

**МІЖНАРОДНІ ЕКОНОМІЧНІ ВІДНОСИНИ. ЕКОНОМІКА ТА УПРАВЛІННЯ
НАЦІОНАЛЬНИМ ГОСПОДАРСТВОМ**

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**Efficiency Assessment of Strategic Management of Innovative Development
in the Conditions of Global Asymmetries**

The article develops and checks a scientific-methodical approach to the analysis and evaluation of the efficiency of strategic management of the innovative development of Ukraine in the conditions of global asymmetries. The scientific-methodical approach is based on the selection of statistical indicators for the comprehensive assessment of the innovative development of the country, calculation of the integral indicator based on actual values of the indicators for the period 2010-2020, and forecasting of the integral indicator of the effectiveness of the implementation of the state strategy of innovative development of Ukraine based on the forecast values of the indicators for the period 2021-2025.

The conducted research showed that from 2010 to 2020 Ukraine observed a decrease in the level of innovative development due to the mostly decreasing dynamics of the rate of change in the total number of scientific workers, the share of expenses for scientific research and development in GDP, the share of foreign investors' funds in total volumes financing of innovative activities of industrial enterprises, the share of machines and equipment in the total number of introduced innovative products. It has been determined that during the analysed period, negative transformations took place in scientific, technical and innovative sphere of Ukraine, which is evidenced by decrease of the integral indicator of the level of innovative development of the country. The results of forecasting indicators of innovative development in Ukraine indicated the existing possibility of an increase in the integral indicator from 0.56 in 2020 to 0.72-0.74 in 2024-2025.

The improvement of individual indicators will require state intervention in terms of improvement of financial and institutional instruments for the implementation of the state innovative strategy of Ukraine, using the experience of EU countries.

strategic management, innovative development, global asymmetries, evaluation, efficiency

Statement of the problem. Globalisation, as an unchanging process, continuously affects the economy and other spheres of society, causes changes in economic development models, plays a key role in accelerating scientific and technological progress and spreading innovations. Globalisation processes have once again demonstrated that innovation is the basis of economic development, actively influencing the structure of international economic relations and the interaction between economic system participants (governments, businesses, consumers, etc.). Innovations are a key factor in strategic decision-making by the authorities and an important source of ensuring competitiveness of business entities in the context of increased global competition.

The conditions of globalisation are accompanied by global asymmetries that affect scientific, technological and innovative development of countries. These asymmetries include differences in access to skilled professionals, research infrastructures and technologies, and investments in research, development and innovation, which affect the state of national innovation ecosystems. Such global asymmetries should be taken into account while developing and implementing innovation development strategies, as they can affect the competitiveness of countries and their ability to compete effectively in the global market. Therefore, such a strategy is central to the system of state strategic management of the country's innovation development. It should be considered as the main document that reflects the state of scientific and technical potential and contributes to the modernisation of the national economy [2]. As noted in [9, p. 22], 'all documents regulating the sphere of

innovation legal relations should be consistent with the innovation development strategy (hereinafter the Strategy) and aimed at its implementation. Accordingly, the state innovation policy should be developed with a five-year cadence within the framework of the Strategy, and political goals should provide for the achievement of the objectives set out in the Strategy. At the same time, it is extremely important to ensure the consistency of the state innovation policy implementation when political forces change, i.e. outside the timeframe of political cycles, and to avoid direct copying of successful policies of other countries. Ukraine should take advantage of the world's experience, especially in terms of innovation policy implementation tools, but determine the goals and content of its own development model independently, based on its institutional and socio-cultural characteristics.'

To ensure control over the validity and targeted spending of public funds for the implementation of the Strategy, it is necessary to evaluate its effectiveness. Such an assessment involves the use of various methods based on a critical reflection on the value and quality of public decisions – both processes, their implementation and effects, which should be accompanied by reliability, objectivity and systematisation.

Analysis of recent research and publications. In scientific research, assessment is a standard procedure for analysing economic phenomena, including innovation processes. In this case, the concept of 'assessment' should be correlated with the concept of 'monitoring'. Along with planning, organising, motivating and coordinating, they are the main functions of management. Assessment is broadly defined as an action or judgement about something; the act of assessing something [11]. Monitoring is generally defined as an action that involves observing, tracking or checking, usually for a special purpose [10]. Both of these processes (assessment and monitoring) are important for determining the effectiveness and achievement of the goals of the management process. They allow providing good governance and informed decision-making based on the information gathered.

It should be noted that the 'Oslo Manual', developed jointly by OECD and Eurostat, is a widely recognised methodological tool for assessing innovation activities of enterprises [13]. This document defines standards and recommendations for defining, classifying and measuring innovation, including such aspects as research and development expenditures, implementation of innovations and their impact on the economy and society.

The approaches to assessing innovation processes and the effectiveness of innovation activity at different levels (macro-, meso-, micro-) are in the focus of attention of scientists. For example, the authors of the monograph [8, p. 32] define the assessment of innovation activity as 'the formation of conclusions about the degree of effectiveness of innovation activity based on the results of the analysis of its indicators'. They identify the following characteristic features of the concept of 'assessment': the presence of an object of evaluation; consistency of quantitative and qualitative indicators; subjective nature of the assessment results; limited time of the result.

For quantitative assessment, analytical, index, graphical and other methods are used. In works [6; 15], the authors substantiate a methodological approach to the analytical assessment of the level of innovation activity of enterprises and identify the dependence of 'the volume of innovative products sold and their share that is new to the market, as well as the volume of products sold outside Ukraine, from various types of innovation costs'. The study [3, pp. 142-144] calculated an integral indicator for assessing the innovation strategies of countries, using the following indicators: computer, communication and other services (as a percentage of exports of commercial services); computer, communication and other services (as a percentage of imports of commercial services); high-tech exports (as a percentage of exports); research and development expenditures (as a percentage of GDP); number of researchers in the field of research and development (per million people); exports of information and communication

technologies (ICT) goods (as a percentage of total exports of goods); imports of ICT goods (as a percentage of total imports of goods); patent applications (units). This set of indicators allowed the author to focus on the country's ability to develop, implement and sell ICT products on the world market, which are one of the components of innovation activity. At the same time, they do not reflect the state of development of the innovation sphere of countries in general, nor the effectiveness of national innovation strategies.

