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SIMULATION OF THE INFLUENCE OF INVESTMENT AND INNOVATION ACTIVITIES ON ENSURING THE INTERNATIONAL COMPETITIVENESS OF COUNTRIES

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Abstract. *The purpose of this work is to study the quality of the innovation-investment component of the international competitiveness of EU countries and Ukraine, to reveal the potential of innovation-investment activity in ensuring the effectiveness of the national economy, as well as to substantiate the priority vectors of leveling external shocks and promoting economic growth in Ukraine. The work evaluates the quality of the innovation and investment component of the international competitiveness of Ukraine and its close neighbors – the countries of the Visegrad Group (Poland, the Czech Republic, Hungary and Slovakia) using econometric analysis; a multifactor economic-mathematical model was built, which determines the strength of the connection between indicators of innovation and investment activity in Ukraine and the main macroeconomic indicator – GDP; the European practice of developing strategic programs to increase the competitiveness of the country's economy was studied; strategic innovation and investment initiatives of Ukraine are substantiated. In addition, the article made a significant theoretical and practical contribution to solving the outlined problems. The results of the study revealed the main problems of the innovation-investment component of Ukraine's international competitiveness, as well as highlighted the potential prospects for its improvement, taking into account advanced European practices.*

Keywords: international competitiveness, innovation and investment activity, globalization, institutional environment

SYMULACJA WPŁYWU DZIAŁAŃ INWESTYCYJNYCH I INNOWACYJNYCH NA ZAPEWNIENIE MIĘDZYNARODOWEJ KONKURENCYJNOŚCI KRAJÓW

Streszczenie. *Celem pracy jest zbadanie jakości komponentu innowacyjno-inwestycyjnego konkurencyjności międzynarodowej krajów UE i Ukrainy, ujawnienie potencjału działalności innowacyjno-inwestycyjnej w zapewnieniu efektywności gospodarki narodowej, a także uzasadnienie priorytetowe wektorów niwelowania wstrząsów zewnętrznych i promowania wzrostu gospodarczego na Ukrainie. W pracy dokonano oceny jakości komponentu innowacyjno-inwestycyjnego międzynarodowej konkurencyjności Ukrainy i jej bliskich sąsiadów – krajów Grupy Wyszehradzkiej (Polska, Czechy, Węgry i Słowacja) za pomocą analizy ekonometrycznej; zbudowano wieloczynnikowy model ekonomiczno-matematyczny, który określa siłę związku między wskaźnikami aktywności innowacyjnej i inwestycyjnej na Ukrainie a głównym wskaźnikiem makroekonomicznym – PKB; zbadano europejską praktykę opracowywania strategicznych programów zwiększania konkurencyjności gospodarki kraju; strategiczne inicjatywy innowacyjne i inwestycyjne Ukrainy są uzasadnione. Ponadto artykuł wniósł znaczący wkład teoretyczny i praktyczny w rozwiązanie przedstawionych problemów. Wyniki badania ujawniły główne problemy komponentu innowacyjno-inwestycyjnego międzynarodowej konkurencyjności Ukrainy, a także zwróciły uwagę na potencjalne perspektywy jego poprawy, biorąc pod uwagę zaawansowane praktyki europejskie.*

Słowa kluczowe: konkurencyjność międzynarodowa, działalność innowacyjna i inwestycyjna, globalizacja, otoczenie instytucjonalne

Introduction and literature review

The basis of the economic growth of any country is the formation of a highly competitive environment, which is aimed at creating goods and services with high added value. The production of such goods is impossible without the activation of innovative research and appropriate investment support. The mechanism of the relationship between the country's international competitiveness and the pace of innovation and investment activity is that the intensity of accumulation of all types of capital by the country correlates with the growth of labor productivity, which, in turn, is determined by the quality of technological support for production. The intensity of the development of technological support, in turn, depends on the level of competitiveness of the operating conditions of economic entities and the effectiveness of motives for carrying out innovative and investment activities.

The intensity of implementation of all innovation and investment transformations depends on the incentives, tools and levers that will be determined as priorities in the country's policy, which, in turn, form the institutional environment for strategic changes in the country's economic system.

