Innovation and Investment Factors in the State Strategic Management of Social and Economic Development of the Country: Modeling and Forecasting

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Abstract

The aim of the article is the modeling of impact of innovative and investment factors on the social and economic development of Ukraine, and forecasting Ukraine's GDP growth in the short term to improve the state strategic management. The model-based approach moves away from classical regression analysis and instead uses combination of production functions and regression analysis. The forecast was made for a short-term period by means of Box-Jenkins method (ARIMA) with the use of Statistica. By means of the regression model, there was established that forecast values of GDP volume over the long term will gradually decrease. It was found out that the highest priority factors of a competitiveness according to the innovative component of Ukraine are the amount of scientific and technological works, a number of innovative technologies and technological processes introduced, fixed investments, a number of innovative products sold. The effective investments in basic capital and increase of sold innovative products volume will also cause GDP growth. All these require the development and realization of the preventive measures, improvement of state programs of social and economic development and implementation of state policy.

Keywords 1

Regression analysis, production function method, forecast, GDP, innovative and investment factors, state programs of social and economic development

1. Introduction

Modern science uses many methods to assess the impact of factors on the level of social and economic development of the country, but a special place is occupied by correlation regression analysis. Multifactor correlation-regression analysis allows to estimate the degree of influence of the factors that are included in the model on the performance indicator [1]. The use of machine learning tools for economic decision-making remains important today.

The state strategic management is a functional system involved in the development and implementation of the strategy of social and economic development of the state, regions, cities, districts, municipalities. The mechanism of state strategic management is in the form of an integrated system of measures conducted by the management subject on the basis of functions, principles, predicates, social and economic development forecasts, in the direction of the control object

MoMLeT+DS 2021: 3rd International Workshop on Modern Machine Learning Technologies and Data Science, June 5, 2021, Lviv-Shatsk, Ukraine
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(economic quantifier) to ensure the effective functioning towards achieving social and economic goals. The state strategic management based on organizational and legal principles. Organizational principles include: planning and forecasting, innovation and investment dynamics, technological progress, optimal engagement of human and intellectual capital in process of reproduction of material goods and services [2]. Modeling and forecasting of innovation and investment dynamics give the information that serves as a basis for social and economic development forecasts for the country. The results of forecasting have an influence on action strategic plan in a state management, featuring the economic and social programs. It can be said that the economic and social programs orientate towards a strategy of social and economic development of the country.

Gross domestic product (GDP) is one of the most important indicators of social and economic development of the country. Within a market economy, the innovations and investments are the important factors for the production efficiency improvement and competitiveness. The world's experience shows that a country should, first of all, concentrate its efforts on innovations, forming of the effective business environment that provides a sustainable social and economic development of the country based on the use of investments and intellectual potential [3]. The considered and laid GDP forecasting results of the country promote the definition and formation of the demand for innovations and investments [4], building of potential needs and market condition forecasts, make the consideration of the competitive advantages of the innovative goods and services important [5]. All this is necessary for the adequate scientific ideas system building concerning formation of the state programs of social and economic development of the country.

State programs of social and economic development for the strategic perspective are developed in accordance with the country's GDP forecasts. It is important to forecast GDP based on innovation and investment factors, which are the foundation of any developed economy. And in this way, the state programs of social and economic development of Ukraine should be based on analytical results of forecasting directions of innovative development of the country. This will allow the government to concentrate investment and human resources for implementation competitive advantages and ensuring progressive technological structural changes in economy. There is a certain demand for further study of the investment and innovative factors effect on GDP of Ukraine with the application of the econometric modeling. Based on the aforesaid, the development of the existing and building of the new dynamics models is up-to-date and essential because of their theoretical value and applied meaning.

The aim of the article is the modeling of impact of innovation and investment factors on the social and economic development of Ukraine, and Forecasting Ukraine's GDP growth in the short term to improve the state strategic management. The model-based approach moves away from classical regression analysis and instead uses combination of production functions and regression analysis.

2. Literature review

Representatives of classical economics [1; 6] offered lots of ideas, which are used in the present-day theory of growth. On the basis of these models there are completed multiple parsing tasks and forecasting of social and economic development.

Scientists considered different factors that influence social and economic development and GDP growth, for example, foreign direct investments [7], public expenditure [8], various economic, industrial, financial indicators [9] etc.

We wish to emphasize a research team [10; 11], who included such factors as innovative products, technological processes into growth models. From those scientific papers there was identified that the economic growth can result from research and development (R&D) sector work (through research and development works increase) or innovations sector of the enterprises (through costs of the enterprises introducing innovations increase). The higher is the rate of social and economic growth of the country the more significant for the social and economic growth is the results of intellectual work of personnel. The value of the innovation, science and technology spheres in the economy of the developed countries continuously grows together with the growth of GDP.

Most countries with the developed economy have to stimulate the social and economic advance, however, such growth requires innovations and investments. The innovative and investment issues study is mostly concentrated on the study of the organization forms of innovative activity,

occupational groups, patent activity [12]. The scientific studies are mostly focused on the process of innovations development and introduction, study of the specific elements of this process [13].

For many years there exists a trend to compare and analyze the innovative activity at the domestic level [14] with due consideration of data bulks. The most popular for the innovative and investment factors diagnostics and evaluation appear to be expert methods, simulation modeling, correlational and regressive and factorial analysis, principal components method, fuzzy sets, index analysis, neural networks, expert systems [15]. The complexity of the subject, data availability and mastered mathematical tools exert an influence on model choice.

Economic and mathematical modeling and forecasting confer the possibility to use the results of calculations in the planning of social and economic development of the country in order to provide scientific validation and plans optimization. Based on econometric modeling there is defined the dependence of GDP growth on a change of specific factors: the investment factors of reproduction and renewal, the innovative growth results, number of people involved in the national economy in the context of educational background [15], intramural expenditures for the research and development (R&D), use of advanced technologies, created advanced manufacturing technologies [16]. The received dependences give an opportunity to set GDP growth rate on the change of each model factor and evaluate the structural changes influence level in separate indices on GDP growth rate.