In Ukraine, the following indicators are used to determine the degree of achievement of the expected results and to evaluate the implementation of the current Strategy for the Development of Innovative Activities of Ukraine for the period until 2030: the share of expenses for the implementation of scientific and technical works in the gross domestic product – 3%; the share of innovative enterprises in the total number of enterprises is at least 30%; the share of export of goods produced by enterprises of high- and medium-tech sectors of industry in the total volume of export of goods – 30%; the share of employees employed at the enterprises belonging to the high- and medium-tech sectors of industry in the total number of employees in industry is 29%; the share of sold innovative products in the total volume of sold industrial products is 10% [4]. However, the list of these indicators does not fully reflect the effects obtained at each stage of the innovation process, starting from scientific and technical development and ending with its introduction and implementation on the market.

For a comprehensive assessment of the country's innovation development, it is necessary to measure additional indicators that, on the one hand, reflect the processes and results at each stage of the innovation process and allow assessing the efficiency of state strategic management, and, on the other hand, take into account factors of global asymmetry. Such an approach will provide a more comprehensive view of the effectiveness of the innovation strategy being implemented and will enable informed management decisions to be made on the prospects for further development of the country's innovation sector, taking into account global asymmetries.

Statement of the objective. The objective of the article is to develop and test a scientific and methodological approach to analysing and assessing the effectiveness of strategic management of Ukraine's innovation development in the context of global asymmetries.

The main research material. Based on the approaches described above to assessing the efficiency of the implementation of innovation strategies in general and the innovation activities of enterprises in particular, and taking into account the possibility of obtaining statistics from official sources (the latest official statistics are available for 2020), we propose a system of indicators for our own assessment and calculation of an integral indicator characterising the level of innovation development and the effectiveness of the innovation strategy implemented in Ukraine (Table 1).

The integral indicator is calculated as the arithmetic mean of the standardized values of the features Z_{ij} - for j aggregate unit [4, c. 145]:

$$\bar{\rho}_j = \frac{1}{m} \sum_{i=1}^m Z_{ij} \quad (1.1)$$

where m is the number of indicators characterizing innovative development.

Standardized values of the actual values of the indicators are calculated using the formula:

$$Z_{ij} = \frac{X_{ij} - X_j^{\min}}{X_j^{\max} - X_j^{\min}} \quad (1.2)$$

where: X_{ij} is the actual value of the indicator, calculated on the basis of the data of official statistics per year t ; X_j^{\min} is the lowest actual value of the indicator for the studied period; X_j^{\max} is the highest actual value of the indicator for the studied period.

Table 1 - System of indicators for assessing the level of innovation development and the efficiency of the implementation of the innovation development strategy of Ukraine

1. Basic conditions of innovative development of the country	3. Basic conditions of innovative development of the country
1.1. The share of Doctors of Science in the total number of scientific workers, % 1.2. The share of researchers in the total number of scientific workers, % 1.3. Growth rates of the total number of scientific workers, % compared to the previous year	3.1. The share of industrial enterprises that introduced innovations in the total number of industrial enterprises, % 3.2. Innovative products new to the market, % of the total number of introduced innovative products 3.3. Machines and equipment, % of the total number of introduced innovative products
2. Investment in innovation	4. Impact of innovations on the economy
2.1. The share of expenses for scientific research and development in GDP, % 2.2. The share of fundamental research in the total amount of research and development expenditures, % 2.3. The share of own funds of enterprises in the total volume of financing of innovative activities of industrial enterprises, % 2.4. The share of funds of foreign investors in the total financing of innovative activities of industrial enterprises, %	4.1. The share of innovative products in the total volume of products sold by industrial enterprises, % 4.2. The share of high-tech products in the export of goods, % 4.3. The share of knowledge-intensive services in the export of services, %

Source: compiled by the author

The value of the integral indicator varies in the range from 0 to 1, the higher its value, the higher the level of innovative development of the country and the effectiveness of the implemented innovation strategy. Based on the selected indicators, we will calculate the forecast values of each of them separately and the integral indicator in general.

The study will be conducted in the following order: calculation and analysis of the dynamics of actual values of indicators; building a trend of changes in each indicator for the period under study (2010-2020) and extrapolating the trend for the next three periods (2021-2023); calculation of forecast values of indicators; determination of the integral indicator of innovation development of Ukraine based on actual values of indicators for the period 2010-2020; forecasting the integral indicator of efficiency of implementation of the state strategy of innovation development of Ukraine based on forecast values of indicators during 2021-2025.

The first group of indicators characterises the existing scientific potential and forms the basic conditions for Ukraine's innovative development (see Table 1). As can be seen from Table 2, the total number of researchers in 2020 was 78.8 thousand people, which was only 43.2% of their number in 2010 (or 182.4 thousand people).

The total number of research staff decreased by an average of 7% annually during the study period. The worst situation was observed in 2016, when the number of employees decreased by 20.1% compared to 2015. During the period under study, there was a deterioration in the qualitative structure of researchers, as evidenced by a decrease in the share

of researchers in the total number of researchers from 73.3% in 2010 to 65.2% in 2020. It should be noted that a slight increase in this indicator in 2020 compared to 2019 is due to an increase in the number of researchers from 51121 in 2019 to 51427 in 2020, while the total number of researchers decreased from 79262 to 78860 over the same period. At the same time, during 2010-2020, another indicator of the qualitative structure of researchers – the share of Doctors of Sciences in the total number of researchers – increased from 6.6% to 9.0%. Such dynamics of this indicator is due to a significant increase in the number of doctors of sciences in educational institutions and mainly in the Humanities.

Table 2 - Indicators of the basic conditions for Ukraine's innovation development in 2010-2020

Years	Share of Doctors of Science in the total number of scientific workers, %	Share of researchers in the total number of scientific workers, %	Growth rates of the total number of scientific workers, 2010 p. =100%
2010	6,6	73,3	100
2011	6,7	74,4	96,1
2012	6,8	74,3	90,1
2013	7,2	74,5	85,2
2014	7,3	74,5	74,6
2015	7,8	73,7	67,1
2016	7,2	65,1	53,7
2017	7,4	63,0	51,7
2018	8,0	65,4	48,3
2019	8,2	64,5	43,4
2020	9,0	65,2	43,2

Source: calculated by the author according to data [7]

The share of R&D expenditures in GDP is considered to be the main indicator of the adequacy of financial resources for innovation. The dynamics of this indicator in 2010-2020 was downward (Table 3), which indicates the ineffectiveness of the mechanisms used in Ukraine to finance R&D, despite the declared importance of the financial component in the Strategy.