The innovative and investment component of competitiveness growth is being studied by many international organizations. Based on the methodology developed by them, basic indicators and criteria were formed, which make it possible to compare different countries. Key among them are the Index of Economic Freedom [1], the Global Innovation Index (GII) [2], the Corruption Perception Index [3] compiled by Transparency International since 1995, and the Global Competitiveness Index [4]. Accordingly, the presence of an analytical base actualizes the issue of modeling the impact of basic indicators on economic growth, which is manifested in the gross domestic product. The basis of this work is the study of the dynamics of indicators that reflect the innovation-investment component of the international competitiveness of the countries of the Visegrad Group and Ukraine, the use of economic and mathematical modeling to substantiate their impact on the international competitiveness of the outlined countries. These findings will make it possible to develop recommendations based on the European practice of forming strategic programs to increase the competitiveness of the country's economy.

1. Materials and methods

To achieve the goal of the research, the following scientific tasks were defined:

1) to assess the quality of the innovation and investment component of the international competitiveness of Ukraine and its close neighbors – the countries of the Visegrad Group (Poland, the Czech Republic, Hungary and Slovakia) using econometric analysis;
2) build a multi-factor economic and mathematical model that determines the strength of the connection between indicators of innovation and investment activity in Ukraine and the main macroeconomic indicator – GDP;
3) to investigate the European practice of developing strategic programs to increase the competitiveness of the country's economy;
4) the strategic innovation and investment initiatives of Ukraine are substantiated in order to ensure the optimal level of its international competitiveness.

Methods of abstraction, dialectics, economic-mathematical and correlational analysis, system-structural and comparative analysis, as well as quantitative and qualitative analysis form the methodological basis of the research.

The main data for the analysis were statistical data from the State Statistics Service of Ukraine, the Ministry of Finance of Ukraine, analytical materials from the Wall Street Journal and the Heritage Foundation, the World Intellectual Property Organization, Transparency International, and the World Economic Forum.

After the collection and processing of statistical data, a qualitative analysis of the relevant indicators was conducted. The collected and processed statistical material of the analysis made it possible to describe the state, structure, and dynamics of the relevant indicators of innovation and investment activity of Ukraine and the countries of the Visegrad Group, as well as to diagnose the level of correlation with the factors of determining international competitiveness.

The results of the economic-mathematical analysis made it possible to identify problematic points, positive aspects and shortcomings for the outline of strategic innovation and investment initiatives of Ukraine in order to ensure the optimal level of its international competitiveness.

2. Results and discussion

Prospective priorities of the country's development in the system of the world economy are determined by the factors that determine its competitiveness.

The rapid spread of globalization processes, the deepening of transformations, the transformation of competitive advantages leads to the emergence of new challenges for state policy regarding the formation of conditions for ensuring the international competitiveness of subjects of various levels. Globalization, like any profound process taking place in society, carries both new opportunities and risks. As a rule, opportunities are not available to all economic entities, and risks threaten both micro and macro entities. Among the most significant challenges of our time are economic instability, social inequality, economic discrimination and global problems of various directions.

The permanent task of modernity is to find the driving forces of rationalization of economic activity through the practical exhaustion of extensive factors of economic growth. Negative trends in the economic system of Ukraine are evidence of the lack of systematicity in the management of innovation and investment processes in the country. This state of affairs requires the development of a system of effective measures at all levels of management regarding the formation of an optimal innovation environment in order to increase the overall level of the country's international competitiveness under the conditions of global socio-economic transformations.

In world practice, in the vast majority of cases, the following approaches are used to quantify the level of international competitiveness of countries:

- a comparison of costs and prices, which gives an approximate value of specific remuneration, which is a function of, for example, productivity, wages or exchange rates;
- analysis of the results of the country's foreign trade activity, changes in the share of domestic goods in the domestic turnover, volumes and structure of exports;
- comparison of a group of weighted indicators of the functioning of the country's national economy.

In our opinion, the last of the mentioned approaches is the most optimal not only from the point of view of greater systematicity and multifacetedness, but also best suited if the assessment is carried out by comparing the level of international competitiveness of a group of countries.

Taking into account the European integration vector of the development of Ukraine's economy, we consider it expedient to assess the quality of the innovation and investment component of the international competitiveness of Ukraine and its close neighbors – the countries of the Visegrad Group (Poland, the Czech Republic, Hungary and Slovakia). To do this, we will apply econometric analysis, which involves establishing such a type of linear function that would most accurately describe the development of the economic process. The economic analysis is conducted on the basis of four institutional indices that reflect the quality of the investment and innovation component of the international competitiveness of countries for the period from 2013 to 2022 – the Index of Economic Freedom, the Global Innovation Index, the Corruption Perception Index, and the Global Competitiveness Index (table 1).

