УСТОЙЧИВОЕ РАЗВИТИЕ НАЦИОНАЛЬНОЙ ЭКОНОМИКИ И ЕЕ СЕКТОРОВ

SUSTAINABLE DEVELOPMENT OF THE NATIONAL ECONOMY AND ITS SECTORS

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RESEARCH OF FACTORS OF GROWTH OF INNOVATION ACTIVITY IN THE REPUBLIC OF BELARUS

Today, innovative activity, generating an increase in export revenue, plays an increasingly important role in the Belarusian economy and not only. The authors of the article substantiate the need to study the experience of 10 countries of the world in order to identify the elements of the economic mechanism, influencing which it is possible to increase the effectiveness of the information and communication technologies sphere and strengthen its competitive position. This study examines 35 indicators for ten countries for the period from 2006 to 2020. Using econometric methods of analysis, the authors constructed a regression model of the dependence of the amount of research and development costs (COST) (percentage of GDP) on twelve exogenous variables, analyzed the degree of influence of these variables and the possibility of managing them.

Key words: innovation activity, econometric model, innovation susceptibility, research costs, innovation activity, variable research.

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ИССЛЕДОВАНИЕ ФАКТОРОВ РОСТА ИННОВАЦИОННОЙ ДЕЯТЕЛЬНОСТИ В РЕСПУБЛИКЕ БЕЛАРУСЬ

Сегодня инновационная деятельность, генерируя рост экспортной выручки, играет все большую роль в белорусской экономике и не только. Авторами статьи обоснована необходимость исследования опыта 10 стран мира для того, чтобы выявить элементы хозяйственного механизма, воздействуя на которые можно увеличить результативность деятельности сферы информационно-коммуникационных технологий и укрепить ее конкурентные позиции. В рамках настоящего исследования рассматриваются 35 показателей для десяти стран за период времени с 2006 по 2020 г. С применением эконометрических методов анализа авторами была построена регрессионная модель зависимости величины затрат на исследования и разработки (COST) (процент от ВВП) от двенадцати экзогенных переменных, проанализирована степень влияния этих переменных и возможность управления ими.

Ключевые слова: инновационная деятельность, эконометрическая модель, инновационная восприимчивость, затраты на исследования, инновационная активность, исследование переменной.

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Introduction. The relevance of the topic of this study is determined by the processes taking place in the economy of the Republic of Belarus and aimed at reforming the entire economic mechanism in connection with its reorientation to the post-industrial type of the sectorial structure of gross domestic product.

Table 1

Rating of the Global Innovation Index

Country	Overall GII	Institutions	Human capital and research	Infrastructure	Market sophistication	Business sophistication	Knowledge and technology outputs	Creative outputs
Switzerland	1	13	6	2	6	4	1	2
Sweden	2	9	2	3	11	1	2	5
United States of America	3	12	11	23	2	2	3	12
United Kingdom	4	15	10	10	4	21	10	4
Republic of Korea	5	28	1	12	18	7	8	8
Netherlands	6	6	14	16	31	5	7	7
Finland	7	2	4	11	19	6	5	16
Russian Federation	45	67	29	63	61	44	48	56
Ukraine	49	91	44	94	88	53	33	48
Belarus	62	85	38	59	101	69	37	93
Angola	132	128	119	125	127	130	129	130

Source. Compiled by the authors based on [2, 3].

Also, the relevance of innovation activity is determined by social priorities, placed in accordance with the goals of a particular economic system. This area is directly regulated by the State. The ratio of results and costs, which determines the very possibility of innovation, can be different and is determined by the demand [1].

The status of the issue. According to the rating of the Global Innovation Index (GII), in 2021 the Republic of Belarus ranked 62nd among 132 leading countries in terms of investment in innovation (Table 1) [2].