Table 3 - Indicators of the adequacy of investment in innovation in Ukraine in 2010-2020

Years	The share of expenditures on scientific research and development in GDP, %	The share of fundamental research in the total amount of research and development costs, %	The share of own funds of enterprises in the total volume of financing of innovative activities of industrial enterprises, %	The share of funds of foreign investors in the total financing of innovative activities of industrial enterprises, %
2010	0,75	26,8	59,4	30,0
2011	0,65	25,9	52,9	0,4
2012	0,67	27,8	63,9	8,7
2013	0,70	26,3	72,9	13,1
2014	0,60	25,9	85,0	1,8
2015	0,55	22,4	97,2	0,4
2016	0,48	19,3	94,9	0,1
2017	0,45	21,9	84,5	1,2
2018	0,47	22,4	88,2	0,9
2019	0,43	21,7	87,7	0,3
2020	0,41	25,0	85,4	0,9

Source: calculated by the author according to data [1; 17]

The share of fundamental research in total R&D expenditures does not exceed 27%, which, on the one hand, indicates a relatively balanced distribution of financial resources between all stages of the R&D process and the allocation of the rest to finance applied research (20-23%) and experimental work (55-59%). On the other hand, this ratio of funding signals insufficient support for inventive activity and the creation of basic innovations. The structure of sources of financing innovation activity is traditionally dominated by enterprises' own funds. Their share in total funding increased by 26% over the period under review. At the same time, we would like to draw attention to a significant (30-fold) decrease in the share of foreign investors in the total amount of financing of innovative activities of enterprises, which indicates a lack of incentives for investment in innovative enterprises under high risks of doing business in Ukraine.

The dynamics of indicators of innovation activity of enterprises shows that despite growth of the share of enterprises that implemented innovations in the total number of industrial enterprises, the quality indicators of innovation activity decreased (Table 4). For example, the share of innovative products new to the market decreased from 25.2% to 17% of the total number of innovative products introduced, which indicates a decrease in the level of product novelty, resulting in a deterioration in the competitive position of enterprises. In its turn, their products are gradually losing their novelty and becoming traditional. The introduction of embodied innovations, in the form of machinery and equipment, also slowed down, which is to some extent a consequence of the lack of funds for the purchase of new technologies, the reduction in the number of industrial enterprises and the decline in industrial output.

Table 4 - Indicators of innovation activity in Ukraine in 2010-2020

Years	Share of industrial enterprises that implemented innovations in the total number of industrial enterprises, %	Innovative products new to the market, % of the total number of innovative products introduced	Machinery and equipment, % of the total number of innovative products introduced
2010	11,5	25,2	27,5
2011	12,8	27,8	27,7
2012	13,6	19,7	27,7
2013	13,6	20,4	25,8
2014	12,1	14,8	35,9
2015	15,2	17,5	30,8
2016	16,6	23,6	31,5
2017	14,3	20,0	31,5
2018	15,6	25,2	23,9
2019	13,8	19,5	35,4
2020	14,9	17,0	15,9

Source: calculated by the author according to data [14]

The dynamics of indicators of the impact of innovation on the economy shows how the results of scientific, technical and innovation activities in the country have changed due to the implementation of the state innovation strategy. The effectiveness of strategic decisions to intensify the innovation activities of industrial enterprises can be evidenced by the growing dynamics of the volume of innovative products sold and exported. In Ukraine, the share of innovative products in the total volume of industrial products sold in the long term has halved from 3.8% in 2010 to 1.9% in 2020 (Table 5). However, in the short term (2017-2020), there was an increase in this indicator.

Table 5 - Indicators of the impact of innovations on the Ukrainian economy in 2010-2020

Роки	The share of innovative products in the total volume of industrial products sold, %	The share of high-tech products in exports of goods, %	Share of knowledge-intensive services in service exports, %
2010	3,8	6,0	7,3
2011	3,8	5,9	7,9
2012	3,3	6,8	10,3
2013	3,3	6,3	13,8
2014	2,5	6,4	16,4
2015	1,4	6,5	15,7
2016	1,1	6,8	16,9
2017	0,7	6,7	17,3
2018	0,8	7,1	19,5
2019	1,3	6,5	18,0
2020	1,9	6,2	27,5

Source: calculated by the author according to data [14; 16; 12]

The share of high-tech products in merchandise exports fluctuated between 6.0 and 7.0% in 2010-2020. Although this figure increased slightly in the long term (by 0.2%), in the short term the decline was more significant (by 0.9%) and occurred at a faster pace. Such dynamics indicate a gradual loss of innovation potential by the national industry.

Nevertheless, a positive trend in the share of knowledge-intensive services in exports should be noted. For example, in 2020, computer services accounted for the largest share in exports of services – 20.3%, which was 10 times higher compared to 2010. There was also an increase in the share of professional and consulting services in exports – from 3.1% in 2010 to 5.3% in 2020. In contrast, the share of research and development services is smaller compared to the above-mentioned types of services, and decreased from 2.8% to 2.3% over the same period. This confirms the ineffectiveness of the Strategy's implementation in terms of supporting basic and applied research.

To calculate the integral indicator characterising the level of innovation development of Ukraine, it is necessary to determine the normalised values of the indicators of scientific, technical and innovation activities given in Tables 2-5 by Formula 1.2. The results of calculating the normalised values of the indicators and the integral indicator of innovation development (according to formula 1.1) are presented in Table 6. According to the results obtained, the integral indicator decreased from 0.835 in 2010 to 0.568 in 2020, which indicates a significant decrease in the level of innovation development of Ukraine and the declarative nature of the Strategy's goals.

