of developing an information site with Workflow support for publishing articles: content preparation (texts, photos); installation and configuration of the local server; installation on Joomla

settings; installation and configuration of the site template; installation and configuration of additional Joomla extensions; creation of the main page of the site; settings of the “Processes” component; creation of news pages; creation of a contact page; site testing in a local server environment; making corrections to the website based on the results of testing.

The development of an information site with Workflow support for the publication of articles should be carried out taking into account the following list of criteria (Table 3) proposed by the authors and based on the systematization of literary sources [2; 8; 11]:

Table 3. Criteria for the development of an information site

Criterion	The practical significance of the criterion for the development of an information site
responsive design, mobile version or mobile application	provides a visual perception of the site
availability of the AMP version	contributes to the mobile version of the site
availability of site search	gives navigation capabilities
work on the https protocol	makes it possible to process hypertext information
the possibility of registration on the website	gives the possibility of registration on the website
availability of news categories	makes integration with news resources
the ability to comment on articles	provides feedback to users
the presence of tables, diagrams, graphs, infographics, etc. in the articles	provides a visual perception information of the site
availability of links to the RSS feed, website pages in social networks, channels in messengers, etc.	responsible for integration with social networks
the ability to configure the display of news of the desired topic by registered users	cuts off random site visitors
availability of information about the site administration	promotes feedback optimization
availability of contact information indicating the address of the site administration office;	
availability of a block with popular topics – “tag cloud”	
availability of site management tools for people with physical disabilities	ensures the provision of equal opportunities for access to site information
automatic display of recommended news based on user recognition or location	provides maximum orientation of site content to a specific user
the possibility of adding news topics to favorites (for registered users)	optimizes site content for registered users

Source: the authors’ development based on the systematization of literary sources [2; 8; 11]

A consistent and logical website structure is an important factor influencing the user loyalty. Creating an interface design is one of the most important stages of development, which must be done before writing the software code. Errors in the structure of the user interface cannot be corrected during programming and, as a result, the product is created in the wrong way. At the same time, the correction of defects in the UX/UI interface with subsequent reprogramming will require the expenditure of significant resources.

The choice of the appropriate structure is made at the design stage and depends on the purpose of the site.

The structuring presented on the site is carried out on two levels: internal and external.

Internal structure defines logical links between web pages, in SEO this is called internal linking. A well-thought-out internal structure allows you to avoid

situations such as the appearance of pages on the site in more than 3 clicks.

An external structure is actually a navigation scheme written into the design of the site, be it humans or robots, it is the external structure of the visitors. With the help of links, they gain (or lose) access to the information provided by the site. A carefully designed external structure not only facilitates page navigation, but also helps to promote sites in search engines.

The pages of the site have a simple and natural structure that is constantly connected to each other. On such website, navigation is mainly reduced to pointing to links to the previous and next pages – when moving through them, the user seems to be flipping through a book. Information on the site should be presented in the form of sections, blocks and buttons. Figure 5 shows the structural diagram of creating a site with Workflow support for publishing articles.

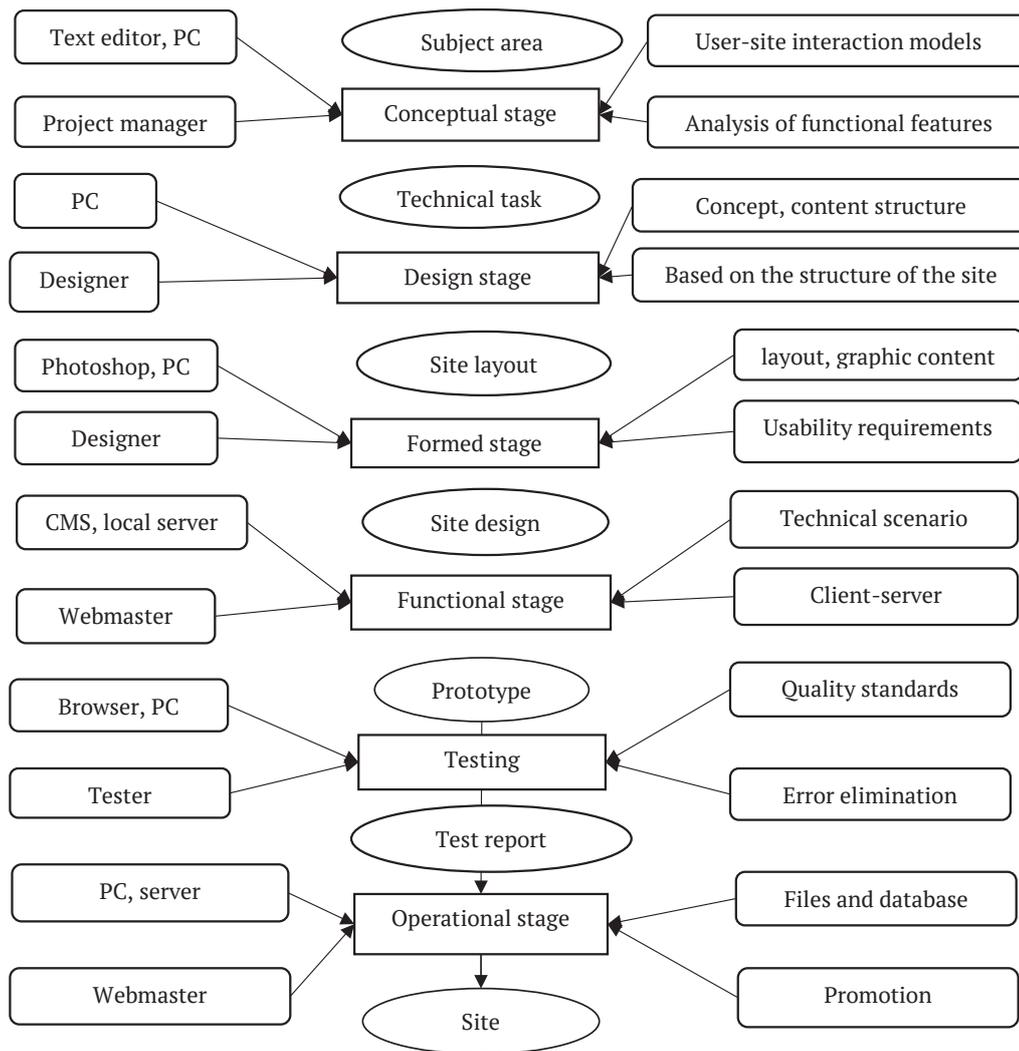


Figure 5. Structural scheme of creating a site with Workflow support for publishing articles

Source: the authors' development

If needed, necessary changes are made to the technology, in agreement with the customer, until the project is finally approved.

The result of the research is an aggregated technological scheme, according to which a website with Workflow support for publishing articles was developed. Aggregation consists in simplifying each of the models and obtaining the most suitable stages from it, which makes this model more suitable for the development of small sites.

Simplification is achieved not only by reducing the number of stages, but also by simplifying each of them. Analysis and design are carried out superficially, and development is carried out using ready-made software, with minimal involvement of highly qualified programmers. For projects with a limited budget, this can give a much better result.

● DISCUSSION

The proposed methodological developments for the creation of an information site with Workflow support for publishing articles are continuation of the authors' research on the issues of information support of publishing processes. The designed technique can be used to manage the work

processes of web publishing, as well as to assess the quality of multimedia publishing workflows and to provide information support for the creation of web resources.

In this work, as well as in studies [1; 6; 18], the process of creating workflows was algorithmized. A workflow component selection problem was detected while building the problem tree. Its solution was based on conducting a comparative analysis of existing Joomla components for the implementation of the workflow and creating an algorithm for selecting the appropriate component. However, in the mentioned studies [1; 6; 18], in the process of further creation of the information system, there are no tools to simplify the navigation of people with limited physical capabilities, third-party advertising is present, and there are no options for adjusting the display of site news according to the interests of each registered user.

In the conducted study, the organization of the work process of a web publishing house for the publication of articles is proposed. In studies [4; 7; 12] various ready-made information systems are proposed for the implementation of the workflow in the publishing house. But these information systems are designed for medium and large publishing houses. It is not advisable for a small web publishing house,

which only has a website and consists of 5-10 employees, to implement such systems. Developing your system will also cost quite a lot. The best option for a small web publisher is to choose a content management system with built-in workflow support, which was offered in this study. This provides an opportunity to significantly reduce costs and time to implement the workflow.

In addition, this paper considered an example of the publication of articles by a small author-editing team. In this work, the main problems related to the development of an information site with Workflow support for publishing articles based on an open source content management system and using a workflow component were identified. Scientific articles [10; 17] provide a review of work processes with a more classic employee structure for a larger publishing company.

In this work, as well as in studies [12; 20], algorithmization of the work process of multimedia publishing was created. To carry out the development, a study of recommendations for the implementation of modern web design and the direct implementation of these recommendations were carried out. However, unlike works [12; 20], this study took into account the opinions of leading experts in the field of multimedia publishing, regarding the formation of an algorithm for selecting a component for the organization of the workflow.

The limitations of the created methodology for the development of an information site with Workflow support for the publication of articles was that it does not take into account the likely situations of risk and uncertainty that may arise in the process of managing the information flows of a web publishing house and in the course of making relevant management decisions.

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● CONCLUSIONS

The formation of the general structure of sections and subdivisions of the information site was carried out. A study of the rating of free content management systems was conducted. A tree of goals for solving the problem of organizing workflows for creating an information site with Workflow support has been created. The main criteria for the basic decision-making model regarding the choice of a content management system are identified and substantiated. A basic decision-making model for choosing a content management system has been created. A comparison of the components of the work flow organization on the information site was made. An algorithm for selecting a component for organizing the workflow has been created. The stages of development of an information site with Workflow support for publishing articles are highlighted. A criterion base for the development of an information site with Workflow support for publishing articles has been formed. The structural diagram of the website creation technology with Workflow support for the publication of articles has been developed.

The scientific result of the article consists in creating the method of developing an information site with Workflow support for publishing articles.

Further areas of research of the proposed method of developing an information site with Workflow support for publishing articles can be as follows: assessment of the effectiveness of user interaction with the information site with Workflow support for publishing articles; development of risk management techniques for the technological process of information support for the creation of a Workflow for the publication of articles; development of decision-making support methodology for improving the quality of web publishing workflow management.

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Методика розробки інформаційного сайту з підтримкою Workflow для публікації статей

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Анотація. Ефективним вирішенням задачі оптимізації робочих потоків руху інформації у системі електронного видавництва є система Workflow, яка може зменшити кількість виникнення помилок та оптимізувати процес публікації статей. Метою даної статті було створення методики розробки інформаційного сайту для веб-видавництва. Для досягнення мети дослідження було використано наукові методи узагальнення, класифікації, дедукції та аналізу. Створено дерево вирішення проблеми, кінцева мета подолання якої є розробка інформаційного сайту з підтримкою Workflow. В дослідженні окреслено загальну структуру розділів та підрозділів інформаційного сайту. В контексті даної статті було здійснено розробку методики підтримки процесу публікації статей на інформаційному сайті на основі використання сучасної системи керування контентом. Для цього було запропоновано ключові критерії для базової моделі прийняття рішень щодо вибору системи керування контентом і подано рейтинг безкоштовних систем керування вмістом. В результаті аналізу запропонованих критеріїв зроблено висновок, що слід використовувати інструментальне середовище Joomla для підтримки процесів веб-видавництва. В роботі наведено порівняння компонентів організації робочого потоку на інформаційному сайті. Створено алгоритм вибору компоненту для організації робочого процесу. Для створення сайту з підтримкою Workflow для публікації статей проведено планування етапів розробки, запропоновано перелік критеріїв, на основі яких слід здійснювати розробку, наведено структурну схему для створення такого сайту. Розглянуто обмеження створеної методології розробки інформаційного сайту, які можуть виникнути в процесі практичної реалізації та прийняття відповідних управлінських рішень. Практичним результатом роботи є рекомендації веб-розробникам для створення інформаційного сайту з підтримкою Workflow для публікації статей

Ключові слова: алгоритм, дерево вирішення проблеми, інтерфейс, базова модель прийняття рішень, система керування контентом

Analysis of European experience in improving public administration mechanisms

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Abstract. No country is capable of building a progressive society without resorting to systematic modification of the model of public management, as the states of the Baltic Sea region have proven by their own example. The relevance of the analysis of the public administration mechanisms of the Baltic countries is explained by the success of the modernized policy of the administration system in Estonia, Latvia and Lithuania, whose experience is a vivid illustration of successful reform and the desire for permanent socio-economic growth. The purpose of this scientific work is to study the multifaceted components of the functioning of the updated concept of public administration of the Baltic republics through the prism of European integration processes within the countries, in particular. The leading methods of research work were the methods of analysis and generalization, with the help of which the key means of improving the public sector of Lithuania, Estonia and Latvia were revealed in combination with the method of comparison, which made it possible to compare the public management models of the three Baltic states. This article reveals the importance of the implementation of innovative decisions by subjects of power in order to realize the civil liberties of the population and ensure the principles of public administration. It was established that the change in the principles of state leadership in the Baltic states was due to the preparation for joining the European Union. In particular, the idea of interaction between state institutions and the civilian population was introduced, the latest information technologies were involved, and an anti-corruption policy was implemented. It was determined that the reformation of the public sector depends on ensuring its smooth functioning. The practical value of the mentioned scientific work lies in the possibility of using its materials in the process of developing reform solutions for the reconstruction of the public administration system

Keywords: transformation, European integration, administrative rebranding, information technologies, principle of public involvement

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● INTRODUCTION

The Baltic countries are significantly ahead of any other post-Soviet state economically and in terms of the level of development of democracy [1]. Having regained their independent status in the early 1990s, Lithuania, Latvia and Estonia began their own path, which was accompanied by a complete transformation of all state institutions. Despite the long international isolation, the functioning of the ineffective Communist Party-Soviet system of power for fifty years, the Baltic countries confidently began the process of modernization, getting rid of archaic mechanisms for organizing public administration bodies.