In general, Belarus is in the golden mean. In terms of the number of institutions, Belarus ranks 85th compared to Ukraine (91st place). Belarus (38th place in human capital and research). It is inferior to Russia (29th place), but ahead of Ukraine (44th place). In terms of infrastructure, Belarus ranks 59th, ahead of Russia (63rd) and Ukraine (94th). In terms of market and business sophistication, as well as creative results, Belarus (101st, 69th and 93rd place, respectively), is inferior to Russia (61st, 44th and 56th place, respectively) and Ukraine (88th, 53rd and 48th place, respectively). According to the results in the field of knowledge and technology Belarus (37th place). It is inferior to Ukraine (33rd place), but overtakes Russia (48th place). The following table shows the rankings of Belarus over the past three years, noting that data availability and changes to the GII model framework influence year-on-year comparisons of the GII rankings. The statistical confidence interval for the ranking of Belarus in the GII 2021 is between ranks 49 and 64 (Table 2).

Belarus performs better in innovation outputs than innovation inputs in 2021. This year Belarus ranks 68th in innovation inputs lower than both 2020 and 2019. As for innovation outputs, Belarus ranks 62nd. This position is lower than last year but higher than 2019 (Table 3).

Table 2

Belarus' place in the Global Innovation Index ranking for 2019–2021

Indicator	2019	2020	2021
GII	72	64	62
Innovation inputs	50	67	68
Innovation outputs	95	61	62

Source. Compiled by the authors based on [4].

Table 3

Countries by spending on science as % of Gross Domestic Product (GDP)

Country	R&D expenditures as % of GDP, 2019
South Korea	4,24
Switzerland	3,37
Sweden	3,25
Taiwan	3,16
Japan	3,14
Austria	3,09
Germany	2,94
USA	2,74
France	2,25
China	2,12
Belarus	0,58
Kazakhstan	0,10

Source. Compiled by the authors based on [5, 6].

As we can see, Belarus has something to strive for in relation to spending on science as a % of GDP [7].

Problem statement, object selection. As follows from the above, the issue of improving the efficiency of the functioning of the Belarusian innovation activity and its competitiveness in the world market is of great importance for the economy of the Republic of Belarus as a whole. However, for the successful development and further prosperity of this industry, it is necessary to apply an integrated approach to assessing and analyzing the effectiveness of both individual enterprises and the entire industry [8]. One of the most common and widely used groups of methods for carrying out such an analysis are econometric methods. The use of such methods makes it possible to simulate the dynamics of individual indicators in their relationship with other elements of the system, which allows predicting the further development of these indicators and the system as a whole with a sufficiently high accuracy. Using such methods, in this study it is proposed to study the experience of foreign countries and identify the elements of the economic mechanism, influencing which it is possible to increase the effectiveness of innovation and strengthen its competitive position in the world market. To achieve this goal, it is planned to build an econometric model based on available statistical data for ten countries of the world over a period of time from 2006 to 2020. Such states as Ukraine, the Russian Federation, Sweden, Great Britain, France, India, China, the USA, Japan and the Republic of Belarus were taken, paying close attention to the development of innovation activities and gradually achieved some success in this field, significantly increasing the share of innovation in their economy [9].

Selection of variables. At the next stage of the study, the variables for the future model were selected. The authors of the study suggested that all factors affecting innovation can be divided into three groups: demographic factors, economic factors and scientific and technical factors [10]. The first group is proposed to include population growth (% per year), labor force with tertiary education, researchers (per million people). The second group includes the inflow of net foreign investment (% of GDP), the growth rate of high-tech exports, government spending on education, inflation, unemployment (% of the labor force), and the interest rate. The third group includes the number of patent applications from residents, the duration of secondary education, the number of procedures for starting a business (Table 4).

Building a model. In total, at the first stage of the study in all groups, the authors considered 35 different indicators using World Bank data that are freely available [11]. Based on the correlation analysis, 12 variables were selected for the future model:

1. Research and development costs (COST), percentage of GDP – y. An endogenous variable. It characterizes the place of innovation activity in the national economy and is of great importance for the Republic of Belarus at the moment.

2. Duration of secondary education (ED) – x_1. An exogenous variable. The functioning of innovation activity is closely related to the time lag of secondary education: the better and longer secondary education is, the more investments need to be made in innovation activity.