The general economic equilibrium method is the best suited for the social-economic forecasting, which allows creating complex, non-linear models with theoretical underpinning of non-linear links. Among foreign models there may be distinguished the Norwegian MSG6 model [17], which considers innovation development factor through the innovative economy sector, and GDP forecasting model presented in the scientific work [18] is based on branch forecasts of the relevant ministries.

The author offers to use the production function method for the econometric modeling, to establish the dependence of GDP growth of Ukraine on the innovation and investment factors, and make forecast of social and economic development of the country for a short period of time.

3. Methodology

Using the production function method, there was carried out the modeling of GDP (Y) volume with the consideration of the amount of introduced new technologies, technological processes, total costs of the enterprises, introducing innovations and volume of financing of the research and development works.

In the economic researches the production function is mostly used in the form of single equation, where the output components are united into a single scalar value (y), and the amount of different production resources (factors x_i) is reduced to minimum that gives the opportunity to calculate the functions parameters.

$$y = f(x_1, x_2, \ldots, x_n). \quad (1)$$

In scientific works [16, 19] the authors emphasize the importance of influence new technologies and technological processes, total costs of the enterprises introducing innovations, financing of the research and development works on economic growth and GDP.

In [17] the relationship between the number of completed research and development works, research and development works volume and the number of the inventions used was studied.

Ramadani [20] found a relationship between the number of granted patents, the number of organizations conducting the research studies and explorations and the number of inventions used.

Morris [21] found a relationship between research and development works volume, number of completed research and development works and financing of research and development works.

Kovchuha [22] investigated the impact of fixed investment, volume of sold innovative products, number of completed research and development works on the total costs of the enterprises introducing innovations

We took into account the research of scientists and developed an original model. To build the econometric model there was carried out the statistic information analysis of Ukraine within the period from 2005 to 2019. In the result of the carried out analysis there was received the following econometric dependence:

$$Y = b x_3^{\alpha} (\ln x_4)^{\beta} (\ln x_9)^{\gamma}, \quad (2)$$

$$x_4 = a_4 + a_5 x_1 + a_6 x_1^2 + a_7 x_2 + a_8 x_2^2 + a_9 x_{10} + a_{10} x_{10}^2,$$

$$x_8 = a_{16} + a_{17} x_5 + a_{18} x_7, \; x_9 = a_1 + a_2 x_6 + a_3 x_{10}$$

$$x_{10} = a_{11} + a_{12} x_6 + a_{13} x_6^2 + a_{14} x_8 + a_{15} x_8^2,$$

where Y – GDP volume; x_1 – fixed investment, mln. UAH; x_2 – volume of sold innovative products, mln., UAH; x_3 – applied new technologies, technological processes, units; x_4 – total costs of the enterprises introducing innovations, mln. UAH; x_5 – number of granted patents in Ukraine, units; x_6 – research and development works volume, mln. UAH; x_7 – number of organizations conducting the research studies and explorations, units; x_8 – number of the inventions used, units; x_9 – financing of the research and development works, mln. UAH; x_{10} – number of completed research and development works, units.

Other multifactor model values (b,α, β and γ) are the evaluating parameters. The model parameters are determined according to the statistics data.

The forecast of the main innovation factors of Ukraine was made for a short-term period by means of Box-Jenkins method (*ARIMA*) with the use of Statistica. In *ARIMA* model, the level of the time series y_t is defined as a calculated amount of its previous values and residual values u_t – current and previous. The applied modeling method let provide adequate representation of the object, significance of the estimated models parameters and reliable results. All the built models are adequate, significant and are characterized by high level of statistic performance.

4. Empirical results

Analyzing the behavior of autocorrelation and partial autocorrelation functions there may be drawn a conclusion that ARIMA (0,0,1) is the best suited model for the range of fixed investments, for the range of granted patents - *ARIMA*(1,0,0), for the range of sold innovative products - *IMA*(1,0,0), for the range of implemented new technologies and technological processes - *ARIMA*(0,0,1), for the range of scientific and technological work volume - *ARIMA*(1,0,0), for the range of number of organizations completing the scientific researches and explorations - *ARIMA*(0,0,1).

The results of selected factors forecasts are shown in Tables 1-6.

Table 1

Forecast results and their confidential intervals for observations over fixed investments factor

CaseNo.	Forecasts; Model:(0,0,1) Seasonal lag: 12 Input: X1 Start of origin: 1 End of origin: 15		
	Forecast	Lower	Upper
20	43083,53	23801,03	77987,82
21	42834,16	20960,38	87534,94
22	42834,16	20960,38	87534,94

Table 2

Forecast results and their confidential intervals for observations over volume of sold innovation production factor

CaseNo.	Forecasts; Model:(1,0,0) Seasonal lag: 12 Input: X2 Start of origin: 1 End of origin: 15			
	Forecast	Lower	Upper	Std.Err.
20	5406,473	-1111,49	11924,44	3700,633
21	5173,311	-3847,91	14194,53	5121,878
22	4950,203	-5866,36	15766,77	6141,204

Table 3
Forecast results and their confidential intervals for observations over new technologies, technological processes factor

CaseNo.	Forecasts; Model:(0,0,1) Seasonal lag: 12 (Spreadsheet1) Input: X3 Start of origin: 1 End of origin: 15			
	Forecast	Lower	Upper	Std.Err.
20	1749,652	1171,701	2327,604	326,3540
21	1663,608	1012,549	2314,668	367,6361
22	1663,608	1012,549	2314,668	367,6361

Table 4
Forecast results and their confidential intervals for observations over research and development works volume factor

CaseNo.	Forecasts; Model:(1,0,0) Seasonal lag: 12 (Spreadsheet1) Input: X6 Start of origin: 1 End of origin: 15			
	Forecast	Lower	Upper	Std.Err.
20	2396,906	1850,795	2943,018	308,3750
21	2383,621	1617,635	3149,606	432,5319
22	2370,554	1440,068	3301,040	525,4214