Taking into account the European integration policy of the Baltic republics, it is completely understandable that

the leadership wants to ensure a sustainable system of public administration that will meet the European principles of good governance. Most of the spheres of public administration include or affect the principles, regulations and legal norms that must be preserved and constantly developed within the framework of the European Union by all members of this alliance – *acquis communautaire*. Transparency and openness, people-centered approach, accountability, the rule of law and legality – each of these categories has a significant impact on the preservation of democratized power and is the result of a purposeful course to modernize the public sphere of service provision. As S. Halimi rightly pointed out: “Public administration reforms must adapt to

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the general socio-economic and political level in society in order to promote and accelerate the pace of reforms, and this is achieved by presenting reforms as actions, first in the interests of citizens, and then as actions to fulfill EU criteria" [2]. At the current stage of society's development, the state needs continuous changes, constant search for renewal of public administration mechanisms, and it is the Baltic countries that present the flexibility of state management. That is why the purpose of this work was to study the available tools of the administration of Lithuania, Latvia and Estonia, which daily prove the sustainability of the organization of public administration and the productive use of state resources.

Since economic growth, political unity and the development of civil society directly depend on creating an operational and effective administration, the issue of modernization of the public sector is systematically the subject of discussion among scientists. For example, analyzing the foreign experience of the transformation of public administration and the prospects of its application in Ukraine, Yu. Liakh came to the conclusion that increasing the efficiency of public administration can be seen in the development of a system focused on interacting with the public, establishing communication relations, finding a common consensus, and changing the mentality of citizens [3]. O. Volska supports a similar opinion, at the same time emphasizing that partnership relations between the government and the population should be built not only at the central, but also at the local levels, based on a rational political and managerial analysis with an orientation to the public interest, which is revealed through the use of various forms of public participation in the discussion of projects of state and local decisions [4], and G. Starykova proposed to develop recommendations for the introduction of an incentive system for territorial communities that work most effectively with the public [5]. However, in her own research, Yu.-B. Khanyk proved that with the help of means of marketing communications it is possible to positively influence some factors affecting public trust, in particular, transparency or accountability of public authorities [6]. Also, one cannot fail to mention the complex work of O. Romanchuk, Yu. Bysaga, V. Berch, G. Nechiporuk, V. Chechersky, who, having analyzed the experience of Estonia in the application of e-governance, emphasized that the expansion of the field of e-governance as a qualitative mechanism for increasing the level of economic well-being of the state and the expanded network of public services in electronic form are among the fundamental factors of successful implementation of e-administration [7]. Therefore, the mentioned topic attracts the attention of a considerable number of Ukrainian researchers, but nevertheless the category of public administration tools is diverse and quite dynamic, and that is why the purpose of the study was to reveal the impact of the introduction of the latest mechanisms of public sector governance on the functioning of the administration system of the Baltic states.

● MATERIALS AND METHODS

The methodological basis of scientific research is the methods of analysis, generalization and comparison. In particular, the method of generalization made it possible to determine the main components of the transformation

path of the Baltic republics in the process of fundamental renewal of the public administration system. The leading factors of the effective use of information and communication technologies in the activities of state authorities were also revealed. At the same time, the comparison method was used to identify shortcomings in the implementation of innovative administration mechanisms, and also to record the consequences of improving public administration in the Baltic States. Using the general scientific method of analysis, the following normative documents were studied: Comprehensive monitoring report on Latvia's preparation for membership in the European Union dated November 5, 2003 [8], Memorandum on cooperation between public organizations and the Cabinet of Ministers of the Republic of Latvia dated January 7, 2014 [9], as well as the Report of the European Commission on public administration and management in Latvia for 2020 [10].

In addition to normative legal acts, scientific works of Estonian, Lithuanian, Latvian, Albanian, and Ukrainian researchers served as materials of the work. For a deeper understanding of the role of public administration in integration processes, the works of O. Volska [4], Reinholde *et al.* [11] and M. Holzer [12] were analyzed. Works by V. Korenkova [13], K.H. Pedersen and L. Johannsen [14], K.K. Ibodullaevich and O. Mahmatkobil [15] and other scientists were useful in analyzing the experience of the transition to a new system of public administration in the Baltic countries. It is worth noting that the work of I. Lakstigala and S. Balina [16] made it possible to consider the implementation of digitalization in the process of changing the course of public administration, to better understand the advantages of this practice and to pay attention at additional requirements to ensure the effectiveness of innovations. Also, among the materials used to form the theoretical basis of the research, scientific works related to the implementation of foreign experience in the modernization of public administration in Ukraine were used. In particular, these are the works of Yu. Liakh [3] and Yu.-B. Khanyk [6]. Together with the published works, the author used statistical data compiled by the American organization Freedom House [17] and the global anti-corruption organization Transparency International [18]. Based on the statistics of the organization Freedom House, the author was able to assess the level of citizens' access to political rights and freedoms and the level of government accountability to the people in post-Soviet countries. Statistics from the anti-corruption structure Transparency International were used to illustrate the effectiveness of implementing transparency and openness together with the concept of e-governance in Estonia [1]. To analyze the economic development of the countries that left the Soviet Union, data on the volume of gross domestic product per capita covering the period from 1990 to 2019 were used.

● RESULTS AND DISCUSSION

Having chosen the course of rapprochement with the European Union (EU), the states have committed to overcome the outdated Soviet administrative management system, which was primarily characterized by strict centralization, high costs for maintaining the state apparatus and strict control over the activities of public organizations, developing local self-government and civil society

institutions. Currently, it can be said that all three Baltic states, faced with common challenges, managed to reorganize public administration bodies, ensuring sustainable democracy within the state. After all, in the presence of a high level of corruption, a shadow economy, and the lack of necessary transparency of financial flows, it is impossible to ensure neither healthy competition, nor impartial and effective state control, nor effective protection of the rights and legitimate interests of participants in public relations [13]. In particular, according to a recent study by Freedom House, which assesses people's access to political rights and freedoms, as well as the level of accountability of governments to their citizens, Lithuania, Latvia and Estonia are recognized as free states with an overall score of 89/100, 88/100 and 94/100, respectively, leaving behind such countries as Georgia (58/100), Moldova (62/100) and Ukraine (61/100) [17]. And although all the listed states declared their sovereignty almost at the same time, the Baltic countries undoubtedly carried out the most successful political and administrative rebranding in the last few decades.

First of all, it should be noted that the significant progress in the public sector restructuring in the Baltic states was initially preceded by a problematic reform process, which was supposed to bring the mechanisms of state institutions closer to European standards. For example, the Comprehensive Monitoring Report on Latvia's Preparation for EU Membership for 2003 stated that, although Latvia is generally meeting the commitments made during the negotiations, the preparation of administrative capacity for membership remains one of the biggest challenges faced

by the country [8]. The transformation of the model of public management in Latvia and other post-communist countries was even more exhausting than in Western countries, because before the reforms of 1990-2000, there was preserved the "occupational, alien, artificial, completely lifeless Soviet system of administration" [11]. Here it is appropriate to highlight several crucial components that actually formed the foundation for the future renewal of the public administration sector in the Baltic States. First, although the departure from the Soviet administrative model was gradual, and sometimes not completely successful, the European perspectives and experience of the Western neighbors provided an impetus for faster changes in the administrative structure and bureaucratic system of the states. Secondly, it was the stability of state institutions, the rule of law and normative guarantees of the inviolability of civil and political freedoms of society, which were not characteristic of the totalitarian model of management, but formed the basis of the international community, that led to the concept of New Public Management [14], which provided for significant public involvement as a means of increasing efficiency and legitimacy.

Since the updated picture of public administration required respect for citizens and their preferences and condemnation of the superiority of the elite and technocratic government [14], the implementation of innovative policies definitely modified the paradigm of the traditional management system of that time. Figure 1 presents the leading principles and values of the updated concept of public management, which formed the core of the initial transformations.

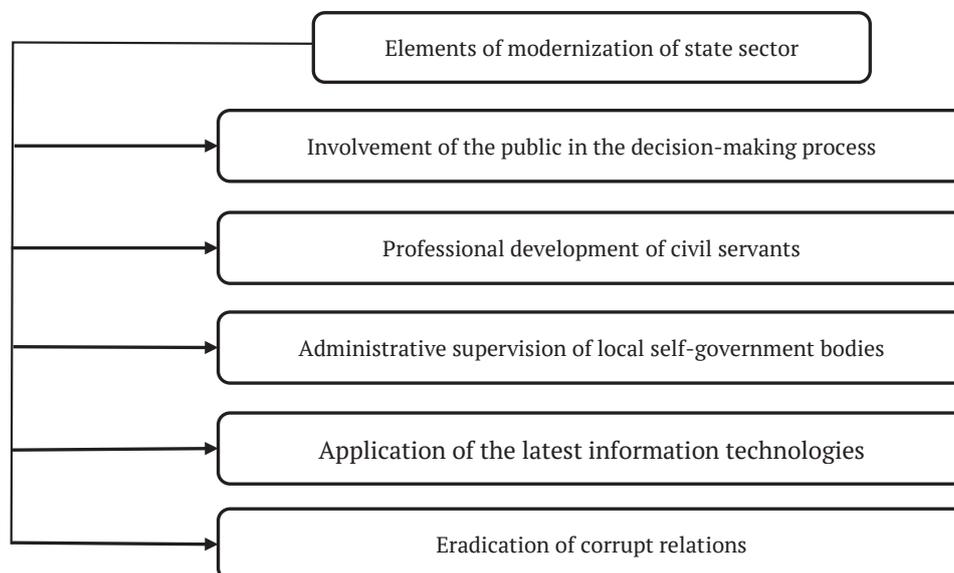


Figure 1. Elements of modernization of state sector

Source: developed by the author

Each of the mentioned categories is the subject of discussion and reform in any country of the world with a rule of law, however, the experience of the Baltic countries perfectly demonstrates the process of restructuring administrative system in combination with the simultaneous modernization and development of the institution of civil society. A vivid example is the struggle of the Estonian

authorities against corruption, which is successfully integrated into the continuous evolution of e-governance. Certainly, there is no country that is characterized by the absence of favoritism, fraud or nepotism in the public or political sectors. The problem also exists among Estonian public servants, but today the active involvement of information technologies has become one of the main principles

of fighting corruption in this country [15]. Electronic document flow, modernization of communal services through the creation of online platforms for the provision of services, the possibility of submitting tax returns without even leaving home – the country's leadership has almost completely cut off communication between citizens and civil servants in an offline format, significantly reducing the risks of bribery, extortion, or other forms of corruption phenomenon. According to Transparency International's Corruption Perceptions Index for 2021 [18], Estonia ranked 13th among 180 countries, significantly ahead of Lithuania and Latvia. In addition, by developing the concept of e-governance, increasing the level of transparency and openness, Estonia clearly demonstrated the value of the administration's communication with its citizens and their involvement in the functioning of public administration.

Involvement of society in the processes of public administration has also become a priority task of the Latvian government's new public administration development policy. In order to activate the population, maintain a bilateral dialogue and increase the awareness of citizens, the country's leadership has been fruitfully cooperating with non-governmental organizations (NGOs) for several decades. In particular, with the aim of promoting effective public administration in accordance with public interests, in 2005 a Memorandum on cooperation between public organizations and the Cabinet of Ministers was signed, the text of which was updated in 2014 [9]. As of October 2022, 502 organizations have signed the document. Thanks to the Memorandum, as well as further rule-making activities of the Government of the Republic of Latvia, a number of mechanisms were created to involve society in the decision-making process. Implementation of joint projects, education of the public on issues of state management, financial stability and independence of NGOs, involvement of interested representatives of public organizations in the coordination of regulatory acts – it can be argued that the state leadership gradually but purposefully increased the participation of NGOs in public administration. For example, already in 2010, only a few years after the signing of the Memorandum, the conclusions of NGOs were received for 40% of the documents from the total number of normative legal acts and projects developed by the ministries, which indicates a relatively high degree of initiative and participation of public organizations [19]. The policy of public participation had considerable success and influence on the formation of democratic institutions, as in its 2020 report, the European Commission gave a positive assessment of the process of re-planning the public service in Latvia, noting that the country has generally demonstrated good progress in reforming public administration [10]. Thus, the country's leadership managed to optimize the activities of the executive authorities, ensuring transparency by involving all interested parties.

Likewise, the activities of local self-government in the Baltic States, where municipal bodies are becoming more and more important participants in the administration system, cannot be ignored. Of course, successful democratization directly depends on the degree of development of municipal institutions and their ability to cooperate with local residents, which explains the constant modification of the administrative system of the Baltic republics. Since

the quality of public services, the redistribution of budget revenues or the level of life activity support of a separate territorial unit depends on the functioning of regional authorities, the Lithuanian government actively supports the concept of administrative supervision of local self-government in order to guarantee legality, stability and social equality at the local level. Although this concept exists in both Estonia and Latvia, monitoring of the legality of all legal acts adopted by all municipal institutions is carried out only in Lithuania [20]. Assessing the legality of the use of state assets, regulating the pricing of communal services, checking the systematicity of regional development – in this case, the government's activities cannot in any way be aimed at weakening the autonomy or independence of local self-government, but must necessarily contribute to increasing the productivity of municipalities and ensuring the principle of the rule of law.