3. Net foreign investment inflow (GDP), percentage of GDP – x_2. An exogenous variable. The inflow of net foreign investment is closely related to the activity in the innovative direction.

4. The growth rate of high-tech exports (GDPGROWTH) – x_3. An exogenous variable. It directly depends on the growth of innovation in the country.

5. Government spending on education (GOVERMENTCOST) (% of total) – x_4. An exogenous variable. Innovative activity requires highly qualified personnel with high-quality higher education.

6. Growth rate (GROWTHRATE) – x_5. An exogenous variable. The impact of innovation on the pace of economic growth is manifested as a consequence of an increase in labor productivity and capital.

7. The number of patent applications from residents (PATENT) – x_6. An exogenous variable. Innovation is the driving force behind the growth of patent applications from residents.

8. Population growth (POPULATION GROWTH) (% per year) – x_7. An exogenous variable. The larger the population in quantitative terms, the higher the share of the introduction of innovative developments in the real sector of the economy.

Table 4

Factors influencing the growth of innovation activity

Demographics	Economic	Scientific and technical
Population growth (% per year)	Net foreign investment inflow (% of GDP)	Number of patent applications from residents
	The growth rate of high-tech exports	
Tertiary education workforce	Government spending on education	Duration of average education
	Inflation	
Researchers (per million people)	Unemployment (% of the labor force)	Number of procedures for starting a business
	Interest rate	
	GDP growth (% per year)	

Source. Author's development.

9. Inflation (INFLATION) – x_8. An exogenous variable. The impact of inflation should always be taken into account in innovative calculations, even if the rate of price growth is low. Inflation significantly changes the profitability of certain

projects, both focused on the domestic market and betting on the export of innovative products abroad.

10. Unemployment (UNEMPLOYMENT) (% of the workforce) – x_9. An exogenous variable. The quantity and quality of innovation correlates directly with unemployment.

11. The workforce with tertiary education (THREEEDUCATION) – x_{10}. An exogenous variable. This is the basis for innovation.

12. Researchers (RESEARCHERS) (per million people) – x_{11}. Exogenous variable. Conducting a large variety of scientific research is the basis for the growth of innovation in the Republic of Belarus.

13. The interest rate (RATEPROCENT) – x_{12}. An exogenous variable. The development of innovation activity in the country is the basis for the successful functioning of the national economy [12].

After selecting variables using the software capabilities of the EViews package, an econometric model of the form was constructed:

$$Y = 0.955746 + 0.112812x_1 - 0.018887x_2 - 0.000191x_3 - 0.054927x_4 - 3.22\text{E-}09x_5 + 2.33\text{E-}09x_6 + 0.007787x_7 + 0.004276x_8 - 0.009363x_9 + 0.001233x_{10} + 0.000288x_{11} - 0.017642x_{12}.$$

The R-squared value shows how much the selected factors explain the variation of Y. In this case, it is 77%.

To improve the quality of the Probability model, we remove the x's with the least impact on Y – growthrate, populationgrowth, threeeducation, since their Probobility values are >0.5 [13].

The improved model looks like:

$$Y = 1.024666 + 0.105937x_1 - 0.018334x_2 - 0.000186x_3 - 0.054432x_4 + 2.37\text{E-}06x_6 + 0.004371x_8 - 0.009955x_9 + 0.000290x_{11} - 0.018073x_{12}.$$

Interpretation of the model. As can be seen from the model constructed above, the exogenous variables under consideration have a different impact on the share of research and development costs in GDP. At the final stage of the study, it is proposed to analyze the economic nature of these differences. To begin with, we will rank exogenous variables by the strength of their influence on the endogenous variable, based on the magnitude of the coefficients b_1, b_2, b_3, b_4, b_6, b_8, b_9, b_{11}, b_{12}, as well as the significance level of these variables, determined by the value of their t-statistics (Table 5).