To forecast the innovative development of Ukraine, we will use a dynamic series of indicators of scientific, technical and innovation activities in Ukraine for the period 2010-2020 (Tables 2-5). It should be noted that it is incorrect to use data for the period before 2010. The State Statistics Service has changed the methodology for conducting statistical observations for certain indicators, and data starting from 2021 has not yet been published. Taking into consideration the relatively short time period that characterises the time series, forecasting these indicators is possible for a period of 3-5 years. Global asymmetries and uncertainty factor caused by the full-scale Russian aggression, we will make forecasts for a period of 5 years, which will compensate for the lack of statistical data for 2021-2022 and calculate the forecast for the following periods.

The forecast scenarios of Ukraine's innovative development will be developed using a number of assumptions: the cessation of hostilities in 2024, the availability of real opportunities to implement financial and institutional instruments to support scientific and technical sphere and innovative activities of enterprises; changes in the indicators of scientific and innovative activities will occur under the most likely scenarios.

Based on the dynamic series for the indicators characterising basic conditions of Ukraine's innovation development, we will build trend functions of their change and, extending the trend line forward for 5 years, determine the most likely forecast scenarios for the change in these indicators. As shown in Fig. 1, there is a high probability (84.3%) of the forecast scenario of changes in the share of doctors of sciences in the total number of researchers, according to which this indicator is expected to grow further gradually according to an exponential function. With a somewhat lower probability (51.2%), we can expect a slight decrease in the share of researchers in the total number of researchers according to the power function. The highest probability, at 97.6%, is the forecast of the dynamics of the growth rate of the total number of researchers, according to which this indicator will further decline over the next forecast periods.

Based on the obtained functional equations of changes in the indicators of basic conditions for the innovative development of Ukraine in 2010-2020, we calculate their forecast values for the period 2021-2025. According to the forecast results, we can expect a slight increase in the share of doctors of sciences in the total number of researchers from 9.17% in 2023 to 9.67% in 2025 (Table 7).

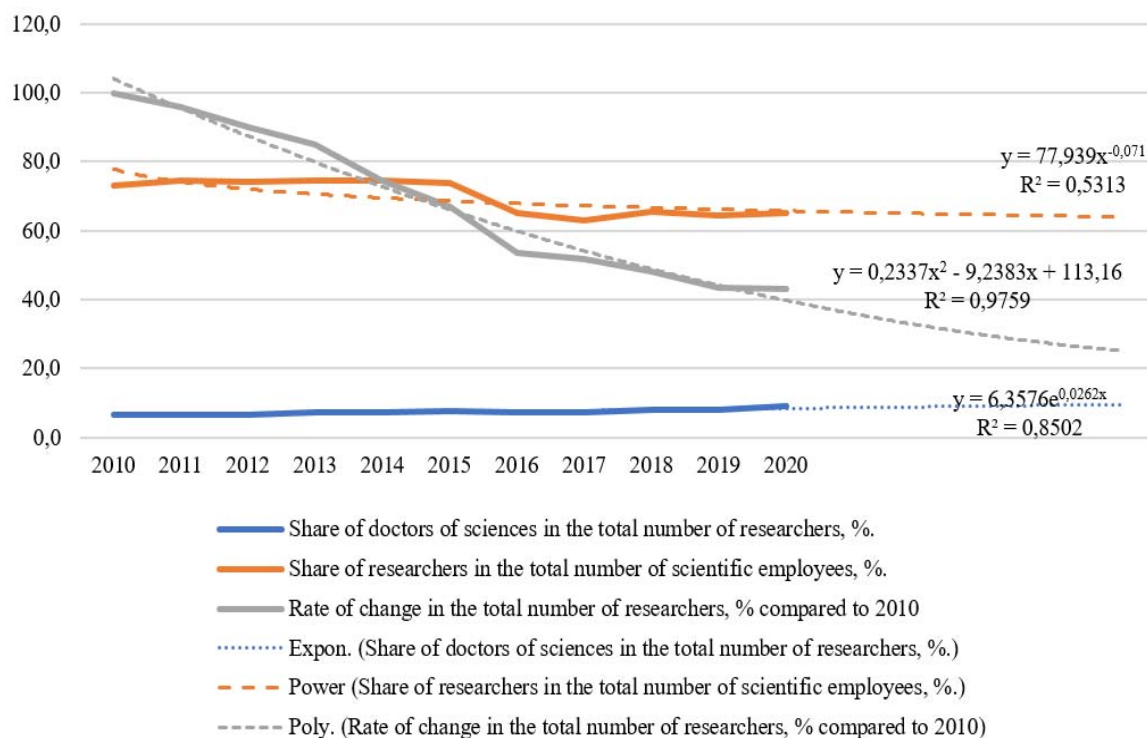


Figure 1 - Dynamics and forecast of changes in indicators of basic conditions for innovation development of Ukraine in 2010-2025

Source: worked out by the author

Table 6 - Standardised values of indicators and the integral indicator characterising the level of innovation development in Ukraine in 2010-2020

	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	Years
0,547	0,573	0,627	0,600	0,640	0,733	0,800	0,933	0,893	0,867	1,000	Share of R&D expenditure in GDP	
0,365	0,753	1,000	0,479	0,148	0,077	0,860	0,050	0,376	0,200	0,208	Share of state budget funds in total expenditures on innovation	
0,030	0,010	0,029	0,040	0,003	0,014	0,060	0,438	0,290	0,013	1,000	The share of foreign investors' funds in the total amount of financing of innovation activities of industrial enterprises	
0,898	0,831	0,940	0,861	1,000	0,916	0,729	0,819	0,819	0,771	0,693	Share of industrial enterprises that implemented innovations in the total number of industrial enterprises	
0,611	0,700	0,906	0,719	0,850	0,629	0,531	0,734	0,710	1,000	0,905	Share of products new to the market in the total number of innovative products introduced	
0,443	0,986	0,667	0,876	0,878	0,858	1,000	0,718	0,771	0,772	0,767	Share of machinery and equipment in the total number of innovative products introduced	
0,500	0,342	0,211	0,184	0,289	0,368	0,658	0,868	0,868	1,000	1,000	The share of innovative products in the total volume of industrial products sold	
0,873	0,915	1,000	0,944	0,958	0,915	0,901	0,887	0,958	0,831	0,845	The share of high-tech products in exports of goods	
0,875	0,866	0,878	0,846	0,874	0,989	1,000	1,000	0,997	0,999	0,984	Share of researchers in the total number of researchers	
0,537	0,561	0,610	0,634	0,683	0,732	0,805	0,878	0,829	1,000	0,951	Number of patents granted for inventions	
0,568	0,654	0,687	0,618	0,632	0,623	0,734	0,733	0,751	0,745	0,835	Integral indicator	