So, we can come to the conclusion that each of the analyzed states has introduced its own mechanisms for improving public administration, carrying out operational work on solving complex problems. The minute-by-minute reformation of the public administration model determined both the internal policy of the countries and their place in the international arena as members of the European Union.

Based on the conducted analysis, it can be established that the concept of the New Public Administration had a considerable influence on the formation of the development strategy of public administration in the Baltic countries, in particular the Republic of Latvia. The introduction of the appropriate model within the country should primarily contribute to increasing trust in the government among civil society. Here it is important to mention the scientific work of M. Holzer, in which the researcher emphasized that lack of trust undermines the ability of governments to perform and provide services as promised in their founding documents, legislation, agency mission and oath [12]. It is impossible not to agree with this statement, because the trust of the population allows for the successful implementation of new changes and innovations in the activities of public authorities, moreover, lack of confidence in one's government deprives the latter of its legitimacy and legality. According to *Standard Eurobarometer 90*, trust in institutions is relatively low in Latvia: 32% of citizens trusted the state administration in 2018 [21]. Thus, it can be emphasized that, although the involvement of the population in the policy of public administration is indeed a crucial component of the sustainable development of the public sector, which proves the administration's desire for a stable two-way dialogue with society, it has little effect on strengthening trust. There is no doubt that the functioning of NGOs in the public sector clearly demonstrates the position of public authorities regarding transparency and openness, and nevertheless, mostly such organizations seek to respond to manifestations of lawlessness, performing the function of a defender of the population, and by no means an apparatus of public administration.

However, as already noted earlier, the possibility of establishing relations with local residents is a leading mechanism for the modernization of the administration system, and therefore it is equally important to provide appropriate and accessible tools for such cooperation. According to L. Mirlin, the use of the latest information technologies and their

variants during the selection of appropriate forms of communication and the formation of the content of communication is the fundamental means of “connecting” the government and the people [19]. Given the incredible success of e-governance in Estonia, it is difficult to disagree with this statement, but it is necessary to note several important factors.

First, in order to guarantee the efficiency and sustainability of e-government, the public administration needs to create and implement a modern system of electronic interaction. First of all, this concerns the constant updating of technological means, in the absence of which it is impossible to achieve the proper quality of service provision. In addition, as N. Linde rightly noted, the transition to a modern architecture of technological solution will ensure not only the flexibility of systems for the dynamic development of services, but also require data processing with less negative impact on the environment [22]. Thus, the development of digital infrastructure will lead not only to the possibility of using modernized platforms, but also to the improvement of the country’s ecosystem through the introduction of environmentally friendly technologies.

Secondly, one of the most important factors in the effective improvement of the model of public administration is the permanent improvement of the qualifications of civil servants. The author fully agrees with the position of I. Sudziute and A. Jakubavicius: “National governments should focus on politics and investments in human capital and education to prepare the workforce for future work” [23]. Indeed, the lack of knowledge, technical skills and digital literacy significantly slows down the process of adaptation and modernization of the public sector, effectively destroying the prospects for successful digitalization. At the same time, researching the competencies of public administration personnel, I. Lakstigala and S. Balina emphasized that although the rapid information development of recent decades really facilitates the performance of complex work, the work process requires an emphasis not only on digital skills, but also on communication skills, leadership skills, creativity thinking and flexibility, thus adapting to modern demand [16]. Therefore, it can be concluded that the training of management personnel of public authorities should be based not only on the work of information and communication technologies, but also focus on the professional development of each civil servant, since it is the human factor that forms the foundation of any transformations.

Thirdly, although the launch of information systems is aimed at improving the quality of services in a significant way and reducing the costs of their implementation, the success of such a management model depends on both successful strategic planning and the level of demand for service use. For example, in 2009, the introduction of LIMIS (Lithuanian Integrated Museum Information System), a national integrated system of digital information about exhibits in museums, was started. This initiative is certainly a significant finding for increasing public access to scientific research institutions, but according to A. Kimura’s research, the creation of a digitization department in museums is still not popular because many museums are already digitizing without such a department, and also because many museums cannot afford it [24]. At the same time, you can refer to the Estonian example of the use of the ERA (Estonian Road Administration) e-service,

which implements the state policy in the field of road safety. In the author’s scientific work, L. Roots proved that ERA promotes e-services very well, offering socially demanded categories: from registration for a theoretical exam to issuing an instructor’s certificate [25]. Thus, we can say that the process of improving the public sector and introducing the latest models of administration depends on a considerable number of factors. An unchanging course towards digitalization, cooperation with the population and civic support, increasing the level of competence of civil servants – each of the listed categories is designed to contribute to the evolution of public administration.

It cannot be assumed that the governments of the Baltic republics did not make mistakes along the path of transformation, but the experience of Estonia, Latvia and Lithuania proves that a purposeful course to modernize and democratize the model of public administration is a convincing factor in the modernization of the Baltic countries.

● CONCLUSIONS

So, summarizing all of the above, it can be stated that the introduction of the latest administrative mechanisms into the public power structure of the Baltic Sea region undoubtedly affected the democratic development of Estonia, Latvia and Lithuania. Each state, pursuing the initial goal of joining the European alliance, laid a solid foundation for a fundamental modification of the state leadership paradigm.

Giving preference to the liberal concept of management, which was primarily characterized by openness and a high level of development of local self-government, the Baltic countries began the exhausting process of comprehensive reformation of the sphere of state policy. Centralized leadership gave way to the latest ideas of interaction between state institutions and the civilian population, which provided an opportunity to establish a strong base for the creation of a renewed doctrine of public administration.

The theory of New Public Administration presented a modern concept of public management, which, in addition to expanding the powers of civil society, emphasized the involvement of advanced information technologies in order to meet the current needs of consumers of public services. Undoubtedly, the modernization of the public sector laid effective mechanisms for fighting corruption, contributed to the implementation of the principle of accountability and transparency of the government, ensured the financial stability and independence of non-governmental organizations, and at the same time, the transformation process of the Baltic countries was accompanied by both unsuccessful strategic decisions and public distrust. At the same time, it should be noted that the success of reforming the public sector does not depend on the very fact of introducing electronic governance or administrative supervision, but on ensuring the proper conditions for its functioning: permanent updating and increasing of digital government tools, mandatory maintenance of professional skills of civil servants, which will include both acquisition of digital literacy and improvement of organizational competences, as well as maintenance of public interest by involving the public in the management of state affairs.

Thus, after analyzing the reengineering process of the administration system in the Baltic States, a number of mechanisms responsible for the improvement of public

administration were identified, but there are still many categories that require additional research, such as deregulation policy or the control system for budget revenues and

expenditures, and therefore the specified scientific work is intended to become a starting point for further study of the specified issues.

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Аналіз Європейського досвіду вдосконалення механізмів публічного адміністрування

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Анотація. Жодна країна не здатна будувати прогресивне суспільство, не вдаючись до систематичної модифікації моделі публічного менеджменту, що на власному прикладі довели держави регіону Балтійського моря. Актуальність аналізу механізмів публічного адміністрування країн Балтії пояснюється успіхом модернізованої політики системи адміністрування у Естонії, Латвії та Литві, досвід яких є наглядною ілюстрацією вдалого реформування та прагнення до перманентного соціально-економічного зростання. Метою даної наукової роботи було дослідження різнобічних складових функціонування оновленої концепції публічного управління балтійських республік, в тому числі через призму євроінтеграційних процесів всередині країн. Провідними методами науково-дослідної праці виступили методи аналізу та узагальнення, за допомогою яких було розкрито ключові засоби вдосконалення державного сектору Литви, Естонії та Латвії, у поєднанні з методом порівняння, що дозволив зіставити моделі публічного керування трьох балтійських держав. Дана стаття розкриває значення впровадження інноваційних рішень суб'єктів владних повноваження задля реалізації громадянських свобод населення та забезпечення принципів державного управління. Було встановлено, що зміна засад державного керівництва у країнах Балтії була зумовлена підготовкою до вступу до Європейського Союзу. Зокрема, було впроваджено ідею взаємодії державних інститутів із цивільним населенням, залучено новітні інформаційні технології та проведено антикорупційну політику. Було визначено, що реформація публічного сектору залежить від забезпечення його безперешкодного функціонування. Практична цінність зазначеної наукової роботи полягає у можливості використання її матеріалів у процесі розробки реформаторських рішень реконструювання системи публічного адміністрування

Ключові слова: трансформація, євроінтеграція, адміністративний ребрендинг, інформаційні технології, принцип залучення громадськості

Construction of canal surfaces based on a specified flat curvature line

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Abstract. The research relevance is predefined by the widespread use of elements and structures that have the shape of canal surfaces in engineering practice and the possibilities of reproducing the surface through kinematics. The research aims to develop new means of modeling canal surfaces referred to as a grid of curvature lines by introducing elements with special properties into the structural model that simplify the solution of differential equations and reduce the amount of computation. To achieve the research methods, the synthetic geometric method, methods of linear algebra, the theory of differential equations and differential geometry, as well as methods of computer geometric modeling and visualization of three-dimensional objects were used. Studies on modeling and studying the properties of channel surfaces are analyzed. The research on the problem of the surfaces and lines of curvature is considered in more detail and the conditions under which it is possible to simplify the solution of the differential equation are identified. It was proved that the condition of contact between the canal surface and the plane along a given plane curve is sufficient for this curve to be one of the curvature lines of the family of orthogonal to the generating circles. This allowed to reduce the solution of the differential equation to two quadratures. The expressions of the corresponding integrals and an algorithm for modeling the canal surface with the possibility of referring to a grid of curvature lines were obtained. The expressions that define the desired surface include the parametric equations of a given plane line; a function that determines the radii of the spheres of the family depending on the parameter of this line. A specific example of modeling a surface based on a defined formula was also considered, and images of this surface with visualization of the coordinate grid were presented. The research's practical values are defined by the possibility of using the developed modeling tools in the design and computer-aided design of the geometry of real products containing surfaces of a smooth transition of variable radius

Keywords: surface coordinate grid, geometric modeling, sphere, envelope, Riccati's equation

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● INTRODUCTION

Since canal surfaces can be formed kinematically, they are common in engineering practice, from mechanical and hydraulic devices to architectural structures. Information and software for geometric modeling and design consist of many tools that allow the formation of objects of the required shape. These tools can form initial shapes by moving along a given trajectory, deform (mix surfaces), reconstruct shapes, form transition surfaces between given surfaces, etc. The so-called tubular surfaces are common in geometric computer modeling, which are canal surfaces with a generating circle of constant radius and has many practical applications. For example, they can represent the surface of a spring (a perfect spiral), which can be seen in real life on climbing plants, corkscrews, etc. Such surfaces

can also use the form of compartmentalized surfaces of round cylinders. Within canal surfaces, it is possible to emphasize mixing surfaces or smooth connections between two given surfaces. They are obtained from the initial canal surface through an operation consisting of generating one or more auxiliary surfaces that create a differentiated (smooth) transition between them so that the final object is a combination of all previous surfaces into a single part.

Thus, the study of new means of designing canal surfaces is necessary for the further development of computer geometric modeling tools and their implementation in computer-aided design systems for complex objects.

The research aims to develop new tools for modeling canal surfaces based on curvature lines by introducing

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elements with special properties into the structural model that simplify the solution of differential equations and reduce the computation required.

The research novelty is defined by the use of new constructive means (a specified flat line of curvature) in the geometric model of the canal surface instead of the traditional ones (sphere family center line). The introduction of the curvature line into the model allowed simultaneously controlling the surface shape and simplifying the transition to the mesh from the curvature lines on the surface, due to the existence of a known partial solution of the differential equation.

● LITERATURE REVIEW

Numerous studies analyzed canal surfaces, covered various aspects of their formation and properties, identified special cases or classes of such surfaces, and created or improved tools for their modeling.

Researchers [1; 2] focus on the visualization of canal surfaces by various means based on the specified parametric equations. An overview of the applications of canal surfaces in computer geometric modeling of objects is given in [3]. In [4], the design of architectural forms by surfaces with flat curvature lines, including canal surfaces, was considered.

Canal surfaces are a specific cyclic surface case, the standard formation formula of which is stated in [5].

Several studies analyzed the development of tools for modeling canal surfaces. Study [6] considers the problem of transition from representing the canal surface in a parametric form relative to the line of sphere centers to an implicit form of representing the surface by a system of equations. In [7], a special parameterization of the guide curve was proposed using a rational function. In [8], the Bezier curve was chosen as the guideline for the canal surface, and in [9], a hyperbolic curve was chosen.

The study of the properties of canal surfaces was considered in [10; 11]. In [10], the symmetry properties that canal surfaces with rational center curves and the function of changing the radius of the current parent sphere can have were studied. The study [11] considers canal surfaces obtained by conformal transformations.

The study of canal surfaces in four-dimensional space is considered in [12; 13], [14; 15] – in the Minkowski space, in [16] – in the pseudo-Halley three-dimensional space, and in [17] – in the spherical geometry of C. Li.

Among the canal surfaces, it is possible to distinguish special classes that satisfy additional conditions imposed on the geometric characteristics of the surfaces. For example, in [18], canal surfaces that retain the mean curvature under isometric transformations were considered, and [19; 20] studied canal surfaces that are also Weingarten surfaces.

In [21], the mathematical apparatus of quaternions was applied to the modeling of canal surfaces.

