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CORRELATION-REGRESSION ANALYSIS OF INNOVATION FACTOR INFLUENCE ON GDP GROWTH

Introduction. *In order to improve innovation policy given a clear definition of the correlation between innovation-driven development indicators and GDP, it is necessary to critically assess the influence of the innovation factor on the country's economic growth and an increase in its competitiveness.*

Problem Statement. *Modern conditions of the global economic system development require the constant adjustment and improvement of innovation strategies given new civilizational challenges, as well as the intensification of R&D activities of national economies. This highlighted the problem of scholarly research on the influence of innovation andthe determination of correlation between indicators of innovation-driven development and GDP.*

Purpose. *The research is based on the proposed explanatory model built with the use of correlation-regression analysis, which demonstrates the influence of the innovation factor on GDP growth. The article contains forecast estimates of GDP in terms of years, depending on changes in innovation-driven development indicators based on multiple regression analysis, as well as practical recommendations for increasing the innovation capacity of Ukraine.*

Material and Methods. *To identify the impact of innovation on GDP growth, a mathematical model has been built with the use of correlation-regression analysis; to demonstrate and visualize the results of the study we have used tabular and graphical methods.*

Results. *To improve the strategy of innovation-driven development of Ukraine, an economic-mathematical model based on multiple regression analysis has been developed. It demonstrates the influence of the innovation factor on changes in GDP. This model helps to understand the functioning and development of innovation processes, to reveal the causal and functional relationships of individual indicators of innovation-driven economic development, as well as to determine the required level of innovation factor by maximizing the hidden innovation capacity.*

Conclusions. *The basic of the strategic course, its basic principle should be the implementation of government policy aiming at choosing an innovation strategy of structural transformation of Ukraine as a competitive high-tech state. This strategy requires the use of domestic R&D potential and makes its contribution to the innovation-driven development of the national economy a crucial factor.*

Keywords: innovation, innovation-driven development, European innovation scoreboard, multiple regression analysis, strategy of innovation-driven development of Ukraine, and innovation capacity.

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The strategy of effective development of the national economic systems of the leading countries has been closely connected to leadership in the field of research and development, appearance of new knowledge, mass innovation products and successful development of high-tech production in the recent years. The growth of innovationcapacity of the economy is not only a way of dynamic development, but also a method for maintaining security and sovereignty of a state, its competitiveness in the modern world. Today, there is a need to review and to update the content of the national innovation policy, to determine its strategic objectives and directions as well as to create timely mechanisms ensuring increase of the role of science and its innovation capacity in economic and social development of the country understandable to executive bodies, researchers, and society.

Alongside Bulgaria, Macedonia, and Romania, Ukraine was ranked as an 'emerging innovator' by the European Innovation Scoreboard that contains data on EU member states, EU candidate countries and some other countries. The detailed analysis performed shows that Ukraine has substantial unrealized possibilities of innovation-driven development, primarily in the field of commercialization of innovations and protection of intellectual property rights. The main advantages of Ukraine are favorable geographical location, capacious market, availability of a comprehensive free trade area between Ukraine and the EU and a relatively high development level of human potential. In order to increase labor productivity, to receive output from the use of existing natural resources and human potential, to ensure sustainable economic development, competitiveness of domestic products and to increase the level and quality of life on this basis Ukraine shall be moved according to a complex indicator of innovation-driven development from the group 'emerging innovator' to at least the group of countries 'moderate innovators' or, under favorable conditions, to the group of countries 'followers' [1].

A significant number of research works are devoted to the issue of innovation-driven development and search for effective tools for activation and successful implementation of R&D and innovative activities in the national economy, as well as for identifying methods that aim at increasing of the innovation capacity of Ukraine. Certain aspects of this issue were considered by the following Ukrainian and foreign researchers: M. Dodgson, O. Clauser, G. Korsten, B. Gotz-Garth, P. Morone, K. Prahalad, S. Robin, A. Sadekov, T. Schubert, O. Shubin and others. [2, 4, 9, 12—13, 16, 18, 21]. A significant number of aspects of innovation policy remain undisclosed and need theoretical, methodological and practical solution at the same time. The analysis of the latest achievements and publications on innovation with a focus on the mechanisms of increasing GDP growth rates through innovation shows that this area of study is given a lot of attention. Contemporary conditions of development of the global economic system require constant adjustment and improvement of innovation strategies with consideration of new challenges to *civilization* as well as intensification of R&D activities of national economies; this actualized the problem of scholarly research of the impact of the innovation factor on the economic growth of a country and increase of its competitiveness, a clear definition of the correlation between indicators of innovation-driven development and GDP. The macroeconomic analysis of the impact of technological change by assessing the links between theoretical frameworks and empirical models [2] as well as the analysis of innovations and technologies aiming at identification of opportunities and barriers to integration and cooperation of business structures [3] are particularly interesting in this context.

The purpose of the article is to make forecast estimates of GDP by years depending on changes of innovation-driven development based on multiple regression analysis as well as the formation of practical recommendations for increasing innovation capacity of Ukraine through the use of effective mechanisms of favoring innovation on this basis.