Table 1. Comparative values of international ratings reflecting the innovation and investment component of the international competitiveness of the Visegrad Group countries and Ukraine, 2013–2022

Indicator	Country	Years									
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Index of economic freedom	Poland	66	67	68.6	69.3	68.3	68.5	67.8	69.1	69.7	68.7
	Czech Republic	70.9	72.2	72.5	73.2	73.3	74.2	73.7	74.8	73.8	74.4
	Hungary	67.3	67	66.8	66	65.8	66.7	65.5	66.4	67.2	66.9
	Slovakia	68.7	66.4	67.2	66.6	65.7	65.3	65	66.8	66.3	69.7
	Ukraine	46.3	49.3	46.9	46.8	48.1	51.9	52.3	54.9	56.2	54.1
Global Innovation Index	Poland	40.12	40.64	40.16	40.22	41.99	41.67	41.31	39.95	39.9	37.5
	Czech Republic	48.36	50.22	51.32	49.4	50.98	48.75	49.43	48.34	49	42.8
	Hungary	46.93	44.61	43	44.77	41.74	44.94	44.51	41.53	42.7	39.8
	Slovakia	47.32	41.89	42.99	41.7	43.43	42.88	42.05	39.7	40.2	34.3
	Ukraine	35.78	36.26	36.45	35.72	37.62	38.52	37.4	36.32	35.6	31
Index of perception of corruption	Poland	60	61	63	62	60	60	58	56	56	–
	Czech Republic	48	51	56	55	57	59	56	54	54	–
	Hungary	54	54	51	48	45	46	44	44	43	–
	Slovakia	47	50	51	51	50	50	50	49	52	–
	Ukraine	25	26	27	29	30	32	30	33	32	–
Index global competitive capabilities	Poland	–	4.48	4.49	4.56	4.59	68.2	68.9	68.8	68.6	68.9
	Czech Republic	–	4.53	4.69	4.72	4.77	71.2	70.9	70.9	71	71.1
	Hungary	–	4.28	4.25	4.2	4.33	64.3	65.1	65.3	65.1	65.7
	Slovakia	–	4.15	4.22	4.28	4.33	66.8	66.8	66.9	66.9	67.2
	Ukraine	–	4.14	4.03	4	4.11	57	57	56.8	56	54.8

Note:

The index of economic freedom is based on 10 indices, which are evaluated on a scale from 0 to 100, and the indicator 100 corresponds to maximum freedom.

The Global Innovation Index (GII) provides detailed indicators of the innovation performance of 131 countries and economies around the world, on a scale from 0 to 100.

The Corruption Perceptions Index (CPI) is an annual ranking of the countries of the world compiled by Transparency International since 1995. The countries in the rating are ordered according to the level of corruption, which is based on the assessments of entrepreneurs and analysts. The rating reproduces the perception of corruption on a scale from 100 (no corruption) to 0 (extreme corruption).

The Global Competitiveness Index ranks a different number of countries each year on indicators grouped into 12 main components.

Compiled by the authors based on: [1, 2, 3, 4]

The reason for focusing on these metrics is that:

- firstly: they can significantly affect the uncertainty in the sphere of investment and innovation activities in the conditions of ensuring the international competitiveness of the countries' economies;
- secondly: these indices determine the importance of uncertainty factors regarding changes in economic policy in general and the transformation of innovation and investment policy in particular;
- thirdly: on the basis of the search for interrelationships using Excel Microsoft Office, the indicated indices are singled out as indicators characterized by a high level of correlation.

Microsoft Office Excel was used to calculate the economic-mathematical model. The econometric analysis of the innovation-investment component of the country's international competitiveness is based, first of all, on the construction of an econometric model of the following type:

$$Y = a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + u \quad (1)$$

where Y – is the vector of the innovation-investment component of international competitiveness (the sum of innovation costs and direct investments in the country's economy); X_1 – vector of the index of economic freedom; X_2 – global innovation index vector; X_3 – corruption perception index vector; X_4 – global competitiveness index vector; u – is a vector of the stochastic component that accumulates the influence of all random factors on the innovation-investment component of international competitiveness.

The results of the calculations are given in table 2.