The problem of assigning a canal surface to the curvature lines is obtaining a family of lines orthogonal to the characteristic circles on the surface. This problem was considered in general in [22] and is reduced to solving an ordinary first-order differential equation of the Riccati type, which is not integrated into quadratures. This determines the need to study special cases of canal surfaces that allow solving the differential equation of curvature lines in quadratures or to numerically integrate this equation. For

example, if all spheres of a family have the same radius (tubular surface) or the line of centers of the spheres of the family is a flat curve, the curvature lines can be obtained using a single quadrature or without integration at all. Analyzing the known properties of the Riccati differential equation and comparing them with the above studies, the construction of solutions to this equation can be associated with the problem of the curvature line of the family, which is orthogonal to the characteristic circles. Thus, if one partial solution of the Riccati equation is known (one given curvature line), the general solution is found using two quadratures [23], and, therefore, the assignment of two curvature lines requires one quadrature to describe the general solution. Finally, the three known partial solutions of this equation allow us to write the general solution without quadratures.

● MATERIAL AND METHODS

In the first research stage, a mathematical model of the canal surface was considered in a generalized parametric form (the “classical” model), when the surface determinant includes a guideline (line of sphere centers) and a function of the dependence of the radius of the current sphere of the family on the guide parameter. Using the differential geometry methods, it was proved that the coordinate grid on the canal surface obtained by this model is not a grid of curvature lines. It is demonstrated that the transition to such a grid requires solving a Riccati-type differential equation. Known cases when this equation has a quadratic solution are analyzed.

In the second stage, a synthetic geometric method was used to prove the existence of a curvature flat line on the canal surface, provided that the plane touches the surface along this curve. Using the methods of differential calculus, it was verified that it is possible to form one partial solution of the differential equation based on this curve. Based on the obtained partial solution, a general solution of the Riccati-type differential equation was constructed using the methods of the theory of ordinary differential equations, which allowed us to find the lines of the family orthogonal to the generating circles of the canal surface and to refer the surface to the lines of curvature.

In the third stage, based on the obtained mathematical model, images of the surface referred to as the grid of curvature lines were obtained by computer visualization methods using the tools of the Matplotlib library of the Python programming language.

● RESULTS AND DISCUSSION

A canal is the envelope of a one-parameter family of spheres. The characteristic curves of a family of spheres are circles that create one of two families of curvature lines on this surface.

The canal surface equation in a vector form will be presented

$$\mathbf{m} = \rho + a \boldsymbol{\tau} + r \cos u \mathbf{v} + r \sin u \boldsymbol{\beta}, \quad (1)$$

in which $\rho = \rho(t)$ – radius is a vector of a point on the line of centers of the family of spheres; $\boldsymbol{\tau}$, \mathbf{v} , $\boldsymbol{\beta}$ – unit vectors (orthos) of the Fresnel system of this line; t is a parameter that determines the position of the point on the guideline; u is a parameter of the position of the point on the generating circle; $a = a(t)$ is a function that determines the

distance from the point of contact on the line of centers of the spheres to the center of the generating circle along the tangent, and has the form:

$$a = -\frac{RR'}{|\rho'|} \tag{2}$$

in which $R=R(t)$ is the function of the dependence of the radius of the family sphere on the parameter of the guideline;

$$\begin{aligned} \frac{\partial m}{\partial t} &= (|\rho'| + a' - r|\rho'|k \cos u) \tau + (a|\rho'|k + r' \cos u - r|\rho'|v \sin u) \nu + (r|\rho'|v \cos u + r' \sin u) \beta, \\ \frac{\partial m}{\partial u} &= -r \sin u \nu + r \cos u \beta, \quad \frac{\partial^2 m}{\partial u^2} = -r \cos u \nu - r \sin u \beta, \\ \frac{\partial^2 m}{\partial u \partial t} &= r|\rho'|k \sin u \tau - (r' \sin u + r|\rho'|v \cos u) \nu + (r' \cos u - r|\rho'|v \sin u) \beta, \end{aligned} \tag{4}$$

in which a', r' are the derivatives of the corresponding functions, $k=k(t)$ is the curvature of the guideline; v is the twist of the guideline.

First quadratic form coefficients

$$\begin{aligned} M' &= \frac{\partial^2 m}{\partial u \partial t} \left[\frac{\partial m}{\partial u} \frac{\partial m}{\partial t} \right] = -r^2 |\rho'| (r' k \sin u - a k^2 |\rho'| \sin u \cos u - v (|\rho'| + a' - r k |\rho'| \cos u)), \\ L' &= \frac{\partial^2 m}{\partial u^2} \left[\frac{\partial m}{\partial u} \frac{\partial m}{\partial t} \right] = -r^2 (|\rho'| + a' - r k |\rho'| \cos u). \end{aligned} \tag{6}$$

The conditions $F=0$ and $M=0$ are not fulfilled. In other words, in general, the coordinate grid of the surface (1) does not coincide with the lines of curvature. More precisely, the lines $t=\text{const}$ (generating circles) make up one set of curvature lines, as for the lines $u=\text{const}$, they are not curvature lines in general, since the conditions of orthogonality and conjugacy of the coordinate grid are not met.

To find the curvature lines of the family orthogonal to the generating circles, the differential equation of orthogonal trajectories to the family $t=\text{const}$ will be used, which has the form [24]:

$$Fdu + Edt = 0. \tag{7}$$

Substituting the expressions E and F into equation (7), after reductions, the following equations were obtained

$$\frac{du}{dt} = \frac{a}{r} k |\rho'| \sin u - |\rho'| v. \tag{8}$$

Replacing the variable u in the last equation with

$$v = tg \frac{u}{2} \tag{9}$$

resulted in the generalized Riccati equation [23].

$$v' = -\frac{|\rho'|v}{2} v^2 + \frac{a}{r} k |\rho'| v - \frac{|\rho'|v}{2}. \tag{10}$$

Substituting the values of a and r from the right-hand side of equations (2) and (3) into (8) and (10), the following is true:

$$\frac{du}{dt} = -\frac{R'}{\sqrt{|\rho'|^2 - R^2}} k |\rho'| \sin u - |\rho'| v, \tag{11}$$

$$v' = -\frac{|\rho'|v}{2} (v^2 + 1) - \frac{R' k |\rho'|}{\sqrt{|\rho'|^2 - R^2}} v. \tag{12}$$

It is assumed, that function

$$v = v(t, \alpha), \tag{13}$$

is an equation (12) solution, where α is the integral constant.

$|\rho'| = \left| \frac{d\rho}{dt} \right|$ – the modulus of the tangent vector to the guideline; $r=r(t)$ is the function that establishes the dependence of the radius of the generating circle on the parameter of the guideline:

$$r = \frac{R|\rho'|}{\sqrt{|\rho'|^2 - R^2}}. \tag{3}$$

Find the partial derivatives of function (1):

$$E = \left(\frac{\partial m}{\partial u} \right)^2 = r^2, \quad F = \left(\frac{\partial m}{\partial u} \cdot \frac{\partial m}{\partial t} \right) = r^2 |\rho'| (v - \frac{a}{r} k \sin u). \tag{5}$$

The numerators of the coefficients M and L of the second quadratic form

Then, using equality (9), the following expression is true

$$u = u(t, \alpha), \tag{14}$$

in which, when substituted into equation (1), will transform it into the equation of the canal surface referred to as the coordinate grid of curvature lines $t=\text{const}$, $\alpha=\text{const}$.

The four-solution property of the Riccati equation [23] allows to state that the four curvature lines of the family orthogonal to the generating circles intersect these circles at four points with a constant anharmonic ratio. Note that if the ratio $\frac{a}{r}$ in (8) is replaced by

$$\frac{a}{r} = tg \gamma, \tag{15}$$

in which γ is the angle of inclination of the vector directed from any point of the guideline to the points of the corresponding generating circle, then equation (8) can be rewritten as

$$tg \gamma = \frac{k|\rho'| \sin u}{u + |\rho'| v}. \tag{16}$$

Geometrically, this equation is a condition for the normal to the canal surface along the second family of curvature lines to form scanning surfaces, with line (1) serving as the guide curve.

Since the Riccati equation in the form (11) or (12) does not have a general solution in quadratic form, it was advisable to consider finding the curvature lines for specific cases of representing canal surfaces.

Thus, for tubular surfaces ($R=\text{const}$) with the spatial line of the centers of the family of spheres, equation (11) was obtained as

$$\frac{du}{dt} = -|\rho'| v. \tag{17}$$

As such, function (14) becomes

$$u = -\int |\rho'| v dt + \alpha. \tag{18}$$

If, in the case of tubular surfaces, the line of centers is flat ($v=0$), then according to (18) $\frac{du}{dt} = 0$, the coefficients F and M of the first and second quadratic forms will be zero. Consequently, in this case, both the $t=\text{const}$ and $u=\text{const}$ lines of the surface coincide with the curvature lines.

If the dependence for the radius of the sphere is variable, and the line of centers remains a flat curve ($R \neq \text{const}$, $v=0$), then the solution of equation (11) reduces to quadrature:

$$u = 2 \arctg \alpha e^{-\int \frac{R'}{\sqrt{|\rho|^2 - R^2}} |\rho'| k dt}. \quad (19)$$

Note that the values $u=0$ and $u=\pi$, which correspond to the cross-section of the surface by the plane of the line of centers, give two lines of curvature since the normal to the surface along these lines belong to the same plane.

In the case when $R \neq \text{const}$, $v=0$, and $k=0$ is a straight lines, equation (1) gives a surface of rotation in which the lines $t=\text{const}$ are meridians and the lines $u=\text{const}$ are parallels.

As for the case when $R \neq \text{const}$, $v \neq 0$, the radius of the spheres is variable and the line of centers is a spatial curve, the solution of equation (12) is possible only for some special cases [23]. Therefore, if (12) has no solution in quadratures or the quadratures obtained from it have no analytical representation, numerical integration methods can be used to obtain a coordinate grid from the curvature lines, which leads to a significant increase in the amount of computation.

The following geometric model of the canal surface formation is proposed. A certain line C lying on the Oxy plane of the rectangular spatial coordinate system was considered. This plane is called the reference plane. The one-parameter set of spheres was determined from the condition that the spheres of the family and the reference plane touch along the given line.

$$\begin{aligned} x &= \frac{1}{\rho^2 |\rho' \times \rho''|} (f \rho^2 |\rho' \times \rho''| + R [\sqrt{f'^2 + \varphi'^2} (\cos u (f'' (\varphi'^2 + R'^2) - f' (\varphi' \varphi'' - R' R'')) + \sin u |\rho'| (\varphi' R'' - R' \varphi'')) - R' f' |\rho' \times \rho''|]), \\ y &= \frac{1}{\rho^2 |\rho' \times \rho''|} (\varphi \rho^2 |\rho' \times \rho''| + R [\sqrt{f'^2 + \varphi'^2} (\cos u (\varphi'' (f'^2 + R'^2) - \varphi'' (f' f'' - R' R'')) - \sin u |\rho'| (f' R'' - R' f'')) - R' \varphi' |\rho' \times \rho''|]), \\ z &= \frac{R}{\rho^2 |\rho' \times \rho''|} ((f'^2 + \varphi'^2) |\rho' \times \rho''| + \sqrt{f'^2 + \varphi'^2} [\cos u (R'' (f'^2 + \varphi'^2) - R'' (f' f'' - \varphi' \varphi'')) + \sin u |\rho'| (f' \varphi'' - \varphi' f'')]), \end{aligned} \quad (22)$$

in which: $|\rho'| = \sqrt{f'^2 + \varphi'^2 + R'^2}$, f', φ', R', R'' are the first and second derivatives of the corresponding functions, $\rho'' = \frac{d^2 \rho}{dt^2}$ and $|\rho' \times \rho''| = \sqrt{(\varphi' R'' - \varphi'' R')^2 + (f' R'' - R' f'')^2 + (f' \varphi'' - \varphi' f'')^2}$.

As noted earlier, the surface constructed according to equation (22) will not be classified as a curvature line, since only one of its two families of coordinate lines is a curvature line. These are the lines of $t=\text{const}$, which are the generating circles. To move to the system of curvature lines, it is necessary to move in equations (22) from the parameter u to a new parameter obtained from differential equation (12) concerning (9).

Using the known correlations for curvature and torsion, this equation can be remade as:

$$[|\rho' \times \rho''| \sqrt{f'^2 + \varphi'^2} - R'' (f'^2 + \varphi'^2) + R' (f' f'' + \varphi' \varphi'')] v^2 + 2 |\rho'| (f' \varphi'' - \varphi' f'') v + |\rho' \times \rho''| \sqrt{f'^2 + \varphi'^2} + R'' (f'^2 + \varphi'^2) - R' (f' f'' + \varphi' \varphi'') = 0. \quad (24)$$

This equation has a discriminant equal to zero and yields the desired partial solution, $v_1 = v_1(t)$:

$$v_1 = |\rho'| (\varphi' f'' - \varphi'' f') [|\rho' \times \rho''| \sqrt{f'^2 + \varphi'^2} - R'' (f'^2 + \varphi'^2) + R' (f' f'' + \varphi' \varphi'')]^{-1}. \quad (25)$$

Directly substituting the right-hand side of (25) for v , as well as the derivative of this expression for the differential

It has been proved that this condition is sufficient for a given plane line to be a line of curvature on the contour surface of a family of spheres if one exists. According to the transitivity theorem [24], if a surface (S) has a contact with two surfaces ($\Sigma 1$) and ($\Sigma 2$) of order at least n at the same point, then ($\Sigma 1$) has ($\Sigma 2$) a contact of the corresponding order at the same point. Taking the surface (S) to be the sphere of the family, and the surfaces ($\Sigma 1$) and ($\Sigma 2$) to be the reference plane and the canal envelope, we conclude that, if it exists, this surface will touch the plane along the points of the given curve. Considering touching as a limiting case of intersection of surfaces, and given that any line lying on a plane is its line of curvature, according to Joachimsthal's theorem [24], we conclude that a given plane curve is also a line of curvature for the canal surface.