Table 5
Forecast results and their confidential intervals for observations over number of granted patents factor

CaseNo.	Forecasts; Model:(1,0,0) Seasonal lag: 12 (Spreadsheet1) Input: X5 Start of origin: 1 End of origin: 15			
	Forecast	Lower	Upper	Std.Err.
20	2472,003	552,298	4391,707	1089,930
21	2360,293	-293,946	5014,531	1506,968
22	2253,631	-925,662	5432,924	1805,073

Table 6
Forecast results and their confidential intervals for observations over number of organizations conducting the research studies and explorations factor

CaseNo.	Forecasts; Model:(0,1,1) Seasonal lag: 12 (Spreadsheet1) Input: X7 Start of origin: 1 End of origin: 15			
	Forecast	Lower	Upper	Std.Err.
20	895,4	836,1745	954,6800	33,24536
21	860,9	738,2933	983,4896	68,78697
22	826,4	663,4148	989,2965	91,42231

The forecast made for 3- year period (2020-2022) is shown in Figures 1-3.

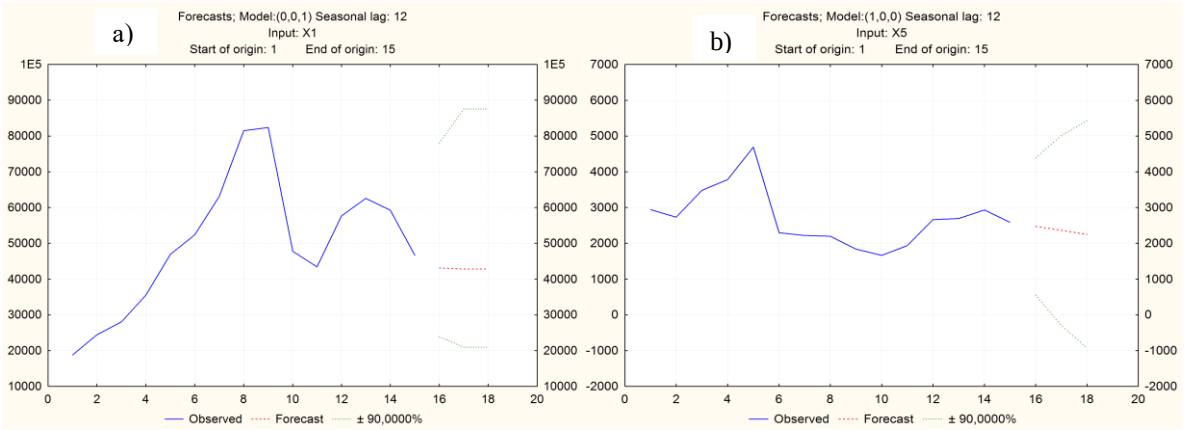

Figure 1: Graph of variance of the fixed investments with the forecast made (a) and number of patents granted in Ukraine (b)

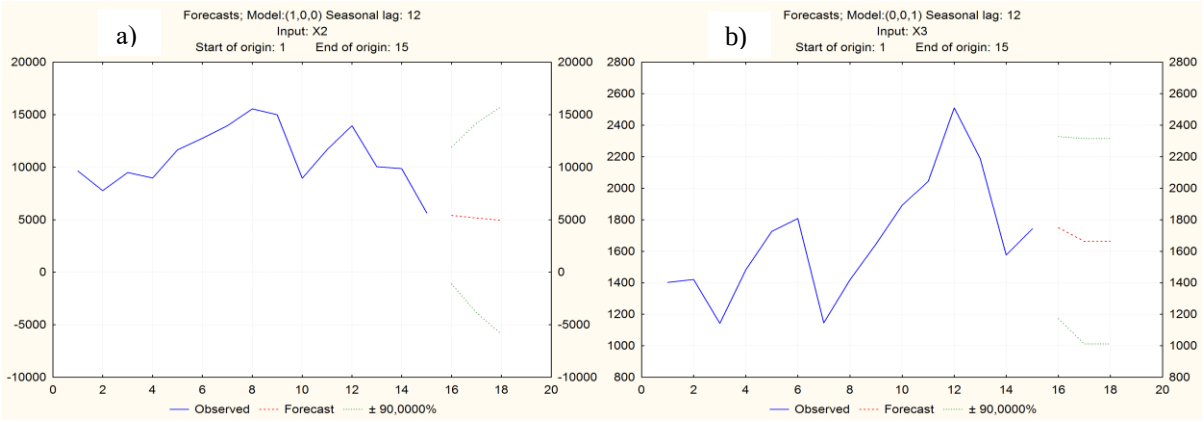

Figure 2: Graph of variance of the volume of sold innovation production with the forecast made (a) and new technologies, technological processes (b)

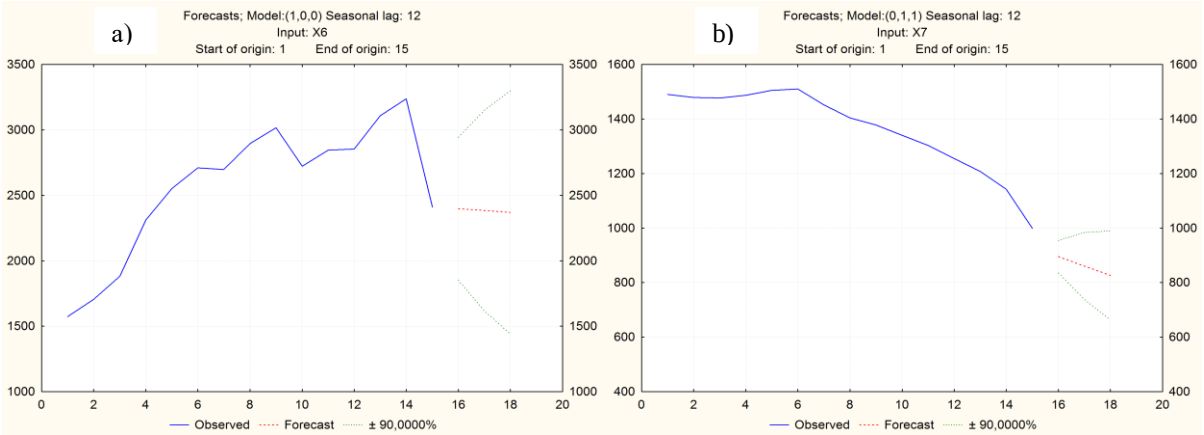

Figure 3: Graph of variance of the research and development works volume with the forecast made (a) and number of organizations conducting the research studies and explorations (b)