Table 2. Regression equation of the innovation-investment component of the international competitiveness of the Visegrad Group countries and Ukraine

Country	The equation of the multivariate model
Czech Republic	$Y = 59.5 \cdot X_1 + 34.0 \cdot X_2 - 1.9 \cdot X_3 + 23.0 \cdot X_4 - 16645.4$
Hungary	$Y = 20.2784 \cdot X_1 + 0.4575 \cdot X_2 - 7.6204 \cdot X_3 + 12.3347 \cdot X_4 + 11.64$
Slovakia	$Y = 10.926 \cdot X_1 + 20.044 \cdot X_2 - 4.302 \cdot X_3 + 11.821 \cdot X_4 - 753.142$
Poland	$Y = 6.2397 \cdot X_1 + 39.9805 \cdot X_2 - 3.6569 \cdot X_3 + 0.8132 \cdot X_4 - 5.6544$
Ukraine	$Y = 2.267 \cdot X_1 + 0.2479 \cdot X_2 - 1.4837 \cdot X_3 + 0.1525 \cdot X_4 + 1.2782$

As we can see from the table, the economic freedom index (X_1) has the most positive effect on the significant indicator (sum of innovation costs and direct investments in the country's economy), in all regression equations it has a positive value and is greater than 1. The opposite factor is the corruption perception index, as it reduces the total amount of innovation costs and direct investments in the country's economy due to a negative value.

When checking the reliability of models on the basis of multiple correlation coefficients, in the theory of statistics such basic indicators as multiple correlation coefficients – R are distinguished (the closer R is to unity, the closer the relationship between the dependent variable Y and factors X_1, X_2,..., X_n) and determinations – R^2 (the closer R^2 is to unity, the better the regression approximates the empirical data), Fisher's test (the tabular value of Fisher's test is searched for the given probability p (p = 0.95) and the number of degrees of equality $k1=m$ and $k2=n-m-1$; for the statistical data collected by us, the number of observations is n=10, therefore the number of degrees of freedom $k1$=1 and $k2$=8. The tabular value of the Fisher criterion: F_{tab}=5.32. If the inequality $F_{dis} > F_{tab}$ is satisfied, then with a probability of p=0.95, it can be stated that the built model is adequate to the statistical data and is suitable for further analysis and forecasting. A summary analysis of multiple correlation coefficients is given in table 3.

Table 3. Validation of models based on multiple correlation coefficients

No	Country	Multiple correlation coefficient (R)	Determination coefficient (R^2)	Fisher's test
1	Czech Republic	0.82745	0.68467	90.4150
2	Hungary	0.99757	0.99515	352.0821
3	Slovakia	0.98551	0.97122	47.5163
4	Poland	0.98295	0.96620	58.4282
5	Ukraine	0.97273	0.94620	35.1772

The analysis of the data in the table shows that all the coefficients correspond to the normative values. This gives us reason to say that the models are reliable and can be used for further forecasting.

A number of indicators are used to assess the effectiveness of innovative capital investments in promoting the country's international competitiveness, in particular: the volume of scientific production as the total number or average number of publications per researcher, completed and defended dissertations, completed topics or submitted reports; the value expression of the savings of live and tangible labor in social production from the use of the results of scientific and research activities and their comparison with the costs of conducting research; the number of introduced scientific and technical products and the term of introduction of scientific development into production; indicators of the effectiveness of applied scientific research: the level of diffusion of results in the spheres of the country's economy; indicator of the ratio of the beneficial effect of research and the costs of conducting it, etc.

Only a comprehensive assessment of these indicators can demonstrate a complete picture of the validity of innovative capital investments. In addition, they should be evaluated from the standpoint of obtaining both quantitative and qualitative results.

Among the quantitative parameters of innovation activity in the country, it is worth noting innovation costs for the purchase of machines, equipment and software; innovation costs for another; the number of organizations that implemented the NDR; the number of employees involved in the implementation of the NDR; number of innovatively active industrial enterprises; direct foreign investments in Ukraine; the number of industrial enterprises that introduced innovations; specific weight of the volume of scientific and scientific and technical works performed in GDP, %.

3. Experiment

The next step in our research will be the construction of a multifactor economic-mathematical model that will determine the strength of the connection between indicators of innovation and investment activity in Ukraine and the main macroeconomic indicator – GDP. The initial data for building this model are presented in table 4.

The use of software products (package extension "Data Analysis" Microsoft Excel) made it possible to determine the equation of the multifactor model of the dependence of GDP (Y) on indicators of the effectiveness of innovation and investment activity in Ukraine.