Source: calculated by the author

Table 7 - Forecast values of indicators of the basic conditions for Ukraine's innovation development in 2021-2025

Indicator	Equation	Forecast values by years				
		2021	2022	2023	2024	2025
Share of doctors of science in the total number of researchers, %	$y = 6,3576e^{0,0262x}$	8,71	8,94	9,17	9,42	9,67
Share of researchers in the total number of scientific employees, %.	$y = 77,939x^{-0,071}$	65,33	64,96	64,62	64,31	64,01
Growth rate of the total number of researchers, 2010 = 100%	$y = 0,2337x^2 - 9,2383x + 113,16$	35,95	32,56	29,63	27,17	25,17

Source: calculated by the author

According to our forecast, the share of researchers in the total number of researchers will decrease to 64% in 2025. The growth rate of the total number of researchers will continue to decline, i.e. the number of researchers in 2025 will be only 25.17% of the number recorded in 2010. The pessimistic forecast results of most of the key indicators of Ukraine's innovation development, an important area for improving the tools for implementing the Strategy is to improve the financial support for scientific, technical and innovation activities in Ukraine, which will help strengthen the country's scientific potential and stimulate innovation initiatives in various sectors of the economy.

Considering different values of the indicators of investment in innovation, let us consider separately the indicators of R&D financing in GDP and the share of foreign investors' funds in the total financing of innovation by industrial enterprises. As can be seen from Fig. 2, in 2021-2025, we can expect a high probability (91.4%) of maintaining a low level of R&D expenditures in GDP according to a linear function. With a somewhat lower probability (76%), according to the power function, the low level of financing of industrial enterprises' innovation activities by foreign investors is expected to remain in place over the next 5 years.

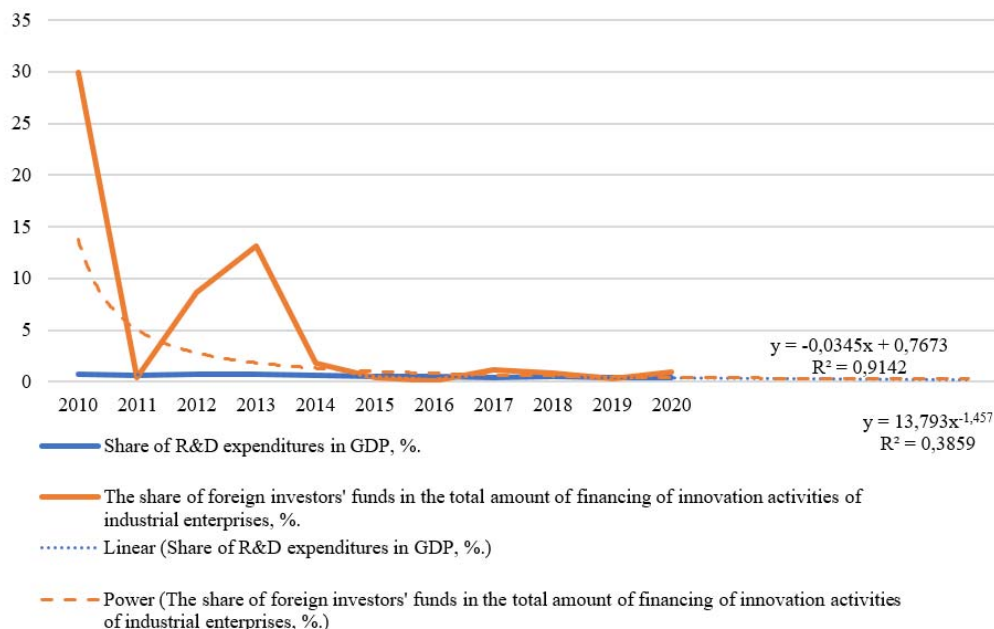


Figure 2 - Dynamics and forecast of changes in R&D and innovation funding indicators in Ukraine in 2010-2025

Source: developed by the author

More optimistic are the results of forecasting the share of basic research in total R&D expenditures (Fig. 3). According to the second-order polynomial function, we can expect an increase in expenditures on basic research funding in 2023-2025 with a probability of 55%. According to the developed forecast based on the logarithmic function, there is a high probability (70.5%) of an increase in the share of enterprises' own funds in financing innovation activities. However, such a scenario is not optimistic, as the state should create favourable conditions for diversifying sources of financing innovation activities, given the high risk of innovation-active enterprises and the need to attract long-term investments.

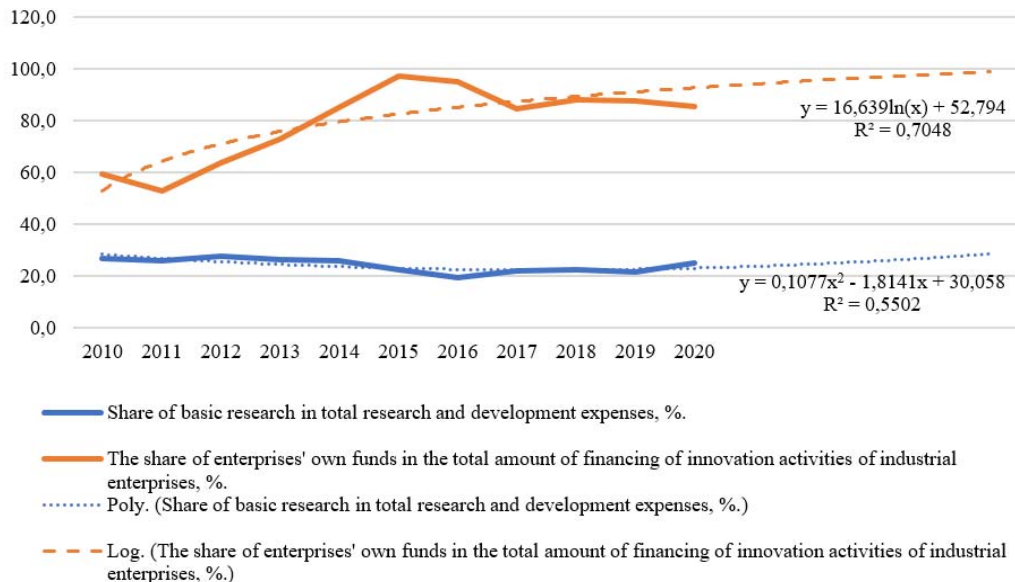


Figure 3 - Dynamics and forecast of changes in indicators of the structure of financing of the research and innovation sphere in Ukraine in 2010-2025