In this case, the condition for the contact of an arbitrary sphere of the family and the Oxy plane was determined from the equation for the line of centers of the spheres in the form:

$$\rho = f i + \varphi j + R k, \quad (20)$$

where: $f=f(t)$, $\varphi=\varphi(t)$ are functions of the parameter t that define a given line on the Oxy plane, i, j, k are the orthoi of the rectangular Cartesian coordinate system.

Then, the vector equation of the canal surface (1) is as follows:

$$m = \rho + \frac{RR'}{\sqrt{\rho^2}} \tau + R \sqrt{\frac{\rho^2 - R^2}{\rho^2}} (\cos u v + \sin u \beta). \quad (21)$$

By substituting the known expressions for calculating the vectors r, r', τ, n, β , and performing the transformation, the following parametric equations are obtained:

$$v' = -\frac{|\rho'| (\rho' \rho'' \rho''')}{2(\rho' \times \rho'')^2} (v^2 + 1) - \frac{R' |\rho' \times \rho''|}{\rho^2 \sqrt{\rho^2 - R^2}} v, \quad (23)$$

where: $(\rho' \rho'' \rho''')$ – is the mixed product of the first, second, and third derivatives of the vector (20), $\rho' \times \rho''$ – is the vector product of the first and second derivatives of the vector ρ .

Since the flat line C is, as proved above, the line of curvature of the canal surface, the corresponding expression for the parameter v must satisfy the differential equation (12) and, therefore, be its partial solution. Note that the reference plane in the coordinate system is characterized by the equation $-z=0$, then by equating the third of equations (22) to zero and making the appropriate replacement of the parameter, we obtain the equation quadratic concerning v :

equation (12), reduces the latter to zero, which confirms the correctness of the result.

It is known from the theory of differential equations [23] that given one partial solution of the Riccati differential equation, its general solution can be obtained using two quadratures.

For equation (12) the general solution is

$$v = v_1 + \frac{1}{\phi(t)(w + \psi(t))}, \tag{26}$$

where: w is the new variable (parameter) for which the integration constant is taken; $\phi(t)$ is the function obtained from the expression:

$$\phi(t) = e^{\int \left(\frac{|\rho'|(\rho''\rho''')}{(\rho' \times \rho'')^2} v_1 + \frac{R|\rho' \times \rho''|}{\rho^2 \sqrt{\rho^2 - R^2}} \right) dt}; \tag{27}$$

$\psi(t)$ is a following function:

$$\psi(t) = \int \left[\frac{|\rho'|(\rho''\rho''')}{2(\rho' \times \rho'')^2} e^{-\int \left(\frac{|\rho'|(\rho''\rho''')}{(\rho' \times \rho'')^2} v_1 + \frac{R|\rho' \times \rho''|}{\rho^2 \sqrt{\rho^2 - R^2}} \right) dt} \right] dt. \tag{28}$$

To move from the original grid on the surface to the coordinate grid of curvature lines, based on the results obtained, it is necessary to replace the parameter u in equation (22) based on the following equation:

$$u = 2 \arctan(v), \tag{29}$$

in which $v=v(t, w)$ has the right side expression (26).

An example of designing a canal surface using the obtained expressions is shown. As a given line of curvature, a circle was chosen, written by the parametric equations on the plane Oxy : $f=r \cos t, \varphi=r \sin t$ and the dependence function for the radius of the spheres of the family, which is as follows: $R=b \cos 2 t+c$.

Figures 1 and 2 show the representations of the canal surface with a given circle of curvature (shown by the bold line in Fig. 2) obtained for two variants of the parametric surface equations: a) based on the equations (22): b) considering the solution of the differential equation (23) by expressions (26)-(28) and substitution (29).

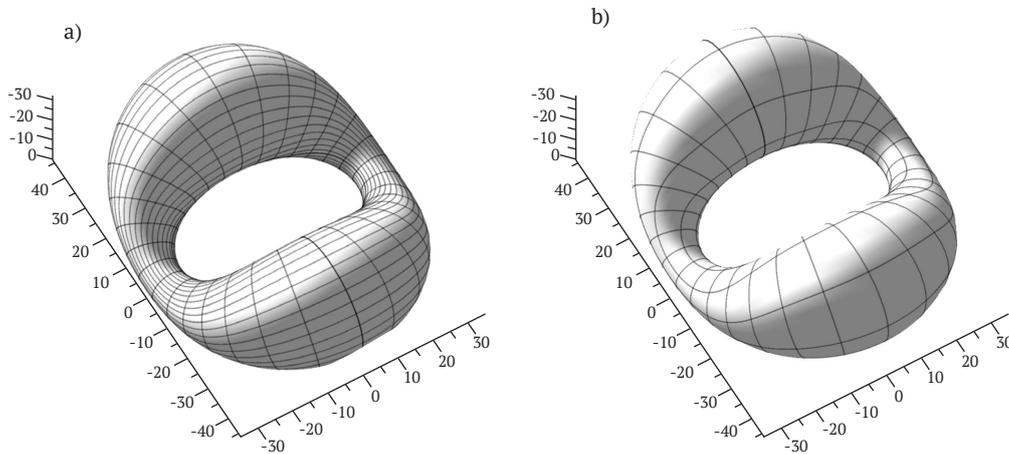


Figure 1. Canal surface (general view) at $r= 3.0, b=5.5, c=10.5$
 a) initial parameter – (22); b) variable parameter u in relation to expressions (26), (29)

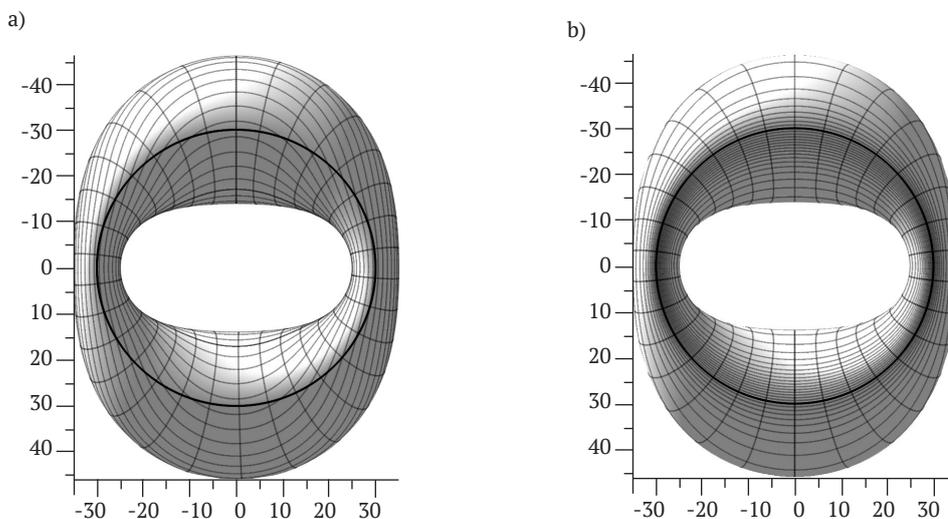


Figure 2. Distribution of coordinate grid lines on the surface near a specified plane curvature line
 a) initial parameter – (22); b) variable parameter u in relation to expressions (26), (29)

Note that when constructing three-dimensional (3D) surface models, the same number of lines forming the coordinate grid was set for both parameterization options. Figure 1 is an arbitrary rectangular projection for both variants of surface visualization with the same orientation. Figure 2 shows a rectangular projection of the surface on a horizontal plane (top view).

Analyzing the results of 3D surface model visualization models built on the basis of the initial parameterization and based on the solution of the differential equation, it is possible to clearly understand the difference in the location of the coordinate grid lines on the surface. The coordinate lines of $t=\text{const}$ (these are the generating circles) remain unchanged, while the direction of the second family of lines changes from non-orthogonal to orthogonal to the generating circles. Figure 2 well explains this difference by the fact that the given curvature guide circle intersects the lines of the $u=\text{const}$ family on the surface (22) (Fig. 2a), and on the surface constructed with the expressions (26) and (29) (Fig. 2b), the given plane guide is part of the $w=\text{const}$ family of lines without intersecting with other lines of the family.

The abovementioned example provides a fairly simple overview of the functions that define the plane line of curvature and the radius of the current family sphere. In more complicated cases, the expressions of the integrals in formulas (27) and (28) may not have a solution in elementary functions, so numerical integration methods will be required.

While comparing the conducted research with other studies, it is possible to state that study [22] is more theoretical in nature. Based on the study of the differential characteristics of the curvature lines of canal surfaces, the presence of no more than two isolated periodic curvature lines for a family of orthogonal generating circles was established, and the conditions for the presence of curves with umbilical points on the surface were revealed in general. In [25], the conditions and special cases of modeling canal surfaces were considered when the parameter of the guideline of the centers of the spheres is also a parameter of the curvature lines of the family orthogonal to the generating circles. Unfortunately, there are no examples of surface modeling in this paper. In [26], only certain cases of the canal surface formed by the circles of curvature of a conical helical line, as well as the case of the generating circles located in the straight plane of the guide curve, which allows integration of the differential equation of curvature lines, were considered. The main difference between the present work and these works is that the constructive model was initially proposed, the existence of which was proved by a synthetic method based on statements and theorems. The basic one is Joachimsthal's theorem. Other studies used an analytical approach when the differential equation of curvature lines was first derived, and then, by analyzing the components of this equation, possible cases were separated that allow for simplified calculations.

The main motivation for this research was to create design tools that would be more convenient for further application in practice. This tool is the inclusion of a given

plane curvature line in the model. Since the constructed surface touches the plane along this line, it has the properties of a line with zero total curvature or a line of parabolic surface points. That is, it has special differential geometric properties. In contrast to the design scheme based on the representation of the line of the centers of spheres as a guide (works [6-7]), this flat line of curvature makes it much easier to coordinate the smooth transition of surfaces in 3D models of composite shapes of parts and structures.

● CONCLUSIONS

The research analyzes the issue of designing canal surfaces under specified conditions, which are represented by a given flat line lying on the surface and simultaneously representing one of the curvature lines of the family of orthogonal to the generating circles. Based on the consideration of the surface determinant in the form of a line of centers of a one-parameter set of spheres and the function of the dependence of the radius of the current sphere on the parameter of the guideline, a general mathematical model of the assignment of canal surfaces to curvature lines was obtained. This model can be represented in the form of the Riccati differential equation concerning the parameter of the guideline. Important cases of simplification of the mathematical model and their geometric meaning are investigated. It was proved by a synthetic method that the condition of contact between the plane of a certain plane line and the canal surface is sufficient for this line to be a line of curvature on the surface. Based on this result, the model with a guide in the form of a line of sphere centers was modified to a model with a given plane curvature line. Based on the modified model, a partial solution of the Riccati equation was found. This allowed to reduce the problem of mapping the canal surface to a grid of curvature lines to the calculation of two quadratures instead of the need to solve the differential equation numerically. Based on the proposed mathematical model, computer simulations were carried out for a specific example of a given plane line of curvature. The results obtained are compared with the results of the most recent studies.

Summarizing the research and developing a synthetic approach to the design of canal surfaces related to curvature lines, it is possible to identify the following promising areas for further research:

- development of the proposed design scheme based on two specified plane lines of curvature, the presentation of which, under certain conditions, will further simplify the obtaining of a coordinate grid from the lines of curvature;
- expansion of the synthetic approach to the case of designing canal surfaces along a specified spherical curvature line;
- a combination of plane and spherical curvature lines in the model;
- design of the canal surface based on a specified curvature line, which is simultaneously the curvature line of the deployed surface and belongs to the family orthogonal to its generating straight lines.