Equation of multifactor dependence of GDP in million hryvnias. looks like:

$$Y = 4820.3237 \cdot X_1 + 5961.334 \cdot X_2 - 4887.1648 \cdot X_3 - 4.2859 \cdot X_4 - 5877.817 \cdot X_5 + 8212.7868 \cdot X_6 + 458.3506 \cdot X_7 + 6285.4X_8 + 3895647.46$$

Checking the reliability of the model based on the multiple coefficients of correlation (R=0.8887) and determination (R^2=0.9773) shows that they are close to 1. This result of the calculation confirms the adequacy of the proposed model, its suitability for use.

Commenting on the weight coefficients in the equation of the multifactor model of the dependence of GDP (Y) on the performance indicators of innovation and investment activity in Ukraine, it is possible to state a significant positive influence of such performance indicators as:

- innovation costs for the purchase of machines, equipment and software;
- innovation costs for other;
- direct foreign investments in Ukraine;
- the number of industrial enterprises that introduced innovations;
- specific weight of the volume of performed scientific and scientific and technical works in GDP.

Taking into account the conducted analysis, significant indicators of the effectiveness of innovation and investment activities in Ukraine, which have a positive impact on the country's GDP, were singled out. In order to develop more thorough recommendations regarding the use of innovation and investment potential to increase the growth of the country's GDP, it is advisable to identify these indicators in more detail and their contribution to the overall economic development of the state. For this purpose, it is possible to build models of direct connection between GDP and selected indicators. Let's build appropriate paired regression models. A summary analysis of all indicators by defined functions describing the interdependence of indicators of innovation and investment activity and GDP is given in table 5.

The data in Table 5 show that almost all the equations that most accurately determine the influence of the resulting indicator and the factors affecting it testify to the hyperbolic nature of the relationship. The wave-like development of the world economy in general and the economy of Ukraine in particular, under the influence of various factors, is reflected by the mathematical function of a quadratic equation.

The most significant coefficient in the models of interdependence from macroeconomic indicators belongs to the factor "Expenditure on innovations and other" (R^2=0.97505), but in the multifactorial equation the coefficient of influence for this indicator is not the highest, therefore, for an in-depth correlation and regression analysis, it is advisable to use the factor "The specific weight of the volume of scientific and scientific and technical works performed in GDP, %" for which R^2=0.96251.

Let's analyze the suitability of this model:

$$y = 4495414.61848x^2 - 11770222.87901x + 7889269.68666$$

To do this, we will check its adequacy with statistical data, using Fisher's test. Let's calculate the value of this criterion using the formula:

$$F_{calculated} = \frac{R^2}{1-R^2} \cdot \frac{n-m-1}{m}$$

$$F_{calculated} = \frac{(0.96251)^2}{1-(0.96251)^2} \cdot \frac{15-1-1}{1} = 163.6916536$$

The tabular value of Fisher's test is calculated with the specified probability p (p=0.95) and the number of degrees of equality: $k1=m$ and $k2=n-m-1$. For the statistical data collected by us, the number of observations is n=15, so the number f degrees of freedom $k1$=1 and $k2$=13. The tabular value of Fisher's test: F_{table} = 4.67.

Table 4. Initial data for building a multifactor regression of the influence of quantitative indicators of the effectiveness of innovation and investment activities in Ukraine on GDP

Year	GDP, million hryvnias	Innovation costs for the purchase of machines, equipment and software, UAH million	Innovation costs for other, million hryvnias	The number of organizations that carried out the NDR, units	The number of employees involved in the implementation of the NDR, persons	Number of innovatively active industrial enterprises, units	Direct foreign investments in Ukraine, million US dollars	The number of industrial enterprises that introduced innovations, units	The specific weight of the volume of scientific and scientific and technical works performed in GDP, %
	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
2007	751100	7441.3	2064.9	1404	155549	1472	9891	1186	0.93
2008	990800	7664.8	2664	1378	147275	1397	10913	1160	0.9
2009	947000	4974.7	2012.6	1340	139760	1411	4816	1180	0.95
2010	1120600	5051.7	1855.8	1303	182484	1462	6495	1217	0.9
2011	1349200	10489.1	2440.2	1255	175330	1679	7207	1327	0.79
2012	1459100	8051.8	2185.5	1208	164340	1758	8401	1371	0.8
2013	1522700	5546.3	2290.9	1143	155386	1715	4499	1312	0.8
2014	1586900	5115.3	778.8	999	136123	1609	410	1208	0.69
2015	1988500	11141.3	548	978	122504	824	-458	723	0.64
2016	2383200	19829.0	878.4	972	97912	834	3810	735	0.61
2017	2983882	5898.8	1027.1	963	94274	759	3692	672	0.56
2018	3558706	8291.3	633.9	950	88128	777	4455	739	0.51
2019	3974564	10185.1	4035.8	950	79262	782	5860	687	0.52
2020	4194102	8788.2	5618.7	769	78860	809	-868	718	0.52
2021	5459574	9325.4	4289.6	789	74256	784	6687	683	0.54