Among the problems of R&D and technological progress an important place is occupied by the problem of evaluating innovations and the results of their implementation, the feasibility of their investment. Modern economists, along with traditional ones, use specific methods and techniques of research: economic and statistical, in particular its methods: comparison, grouping, time series, correlation and regression analysis [3, 4]; by means of a monographic method experience of separate successful innovative enterprises is studied, the analysis of industrial and economic activity of typical and advanced enterprises is carried out, advanced methods of innovative activity are defined [5—7]; on the basis of the experimental method the questions of improvement og the organization of separate technological processes of production are studied [8, 9].

The following general research methods of cognition were used during research within a comprehensive approach: analysis and synthesis, induction and deduction, methods of generalization of theoretical and actual material by means of comparison, qualitative and quantitative economic and statistical analysis. In order to identify the impact of the innovation factor on GDP growth rates a mathematical model was developed using correlation and regression analysis; table and graphical methods were used to demonstrate and to visualize the study results.

The Strategy of Innovation-Driven Development of Ukraine was adopted by the Government for the period till 2030. The expected result of this document implementation should be in particular an increase in the number of natural persons and business entities engaged in invention, applied research, R&D development, especially outside the state sector; increase in the number of business entities engaged in the provision of services in the field of commercialization of technological solutions; increase of revenues from sale and use of intellectual property objects and science-intensive products; increase of the share of enterprises engaged in innovation. The main goal of the Strategy of Innovation-Driven Development has a very specific quantitative parameter. Indicators of implementation of the Strategy are:

- the share of expenditures for R&D activities in GDP is 3%;
- the share of innovatively active enterprises in the total number of enterprises isat least, 30%;
- the share of export of the goods manufactured by enterprises of high- and medium-tech industries in the total exports of the goods is 30%;
- the share of workers employed at enterprises of high- and medium-tech sectors of industry in the total number of workers employed in industry is 29%;
- the share of innovation products sold in the total industrial products sold is 10% [10].

Three-year action plans are developed in order to implement the Strategy. To assess the effectiveness of the Strategy implementation monitoring of both the implementation of action plans and their impact on various sectors of the economy shall be performed. In this regard, it is necessary to develop scenarios and forecast of innovation-driven development, which determine the desired or possible dynamics of the innovation process as well as of GDP growth on this basis.

The development and improvement of a strategy of innovation-driven development and the possibility to influence the formation of GDP through its implementation requires development of an explanatory model. This model should demonstrate the influence of the innovation factor on GDP change and the possibilities to increase this influence by maximizing the hidden potential of the national innovation system as well as to help to understand functioning and development of innovation processes by explaining cause-and-effect or functional relations of individual innovation indices. In this regard, an explanatory model that determines the impact of the growth of the contribution of the innovation factor to economic growth on GDP growth rateshas been proposed. A number of input indicators were set for this purpose, such as the number of organizations that carried out research and development ($x1$); the total number of research and develop-

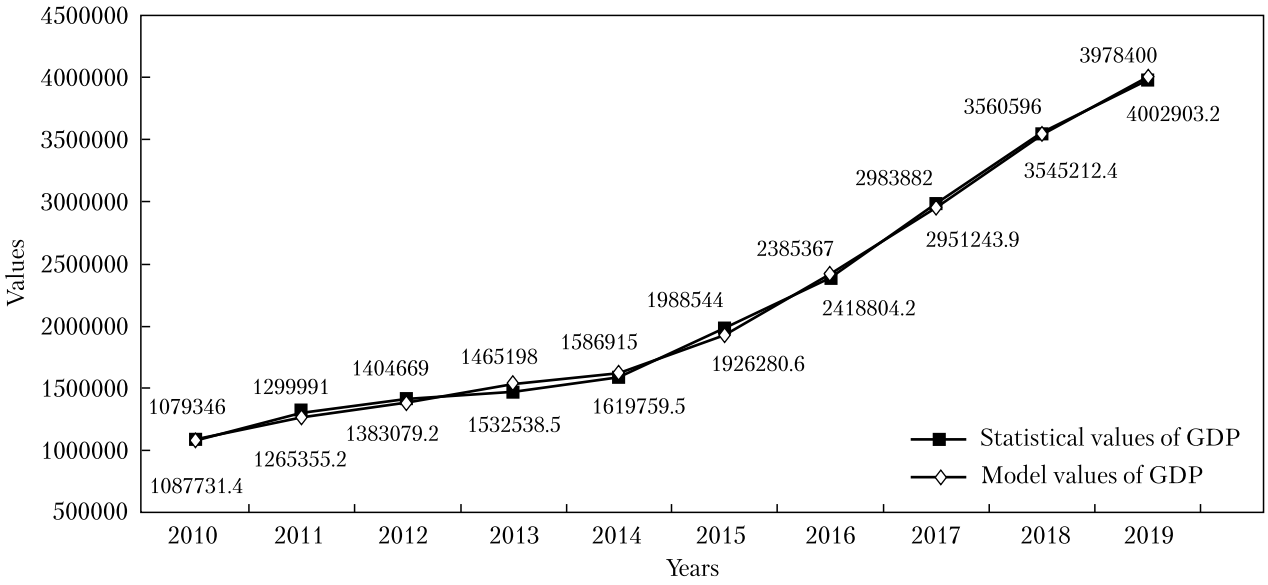

Fig. 1. Comparison of statistical and model values of GDP in 2010—2019

ment performers ($x2$); the number of doctors of sciences involved in research and development ($x3$); the number of candidates of sciences involved in research and development ($x4$); the share of innovatively active enterprises in the total number of industrial enterprises ($x5$); the total amount of costs for innovative activities of industrial enterprises, including funds spent for research and development, acquisition of other external knowledge, purchase of machinery, equipment and

