Models of Scientific and Technical Zonal Formations for Ukraine and Forecast of Their Number Considering Foreign Experience

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Abstract

The article highlights the factors affecting the number of scientific and technical zonal formations in the country and forecasts their number and the indicated models of such structures for Ukraine taking into account foreign experience.

Keywords: scientific and technical zones, pair correlation, regression model, European model, Anglo-American model, forecast.

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Introduction

In the global innovation space, a stiff international competition between leading and developing countries is observed not so much for capital resources, material assets, but for intellectual capital that is capable of producing and innovating. Therefore, the chosen topic of research at the present stage of innovation development of Ukraine is relevant.

Improvement of the organizational and economic mechanism for the functioning of scientific and technical zonal structures (STZ) requires the development of forecasting models regarding the number of such structures for Ukraine, taking into account foreign experience and on the basis of analysis of factors that have a significant influence on their formation, functioning and development through mathematical methods.

Literature review

V. Troian [1] studied the problem concerning the production of innovations and the peculiarities of its implementation into production in Germany, N. Karpenko [2] devoted his work to the problems of restraining the formation of the innovative model of development in Ukraine and the search for ways of their solution taking into account foreign experience, H. Androshchuk [3,4] investigated the problem of intellectual property in China and the peculiarities of the innovation system in Finland, N. Honcharov [5] studied the existing innovative models of world development, but the problem of forecasting the required quantity of scientific and technical zones, as well as the study of factors affecting this figure is not payed enough attention in Ukrainian science.

Results

The innovation sector of Ukraine's economy, namely the sectors of research and development, education, inventions, patenting and intellectual property rights, does not fully meet the potential needs of the global innovation space. The domestic economy is also structurally backward, technologically low-level, and the system of entrepreneurship is ineffective, which has a very negative effect on the level of development and achievements in the spheres of science, technology and technological innovations.

Therefore, it is necessary to investigate and analyze existing strategies and models for the formation and development of STZ in the leading countries of the world and in Ukraine, to determine whether there is a cause-and-effect relationship between economic phenomena, processes and the number of scientific and technical formations.

To do this, it is necessary to conduct a correlation analysis of the dependence of the number of STZ and independent variables of the model on the example of the following countries: the USA, Japan, the Russian

Federation, Ukraine, Germany, France, China, Turkey, the Republic of Kazakhstan, the United Kingdom. When choosing countries, the above-mentioned tendencies of the world innovation space were considered.

The dependence of the result index (Y) on the joint and one-time operating factor indices ($X_1 \dots X_n$) is calculated by the following formula:

$$Y = f(X_1, \dots, X_n) + U \quad (1)$$

where Y – dependent variable;

$f(X_1, \dots, X_n)$ – function that expresses an objective regularity between the result index Y and the factor indices X, ..., X;

U – random variable expressing the influence of objective and unconsidered factors, as well as measurement errors.

According to the analysis, the main variables are determined:

– result index (Y) in our study is an indicator of the number of scientific and technical zonal formations in the country,

– factor indices: X_1 – number of people in the country, X_2 – volume of GDP,

X_3 – volume of investments for innovation, X_4 – number of higher education institutions; X_5 – number of scientists in the country.

When measuring the degree of dependence between the above-mentioned factors and checking the multicollinearity, the following results were obtained (Table 1).

Table 1. Matrix of coefficients of pair correlation

	Y	X_1	X_2	X_3	X_4	X_5
Y	1					
X_1	0.07662756	1				
X_2	0.65059816	0.658836	1			
X_3	0.80321874	0.421158	0.953946508	1		
X_4	0.61937936	0.563651	0.915241545	0.875470142	1	
X_5	0.29013829	0.342363	0.499175525	0.420488448	0.678711	1

The analysis of matrix of coefficients of pair correlation shows that the variable Y has a close connection with the variables X_2, X_3, X_4, which testifies to the existence of the influence of GDP volume, investment in innovation and the number of HEIs on the number of STZ. It is found that the most influential factor is the index X_3 - the volume of investment in innovation, followed by X_2 (volume of GDP), X_4 (number of HEIs), and the number of population (X_1) and X_5 (scientific personnel) are not significant impact factors, therefore it is inappropriate to use them in further calculations.