Source: compiled according to [5, 6, 7, 8]

Table 5. Equations describing the dependence of the influence of innovation and investment factors on GDP and the corresponding coefficients of determination

Linear equation	Logarithmic equation	Polynomial equation	Power equation	Exponential equation
Innovation costs for the purchase of machines, equipment and software				
y = 22.24565x + 622817.76518 R^2 = 0.19849	y = 147017.88160ln(x) – 62456.04346 R^2 = 0.45933	y = -0.00310x^2 + 135.78126x + 357449.52816 R^2 = 0.58652	**y = 161503.07611$x^{0.20369}$ R^2 = 0.73693**	y = 363466.70874$e^{0.00004x}$ R^2 = 0.47428
Spending on innovation for another				
y = 144488.22910x – 296994.73203 R^2 = 0.91460	y = 827187.78107ln(x) – 596904.75349 R^2 = 0.67625	y = 7895.10939x^2 – 5518.84933x + 203028.86275 R^2 = 0.97286	y = 93456.08140$x^{1.05039}$ R^2 = 0.91137	**y = 165849.34724$e^{0.16319x}$ R^2 = 0.97505**
Direct foreign investments in Ukraine				
y = -2953729.45015x + 3620773.65399 R^2 = 0.90268	y = -2409176.39474ln(x) + 602668.34181 R^2 = 0.94679	**y = 3450890.80678x^2 – 8797205.21121x + 5874349.74320 R^2 = 0.95128**	y = 476437.95994$x^{-2.52142}$ R^2 = 0.86676	y = 12598844.82770$e^{-3.22632x}$ R^2 = 0.90013
The number of industrial enterprises that introduced innovations				
y = 735.98698x – 219857.19806 R^2 = 0.26347	y = 1446154.84809ln(x) – 673776.47848 R^2 = 0.25357	y = -0.00483x^2 + 757.38751x – 241126.65197 R^2 = 0.26348	y = 3.19377$x^{1.66928}$ R^2 = 0.28237	y = 186429.64859$e^{0.00081x}$ R^2 = 0.26954
The specific weight of the volume of scientific and scientific and technical works performed in GDP, %				
y = -3674314.16534x + 4431662.85491 R^2 = 0.91247	y = -3241222.07886ln(x) + 695395.84735 R^2 = 0.94986	**y = 4495414.61848x^2 – 11770222.87901x + 7889269.68666 R^2 = 0.96251**	y = 524795.30684$x^{-3.39544}$ R^2 = 0.87122	y = 29979358.87863$e^{-3.99280x}$ R^2 = 0.90057

Source: calculated by the authors.

Inequality $F_{calc} > F_{tab}$ (163.692 > 4.49) is fulfilled, so with a probability of 95% it can be stated that the proposed model is adequate to the statistical data.

It is necessary to evaluate the indicators of the closeness and direction of the relationship between *X* and *Y*, using the correlation coefficient, which is calculated according to the following formula:

$$K_{correl}[X,Y] = \frac{\sum_{uu=1}^{n}(Xi - \overline{X}) * (Yi - \overline{Y})}{\sqrt{\sum_{i=1}^{n}(Xi - \overline{X})^2 * \sum_{i=n}^{n}(Yi - \overline{Y})^2}}$$

The value of the correlation coefficient is calculated using the built-in function of the Microsoft Excel program, in particular the function of the CORELL category.

The coefficient and correlation r [x; y] = 0.93258 were obtained.

Based on the obtained value, we conclude: since r [x; y] < 0, then the relationship between *X* and *Y* is direct; since $0.7 < |r[x; y]| < 1$, then the relationship between *X* and *Y* is strong.

Therefore, the indicator of the specific weight of the volume of performed scientific and scientific and technical works in GDP exerts the greatest influence on the volume of GDP. Negative trends are observed in the field of innovative development in Ukraine, in particular, problems associated with low volumes of financing of scientific and scientific and technical works. These problems increase in conditions of economic recession, as the opportunities to invest in innovative development are narrowing.