Table 1. **Correlation Between Input Parameters and GDP***

	Number of organizations that carried out scholarly research and development ($x1$)	Total number of performers of scholarly research and development, persons ($x2$)	Number of doctors of sciences involved in scholarly research and development, persons ($x3$)	Number of candidates of sciences involved in the implementation of scholarly research and development, persons ($x4$)	Share of innovatively active enterprises in the total number of industrial enterprises, ($x5$)	Total expenditures on innovation activities of industrial enterprises, million UAH ($x6$)	Expenditures for scholarly research and development, million UAH ($x7$)	GDP, million UAH
2010	1303	182484	11974	46685	13.8	8045.5	8107.1	1079346
2011	1255	175330	11677	46321	16.2	14333.9	8513.4	1299991
2012	1208	164340	11172	42050	17.4	11480.6	9419.9	1404669
2013	1143	155386	11155	41196	16.8	9562.6	10248.5	1465198
2014	999	136123	9983	37082	16.1	7695.9	9487.5	1586915
2015	978	122504	9571	32849	17.3	13813.7	11003.6	1988544
2016	972	97912	7091	20208	18.9	23229.5	11530.7	2385367
2017	963	94274	6942	19219	16.2	9117.5	13379.3	2983882
2018	950	88128	7043	18806	16.4	12180.1	16773.7	3560596
2019	950	79262	6526	16929	15.8	14220.9	17254.6	3978400
Correlation	–0.79	–0.93	–0.93	–0.93	0.11	0.26	0.99	

* The calculations are made by the author based on the data of the State Statistics Committee [22].

software ($x6$); costs for the implementation of research and development, including implementation of fundamental and applied research, R&D (experimental) development ($x7$); the initial parameter is the gross domestic product (GDP).

Based on correlation analysis the correlation coefficients between the input parameters and the GDP in terms of years were determined (Table 1). As we can see on Table 1 the correlation coefficients are higher than 0.9 (with the only exception of the correlation between x5, x6 and GDP, which is explained below); this makes it possible to use multiple regression analysis to build an explanatory model:

$$\begin{aligned} GDP = {} & 5272.37535 \cdot x1 - 51.444 \cdot x2 - \\ & - 456.65 \cdot x3 + 143.643 \cdot x4 + \\ & + 6406.36 \cdot x5 - 15.141 \cdot x6 + \\ & + 146.3498 \cdot x7 - 1202413 \end{aligned} \quad (1)$$

Table 2. **Statistical and Model Data on GDP in 2010–2019***

Years	Statistical GDP	Model estimates of GDP
2010	1079346	1087731.36
2011	1299991	1265355.23
2012	1404669	1383079.24
2013	1465198	1532538.47
2014	1586915	1619759.48
2015	1988544	1926280.56
2016	2385367	2418804.23
2017	2983882	2951243.86
2018	3560596	3545212.38
2019	3978400	4002903.2

* The calculations are made by the author.

Table 3. **Change in GDP Depending on Changes in Input Indicators x1-x7 by 1%, 5%, 10%***

	90%	95%	99%	100%	101%	105%	110%
$x1$	855	903	941	950	960	998	1045
GDP, million UAH	3502027.54	3276633	3233809	3233809	3276205	3490308	3939924
GDP, %	108%	101%	100%	100%	101%	108%	122%
$x2$	71336	75299	78469	79262	80055	83225	87188
GDP, million UAH	4410656.69	4594146	4629009	4629009	4594494	4420197	4054173
GDP, %	95%	99%	100%	100%	99%	95%	88%
$x3$	5873	6200	6461	6526	6591	6852	7179
GDP, million UAH	4300261.24	4434072	4459496	4459496	4434327	4307219	4040292
GDP, %	96%	99%	100%	100%	99%	97%	91%
$x4$	15236	16083	16760	16929	17098	17775	18622
GDP, million UAH	3759729.82	3650302	3629510	3629510	3650094	3754040	3972327
GDP, %	104%	101%	100%	100%	101%	103%	109%
$x5$	14.22	15.01	15.64	15.80	15.96	16.59	17.38
GDP, million UAH	3992781.15	3988226	3987361	3987361	3988218	3992544	4001630
GDP, %	100%	100%	100%	100%	100%	100%	100%
$x6$	12799	13510	14079	14221	14363	14932	15643
GDP, million UAH	4024434.53	4034124	4035965	4035965	4034142	4024938	4005610
GDP, %	100%	100%	100%	100%	100%	100%	99%
$x7$	15529.1	16391.9	17082.1	17254.6	17427.1	18117.3	18980.1
GDP, million UAH	3750382.42	3636748	3615158	3615158	3636532	3744474	3971152
GDP, %	104%	101%	100%	100%	101%	104%	110%

* The calculations are made by the author.