In the course of investigation there was received an optimistic, a pessimistic, and an expected (the most probable) forecast. According to the expected forecast:

- The results obtained my means of *ARIMA* (0,0,1) model showed that the fixed investments in 2020 will be 43083,5 mln. UAH, in 2021-2122 the index will be 42834,2 mln. UAH.
- The results obtained my means of *ARIMA* (1,0,0) model showed that the number of granted patents in Ukraine will gradually decrease (in 2020 – 2472 patents, in 2021 – 2360 patents, and in 2022 – 2253 patents).

- As for the amount of innovative products sold, the results obtained by means of *ARIMA* (1,0,0) model showed that in 2020 this index will be 5406,5 mln. UAH, in 2021 – 5173,3 mln. UAH, and in 2022 – 4950,2 mln. UAH.
- The results obtained my means of *ARIMA* (0,0,1) model showed that the number of the implemented new technologies and technological processes in 2020 will be 1565,5 units, in 2021-2021 this index will grow up to 1646,4 units.
- The calculation results obtained my means *ARIMA* (1,0,0) model showed that volume of scientific and technology works will gradually decrease (in 2020 – 2396,9 mln. UAH, in 2021 – 2383 mln. UAH, in 2022 – 2370 mln. UAH).
- As for the amount of organizations, completing research activities and exploration then the results obtained by means of *ARIMA* (0,0,1) model showed that index value will gradually decrease (in 2020 – 895 units, in 2021 – 860 units, in 2022 – 826 units).

Modeling of the following factors is the next exploration phase:

- the financing volume of the research, scientific and technological works considering the influence of the scientific and technological works volume and amount of completed research works and scientific and technological works (Tables 7, 8 and Figure 4);
- the total costs of the enterprises, introducing innovations considering the fixed investments influence, amount of sold innovative products and amount of complete research, scientific and technological works (Tables 9, 10 and Figure 5);
- the amount of completed research, scientific and technological works considering the influence of applied inventions amount and volume of scientific and technological works (Tables 11, 12 and Figure 6);
- the amount of inventions applied considering the influence of number of patents granted in Ukraine and number of organizations, which accomplish the research studies and explorations (Tables 13, 14 and Figure 7).

Using the statistical data, there was constructed a correlation matrix of the above-mentioned factors (the financing volume of the research, scientific and technological works; total costs of the enterprises, introducing innovations; the amount of completed research, scientific and technological works; the number of applied inventions).

Table 7

Correlation matrix that characterizes the volume of financing factor of the research, scientific and technological works

	Correlations (Spreadsheet1)		
Variable	**X6**	**X10**	**X9**
X6	1,000000	0,568622	0,951451
X10	0,568622	1,000000	0,692699
X9	0,951451	0,692699	1,000000

Table 8

Conclusive results of the econometric model evaluation in regard to the volume of financing of the research, scientific and technological works

N=15	Regression Summary for Dependent Variable: X9 (Spreadsheet1) R= ,96915431 R?= ,93926008 Adjusted R?= ,92913676 F(2,12)=92,782 p<,00000 Std.Error of estimate: 110,53					
	Beta	Std.Err.	B	Std.Err.	t(12)	p-level
Intercept			245,6791	180,0359	1,364612	0,197418
X6	0,823987	0,086488	0,6775	0,0711	9,527130	0,000001
X10	0,224163	0,086488	0,0096	0,0037	2,591820	0,023579

Analyzing the correlation matrix (Table 7), there was detected the influence of each factor on volume of financing sources of the research, scientific and technological works. The previous analysis

of the statistical ensemble gave the opportunity to draw the conclusion concerning its uniformity and closeness of the empiric distribution to the theoretical one, as well as, concerning absence of multicollinearity. Thus, for finding factor model parameters there was used the least square method. The results of the econometric model construction are shown in Table 8.

On the basis of the achieved parameters the factor model will appear as follows:

$$x_9 = 245{,}7 + 0{,}6775x_6 + 0{,}0096x_{10} \quad (3)$$

The comparison of calculated value of Student's test with the table one confirms the statistical significance of the model coefficients. The value of the multiplying determination coefficients gives the opportunity to draw a conclusion regarding the sufficient determination of the resultative feature x_9 in the model with factor features x_6 and x_{10}. The estimated value of the multiplying correlation coefficient for the assumed model equals to R = 0,97 that shows a close connection between the factor and resulting features. The calculated model residues are uncorrelated and approximately distributed under the normal law that also proves the models adequacy. According to F- criteria (F = 92,8) with about P=0,95 reliability the econometric model may be considered adequate to the experimental data and based on the assumed model there may be carried out an economic analysis and found a forecast value.

The analysis of Beta coefficients and partial correlation coefficients shows that the volume of the scientific and technological works has the greatest influence on the increase of sold innovative products volume.

Based on the econometric model there was made a forecast of influence of scientific and technological works volume and amount of completed research, scientific and technological works on the volume of financing sources of the research, scientific and technological works (Figure 4).