Investment and innovation activity in terms of ensuring the international competitiveness of countries is directly determined by the strategic initiatives of the state. Some countries emphasize the implementation of programs aimed at developing the technological factor of competitiveness, others direct resources to increase the country's innovation capital. A number of states prefer to develop resource conservation in order to restore the natural capital of the country, and some of them increase the use of non-renewable resources. The variety of these strategies is explained by the different degree of economic development of countries, the availability of production factors and many other reasons.

The countries with a fairly high international assessment of competitiveness are the countries of the European Union, which traditionally have a consistently high level of innovative development, quality of education, technological equipment and infrastructure. Framework programs for the development of scientific research and technology are one of the instruments for the development of innovations in the region.

Examples of such programs include "HORIZON-2020", which was a tool for the development of high-tech competitiveness in the context of the "Europe 2020" strategy [9]. The purpose of this program was to develop Europe's competitiveness through the implementation of large-scale research and the introduction of innovations aimed at solving modern problems. In particular, during the implementation of the project, about 78 billion euros were invested, and about 900 new innovative products were created.

There are a number of other strategic programs and initiatives of the European region aimed at increasing the competitiveness of European countries through the expansion of innovative cooperation. For example, the ERA-NET project [10] is aimed at coordinating national and regional research programs, holding joint events, and discussing international cooperation. The initiative "European Technology Platforms" [11] is aimed at technology transfer and international cooperation in the industrial sector.

Getting acquainted with the European experience of developing strategic programs to increase the competitiveness of countries, it can be concluded that the countries of this region have managed to build a chain of effective interaction "education – research and development – high-tech business". This system of ensuring competitiveness and growth in Europe performs the functions depicted in Fig. 1.

The purpose of joint technology initiatives in the European Union is the strategic development of areas in which research and innovation are important for competitiveness, for example bio-industry, "clean sky", electronic components and systems, as well as innovative medicines. These initiatives are implemented through special legal entities – joint ventures – created in accordance with the Treaty on the Functioning of the European Union (TFEU). Currently, several projects are being implemented in the region, aimed at creating coordination platforms, within which it is expected to combine the efforts of representatives of political circles, the scientific community, business and third countries to determine the priority areas of research (Fig. 2).

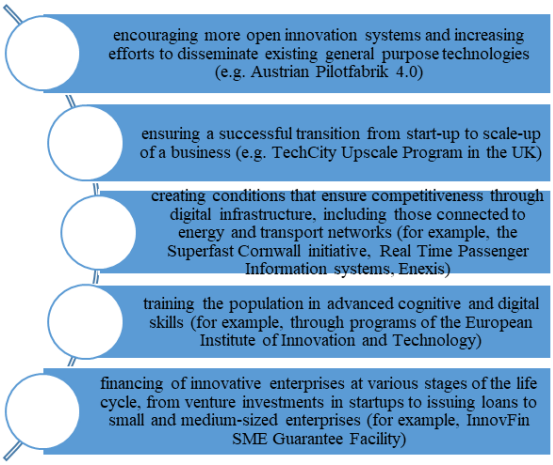

Fig. 1. Functions of the system for ensuring competitiveness and growth in EU countries Source: constructed by the authors

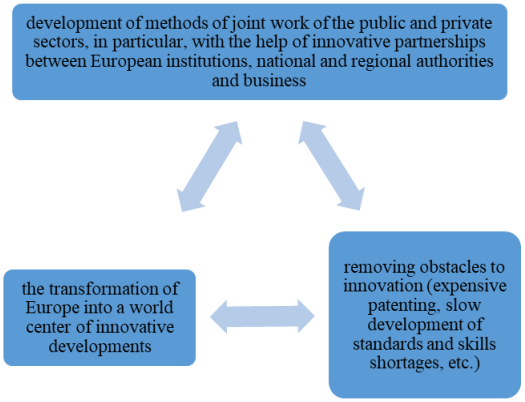

Fig. 2. Strategic goals of the system for ensuring competitiveness and growth in EU countries Source: constructed by the authors

It is worth noting that European countries not only develop and implement strategic initiatives at the national level, but also actively work with private business and the population. For example, in environmental issues, which are determinants of the development of international competitiveness in the long term, consumer preferences are being changed towards conscious consumption and businesses are being supported in the transition to low-carbon practices [12].

In general, the strategic policy of the EU in matters of increasing the competitiveness of the region is aimed at the development of innovations, education and high-tech industry. This statement is confirmed by the regression equations of the innovation-investment component of international competitiveness compiled by us and the equations describing the dependence of the influence of innovation-investment factors on GDP.