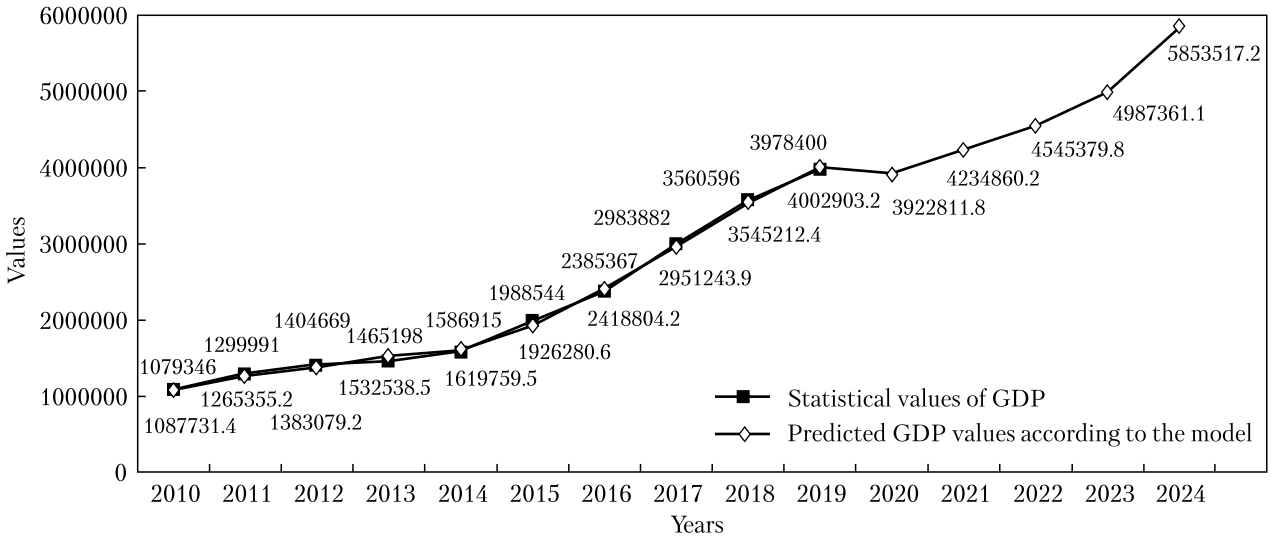

Fig. 2. Predicted GDP values for 2020–2024 according to the explanatory model (1)

The relevance of this model is confirmed by high determination coefficient ($R^2 = 0.99$) and slight deviation of the forecasts for the model from the actual GDP in terms of years (Table 2 and Fig. 1). The degree of approximation is high in this case; we can make a conclusion that the above input parameters have a significant influence on GDP in Ukraine.

This model that should form the base for the system of economic decision-making in the field of innovation-driven development strategy and its influence on GDP formation made it possible to identify how a change in input indicators of innovation-driven development by 1%, 5%, 10% affects the GDP by means of the 'what-if' analysis (Table 3). Analysis of change in GDP depending on the change in input indicators $x1$-$x7$ by 1%, 5%, 10% will be presented after the forecast of innovation indicators and their influence on GDP.

Thus, the model of economic decision-making related to innovation-driven development strategy should be based on explanatory models (it is possible to make decisions on changes of exogenous quantities by giving certain specific values to an endogenous quantity). With consideration of the said above the author made a forecast of input parameters and GDP for the years 2020–2024 on the basis of the following models obtained by multiple regression analysis:

$$x1 = 5978.9 - 42.855 \cdot y; \quad (2)$$

$$x2 = 1570042 - 12580.5 \cdot y; \quad (3)$$

$$x3 = 89271.87 - 698.33 \cdot y; \quad (4)$$

$$x4 = 477477.74 - 3889.46 \cdot y; \quad (5)$$

$$x5 = -1561.32 + 27.45 \cdot y - 0.12 \cdot y^2; \quad (6)$$

$$x6 = -40236.06 + 459.42 \cdot y; \quad (7)$$

$$x7 = -103142.8 + 1001.875 \cdot y, \quad (8)$$

where y is a calendar year.

This forecast is presented in Table 4 and on the diagram (Figure 2).

There is an interesting assumption that the value of each of the seven input parameters over the next five years will remain at the level of 2019 one by one. The data obtained as a result of 'what-if' analysis show the change of GDP at a fixed value of the parameters $x1$-$x7$; this is presented in Table 5.

The following conclusions were made based on the obtained calculation results and forecasts:

1. With consideration of the fact that 'competitiveness depends on the formation of intellectual capital and ability of the society to perform innovative activities innovation and productivity were identified by economic research as key dri-

vers of competitiveness' [8]. Despite the fact that inventors are namely the basis of innovation-driven development of any country and the fact that Ukraine is one of the leading countries in the world relative to the number of researchers per 10 thousand of the population their work and abilities remain unrequested in Ukraine. Thanks to the model, it can be argued that the increase of the total number of performers of research and development as well as the number of doctors of the sciences involved in research and development for one percent will not lead to GDP growth and growth of the mentioned indices for 5% and 10% may even reduce GDP. A completely opposite situation can be observed with the increase of the number of organizations engaged in research and development as well as of the number of candidates of sciences involved in the implementation of research and development. The projected values of GDP in case if these indicators will remain unchanged over the next five years prove the need for greater involvement of candidates of science in research and development and the growth of the number of organizations engaged in research and development. This influence on GDP input parameters $x1$-$x4$ can be explained by a number of factors.