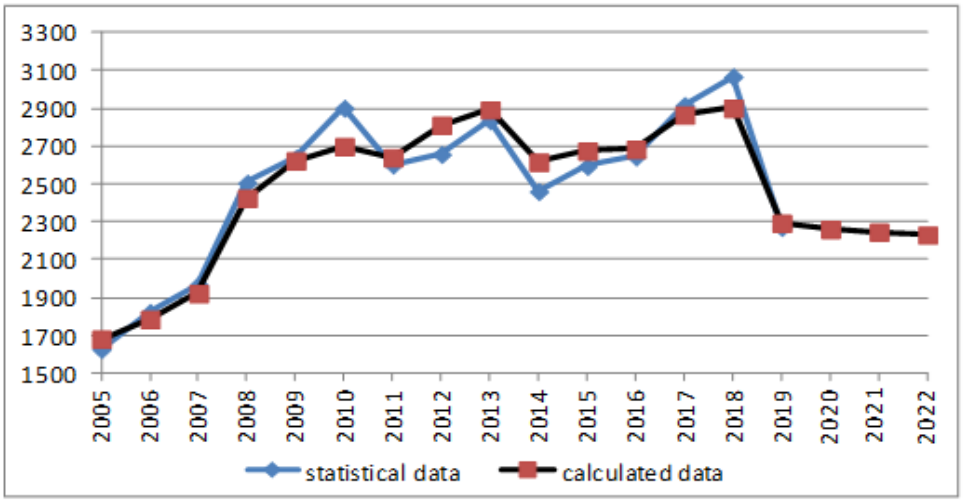

Figure 4: Dynamics of the volume of financing of the research, scientific and technological works

The achieved results have showed that financing of the research, scientific and technological works will gradually decrease in future. At present, the government financing of scientific and technological activity in Ukraine is bound with the development of III and IV technologic modes and promotes economic model construction that does not need any innovations and does not form any impulses for the investments to human capital assets development [23]. The increase of government financing of the scientific researches will make no sense if the negative trends of the scientific and technological works self-closing continue developing on the level of creation and improvement of technologies increasing their disconnection from market demands.

Analyzing the correlation matrix (Table 9), there may be seen the influence of each factor on the total costs of the enterprises, introducing innovations. The previous analysis of the specific statistical ensemble gave the opportunity to conclude about its uniformity and closeness of the empiric distribution to the theoretic one, as well as about its multicollinearity. Thus, to find the factor model parameters there was used a ridge regression method.

Table 9

Correlation matrix that characterizes the factor of the total costs of the enterprises introducing innovations

	Correlations (Spreadsheet1)			
Variable	**X1**	**X2**	**X10**	**X4**
X1	1,000000	0,700105	0,614317	0,894897
X2	0,700105	1,000000	0,627604	0,873504
X10	0,614317	0,627604	1,000000	0,663062
X4	0,894897	0,873504	0,663062	1,000000

Ridge-value of the regression parameters vector

$$\hat{A} = (X^T X + \lambda I)^{-1} X^T Y , \tag{4}$$

where $\lambda \in [\underline{\lambda}; \overline{\lambda}]$ (usually, $\underline{\lambda} = 0{,}1$; $\overline{\lambda} = 0{,}4$).

Standard error of *k* ridge-value of the regression parameter equals to the square root of the corresponding diagonal element of the covariance matrix vector value:

$$\sigma_A = \sigma_u \sqrt{(X^T X + \lambda I)^{-1}} , \tag{5}$$

$$\hat{\sigma}_u^2 = \frac{\sum_{i=1}^{n} (Y - \hat{Y})^2}{n - m - 1} = \frac{u^T u}{n - m - 1} .$$

The results of econometric model construction are shown in Table 10.

Table 10

Conclusive results of econometric model evaluation

N=15	Ridge Regression Summary for Dependent Variable: X4 (Spreadsheet1) l=,30000 R= ,88986086 R?= ,79185234 Adjusted R?= ,73508480 F(3,11)=13,949 p<,00046 Std.Error of estimate: 495,25					
	Beta	Std.Err.	B	Std.Err.	t(11)	p-level
Intercept			753,3908	677,0142	1,112814	0,289516
X10	0,154342	0,140927	0,0154	0,0141	1,095188	0,296835
x1^2	0,414703	0,163657	0,000000192	0,000000076	2,533979	0,027776
X2^2	0,343377	0,164433	0,00000526	0,0000025	2,088242	0,060825

Based on the achieved parameters the factor model will appear as follows:

$$x_4 = 753{,}4 + 1{,}9 \cdot 10^{-7} x_1^2 + 5{,}26 \cdot 10^{-6} x_2^2 + 0{,}0154 x_{10} . \tag{6}$$

The comparison of calculated value of Student's test with the table one confirms the statistical significance of the model coefficients. The value of the multiplying determination coefficients gives the opportunity to draw a conclusion regarding the sufficient determination of the resultative feature x_4 in the model with factor features x_1, x_2 and x_{10}. The estimated value of the multiplying correlation coefficient for the assumed model equals to $R = 0{,}89$ that shows a close connection between the factor and resulting features. The calculated model residues are uncorrelated and approximately distributed under the normal law that also proves the models adequacy. According to *F*-criteria ($F = 13{,}95$) with about P=0,95 reliability the econometric model may be considered adequate to the experimental data and based on the assumed model there may be carried out an economic analysis and found a forecast value. The analysis of Beta-coefficients and partial correlation coefficients shows that the fixed investment factor has the greatest influence on the increase of total costs of the enterprises, introducing innovations.

Based on the econometric model there will be made a forecast of influence of the fixed investments, the volume of sold innovative products and amount of completed research, scientific and technological works on the total costs of the enterprises, introducing innovations (Figure 5).

It is worthwhile noting that over the long-term the innovations financing that is mostly realized at the sole cost and expense of the enterprise will decrease. At the same time, the existing financial credit system is unable to provide the enterprises with the economic cost credit resources in sufficient quantity. Besides, low ability to meet payments will have an influence over it as well.