Source: developed by the author

Based on the scenarios of changes in the indicators characterising investment support for research and innovation activities developed by the graphical method (Figs. 2, 3) and the obtained functional dependencies of changes in these indicators, we calculate their forecast values for the period 2021-2025. If the existing mechanisms for financing the research sector are maintained and applied in the future, the share of R&D expenditures in GDP will decrease. According to our calculations, it is highly likely that this indicator will decline to 0.22% in 2025 (Table 8).

Table 8 - Forecast values of investment in innovation indicators in Ukraine in 2021-2025

Indicator	Equation	Forecast values by years				
		2021	2022	2023	2024	2025
Share of R&D expenditure in GDP, %	$y = -0,0345x + 0,7673$	0,35	0,32	0,28	0,25	0,22
Share of basic research in total research and development expenditure, %	$y = 0,1077x^2 - 1,8141x + 30,058$	23,8	24,7	25,8	27,1	28,6
The share of enterprises' own funds in the total amount of financing of innovation activities of industrial enterprises, %	$y = 16,639\ln(x) + 52,794$	94,1	95,5	96,7	97,8	98,9
The share of foreign investors' funds in the total amount of financing of innovation activities of industrial enterprises, %	$y = 13,793x^{-1,457}$	0,36	0,33	0,29	0,27	0,24

Source: calculated by the author

Therefore, an urgent task is to study the possibilities of implementing the European experience of supporting scientific and innovation activities in terms of improving financial instruments for implementing Ukraine's innovation strategy. A similar trend is expected with regard to the dynamics of the share of foreign investors funds in the total financing of industrial enterprises innovation activities with a high probability, its value will decrease to 0.24% in 2025. Thus, in the event of a continued lack of effective incentives for investors to invest in innovative projects or in the development of high-tech industries, foreign investors' interest in investing in innovative enterprises will decline.

As can be seen from Table 7, due to the constant underfunding of the innovation sector by the state and the ineffectiveness of existing financial instruments to support the innovation activities of enterprises, the most likely forecast scenario is a further increase in the share of enterprises own funds in the total financing of innovation activities of industrial enterprises (up to 98.9% in 2025). Positive expectations are associated with an increase in the share of basic research in total research and development expenditures up to 28.6% in 2025.

As a result of forecasting changes in the indicators of innovation activity of enterprises, a relatively high probability (51%) of the forecast trend was obtained for the share of industrial enterprises that implemented innovations in the total number of industrial enterprises (Fig. 4). According to the logarithmic function, this indicator can be expected to grow in 2025. The probability of growth in the share of new products in the total number of innovative products introduced is somewhat lower and amounts to 22.5%. The lowest probability is characterised by the forecast trend in the share of machinery and equipment in the total number of innovative products introduced, only 2.5%, due to sharp fluctuations in this indicator in 2014, 2018 and 2020.

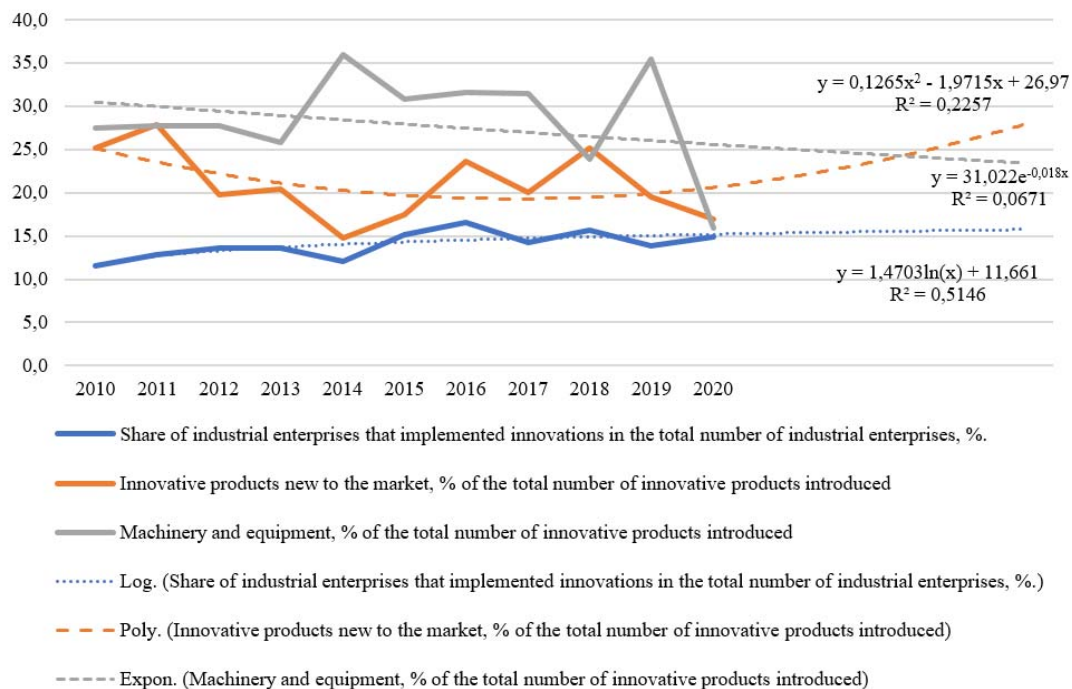


Figure 4 - Dynamics and forecast of changes in indicators of innovation activity of enterprises in Ukraine in 2010-2025

Source: compiled by the author

Based on the graphical models of the dynamics of indicators of innovation activity of enterprises, we calculate the forecast values of these indicators. According to our calculations, the share of industrial enterprises that implemented innovations in the total number of

industrial enterprises will grow very slowly and in 2025 will amount to 15.7% (Table 9). The change in the share of products new to the market in the total number of innovative products introduced, despite the decrease in forecast values in 2021-2025, is characterised by an upward trend, as the forecast value in 2025 is higher than the actual values in 2019-2020. According to the forecast scenario, the share of machinery and equipment in the total number of innovative products introduced will increase to 27.8% in 2025. Despite the low probability of this forecast, its implementation may be quite realistic, as the forecast value in 2025 is 7.6% lower than the actual value of this indicator in 2019. The implementation of this positive scenario will be facilitated by improving financial and institutional mechanisms to support innovation, taking into account the experience of EU countries.