Table 5

Model analysis of the form $Y = 1.024666 + 0.105937x_1 - 0.018334x_2 - 0.000186x_3 - 0.054432x_4 + 2.37\text{E-}06x_6 + 0.004371x_8 - 0.009955x_9 + 0.000290x_{11} - 0.018073x_{12}$

Dependent Variable: COST				
Method: Panel Least Squares				
Date: 01/20/21 Time: 20:18				
Sample: 2006 2020				
Periods included: 15				
Cross-sections included: 21				
Total panel (balanced) observations: 315				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ED	0.105937	0.026411	4.011141	0.0001
GDP	–0.018334	0.005117	–3.582681	0.0004
GDPGROWTH	–0.000186	5.96E-05	–3.110364	0.0020
GOVERMENTCOST	–0.054432	0.008526	–6.384219	0.0000
PATENT	2.37E-06	2.97E-07	7.972024	0.0000
INFLATION	0.004371	0.001493	2.927991	0.0037
UNEMPLOYMENT	–0.009955	0.006208	–1.603530	0.0099
RESEARCHERS	0.000290	1.62E-05	17.87749	0.0000
RATEPROCENT	–0.018073	0.003584	–5.042997	0.0000
C	1.024666	0.221386	4.628414	0.0000
R-squared	0.773011	Mean dependent var		1.398198
Adjusted R-squared	0.766312	S.D. dependent var		1.005252
S.E. of regressin	0.485951	Akaike info criterion		1.425814
Sum squared resid	72.02534	Schwarz criterion		1.544944
Log likelihood	–214.5658	Hannan-Quin criterion		1.473411
F-statistic	115.4083	Durbin-Watson stat		0.650242
Rob (F-statistic)	0.000000			

Source. Author's development.

As can be seen in the figure, the variable x_1 (b_1 = 0.105937), which represents the duration of secondary education, has the greatest influence on Y. As noted above, the higher the initial level of education, the more opportunities there are for the growth of the number of innovations. The second most significant variable is x_8 (b_8 = 0.004371) – inflation. This exogenous variable must necessarily be taken into account when planning research and development costs, since the same amount for costs today will differ from the same amount tomorrow. X_{11} (b_{11} = 0.000290) has a slightly smaller effect on the endogenous variable – researchers. The impact of this variable can be explained by the direct impact of the country's financial stability on the economic conditions of innovation. The variable x_6 (b_6 = 2.37E-06) characterizes the number of patent applications from residents. The more applications, the higher the demand for innovation. Variable x_3 (b_3 = –0.000186) – the growth rate of high-tech exports has a slightly smaller impact on research and development costs, and the results of such an impact are manifested with a time delay of one year. This fact can be explained by the fact that innovation activity reacts to changes in the conditions of innovation growth not instantly, but after some time, exactly the same as to changes in the quality of national higher education. X_9 (b_9 = –0.009955) – unemployment has a slightly smaller effect on the endogenous variable. The impact of this variable can be explained by the indirect and direct impact of the country's financial stability on a number of macroeconomic indicators and on the economic conditions for innovation. Next in terms of the impact on the variable under study is x_{12} (b_{12} = –0.018073) – the interest rate. A more loyal interest on the loan will give more opportunities for innovation activity of the country as a whole. Then, according to the level of impact on the endogenous variable, there is x_2 (b_2 = –0.018334) – the inflow of net foreign investment. The higher the investment in innovation, the better the product will be at the output. And further, the level of research and development costs is influenced by the exogenous variable x_4 (b_4 = –0.054432) – government spending on education. Education is the starting point in any field of knowledge, including innovation [14].

Conclusions. Within the framework of this study, 35 different indicators for 10 countries of the world over the past 15 years were considered in order to build an econometric model of the dependence of the share of research and development costs (percentage of GDP) on other variables. In the constructed model of twelve exogenous variables, the duration of secondary education, inflation, researchers, the number of patent applications from residents, the growth rate of high-tech exports, unemployment, the interest rate, the inflow of net foreign investment, government spending on education, which the authors of the study consider the foundation for creating new innovations, have the greatest significance [15]. As shown by the analysis of variance, these variables in comparison with the rest are least susceptible to variability, as also evidenced by the value of the standard deviation. However, according to the authors, in order to achieve the desired level of research and development costs, it is necessary to have a comprehensive impact on all the variables proposed in the model.

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