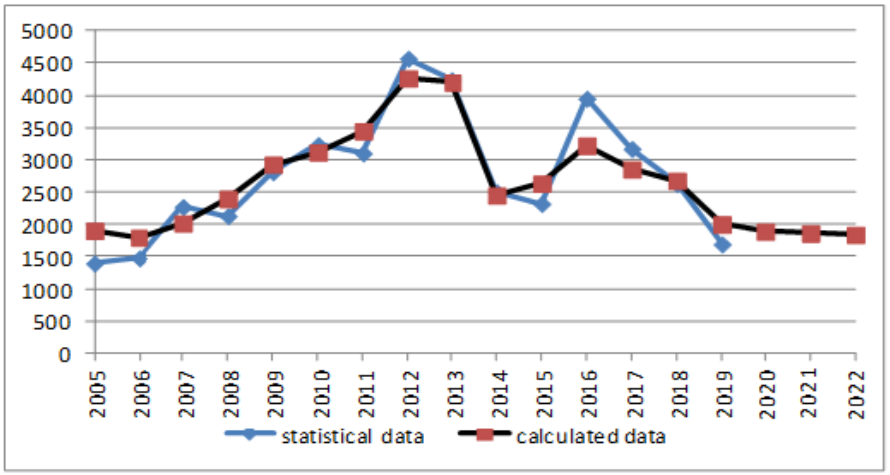

Figure 5: Dynamics of the total costs of enterprises, introducing innovations

Analyzing the correlation matrix (Table 11), there may be seen the influence of each factor on the amount of completed research, scientific and technological works.

Table 11

Correlation matrix that characterizes the factor of the amount of completed research, scientific and technological works

Variable	Correlations (Spreadsheet1)		
	X6	X8	X10
X6	1,000000	-0,109945	0,568622
X8	-0,109945	1,000000	0,654858
X10	0,568622	0,654858	1,000000

The previous analysis of the statistical ensemble allowed concluding about its uniformity and closeness of the empiric distribution to the theoretical one as well as about absence of multicolleniarity. Thus, to find the factor model parameters there is used the least square method.

The results of econometric model construction are shown in Table 12.

Table 12

Conclusive results of the econometric model evaluation

N=15	Regression Summary for Dependent Variable: X10 (Spreadsheet1) R= ,90734404 R?= ,82327322 Adjusted R?= ,79381875 F(2,12)=27,951 p<,00003 Std.Error of estimate: 4379,7					
	Beta	Std.Err.	B	Std.Err.	t(12)	p-level
Intercept			23772,61	4314,374	5,510094	0,000134
X8^2	0,753380	0,122803	0,0017	0,00028	6,134843	0,000051
X6^2	0,633986	0,122803	0,0025	0,00049	5,162609	0,000236

According to the received parameters the factor model will appear as follows:

$$x_{10} = 23772 + 0{,}0025x_6^2 + 0017x_8^2, \quad (7)$$

The comparison of calculated value of Student's test with the table one confirms the statistical significance of the model coefficients. The value of the multiplying determination coefficients gives the opportunity to draw a conclusion regarding the sufficient determination of the resultative feature x_{10} in the model with factor features x_6 and x_8. The estimated value of the multiplying correlation coefficient for the assumed model equals to R = 0,91 that shows a close connection between the factor and resulting features. The calculated model residues are uncorrelated and approximately distributed under the normal law that also proves the models adequacy. According to F-criteria (F = 28) with about P=0,95 reliability the econometric model may be considered adequate to the experimental data and based on the assumed model there may be carried out an economic analysis and found a forecast value. The analysis of Beta-coefficients and partial correlation coefficients shows that the number of the inventions used factor and the research and development works volume factor has the greatest influence on the increase of number of completed research and development works.

Based on the econometric model there will be made a forecast of influence of the number of the inventions used, the research and development works volume on the number of completed research and development works (Figure 6). It is worth mentioning that the indices of effectiveness of the use of scientific potential in Ukraine, which are manifested in the amount of completed research, scientific and technological works are still low and actually are not going to be increased in the long view. Not very positive dynamics of the total amount of completed research, scientific and technological works is caused by decrease of quantitative indices related to the results of scientific potential use, gradual decrease of relative share and the innovative work quality, enforcement of "compilation" of the scientific and research works, absence of demand for them in the national production, noncompliance with market demands and world trends.

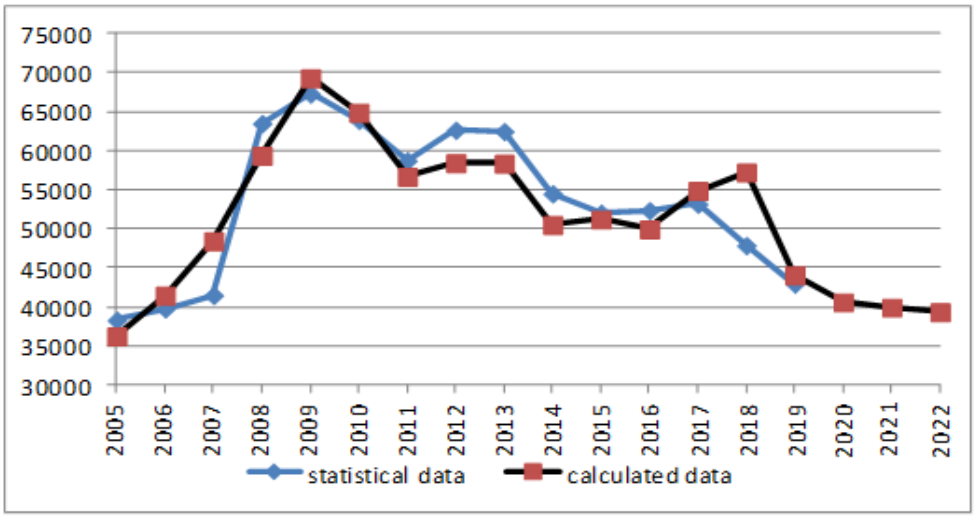

Figure 6: Dynamics of the amount of completed research and development works

Besides, the issue of the research works commercialization is not always the major priority of the scientists. The possibility of real implementation of the innovations is perceived as the remote and unreal prospect that significantly decrease the practical application of the research, scientific and technological works.

Table 13

Correlation matrix that characterizes the factor of the number of inventions used

	Correlations (Spreadsheet1)		
Variable	**X5**	**X7**	**X8**
X5	1,000000	0,273433	0,541520
X7	0,273433	1,000000	0,699607
X8	0,541520	0,699607	1,000000

The results of the econometric model construction are shown in Table 14.