Table 9 - Forecast values of indicators of innovation activity of enterprises in Ukraine in 2021-2025

Indicator	Equation	Forecast values by years				
		2021	2022	2023	2024	2025
Share of industrial enterprises that implemented innovations in the total number of industrial enterprises, %	$y = 1,4703\ln(x) + 11,661$	15,3	15,4	15,5	15,6	15,7
Innovative products new to the market, % of the total number of innovative products introduced	$y = 31,022e^{-0,018x}$	24,9	24,5	24,1	23,6	23,2
Machinery and equipment, % of the total number of innovative products introduced	$y = 0,1265x^2 - 1,9715x + 26,97$	21,5	22,7	24,1	25,8	27,8

Source: calculated by the author

The construction of forecast trends for the indicators of the impact of innovation on the economy of Ukraine allowed obtaining forecast scenarios for all three indicators with an acceptable level of probability. The highest probability is the forecast of the share of knowledge-intensive services in total exports of services according to the exponential function (85.4%), which is due to the steady upward trend of this indicator during 2010-2020 (Fig. 5). The probability of the forecast dynamics of the share of innovative products in total sales is also high, according to the second-order polynomial function (84.2%). The probability of a downward trend in the share of high-tech products in exports of goods according to the second-order polynomial function is much lower (50.3%).

Using functional dependencies of changes in the indicators of the impact of innovation on the economy of Ukraine, we calculate the forecast values of the indicators for the period 2021-2025. According to our calculations, the forecast value of the share of innovative products in the total volume of industrial sales in 2025 will reach 3.48% (Table 10), which can be considered a positive scenario, although this value is lower compared to 2010-2011. Such a scenario is quite realistic if the military-industrial complex intensifies its activities both during the war and after its end, as these enterprises are currently actively working on new types of equipment and weapons. According to our forecast, the share of high-tech products in exports will decline to 5.05% in 2025, which may be the lowest value of this indicator for the period 2010-2025.

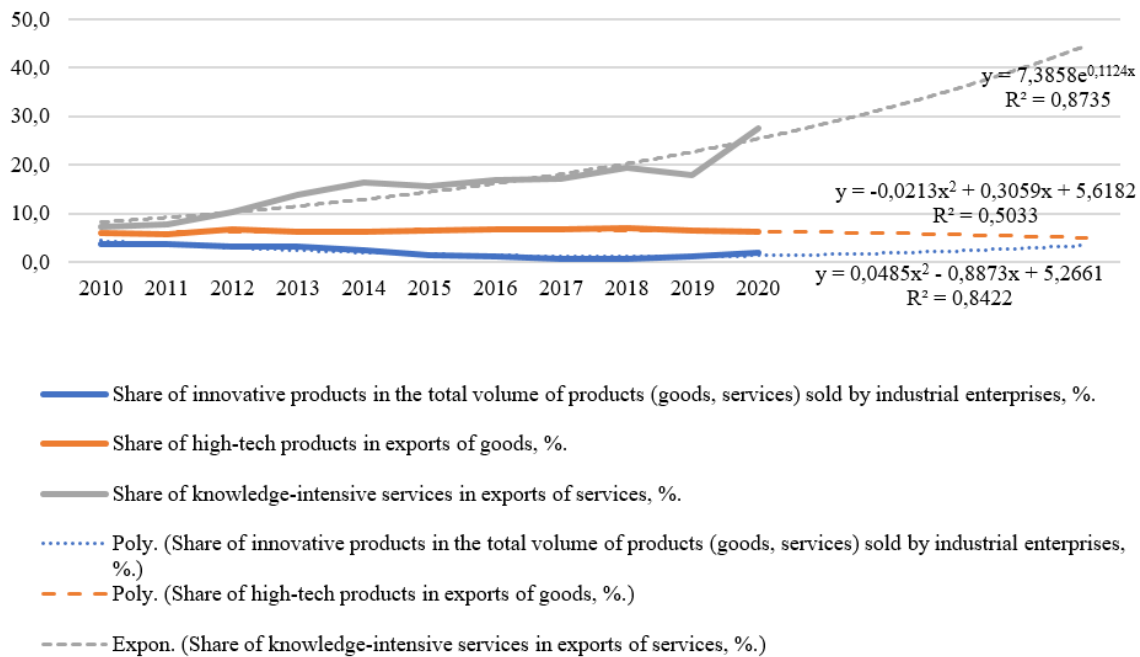


Figure 5 - Dynamics and forecast of changes in indicators of innovation impact on the Ukrainian economy in 2010-2025

Source: developed by the author

Table 10 - Forecasted values of indicators of the impact of innovation on the Ukrainian economy in 2021-2025

Indicator	Equation	Forecast values by years				
		2021	2022	2023	2024	2025
Share of innovative products in the total volume of products (goods, services) sold by industrial enterprises, %	$y = 0,0485x^2 - 0,8873x + 5,2661$	1,60	1,92	2,34	2,86	3,48
The share of high-tech products in exports of goods, %	$y = -0,0213x^2 + 0,3059x + 5,6182$	6,22	5,99	5,72	5,41	5,05
Share of knowledge-intensive services in service exports, %	$y = 7,3858e^{0,1124x}$	28,4	31,8	35,6	39,8	44,6

Source: calculated by the author

At the same time, the share of knowledge-intensive services in total exports of services will grow, with a high probability we can expect an increase in this indicator to 44.6% in 2025. The implementation of this scenario is due to the high level of development of digital technologies in Ukraine, a stable level of demand for computer services and strengthening of the competitive position of Ukrainian IT companies in the global market. The share of the IT sector in GDP is currently 4%, and in 2021, the volume of service exports was USD 6.9 billion. In January-November 2022, the IT sector generated export revenues of USD 6.6 billion. This is 13% more than in the corresponding period of 2021 [5].