The low level of expenditures for research and technological development, the preservation of the system of basic budget funding of research institutions as well as the lack of funds stimulated most of the branch-related scientific communities to obtain the status of a state academy of sciences. Therefore, the number of state academies of sciences is constantly growing and funds are unreasonably scattered over many scientific structures, some of which perform their activities inefficiently and have no world-class results.

The demographic structure and quality of research staff is becoming worse. Given the general reduction of the number of researchers, a small influx of young people into the field of the science

Table 4. **Forecast of Input Parameters $x1$-$x7$ and GDP in 2020–2024***

Years	$x1$	$x2$	$x3$	$x4$	$x5$	$x6$	$x7$	GDP
2020	836	60382	5472	10743	14.6	14894.85	17082	1639010
2021	793	47801	4774	6853	13.3	15354.28	18084	1840670
2022	751	35221	4076	2964	11.7	15813.7	19086	2054725
2023	708	22640	3377	0	9.9	16273.13	20088	2281175
2024	665	10060	2679	0	7.9	16732.55	21090	2520019

* The calculations are made by the author.

Table 5. **Change in GDP in 2020–2024 Relative to Each Input Parameters $x1$-$x7$ * Fixed at the Level of 2019**

Years	Parameters, %						
	$x1$	$x2$	$x3$	$x4$	$x5$	$x6$	$x7$
2020	15.28	–24.76	–12.24	22.65	0.20	0.26	0.64
2021	19.49	–38.22	–18.85	34.18	0.38	0.41	–2.87
2022	23.13	–49.84	–24.56	44.13	0.58	0.53	–5.90
2023	25.61	–58.40	–28.77	48.76	0.75	0.62	–8.31
2024	25.68	–60.82	–29.95	41.54	0.86	0.65	–9.59

* The calculations are made by the author.

and the predominance of senior specialists in the research staff composition a serious personnel crisis may occur in the coming years due to the natural outflow of a rather large number of working retirees that are still employed in the field of scholarly research [11].

The attempts to influence the quality of staff renewal through unjustified growth of the number of postgraduate and doctoral students brought no positive results. There is no appropriate R&D base to train a large number of postgraduate and doctoral students (over 25 thousand people) in Ukraine today. Less than a third of Ukrainian candidates and doctors of sciences are employed directly in the field of science as of today. The share of dissertations defended by postgraduate students is also small and a significant part of postgraduate students will not be engaged in R&D works in the future.

There is no viable and effective mechanism for implementation of the state-defined priorities of R&D and technological development in the country. In addition, no system of unbiased and transparent assessment of the effectiveness of the use of funds allocated to this area has been developed; this makes focusing resources to support successful research teams and provide them with modern technological base impossible.

In the USA, for example, 9 out of 10 defended dissertations lead to creation of small R&D enterprises that bring the results obtained during completion of a dissertation to the market. In Europe, this figure is 1:10. In Ukraine, there are no statistical data on this issue; however, the expert estimates give a ratio of about 1:100. A researcher may hardly create a small business for future economic results and financial success in Ukraine. One has to pay indirect taxes on unearned income in advance, while only direct taxes on income should be levied. Lack of mutual trust between the government and the developers leads to this situation. It is the state that shall take care of development of such trust by establishing appropriate financial and tax policy.

2. Having calculated the impact of changes in the share of innovatively active enterprises in the total number of industrial enterprises and the total innovation expenses of industrial enterprises on GDP on the basis of regression analysis we observe an insignificant correlation and virtually no sensitivity of GDP to change these indices by 1%, 5% and 10%, which may be explained by the lack of experience in Ukrainian market environment; there are objective reasons for this, namely insufficient government funding of projects, excessive control by financial institutions, lengthy consideration of projects, lack of relevant legislation aiming at support of R&D development, etc. These and many other reasons created an unfavorable climate for implementation and use of Ukrainian scientific products, including inventions.

In addition to objective reasons there are also subjective conditions interfering with innovative activities of enterprises and organizations. The analysis of these reasons shows the shortcomings in activities of researchers, developers, project managers, that is direct participants in innovative activities. First of all, it is the academic nature of projects that are not adapted to be a real marketable product. Most projects and their results are new from the point of view of science; however, they do not contain ideas about who and why needs the results obtained. And such idea forms the basis for promotion of the results on the market. Today, companies shall address their customers individually and actively involve them in product designing. And since no company has the resources to create a personal experience of communication with each individual client, the companies shall provide it by using a global resources network. K. Prahalad in his book shows how the social and technical structure of the company is coordinated in a way that makes innovation, efficiency and individuality possible at the same time [12]. In addition, S. Robin and T. Schubert proved that 'cooperation with governmental scholarly research organizations increases the number of innovation products but does not affect the innovation process that depends more on the openness and willingness of enterprises to commercialize their results. In addition, cooperation between a state

and a private enterprise in the field of research should not be encouraged at any cost as it may not support all forms of innovation' [13].