Analyzing the correlation matrix (Table 13), there may be seen the influence of each factor on the amount of realized inventions. The previous analysis of the statistical ensemble provided with the opportunity to conclude about its uniformity and closeness of the empiric distribution to the theoretical one as well as about absence of multicollinearity. Thus, to find the factor model parameters there is used the least square method.

Table 14

Conclusive results of the econometric model evaluation

N=15	Regression Summary for Dependent Variable: X8 (Spreadsheet1) R= ,78868113 R?= ,62201792 Adjusted R?= ,55902091 F(2,12)=9,8738 p<,00292 Std.Error of estimate: 493,11					
	Beta	Std.Err.	B	Std.Err.	t(12)	p-level
Intercept			-2291,72	1183,086	-1,93707	0,076633
X5	0,378525	0,184510	0,35	0,172	2,05152	0,062704
X7	0,596105	0,184510	2,88	0,892	3,23075	0,007209

According to the received parameters the factor model will appear as follows:

$$x_8 = -2291{,}7 + 0{,}35x_5 + 2{,}88x_7, \quad (8)$$

The comparison of calculated value of Student's test with the table one confirms the statistical significance of the model coefficients. The value of the multiplying determination coefficients gives the opportunity to draw a conclusion regarding the sufficient determination of the resultative feature x_8 in the model with factor features x_5 and x_7. The estimated value of the multiplying correlation coefficient for the assumed model equals to R = 0,79 that shows a close connection between the factor and resulting features. The calculated model residues are uncorrelated and approximately distributed under the normal law that also proves the models adequacy. According to F-criteria (F = 9,9) with about P=0,95 reliability the econometric model may be considered adequate to the experimental data and based on the assumed model there may be carried out an economic analysis and found a forecast value. The analysis of Beta-coefficients and partial correlation coefficients shows the factor of the number of organizations conducting scientific and research works has the greatest influence on the increase of realized inventions amount.

On the basis of econometric model there was made a forecast of influence of the number of the granted patents in Ukraine and number of organizations conducting the research works and explorations on the amount of realized inventions (Figure 7).

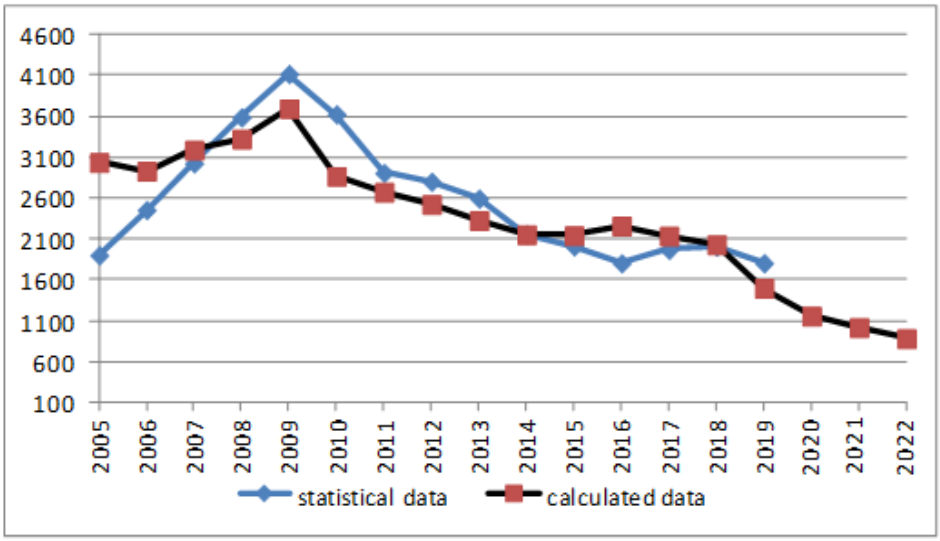

Figure 7: Dynamics of the realized inventions amount

In Ukraine the amount of realized inventions decreases every year. As may be seen from the Figure the number of the realized inventions will decrease year after year. According to the realized inventions per 10 thousand people, Ukraine by 12 times remains short of the average level of EU, however, at the same time by 1.7 times anticipates it in the number of scientists per 10 thousand working people [23].

In spite of critical economy situation, the economic entities have to use and realize innovations, inventions, however, the number of such organizations remains insignificant.

To forecast GDP, using the offered econometric model (2), it is necessary to make a forecast for all the model factors that characterize the scientific and innovative activity of the country. The production function (1) reduces to linearity by means of logarithmation:

$$y = \ln b + \alpha \cdot \ln x_3 + \beta \cdot \ln \ln x_4 + \gamma \cdot \ln \ln x_9, \quad (9)$$

There was constructed the correlation matrix of the investigated factors. Having analyzed the correlation matrix (Table 15) there may be seen the influence of each factor on GDP. The previous analysis of the statistical ensemble gave the opportunity to conclude about its uniformity and closeness of the empiric distribution to the theoretical one as well as about multicollinearity existence. Thus, to find the factor model parameters there is used a ridge regression method.

Table 15

GDP volume correlation matrix

	Correlations (Spreadsheet2)			
Variable	**x3***	**lnx4***	**lnx9***	**y***
x3*	1,000000	0,277653	0,448384	0,581033
lnx4*	0,277653	1,000000	0,784670	0,636863
lnx9*	0,448384	0,784670	1,000000	0,808032
y*	0,581033	0,636863	0,808032	1,000000

The results of econometric model construction are shown in Table 16.