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Конструювання каналових поверхонь за заданою плоскою лінією кривини

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Анотація. Актуальність дослідження обумовлюється поширеністю застосування елементів деталей та конструкцій, що мають форму каналових поверхонь, в інженерній практиці та можливостями відтворення поверхні кінематичним способом. Мета дослідження – розроблення нових засобів моделювання каналових поверхонь віднесених до сітки з ліній кривини за рахунок впровадження в конструктивну модель елементів зі спеціальними властивостями, які дозволяють спростити розв'язок диференціальних рівнянь та скоротити об'єм обчислень. Для вирішенні наукових завдань були використані синтетичний геометричний метод, методи лінійної алгебри, теорії диференціальних рівнянь та диференціальної геометрії, а також методи комп'ютерного геометричного моделювання та візуалізації тривимірних об'єктів. Проаналізовано дослідження з моделювання та вивчення властивостей каналових поверхонь. Детальніше розглянуто дослідження присвячені проблемі віднесення цих поверхонь до ліній кривини та виявлено умови, за якими можливо спростити розв'язок диференціального рівняння. Було доведено достатність умови дотику каналової поверхні та площини вдовж заданої плоскої кривої для того, щоб ця крива була однією з ліній кривини сімейства ортогонального до твірних кіл. Ця обставина дозволила звести розв'язок диференціального рівняння до двох квадратур. Були отримані вирази відповідних інтегралів та алгоритм моделювання каналової поверхні з можливістю віднесення до сітки з ліній кривини. До виразів, що визначають шукану поверхню, входять: параметричні рівняння заданої плоскої лінії; функція, що визначає радіуси сфер сімейства в залежності від параметра цієї лінії. Також був розглянутий конкретний приклад моделювання поверхні у відповідності до визначених формул, наведені зображення цієї поверхні з візуалізацією координатної сітки. Практичне значення роботи полягає у можливостях використання розроблених засобів моделювання при конструюванні та комп'ютерному проектуванні геометрії реальних виробів, що містять поверхні плавного переходу змінного радіусу

Ключові слова: координатна сітка на поверхні, геометричне моделювання, сфера, обвідна поверхня, рівняння Ріккати

Instrumental analysis of the impact of economic factors on the level of a country's economic innovativeness

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Abstract. The rapid development of innovative activity in Ukraine and the instability of the economic and political environment determine the relevance of studying the problems of innovative development in close connection with global and local factors of economic growth. The purpose of the research is to study the budgetary policy factors that have a dominant influence on the level of national innovative development, and their impact on the level of economic growth in order to form directions for innovation policy development based on instrumental analysis methods. The paper uses methods of econometric modeling and adaptive methods of forecasting. The constructed conceptual model includes three aggregated stages of research. The study addressed the problem of assessing the level of a country's economic innovativeness and determining the factors affecting it; it was found that this level grows with an increase in the share of private investment, a decrease in the rate of GDP growth, an increase in the share of taxes in the budget structure, a decrease in the money supply, an increase in education and public security expenditures. The impact of the state budgetary policy was analyzed and the value of the indicator of economic growth and the level of the country's economic innovativeness was forecasted. The practical significance of the results is that a gradual reduction in the level of the country's economic innovativeness is possible in periods of long-term economic growth. To avoid such negative consequences, European governments should pay more attention to internal problems and external trends of innovation activity

Keywords: innovative development, innovative activity, modeling, economic growth, time series model, correlation

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● INTRODUCTION

Global research on innovation shows that innovation is a key driver of economic development. Each country has its peculiarities of innovative development, and therefore its innovation policy. Being a state with a strong innovation potential, Ukraine should take into account the world trends in innovation development and find favorable mechanisms and tools to address the related challenges. Monitoring the effectiveness of innovation policies is necessary to understand whether policies work and how they can be improved. To do this, the authorities must have reliable and up-to-date statistical information, since the effectiveness of managerial decisions depends on its quality. As innovation and economic development are interrelated, it is necessary to constantly monitor the impact of economic factors on the level of innovative development of the country's economy.

At the same time, the role of the state in the economy is being reassessed in the modern world. The 21st-century

crises, the 2008 crisis, and the 2020-2022 pandemic have again brought the issue of the role of the state to the forefront of public and academic discussions. The world is rethinking the impact of state intervention in economic development. With state support, the innovative type of economic development is increasingly becoming the foundation that determines the economic strength of a country and its prospects in the world market. Innovation in the world economy is a key factor to boosting the competitiveness of EU countries and is essential in the context of globalization. Therefore, one of the most important tasks of Ukraine's national innovation policy is to ensure dynamic growth based on advanced technologies and innovations.

Rational and balanced strengthening of the role of the state in the implementation of innovation policy should provide for the importance and relevance of the formation of Ukraine's development budget, the provision of state guarantees and investment insurance to reduce innovation

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risks, reasonable support for domestic producers, the implementation of a balanced foreign policy and economic policy, which should be combined with a plan for the technological transformation of domestic industry.

In the Global Innovation Index (GII) country ranking, Ukraine ranks 45th among the 131 world economies by the level of innovation activities (80 indicators in seven areas). Switzerland, Sweden and the USA top the list of leading innovative countries. Ukraine ranks 30th among the countries of the European region and 2nd in the group of lower middle-income countries [1].

The strengths of Ukraine are university-industry collaboration in scientific research (50th place), the share of employed females with advanced degrees (3rd place), the share of information and communication technologies (ICT) exports in foreign trade (9th place), mobile app creation (15th place), intangible assets (23rd place), trademarks and patents (5th and 20th places, respectively). The weaknesses of Ukraine are the share of higher education graduates in science and engineering (82nd place) and creative goods exports as a percentage of total trade (111th place). In terms of infrastructure development, Ukraine rose from 97th place in 2019 to 94th place in 2020. At the same time, the value of the ecological sustainability indicator increased to 99th from 120th in 2019. Market sophistication led Ukraine to the 99th position in the ranking (90th in 2019) (86th in terms of credit, 79th by microfinance loans as a percentage of GDP, 121st by investment, and 45th by the level of trade and competition) [2].

As can be seen, today the innovative competitiveness of Ukraine is accompanied by a number of the aforementioned problems, so it is considered expedient to analyze the dynamics of national development in the innovation dimension and study the peculiarities of developed countries in terms of innovation activity regulation.

It is important to note that the topic of innovation is often addressed by scholars, yet innovation is more often explored at the micro level, i.e., in the context of corporate competitiveness. In modern scientific research, there are numerous works devoted to the problem of innovative development. However, due to the rapid development of innovations and the constant instability of economic and political processes observed in Ukraine, further studies of the innovative development dynamics in close connection with economic growth factors are still relevant.

Therefore, the purpose of the study is to determine the factors of budgetary policy that have a dominant influence on the level of a country's innovative development, as well as to study the scale of their impact on the level of economic growth in order to justify the priority directions of innovation policy at the national level.

The scientific novelty of the study consists in the proposed conceptual model, which includes the following research stages: assessing the level of innovativeness of a country's economy and determining the factors influencing it; modeling the level of a country's economic growth as one of the most important factors in the development of innovation activity, as well as analyzing the impact of state budgetary policy on it; forecasting resultant indicators based on the built forecasting models.

● LITERARY REVIEW

Among modern Ukrainian and foreign scholars who study approaches to assessing the level of innovative development and economic growth, it should be noted the study of O. Ugolkova, N. Reverenda and T. Lisovych [3], which investigates the state of innovation activity development in the world, analyzes the change dynamics in international innovation rankings and identifies key features of regulating innovation at the state level in leading countries.

The team of scholars – T. Pysarenko, T. Kuranda, T. Kvasha, *et al.* – conducted a research study on the state of scientific and innovative activity in Ukraine in 2020, which is based on the official data of the State Statistics Service of Ukraine, world rankings, international scientometric databases. Particular attention should be paid to the presented analysis of the impact of scientific and innovative activities on the economy of Ukraine [2].

In the context of the problem raised, it is also worth noting the research by W. Gajda, A. Kuznetsov and S. Kuznetsova [4], in which the state of innovative development of Poland and Ukraine is compared; the countries are respectively classified as a moderate innovator and a modest innovator. The authors analyzed 27 indicators of the countries' economic and innovative development in comparison with the achievements of the European Union using comparative analysis methods.

The issues of state regulation of innovative development are raised in the papers of N. Vetsepura [5] and V. Gornyk [6], which address the strategies for the development of Ukraine's innovative economy and recognize the key role of state regulation in ensuring economic and innovative development.

The problem of analyzing the relationship between the innovative level of the economy and economic growth is also covered by foreign researchers. The study [7] determines the impact of the level of innovative development indicators (human capital development, technological development, trade openness, government expenditure and financial system development, etc.) on the economic growth of Albania.

N. Chaabane in his work [8] analyzes and proves the impact of the level of intellectual capital on firms' performance and the level of economic development of a country as a whole. Studying the impact of the level of intellectual capital on the efficiency of a country's economic development, the author used data from 260 companies. The effectiveness of intellectual capital was measured using the smart value added ratio (VAIC) method developed by A. Pulic [9]. As a result of the research method used – multiple linear regression analysis – the author substantiates the fundamental role of intellectual capital components in ensuring economic development.

Researchers W. Al Salamat and K. Batayneh [10] prove the interrelation of the financial market with economic growth on the example of the MENA countries group (MENA stands for Middle East and North Africa – a region consisting of the Middle East and North Africa) during the period 2000-2019. At the same time, the state is recognized as a key participant in the financial market.

Having analyzed the methodology used by modern Ukrainian and foreign scholars to assess the level of

innovative development and economic growth and their interrelation, it should be noted the following:

The authors [7] used empirical analysis to assess the impact of the level of innovative development indicators on economic growth in Albania based on a modification of the model created by E. Borensztein, J. De Gregorio and J.W. Lee [11]. The authors used a multidimensional vector autoregression (VAR) model and an error correction vector model (VECM) to analyze the cause-effect relationships between variables.

The study [12] considers the individual and interacting impact of foreign direct investment, the domestic structure of production, and the share of innovative production on the level of exports and economic development. The econometric estimate is based on an analysis of the general method of dynamic system moments analysis using panel data from 44 countries in sub-Saharan Africa.

Based on the review of the current coverage of the problem of the impact of the level of a country's innovativeness on its economic development in the scientific literature, it can be concluded that there is an insufficient level of analysis of the impact of factors of government expenditure on innovative development on the level of a

country's economic growth, which requires the use of modern mathematical tools.

● MATERIALS AND METHODS

Having analyzed and considered the existing approaches to assessing the level of innovative development and economic growth, it can be said that econometric models occupy an important role in the methodology of studying the indicators of innovative development and their impact on the level of economic growth since they are used for in-depth analysis of a certain set of data and the identification of statistically significant relationships and dependencies of the indicators under study.

Graphically, the scheme of the study using the "black box" principle is shown in Figure 1. To attain the purpose of research and build the models, the United Kingdom was chosen as a country that is among the leading innovative countries according to the data [13]. According to the statistical data given in [14], the United Kingdom is described as a strong innovator, and over time, the indicators of the innovative level of this country's economy relative to the EU remain unchanged.

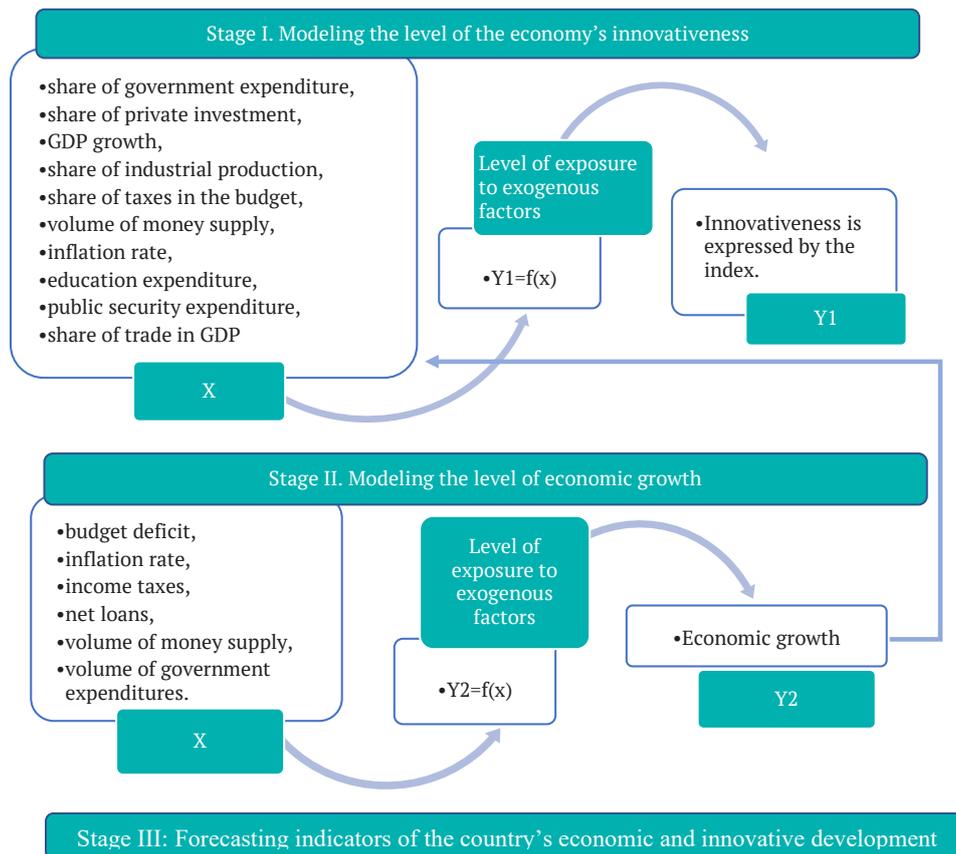


Figure 1. Investigation of factors influencing the level of innovativeness of the country's economy using the "black box" system

Having carried out a detailed analysis of literature sources [3; 5; 6] on the topic of research, in order to implement the tasks of Stage I, it was decided to include in the model ten factors that can affect the innovativeness

index Y_1 and will further help to assess the impact of significant economic factors on the change in the index. The factors selected for the analysis are given in Table 1.

Table 1. Factors affecting the level of innovativeness of developed countries' economies

Indication of the influencing factor	Name of the influencing factor	Scope of influence on the level of innovative development
x_1	share of government expenditure as a percentage of GDP	the indicator demonstrates government investment in the economy, including in the field of innovation
x_2	share of private investment as a percentage of GDP	private investment is usually attracted to areas with high innovation potential, where it is possible to obtain greater added value.
x_3	GDP growth	generally, there is an increase in the share of innovative products in countries where where the production of goods and services increases.
x_4	share of industry in the economy structure	this indicator is included to investigate how the level of industrial production affects innovation, and whether industry is one of those areas where innovation is observed most often.
x_5	share of taxes in GDP	the indicator demonstrates the relation between the revenue side of the budget and the level of innovativeness
x_6	volume of money supply	research on the impact of money supply on the level of innovation
x_7	inflation growth	research on the impact of price increases on the economy's innovativeness
x_8	share of education expenditure in GDP	the development of a country's intellectual potential is a key factor in innovative development
x_9	share of public security expenditure in GDP	the factor of economic security is an important engine for the development of innovation
x_{10}	share of international trade in GDP	the involvement of a country in the world trade exchange has a positive impact on the growth of product competitiveness, and hence will further the development of innovation activities.

The construction of econometric models of dependency of the selected indicators will allow to conduct a more detailed analysis of the level of the economy's innovativeness and the impact of the budgetary policy of the leading countries on it, as well as to borrow subsequently the most optimal directions for development regarding the state innovation policy, which should be applied in Ukraine.