The calculated correlation coefficients characterize the density of the connection between the determined factors, but the question remains as to the influence of these factors on the result index and the possibility of predicting changes in the result at certain combinations of factor values. Such calculations need to be done using regression analysis.

In addition to the connection of the outcome variable Y with variables X_2, X_3, X_4, the Table 1 shows that there is a connection between the variables themselves. So, the correlation coefficient between the variables X_2 and X_3 is 0.95, and between X_2 and X_4 is 0.915. That is, there is a significant multicollinearity, in the presence of which it is inappropriate to construct a multiple regression, therefore, models of pair regression (Table 2) are constructed.

Proceeding from the forms of the equation of regression, shown in Table 2, it should be noted that with an increase in investment for innovation by one billion dollars, the number of scientific and technical formations in the country should increase by 1.65 times. In other words, to form one additional STZ, it is necessary to provide additional investment for innovation in the amount of 606 million dollars, or to increase the GDP by 4.59 billion dollars, or to increase the number of HEIs by 21.

Table 2. Results of the pair regression analysis of trends in the impact of investment in innovation, GDP volume and number of universities on the number of scientific and technical zones

Indicator	Investment in innovation	GDP volume	Number of HEIs
Form of the regression equation	y= 1.6524x + 58.364	y = 0.0474x + 27.893	y = 0.2177x + 28.022
Determination coefficient, R^2	0.9	0,9118	0.9022
F-Fisher criterion	40.3153	64.4913	58.1068
t-Student's criterion	8.5014	10.6198	10.1036
p-value	6.17×10^{-5}	$1{,}43 \times 10^{-5}$	2×10^{-5}

To analyze the quality of models, it is necessary to study their adequacy:

- to check the significance of the regression parameters and statistical characteristics of the models using Student's coefficient: the calculated t-criteria are larger than the table ones;
- to investigate the significance of connections according to Fisher criterion: calculated and brought to the Table 2 F-criteria by all signs give grounds to assert the high probability of the influence of all investigated factors on the number of STZ.

Regarding the statistical significance of the connection, the normative value of the p-criterion in the models is observed. Consequently, the constructed regression models are adequate.

In all cases, the form of the regression equation is linear and the coefficients for variables are positive, which indicates the direct dependence of the number of scientific and technical formations on these factors in all countries.

The determination coefficient R^2 for investment in innovation is 0.9, for the GDP volume - 0.9118, for the number of universities - 0.9022. Since all indicated coefficients approach 1, there is no possibility to allocate only one model for forecasting the number of scientific and technical zones, but it is necessary to apply all regression models. It should also be noted that when constructing the indicated models, input data of not all the above-mentioned countries was used. This is explained by the fact that two points were allocated on the correlation field, and they were far enough from the common array of points and the trend line – the so-called "emissions" (Figure 1). Based on Figure 1, such countries in the built models are Japan and China. That is, we can assume that the number of scientific and technical associations in these countries was significantly influenced by other factors that are more significant, therefore, in the further analysis these countries were removed from the model.

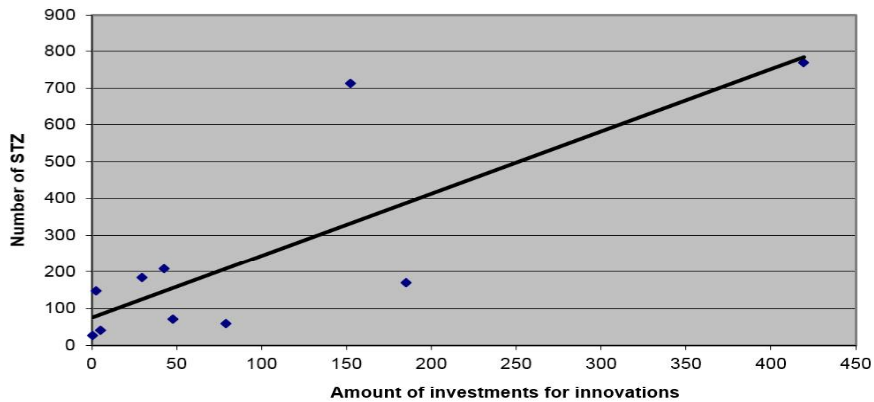

Figure 1. Correlation field of dependence of quantity of STZ from amount of investments for innovations in the studied countries