According to the received parameters, the GDP determination factor model will appear as follows:

$$Y = 0{,}0036 x_3^{0,4} (\ln x_4)^{1,4} (\ln x_9)^{5,9}. \quad (10)$$

Table 16

GDP volume correlation matrix

N=15	Ridge Regression Summary for Dependent Variable: y* (Spreadsheet2) l=,40000 R= ,76272197 R?= ,58174480 Adjusted R?= ,46767519 F(3,11)=5,0999 p<,01876 Std.Error of estimate: ,25975					
	Beta	Std.Err.	B	Std.Err.	t(11)	p-level
Intercept			-5,63098	5,123869	-1,09897	0,295252
x3*	0,252609	0,174015	0,40605	0,279715	1,45165	0,174516
lnx4*	0,184673	0,199052	1,42546	1,536451	0,92776	0,373441
lnx9*	0,392756	0,205946	5,91796	3,103152	1,90708	0,082950

The comparison of calculated value of Student's test with the table one confirms the statistical significance of the model coefficients. The value of the multiplying determination coefficients gives the opportunity to draw a conclusion regarding the sufficient determination of the resultative feature y in the model with factor features x_3, x_4 and x_9. The estimated value of the multiplying correlation coefficient for the assumed model equals to $R = 0{,}76$ that shows a close connection between the factor and resulting features. The calculated model residues are uncorrelated and approximately distributed under the normal law that also proves the models adequacy. According to F-criteria ($F = 5{,}1$) with about P=0,95 reliability the econometric model may be considered adequate to the experimental data

and based on the assumed model there may be carried out an economic analysis and found a forecast value.

The derived estimates allow using the model for GDP forecast (Figure 8). The primary task of the model for GDP forecast is to provide with the basic material for further researches, to serve as a tool for the effective state strategic management and formation of the strategies and programs of social and economic development at different levels of national economy. As is seen from the above-mentioned, GDP forecast value will gradually decrease over the long term. It should be mentioned that the developed countries pay much attention to the development of technological and innovative activity. Unfortunately, in Ukraine the factors that influence GDP growth are neglected.

The increase of investment factor in basic capital by 1% will lead to 0,1% GDP growth. The same result can be achieved with the increase of the sold innovative products volume. Growth of the introduced new technologies and technological processes amount up to 1% will cause 0,4 % GDP gross. At the same time, the increase of research and technological works scope will lead to 0,7 % GDP gross. In the course of the calculation process there has been found that GDP growth of Ukraine can be achieved with the support for research, technological and innovative activities, in particular, with the growth of research and technological works scope, introduction of progressive technical processes, creation of the new technologies and putting them into production.

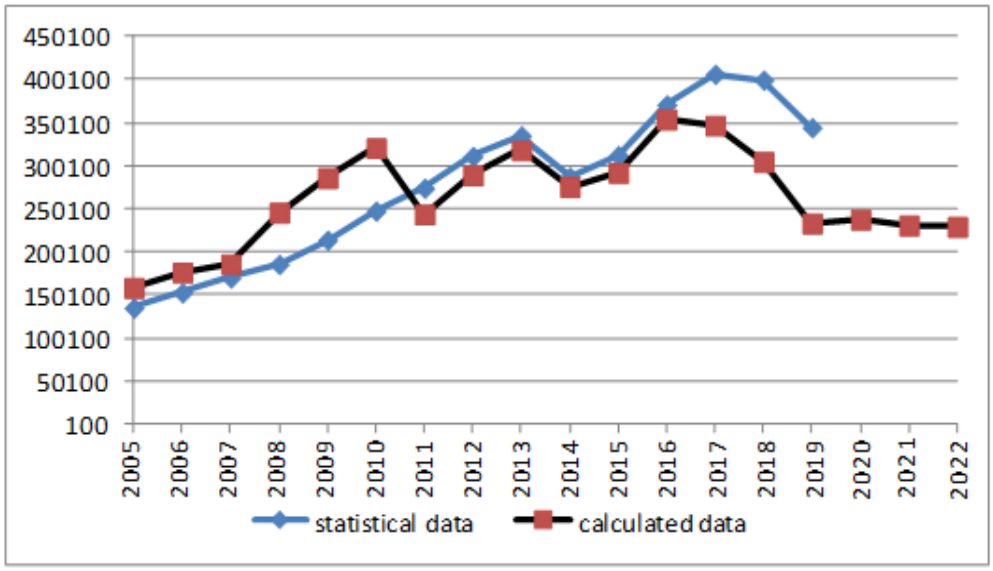

Figure 8: Ukrainian GDP forecast value

All these requires the development and realization of the preventive measures, and improvement of state programs of social and economic development. The effective investments in basic capital and increase of sold innovative products volume will also cause GDP growth.

The result of this study consistently with [24] where the investment, research and development costs has a positive impact on the GDP but this study covers more innovation factors and uses the combined method of modeling for forecasting GDP.

Ukraine realizes opportunities in innovative development at a low level. This is especially true for the commercialization of innovations in the field of protection of intellectual property rights. The innovative way of development of Ukraine's economy turned out to be rather declarative. In fact, Ukraine is still implementing a partially resource model without high-tech production and an intellectual-donor model, from which the production stage has been removed.

These models have a low level of efficiency in the strategic perspective, lead to depletion of the country's resources, leakage of factors of production of the national economy abroad and make it impossible to ensure adequate indicators of the level of population welfare. The consequence of the implementation of such models is an economic downturn.

The most effective for Ukraine is the innovation model, which provides for the transformation of money for research into knowledge, the transformation of knowledge into the skills of employees and innovation, the transformation of innovation into a commodity and the receipt of money.

5. Conclusion

These findings may provide some insight as to which innovation and investment factors are involved with social and economic development of the country and formation of GDP. All the more significant is the studies which are reflect the innovation and investment changes, analyses and forecasts of the public management, economic and social policies of Ukraine. By means of the econometric model, there was established that forecast values of GDP volume over the long term will gradually decrease. It was found out that the highest priority factors of a competitiveness according to the innovative component of Ukraine are the amount of scientific and technological works, a number of innovative technologies and technological processes introduced, fixed investments, a number of innovative products sold. These are the key factors the possibility of social and economic development of Ukraine depends on. The obtained forecast values of GDP volume give the opportunity to form the corresponding programs of social and economic development of the country for the short-term period and can help the public authorities to develop a well-balanced and effective policy of social and economic development. As long as on such grounds there should be taken management decisions of the corresponding administrative bodies regarding the development of the innovative activity in the country.

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