The construction of the econometric model is done in several main stages:

Stage 1. Qualitative analysis (defining the purpose of the analysis, determining the aggregate, determining effective and factor features, choosing the period for which the analysis is conducted, choosing the method of analysis).

Stage 2. Preliminary analysis of the modeled aggregate (testing the uniformity of the aggregate, excluding inconsistent observations, specifying the required volume of properties, defining properties distribution laws).

Stage 3. Construction of an econometric model (establishing a list of factors, calculating estimates of the parameters of regression equations, sorting through competing model variants).

Stage 4. Assessment of the model adequacy (testing the statistical significance of the dependence equation as a whole and its parameters separately; verification of the compliance of formal properties of the assessment with the objectives of the study).

Stage 5. Economic interpretation and practical use of the model.

Let's build a linear multi-factor econometric model and determine all its characteristics. Let's test the statistical significance of the model parameters and the model adequacy using the Fisher criterion. The modeling stages are implemented using the Python programming language.

When constructing an econometric model, the "black box" method of modeling is implemented, i.e. when the researcher is not aware of the mechanism of processes

occurring in the system; this mechanism can be examined by the input and output characteristics of the system. Input and output characteristics of the system are often identified with exogenous and endogenous variables; alternatively, in the correlation and regression analysis such terms as independent (factor) variables, or features, and dependent (outcome) variables, or features, are used.

Modeling the level of economic growth as a result of the implementation of the second stage of the research it will allow to analyze the impact of the most significant indicators of the country's budgetary policy on the main indicator of economic development, which is the growth of the GDP rate (Y_2), as suggested by the present study.

Having carried out a detailed analysis of the linear relationships between the influencing factors on innovative development, it was built a correlation matrix (Fig. 2) and analyzed the variance in the initial data in order to identify factors that have a significant impact on the resulting indicator.

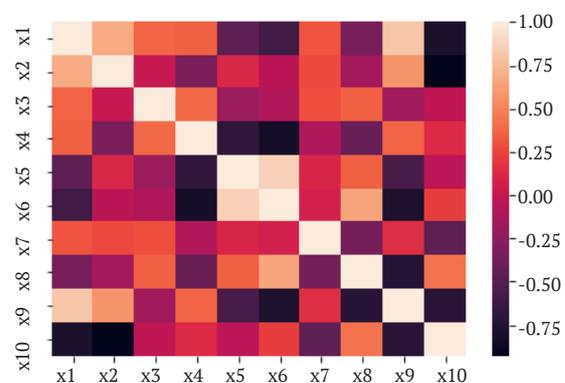


Figure 2. Building a matrix of correlations of factors influencing the level of GDP

As a result of the steps of the analysis, the set of independent variables of the model has been reduced to six factors that can influence the growth of the GDP rate (Y_2),

and will further help to assess the impact of significant economic factors on the outcome indicator. The factors selected for the analysis are given in Table 2 [15; 16].

Table 2. Factors influencing the level of economic growth of developed countries

Indication of the influencing factor	Name of the influencing factor	Scope of influence on the level of economic growth
x_1	budget deficit/surplus	shows the ratio of public sector expenditures and revenues, and reflects the level of government demand stimulation.
x_2	net loans	indicates the level of fundraising to cover government expenditure
x_3	share of government expenditure in GDP	shows the share in GDP of state-manufactured goods
x_4	income tax	reflects the revenue side of the budget
x_5	volume of money supply	research on the impact of money supply on the level of economic growth
x_6	inflation	research on the impact of the price level and its regulation by the state on the level of economic growth

In Stage III, the forecasting of the studied indicators (economic and innovative development of the country) is carried out. The level of economic development is considered the input predictor of influence, and the result is obtaining forecast estimates of the level of innovativeness of the country's economy. The obtained model results for the dependencies and confirm their high quality and allow to confidently use the built models for forecasting.

However, due to the limited statistical information on the forecast values of the factors influencing the indicator of economic growth, it is impossible to make a forecast.

Upon considering the dynamics of the Economic Growth Indicator (EGI), it was decided to use a time series model, namely the ARIMA model, for forecasting. This tool provides a simple yet powerful method for generating quality time series forecasts. For building the model, the

following parameters should be set: the order of the lag, the degree of difference, and the order of the moving average. In the modeling process, a linear dependence is built, which allows to exclude trend and seasonal components that negatively affect the regression quality.

● **RESULTS AND DISCUSSION**

To implement the first stage of the study, namely modeling the level of the economy's innovativeness, it was tested the linear relationships between the selected factors and constructed a correlation matrix (Fig. 3a), which revealed possible multicollinearity. From the matrix, it can be seen that the factors x_1 and x_9 have a linear relationship, thus it will be excluded them from further data analysis. After excluding these two factors, it can be seen that the multicollinearity in the array of studied variables was eliminated (Fig. 3b).

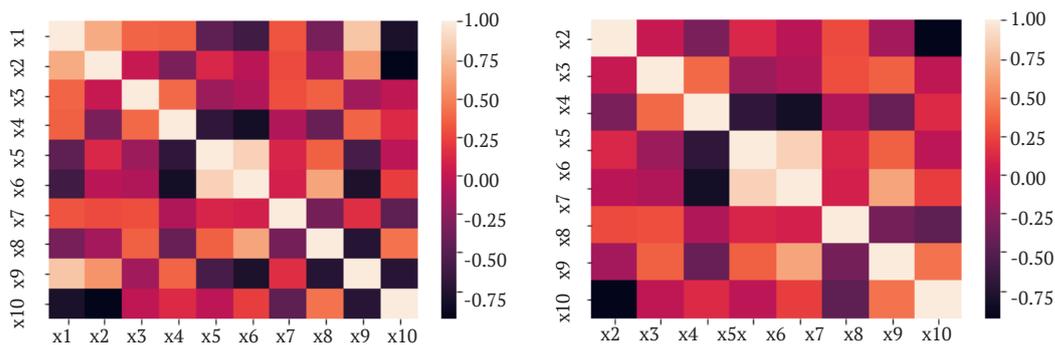


Figure 3. Correlation Matrix: a – building a correlation matrix with the initial set of factors; b – Correlation matrix excluding the factors x_1 and x_9

Further, the indicators of partial correlation between independent factors and the dependent variable are analyzed, for

which it is constructed visualizations that evidently demonstrate which variables explain the variance in the data (Fig. 4).

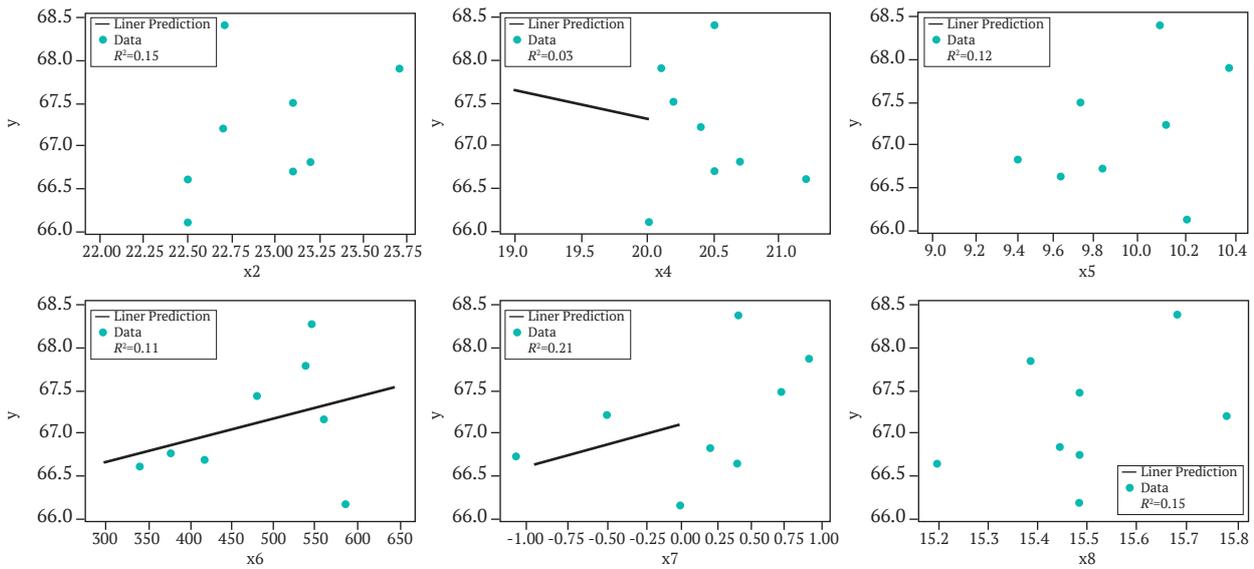


Figure 4. Dependency graphs demonstrating the influence of factors

Taking into account the conducted analysis of variance, it was constructed a multi-factor regression model with factors that significantly affect the level of innovativeness of the country's economy Y_1 . The model results are shown in Figure 5.

```
X = sm.add_constant(df1.loc[:, ['x2', 'x3', 'x5', 'x6', 'x7', 'x8']])
```

OLS Regression Results							
Dep. Variable:	y	R-squared:	0.878				
Model:	OLS	Adj. R-squared:	0.148				
Method:	Least Squares	F-statistic:	1.202				
Date:	Wed, 11 Nov 2021	Prob (F-statistic):	0.603				
Time:	00:52:36	Log-Likelihood:	-0.13541				
No. Observations:	8	AIC:	14.27				
Df Residuals:	1	BIC:	14.83				
Df Model:	6						
Covariance Type:	nonrobust						
	coef	std err	t	P> t	[0.025	0.975]	
const	-101.9820	168.908	-0.604	0.654	-2248.158	2044.194	
x2	0.1038	0.873	0.119	0.925	-10.988	11.196	
x3	-0.6020	1.762	-0.342	0.790	-22.994	21.789	
x5	3.5448	3.689	0.961	0.513	-43.327	50.417	
x6	-0.0214	0.026	-0.812	0.566	-0.356	0.313	
x7	1.5832	1.679	0.943	0.519	-19.755	22.922	
x8	9.2148	10.504	0.877	0.542	-124.249	142.679	
Omnibus:	0.028	Durbin-Watson:	2.849				
Prob(Omnibus):	0.986	Jarque-Bera (JB):	0.187				
Skew:	0.087	Prob(JB):	0.911				
Kurtosis:	2.271	Cond. No.	3.38e+05				

Figure 5. Results of building a multi-factor regression model for the impact of factors on the level of innovativeness

As shown in Figure 6, the coefficient of determination is 87%, which means that the selected factors explain 87% of the patterns and the changes in the innovativeness index, and other factors explain only 13% of the patterns. Let's test the hypothesis against model errors and verify that the measurement error is random and has a constant variance.

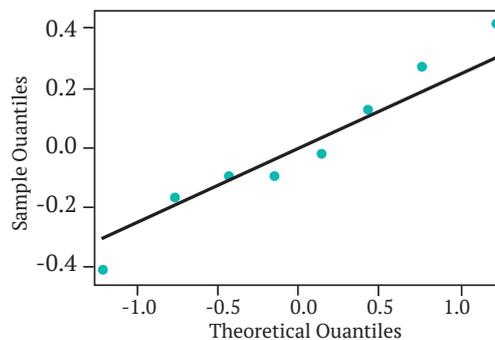


Figure 6. Error distribution graph

Based on the conducted regression analysis, it was obtained a regression equation for the impact of the factors on innovativeness: $Y_1 = 0,1038 \cdot x_2 - 0,602 \cdot x_3 + 3,54 \cdot x_5 - 0,02 \cdot x_6 + 1,5 \cdot x_7 + 9,2 \cdot x_8$.

Based on the constructed dependency and indicators of its quality, it can be predicted that the innovativeness index of the economy increases if there is an increase in the share of private investment, a decrease in the rate of GDP growth, an increase in the share of taxes in the budget structure, a decrease in the money supply, an increase in education and public security expenditure.

For the implementation of the second stage of the research (Fig. 1) to assess the impact of budgetary policies on the growth of the countries' economies, it was studied the indicator of the growth rate of GDP (GDP).

We constructed a linear multi-factor econometric model and determined all its characteristics. The statistical significance of the model parameters and the adequacy of the model were tested by the Fisher criterion. To test the linear relationships between the factors, it was constructed

a correlation matrix and studied the model for multicollinearity (Fig. 7). The findings proved that there was no multicollinearity detected in the data.

The indicators of partial correlation between independent factors and the dependent variable were also analyzed, for which it was constructed visualizations showing how the variables explain the variance in the data (Fig. 8-10).