The second important reason is overestimation of the contribution of technologies and 'know-how' proposed by scholarly research institutes or universities compared to the difficulties of further commercialization of research results. 'Companies involved in implementation of innovations need to reduce the complexity of innovation projects and to promote the exchange of information as well as to develop mutual understanding with research institutes in the early stages" [5]. The lack of experience in the field of presenting competitive projects is also to be mentioned. Such experience can be gained only by participating in various competitive programs. It is always necessary to take into account the purpose and objectives of the program, its direction and capabilities. However, according to K. Westland, the key factors of successful innovation projects and the process by which innovation is transformed into a profit on the world stage remain mainly uncertain [14].

Innovation processes in Ukrainian economy gained no significant scale; the number of enterprises implementing innovations is decreasing every year and is currently 14—15% that is 3—4 times less than the number of similar enterprises in advanced innovative economies [15]. The science-intensity of industrial production is at 0.3% that is much less than the world level. At the same time, almost a third of the funds allocated to innovation activities are spent for purchase of equipment, while the costs of acquiring rights to new intellectual property or research and technological development are significantly lower. Almost half of innovative enterprises do not finance researches related to their production at all.

Virtually no nationwide or branch-scale innovations have been implemented in Ukraine in recent years. The vast majority of innovations have a local nature; the significance of these innovations does not go beyond individual industries, associations, enterprises. Innovations are mostly implemented to improve products, services or processes that have a short market life and cannot be a long-term source of income. Whereas 'international competitiveness depends on whether domestic companies will be able to constantly maintain and develop the technological leadership that is achieved through innovations' [9].

The cause of this situation is both the lack of own funds of enterprises and the lack of an effective state system of stimulation of innovative activities the proposals on which have been gradually abolished by annual changes to relevant budget and other legislative acts over the past five years.

3. The explanatory model has clearly demonstrated the growth of GDP in case of an increase of the total costs for research and development. If these expenses remain unchanged over the next five years the GDP will decline by at least 9.5% in 2024; thus, elaboration of appropriate and efficient research and development funding programs is necessary. The inefficient Ukrainian system of scholarly research financing inherited from the Soviet times has hardly changed over the years of independence; it remains highly dependent on the state funding. However, there has been a significant reduction in investment in science by both the state and business. The investments in domestic science are extremely small (less than 1% of GDP), which objectively deprives it of the ability to perform the function of effective R&D support for innovation-driven economic development. As a result of such level of financial support science in Ukraine has mainly cognitive as well as social and cultural functions, as it is known from world practice that the possibility of the impact of science on the level of economic development arises if it is funded by more than 1.7% of GDP.

One of the reasons of ineffectiveness of innovation policy in Ukraine is the lack of adequate funding of scholarly research. Given that the European standards of spending on research needs remain too high for Ukraine [16] it is necessary to focus one's efforts on a more differentiated and rational use of available material resources by means of im-

proving the mechanism of stimulation of innovation R&D activities.

Based on the mentioned above and the examined works of foreign authors several approaches to increase the share of the innovation factor in GDP growth can be proposed. This is possible by means of:

- the preservation and increase of R&Dcapacity of Ukraine on the basis of development of regional innovation systems using a holistic approach to their formation and support [17];
- the identification of national priorities in the field of science and technology, which should be implemented together with the relevant investment, taxation and depreciation policies as well as immediate implementation of relevant innovative transformations and targeted structural and functional changes in the economy on this basis;
- changes of the structure of industrial products export with a predominance of products with a high rate of value added, in other words, increase of the "intellectualization" of exports;
- the promotion of the movement of direct investments in the field of science, technology and innovative activities both nationwide and internationally;
- government support of venture business (with the focus on venture financing that favors the diversification of large industrial companies and the formation of small and medium-sized independent enterprises that enter the new technologies market with the goal of making competitive products. The process of economic restructuring will be accelerated and self-organized in this way; as a result, goods and services with significant added value will be produced). 'Investing in venture capital can be seen as a sign of the dynamic generation of new companies' [18];
- the formation of an effective system of attracting and increasing the turnover on the stock market of the results of intellectual activities and the share of securities issued by small high-tech companies;
- the modernization of domestic industry with the creation of modern production enterprises based on the use of high technologies, including the provision of preferential depreciation and investment credits;
- reduction of the income tax for a certain part of the total costs of investment in equipment as well as elaboration of an integral practice-focused innovation strategy that creates competitive advantages. Based on many years of experience of selected leading companies B. Kahlfuss proposed a concept that creates a methodological basis and practical support for the development of a successful innovation strategy, which allows the identification of the main directions and options for action and adjustment through recommendations from practical experience [19]. In turn, G. Skarzynski and R. Gibson demonstrate in their work how to effectively organize the innovation process, expand the innovation strategy and maximize the profitability of innovation on the basis of numerous examples of business strategies [6] and G. Trauffler formulates the general concept of strategic management based on the best practical examples that illustrate the processes, methods and organizational structures that improve the successful management of radical innovation that is the key to growth [7];
- further R&D integration of Ukraine, which is favorable to the large-scale involvement of human, material and financial resources in technological development, increase of high-tech products and technologies foreign trade and formation of a 'knowledge-based economy'. 'Establishing the right connections in the international innovation environment is more important than any other factor in the development of innovation systems, which also contributes to the diffusion of knowledge and innovation' [4];
- patenting abroad and preservation of intellectual property rights for Ukrainian inventors and manufacturers;
- application of preferential taxation of funds of industrial enterprises, which aims at the deve-

lopment of high technologies as well as of the costs of research and development.