The conducted monitoring of Ukraine's place in international ratings reflecting the innovation and investment component of the country's international competitiveness in 2013–2022 shows relatively low rating positions. However, the built multifactorial regression of the influence of quantitative indicators of the effectiveness of innovation and investment activity in Ukraine on GDP indicates its weight of influence on the macroeconomic situation in the country and its international competitiveness.

The dynamics of the transformation of investment and innovation factors of international competitiveness prove that there is a global trend for the development of high-tech production, innovative capital and the environmental factor [13, 14, 15]. At the same time, the instability of the financial market and the strengthening of the protection of national producers often hinder the development of the country's competitiveness. Most developed economies are developing strategic programs aimed at developing the three aforementioned factors and mitigating the destructive effects of the other two.

In Ukraine, the government has already taken a number of strategic decisions regarding the technological modernization of the economy, but the effectiveness of many of them would be better. Of course, there are endogenous circumstances (armed aggression of the Russian Federation against Ukraine) that reduce the effectiveness of the country's innovation and investment activities. In addition to military operations on the territory of our country, Ukraine has socio-economic problems typical of developing countries (social inequality, economic instability, etc.). At the same time, Ukraine already needs to respond to the challenges of post-industrial development, which arise under the influence of global transformations of the world economy, and to promote the transition from a resource-dependent to a high-tech economy.

Ukraine's strategic innovation and investment initiatives should outline sources of investment in new infrastructure and modernization of outdated technological capacities. It is also necessary to work out the mechanism of their insurance in order to increase the confidence of domestic and foreign investors. It is also necessary to clearly define the organization of vocational training and retraining programs for employees who may lose their jobs due to increased innovation in the economy. A strategic approach to product diversification, development of raw materials industries with a high degree of processing and the use of high-tech developments is necessary to create the stability of raw materials enterprises under conditions of changing economic conditions.

These points should be taken into account during the development of relevant programs for the development of the competitiveness of the economy. When implementing strategies aimed at the development of innovations in the country, it is necessary to pay attention to high-tech industries with a significant multiplier effect, which stimulates innovative activity in related areas. Additional investments will be needed for the implementation of projects related to the creation of energy-efficient technologies. Their use will allow to reduce the price of products, which means it will increase its price competitive advantages. To solve the problems caused by the transformation of investment and innovation activities, Ukraine needs to develop a scientific and technological program aimed at the implementation of complex target programs through the creation of specialized technological clusters, which include technology parks, industrial parks, technology transfer centers and engineering centers.

It is also advisable to develop a comprehensive program to support small and medium-sized businesses, including through the activation of specialized innovative institutions. Small and medium-sized enterprises are more open to innovation than large ones, but the inherent high risks of innovative projects restrain their development. World practice proves that the high-tech sector needs state protection, especially at the initial stages of development. With the successful implementation of innovations, they can make a significant contribution to the development of the competitiveness of the Ukrainian economy. The country's government should pay special attention to the development of strategic programs to increase market competition, which will contribute to the rational use of resources for the production of products and the optimal activity of entities at all stages of production.

In order to update education, it is necessary to intensify the implementation of scientific and practical programs aimed at developing cooperation between relevant educational institutions and business, increasing public awareness of scientific and technological trends, new opportunities for training and retraining, as well as the development of international dialogue on joint research. Increasing the competitiveness of strategically important industries requires the organization of a modern system of technical regulation, which contributes to the acceleration of the processes of technological and organizational modernization of production. It is also critically necessary for the inclusion of Ukrainian companies in technological and production and sales chains in the world.

4. Conclusions

The conducted research shows the threatening indicators of the corruption perception index in Ukraine. That is why it is advisable to improve the monitoring procedure and methods of detecting fraudulent activities.

Reducing the dependence of the Ukrainian economy on energy resources can significantly contribute to technological development and increase the country's innovation and investment potential. For this, programs for attracting foreign and domestic investments in R&D and education are necessary. This should be accompanied by the improvement of the business climate and legal regulation, the development of investment insurance programs, the organization of a modern system of technical regulation, and an increase in the level of competition on the national market. Thus, it is impossible to ensure the international competitiveness of the Ukrainian economy without using the innovation and investment potential. Increasing the effectiveness of the practical implementation of programs in this area, first of all, it is necessary to improve the interaction of society and business, the formation of institutions of parallel control, which can potentially help solve the problem of corruption and irrational use of state budget funds. The high effectiveness of the implementation of existing and future programs can help the country cope with the uncertainty caused by the current global economic situation, level external shocks and, ultimately, increase the level of the country's international competitiveness.

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