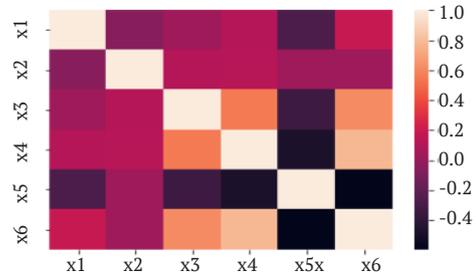


Figure 7. Building a matrix of correlations between independent factors

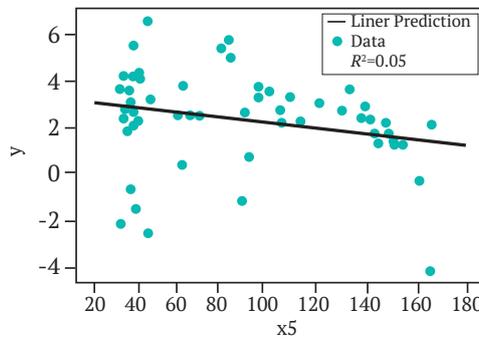


Figure 8. Visualization graph of linear distribution of variable x_5

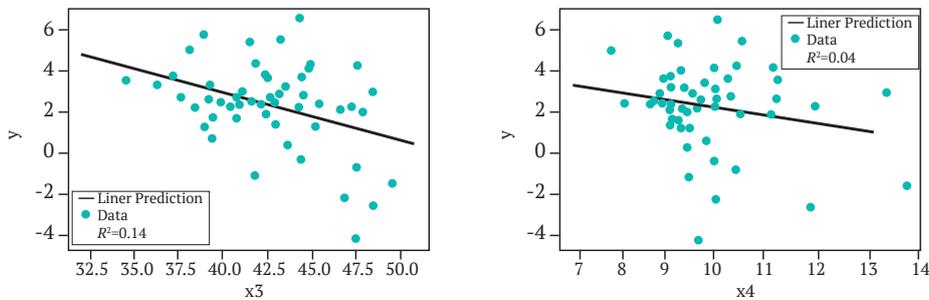


Figure 9. Visualization graph of linear distribution of variables x_3 and x_4

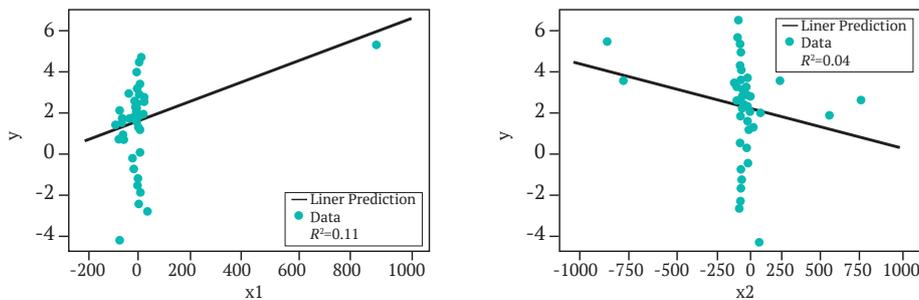


Figure 10. Visualization graph of linear distribution of variables x_1 and x_2

Then, a multi-factor regression model was constructed with the factors that affect.

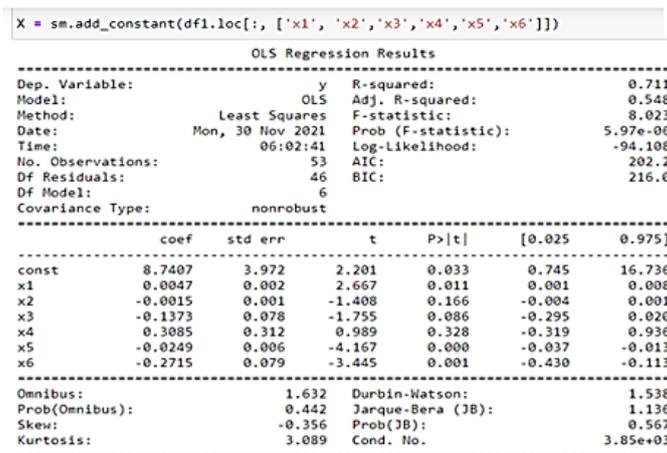


Figure 11. Results of a multi-factor regression model for the impact of factors on the level of economic growth

Figure 11 shows that the coefficient of determination is 71%, which means that these factors explain 71% of the change in the level of economic growth, and other

factors explain 29% of the patterns. Let's verify that the measurement error is random and has a constant variance (Fig. 12).

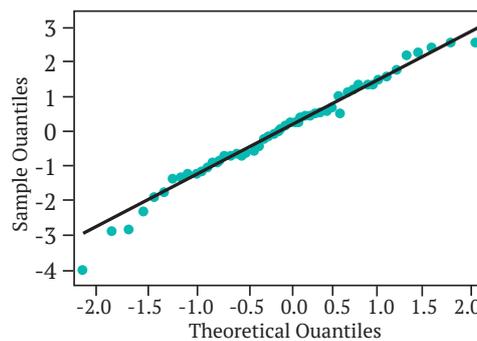


Figure 12. Error distribution graph

All points in Figure 12 are placed tightly along the straight line, which indicates a sufficiently high proximity of the real and model values of the resulting variable. Besides, the calculated coefficient of determination is sufficiently high; thus given the distribution of errors and the value of the Fisher criterion (which is equal to 8.023 and exceeds the tabulated value of 2.13), the regression equation can be used to study the effect of independent indicators on the resulting indicator.

Based on the regression analysis, it was constructed the following regression equation: $Y_2 = 8,74 + 0,0047 \cdot x_1 - 0,0015 \cdot x_2 - 0,1373 \cdot x_3 + 0,3075 \cdot x_4 - 0,0249 \cdot x_5$

The following conclusions can be drawn from the obtained equation: the higher the level of budget surplus and,

accordingly, the revenue side of the budget is, the greater the level of economic growth of the economy is. An increase in the rest of the indicators, on the contrary, leads to a decrease in the rate of economic growth.

For the implementation of the third modeling stage, it was decided to use time series models for forecasting, namely the ARIMA model. Based on the value of the UK economic growth indicator from 1968 to 2021 [17; 18], it was build a forecast for the next ten years.

As can be seen from the above model results, the series under study has a normal distribution, the p-value is more than 5%, and there are single roots; therefore, the series is not stationary. Using the ARIMA model, it was obtained the following results for the forecast of the UK economic growth until 2031 (Fig. 13):

```
array([3.27224943, 3.66074349, 3.75848227, 3.79269485, 3.87928346,
       4.00558777, 4.13714742, 4.26374313, 4.39016539, 4.5208860])
```

Figure 13. Results of forecasting economic growth of the United Kingdom by 2031

Let us substitute the obtained results of forecasting the level of economic growth into the built econometric model of the formation of the level of economy innovativeness. With fixed values of the rest of influencing factors, let us calculate

```
array([21.80939167, 21.83749416, 21.66224222, 21.73324011, 21.58037993,
       21.61689992, 21.49776693, 21.50602646, 21.4109522 , 21.4001869 ])
```

Figure 14. Results of forecasting the level of the UK economy innovativeness by 2031

The dynamics of the indicator of economic growth and the main statistical metrics of the series are presented in Figure 15-18.

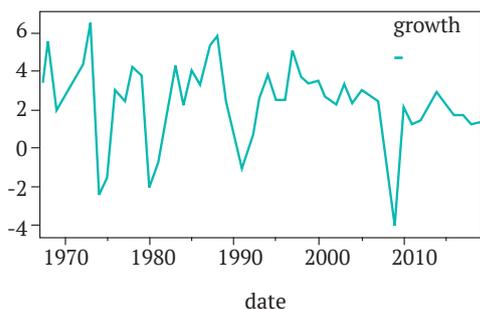


Figure 15. Dynamics distribution of the UK economic growth by year

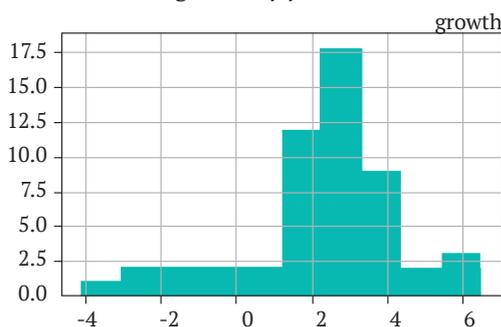


Figure 16. Building a row distribution histogram

```
V = 2.063/2.311321
print(V)
0.892563170585133
```

Figure 17. Calculation of the coefficient of variation of the row

```
test = sm.tsa.adfuller(df2) # код
print('adf: ', test[0])
print('p-value: ', test[1])
print('Critical values: ', test[4])
if test[0] > test[4]['5%']:
    print('есть единичные корни, ряд не стационарен')

adf: -5.145352251315329
p-value: 1.1355422887624574e-05
Critical values: {'1%': -3.5656240522121956, '5%': -;
```

Figure 18. Row stationarity analysis

A graphical interpretation of the obtained forecast values is shown in Figure 19.

the forecast indicators of the level of innovativeness for the next ten years (from 2022 to 2031). The obtained results of forecasting the level of the UK economy innovativeness for the next ten years are as follows (Fig. 14):

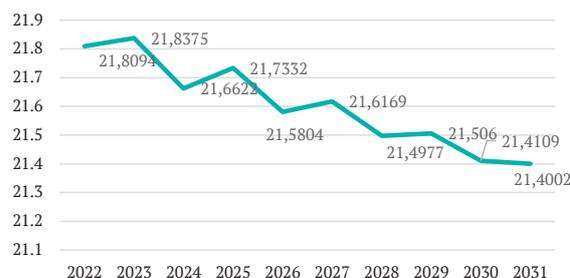


Figure 19. Results of forecasting the level of the UK economy innovativeness for 2022-2031

As can be seen, according to the forecast, the value of the innovation indicator of the UK economy will gradually decrease and may be 21.4% in 10 years.

The research findings are consistent with the results of other scholars who have studied this problematic topic in their research. Thus, for instance, N.V. Vetsepura [5] investigates a set of indicators of innovative activity as the main factor influencing the indicator of aggregate factor productivity, which assuredly forms economic development. However, the author has not proposed any specific toolkit for identifying the nature of this impact or its prediction. This is what constitutes the difference in the results obtained.

V.G. Gornyk [6] also adheres to the opinion that the provision of innovative development of the state is possible only after the formation of the development budget of Ukraine, with specific steps of the state budgetary policy taken into account. However, the author does not provide any mathematical substantiation of his conclusions.

Comparing the methodology for assessing the level of economy innovativeness and its impact on the indicator of economic development proposed in this study and by other scholars, it should be noted that similar research tools are proposed by the scholars [7] in their work. The authors conducted an analysis of the dynamic relations between foreign direct investment and economic growth, particularly stressing the importance of capital absorption variables. For their research, the authors used a model of multidimensional vector autoregression and an error correction vector model for the analysis of cause-effect relationships between variables. The obtained results proved the effectiveness of the proposed methods of analysis and substantiated the hypothesis of the impact of foreign direct investment on economic development (on the example of Albania).

The scholars [17] also assess the impact of public administration factors on economic growth, and similarly

to this study, build econometric models using panel data. However, in their study, the authors supplement the analysis by using the principal component method.

Thus, the research findings are consistent with the conclusions of other authors, thus the proposed research toolkit can be considered effective, and the results obtained – significant.

● CONCLUSIONS

The study identifies the budgetary policy factors that have a dominant impact on the level of national innovation development and investigates the degree of their impact on the level of economic growth.

To achieve the research aim, this paper proposes a conceptual model that includes an assessment of the level of innovativeness of the country's economy and identification of influencing factors; modeling of the level of national economic growth as one of the most important factors in the development of innovative activity and analysis of the impact of state budgetary policy on it; forecasting of performance indicators based on the constructed forecasting model. In particular, the paper examines the factors influencing the innovation index of the United Kingdom and analyzes this indicator. The findings revealed that the changes in the selected factors explain 87% of the patterns and the changes in the innovation index, and other factors explain only 13% of them. The

level of GDP growth was defined as one of the most influential factors, hence the impact of budgetary policy on economic growth was investigated. Forecasting for the UK economic growth indicator for 2022-2031 was done using the ARIMA model; the results obtained made it possible to calculate the forecast indicators of the innovativeness of the country's economy.

Calculations showed that when economic growth is observed, a gradual decrease in the economy's innovativeness should be expected at the same time. Taking this trend of economic development into account, governments of European countries should increase their attention to the problems of innovative activity, with due regard to the interaction of all levels of public-private partnership. The examined example of European countries confirms that state attention and creation of a system of mechanisms and incentives for innovation policy ensures powerful socio-economic development.

Promising areas for further research of the problem under consideration are the development of tools and modeling of the consequences of certain scenarios of the formation of the state budgetary policy using simulation modeling, forecasting models, and decision-making methods. Qualitative development of this set of models will allow to assess the effectiveness of specific managerial decisions in advance in terms of their impact on the level of state economic and innovative development.

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Інструментальний аналіз впливу економічних факторів на рівень інноваційності економіки країни

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Анотація. Швидкий розвиток інноваційної діяльності в Україні та нестабільність економічного та політичного середовища обумовлюють актуальність дослідження проблем інноваційного розвитку у тісному зв'язку зі світовими та локальними факторами економічного зростання. Мета – дослідження факторів бюджетної політики, які мають домінуючий вплив на рівень національного інноваційного розвитку, та їх впливу на рівень економічного зростання для формування напрямів розвитку інноваційної політики на основі методів інструментального аналізу. У роботі використано методи економетричного моделювання та адаптивні методи прогнозування. Побудована концептуальна модель включає агреговані три етапи дослідження. Розглянуто проблему оцінки рівня інноваційності економіки країни та визначення чинників впливу на нього, виявлено, що рівень підвищується від зростання частки приватних інвестицій, зниження темпів зростання ВВП, підвищення частки податків у структурі бюджету, зменшення грошової маси, зростання витрат на освіту та суспільну безпеку. Здійснено аналіз впливу державної бюджетної політики та спрогнозовано значення показника економічного зростання і рівня інноваційності економіки країни. Практичне значення результатів полягає в тому, що в періоди тривалого економічного зростання можливо поступове зниження рівня інноваційності економіки. Для уникнення таких негативних наслідків урядам європейських країн слід посилити увагу до внутрішніх проблем та зовнішніх трендів інноваційної діяльності

Ключові слова: інноваційний розвиток, інноваційна діяльність, моделювання, економічне зростання, модель часового ряду, кореляція

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