Possibilities of increase of innovation capacity and its direct influence on economic development are as follows. Ukraine has a rather stable position in the field of education. This position can be strengthened primarily through a more effective system of continuous professional development ('lifelong learning'). Another aspect of achieving higher values of relevant indicators is the use of young professionals entering the labor market in the relevant field of training and education.

There are certain reserves in increasing the financial support of innovative activities in the public and private sectors. At the same time increase of funding for research and technological development as well as innovation in the private sector can be done through creation of appropriate conditions that will encourage investment in innovation processes and making new products. Considering the experience of rapidly developing countries it should be expected that the level of spending on innovation, research and technological development in terms of gross domestic product can be doubled in the private sector in 12 years and the share of public funding of research and technological development in terms of the GDP share can be increased by 1.5—1.7 times for the same period (at constant prices) [20].

Based on the values of innovative activities of small enterprises and activities of venture funds at the moment an increase of these values in the next five years can be expected; however, this will require appropriate institutional changes and taking measures aiming at stimulation of innovation (primarily of fiscal nature). 'In order to avoid stagnation in the field of technological development companies should pay more attention to new promising technologies and take care of their relevance for the development of innovation products. Thus, the ability to gain profit from technological advances or technological breakthroughs often leads to making successful innovation products by a company and secures its market position.' [21].

It should be noted that the general dynamics of many values depend primarily on the rate of structural changes in the Ukrainian economy, strengthening its sectors with a high degree of processing and increasing their share in the total production output, which significantly improves the mechanism of public management of innovation-driven development. However, even in case of the favorable developments this will not make it possible to reach the level of EU leading countries but will help to increase general level of innovative activities in Ukraine to the average EU level in terms of the innovation index.

One should not expect an increase of Ukraine's position relative to other European countries when implementing an 'inertial' innovation policy; it is more likely that Ukraine will begin to lose even those objectively small advantages that still remain. As a result, the country may be at the bottom of the list of countries analyzed and evaluated using the European Innovation Scoreboard tools.

Taking into *consideration* the *mentionedabove* it is advisable to consider innovation activities and priority measures relative to development from the standpoint of the following main priorities:

- adjustment of the R&D and innovation system of Ukraine to new civilization and global challenges;
- reorientation of the innovation process to market demand and the consumer;
- creation of favorable conditions for inventors of innovations, increase of innovative activities of business;
- Informatization of the society, a system-defined approach to the management of R&D and innovation-driven development.

In order to improve the strategy of innovation-driven development of Ukraine an economic and mathematical model that demonstrates the influence of the innovation factor on the change of GDP has been developed based on multiple regression analysis:

$$\begin{aligned} GDP = {} & 5272.37535 \cdot x1 - 51.444 \cdot x2 - \\ & - 456.65 \cdot x3 + 143.643 \cdot x4 + 6406.36 \cdot x5 - \\ & - 15.141 \cdot x6 + 146.3498 \cdot x7 - 1202413. \end{aligned}$$

This model helps to understand the functioning and development of innovation processes, to reveal the cause-and-effect as well as functional relations of individual indicators of innovation-driven economic development, to determine the required level of innovation factor through maximal use of hidden innovation capacity.

Ukraine shall increase its R&D and production potential in promising areas in advance following the example of innovation-active countries in order to successfully implement its innovation-driven development strategy. The basis of the strategic course, its fundamental principle should be the implementation of government policy aiming at choosing an innovation strategy of structural rearrangement for economic growth; this will lead to the establishment of Ukraine as a competitive high-tech state. This strategy will require the use of domestic R&D and technological potential and will make its contribution to the innovation-driven development of the national economy determinant. The existing intellectual, R&D potential gives a reason to hope for this; combined with the European integration tasks such an ambitious goal can form the basis not only for the economic strategy of the state but also for the political consolidation of the nation.