Using the forecast data of the main indicators of Ukraine's innovative development in 2021-2025, we calculate their normalised values and the forecast values of the integrated indicator of Ukraine's innovative development (Table 11).

Table 11 - Results of forecasting the integral indicator characterising the level of innovation development of Ukraine in 2021-2025

YEARS	Normalised values of forecast indicators													
	Share of doctors of science in the total number of researchers	Share of researchers in the total number of scientific employees	Rate of change in the total number of researchers	Share of R&D expenditure in GDP	Share of basic research in total research and development expenditure	The share of enterprises' own funds in the total amount of financing of innovation activities of industrial enterprises	The share of foreign investors' funds in the total amount of financing of innovation activities of industrial enterprises	Share of industrial enterprises that implemented innovations in the total number of industrial enterprises	Share of innovative products new to the market in the total number of innovative products introduced	Machinery and equipment, % of the total number of innovative products introduced	The share of innovative products in the total volume of products of industrial enterprises	The share of high-tech products in exports of goods	Share of knowledge-intensive services in service exports	INTEGRAL INDICATOR (FORECAST)
2021	0,90	0,88	0,36	0,47	0,83	0,95	0,01	0,92	0,90	0,60	0,42	0,88	0,64	0,67
2022	0,92	0,87	0,33	0,43	0,86	0,97	0,01	0,93	0,88	0,63	0,51	0,84	0,71	0,68
2023	0,95	0,87	0,30	0,37	0,90	0,98	0,01	0,93	0,87	0,67	0,62	0,81	0,80	0,70
2024	0,97	0,86	0,27	0,33	0,95	0,99	0,01	0,94	0,85	0,72	0,75	0,76	0,89	0,72
2025	1,00	0,86	0,25	0,29	1,00	1,00	0,01	0,95	0,83	0,77	0,92	0,71	1,00	0,74

Source: calculated by the author

According to our calculations, the integral indicator characterizing the level of innovative development of Ukraine will increase to 0.72 in 2024, and to 0.74 in 2025. Positive dynamics of the forecast integral indicator is due to the growing forecast dynamics of such indicators as: the share of doctors of science in the total number of scientific workers; the share of basic research in the total amount of research and development costs; the share of own funds of enterprises in the total volume of financing of innovative activities of industrial enterprises; the share of industrial enterprises that introduced innovations in the total number of industrial enterprises; the share of innovative products in the total volume of sold products (goods, services) of industrial enterprises; the share of knowledge-intensive services in the export of services. Taking into consideration a relatively low level of probability of forecasting certain indicators (such as the share of basic research in the total amount of research and development expenditures and the share of industrial enterprises that introduced innovations in the total number of industrial enterprises) to ensure the implementation of positive forecast scenarios based on these indicators, it is necessary to provide corresponding changes in the state innovation strategy of Ukraine, in particular in terms of financial and institutional instruments.

Conclusions and prospects for further research. The analysis and evaluation of the efficiency of strategic management of the innovative development of Ukraine, taking into account global asymmetries, was carried out on the basis of the author's scientific and methodological approach, which involves a selection of statistical indicators for comprehensive evaluation of the innovative development of the country, the calculation of the integral indicator based on actual values of these indicators for the period 2010-2020 and forecasting the integral indicator of the efficiency of the implementation of the state strategy of innovative development of Ukraine based on the forecast values of the indicators for the period 2021-2025. It was determined that during the period from 2010 to 2020, negative transformations took place in scientific, technical and innovative sphere of Ukraine, which is evidenced by decrease of the integral indicator of the level of innovative development of the country from 0.835 in 2010 to 0.568 in 2020. The deterioration of the integral indicator occurred mostly due to the downward dynamics of such indicators as: rates of change in the total number of scientific workers; the share of expenses for carrying out scientific research and development in GDP; the share of funds of foreign investors in the total financing of innovative activities of industrial enterprises; the share of machines and equipment in the total number of introduced innovative products. According to the results of forecasting indicators of innovative development of Ukraine during 2024-2025, it is possible to increase the integral indicator to 0.72-0.74, which indicates a high probability of increasing the level of innovative development of Ukraine. However, the implementation of positive scenarios of changes in individual indicators will require state assistance in terms of improving financial and institutional tools for the implementation of the state innovation strategy of Ukraine using EU experience and taking into account global asymmetries, which is the direction of further research.

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Оцінювання ефективності стратегічного управління інноваційним розвитком в умовах глобальних асиметрій

У статті розроблено та апробовано науково-методичний підхід до аналізу та оцінювання ефективності стратегічного управління інноваційним розвитком України в умовах глобальних асиметрій. Науково-методичний підхід базується на відборі статистичних індикаторів комплексного оцінювання інноваційного розвитку країни, розрахунку інтегрального показника на основі фактичних значень індикаторів за період 2010-2020 рр. та прогнозуванні інтегрального показника ефективності реалізації державної стратегії інноваційного розвитку України на основі прогнозних значень індикаторів за період 2021-2025 рр.

Проведене дослідження показало, що упродовж 2010-2020 рр. в Україні спостерігалось зниження рівня інноваційного розвитку через здебільшого спадну динаміку темпів зміни загальної кількості наукових працівників, частки витрат на виконання наукових досліджень і розробок у ВВП, частки коштів іноземних інвесторів у загальних обсягах фінансування інноваційної діяльності промислових підприємств, частки машин та обладнання у загальній кількості впровадженої інноваційної продукції. Результати прогнозування індикаторів інноваційного розвитку України свідчать про існуючу можливість зростання інтегрального показника з 0,56 у 2020 р. до 0,72-0,74 у 2024-2025 рр.

Поліпшення окремих показників потребуватиме державного втручання в частині удосконалення фінансових та інституційних інструментів реалізації державної інноваційної стратегії України з використанням досвіду країн ЄС.

стратегічне управління, інноваційний розвиток, глобальні асиметрії, оцінювання, ефективність

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