REFERENCES

1. European Innovation Scoreboard Edition 2021. URL: https://interactivetool.eu/EIS (Last accessed: 02.07.2021).
2. Clauser, O., Kalmbach, P., Pegoretti, G., Segnana, L. (1993). *Technological Innovation, Competitiveness and Economic Growth*. Berlin: Duncker and Humblot. 385 p.
3. Baron, W., Häußler, S., Luther, W., Zweck, A. (2003). *Innovations- und Technikanalyse: Chancen und Barrierenbetrieblicher Integration*. Frankfurt [u.a.]: Campus Verl. 343 p.
4. Morone, P., Taylor, R. (2010). *Knowledge Diffusion and Innovation: modelling complex entrepreneurial behaviours*. Cheltenham, UK; Northampton, USA: Edward Elgar. 177 p.
5. Hauschild, J., Salomo, S. (2004). *Innovations management*. München: Verlag Franz Vahlen. 600 p.
6. Skarzynski, P., Gibson, R. (2008). *Innovation to the core*. Boston, Massachusetts: Harvard business press. 295 p.
7. Trauffler, G., Tschirky, H. (2006). *Sustained innovation management*. Great Britain: Palgrave macmillan. 242 p.
8. Carayannis, E., Grigoroudis, E. (2012). Linking innovation, productivity, and competitiveness: implications for policy and practice. *The Journal of Technology Transf*., 39, 199—218.
9. Corsten, H. (1991).*Die Gestaltung von Innovations prozessen*. Berlin: Erich Schmidt Verlag. 172 p.
10. National economic strategy 2030. Economic audit of the country. Re: think. URL: https://nes2030.org.ua [in Ukrainian] (Last accessed: 26.05.2021).
11. Popovych, O. S., Kostrytsa, O. P. (2017). Restoring the scientific potential of Ukrainian science: necessity and real prospects. *Science and innovation*, 13(4), 5—12. https://doi.org/10.15407/scine13.04.005.
12. Prahalad, C. K. (2009). *Die Revolution der Innovation*. München: Redline Verlag, Finanzbuchverlag GmbH. 336 p.
13. Robin, S., Schubert, T. (2013). Cooperation with public research institutions and success in innovation: Evidence from France and Germany. *Research Policy*, 42(1), 149—166. https://doi.org/10.1016/j.respol.2012.06.002.
14. Westland, C. (2008). *Global Innovation Management*. Chicago: Palgrave Macmillan. 383 p.
15. Eurostat official website. URL: https://ec.europa.eu/eurostat (Last accessed: 20.04.2021).
16. Shubin, O. O., Sadiekov, A. A. (2008). Regulation of the innovation sphere: the experience of the Eurorean Union. *Bulletin of the International Nobel economic forum*, 1, 273—276 [in Ukrainian].
17. Pidorycheva, I. Yu. (2015). Topical issues of the national and regional innovation system development. *Science and innovation*, 11(2), 19—28. https://doi.org/10.15407/scine11.02.019.
18. Hotz-Hart, B. (2008). Innovations leistungsfähigkeit der Wirtschaft: hohes Niveaubeimässiger Dynamik. *Neue Zürcher Zeitung*, 253, 92.
19. Kahlfuss, B. (2013). *Partizipative Innovation: ein Konzeptzur Schaffungnachhaltiger Wettbewerbsvorteile*. Hamburg: Selbstverl. Britta Kahlfuss. 332 p.
20. Profitables Wachstumdurch Innovation. URL: https://www.kompass-projektpartner.com/content/profitables-wachstum-durch-innovation (Last accessed: 24.04.2021).
21. Dodgson, M. (2008). *The management of technological innovation*. Great Britain: Oxford University Press. 373 p.
22. Official site of the state statistics committee of Ukraine. URL: http://ukrstat.gov.ua [in Ukrainian] (Last accessed: 02.06.2021).

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КОРЕЛЯЦІЙНО-РЕГРЕСІЙНИЙ АНАЛІЗ ВПЛИВУ ІННОВАЦІЙНОГО ФАКТОРА НА ТЕМПИ ЗРОСТАННЯ ВВП

Вступ. Для вдосконалення інноваційної політики з урахуванням чіткого визначення співвідношення між показниками інноваційного розвитку та значеннями ВВП необхідно критично оцінити вплив інноваційного фактора на економічне зростання країни.

Проблематика. Потребою є постійне корегування й удосконалення інноваційних стратегій з урахуванням нових цивілізаційних викликів, а також активізація науково-технічної діяльності національних економік шляхом наукових досліджень впливу інноваційного фактора та чіткого визначення кореляційної залежності між показниками інноваційного розвитку та значеннями ВВП.

Мета. Прогнозні розрахунки обсягів ВВП в розрізі років залежно від зміни показників інноваційного розвитку, а також формування практичних рекомендацій щодо підвищення інноваційного потенціалу України через застосування ефективних механізмів сприяння інноваційності.

Матеріали й методи. Для виявлення впливу інноваційного фактора на темпи зростання ВВП було побудовано математичну модель з використанням кореляційно-регресійного аналізу; для демонстрації та візуалізації результатів дослідження використано табличний та графічний методи.

Результати. Запропоновано економіко-математичну модель на основі кореляційно-регресійного аналізу, що демонструє вплив інноваційного фактора на темпи зростання ВВП. Така модель допомагає зрозуміти функціонування та розвиток інноваційних процесів, розкриваючи причинно-наслідкові й функціональні зв'язки окремих показників інноваційного розвитку економіки, а також дає можливість визначити необхідний рівень розвитку інноваційного фактора за рахунок максимального використання прихованого інноваційного потенціалу.

Висновки. Основою стратегічного курсу має стати реалізація державної політики, спрямованої на вибір інноваційної стратегії структурної перебудови економіки України. Ця стратегія вимагатиме використання вітчизняного науково-технічного потенціалу і зробить його вклад в інноваційний розвиток національної економіки вирішальним.

Ключові слова: інновація, інноваційний розвиток, Європейське табло інноваційного розвитку, множинно-регресійний аналіз, Стратегія інноваційного розвитку України, інноваційний потенціал.