Thus, from the economic point of view of the existence of "emissions" is explained by the fact that the governments of the studied countries adhere to different strategies for the formation and development of scientific and technical innovation formations:

- the first strategy – the European one followed by such countries as Germany, France, Turkey, the Republic of Kazakhstan, is characterized by the following features: small number of scientific and technical zones, low share of the cost of innovation research and development in the gross domestic product (Germany – 2.52 %, France – 2.13%, Turkey – 0.47%, the Republic of Kazakhstan – 0.24%) and the number of higher education institutions. The peculiarity of the organizational and economic mechanism for the formation and functioning of the scientific and technical zones of these countries is the high level of organization with an organic combination of branched forms of economic stimulation, which include various forms of state and non-state support;
- next – Anglo-American, which is introduced by the world leader in innovation sphere – the USA and such countries as Great Britain, the Russian Federation and Ukraine. The features of this model are as follows: a sufficiently large number of innovation formations (USA – 770, Great Britain – 207, the Russian Federation – 182, Ukraine – 147), significant share of GDP costs on innovation compared to countries in the European model; the large number of higher education institutions;
- concerning the countries that have got to the "emissions", they have their own, different from the previous ones, strategy of the planned creation of scientific formations that are of a large scale – in the form of techno- and ecopolices, which are integrated into regional, natural-climatic and ecological peculiarities of the country. Their formation is based on the development of advanced technologies, fundamental and applied sciences.

The division of the studied countries according to the strategies for the formation and functioning of scientific and technical zones leads to the need to construct correlation-regression models separately in these groups.

The main variables in the models are:
- result index (Y) – indicator of the number of scientific and technical zones;
- factor indices: X_1 – volume of GDP, X_2 – volume of investments in innovations;
- X_3– number of higher education institutions.

According to the European model in determining the degree of dependence between the above-mentioned factors and the verification of multicollinearity the following results were obtained (Table 3).

Table 3. Matrix of coefficients of pair correlation for the European model

	Y	X_1	X_2	X_3
Y	1			
X_1	0.874965	1		
X_2	0.823358	0.972565	1	
X_3	0.335037	0.746717	0.740922	1

When analyzing the matrix of the pair correlation coefficients for the given model, it was found that the result variable Y has a close relationship with the factor variables X_1 and X_2, and with the variable X_3 the correlation coefficient is 0.335, that is, the connection density is not significant. In the subsequent calculations, the third factor variable will not be taken into account, and the results of the regression analysis for this model are given in Table 4.

Table 4. Results of the pair regression analysis of trends in the impact of investment in innovation and GDP volume on the number of scientific and technical zones by the European model

Indicator	Investment in innovation	GDP volume
Form of the regression equation	$y = 0.4192x + 35.608$	$y = 0.0013x + 27.813$
Determination coefficient, R^2	0.6779	0.7656
F-Fisher criterion	1.8482	5.3207
t-Student's criterion	2.9283	4.9195
p-value	0.06108	0.01609

Having analyzed the data presented in Table 4, the following conclusions were made: in this model the scientific component has lost its significance – the number of universities, that is, the scientific potential is not taken into account in the innovative strategy of these countries, but for the functioning of one new scientific and technical construction it is necessary to increase the investment component by 2.386 billion dollars, economic (i.e. volume of GDP) – by 769.23 billion dollars.

The next stage of the analysis is to test the model for adequacy: according to all criteria the model is adequate. The value of the determination coefficient R^2 for investment in innovation is 0.6779, for GDP – 0.7656, they are somewhat lower than in the previous general model, which gives grounds to state that the main driving force behind the formation and development of scientific and technical zonal formations in these countries is investment in innovation, and in developing countries (Turkey, the Republic of Kazakhstan), it is necessary to increase gradually the share of costs on innovations in GDP. Intellectual or scientific potential is practically not taken into account in these models, because according to the number of universities and scientific staff of the countries included in this model they are significantly behind the world leaders (for example, the United States, Great Britain).

Now it is necessary to carry out the regression analysis for the Anglo-American model of strategic development of the STZ, which uses the same factors as the European one. While determining the degree of correlation dependence between these factors, the following results are obtained, which are listed in Table 5.

Table 5. Matrix of coefficients of pair correlation for the Anglo-American model

	Y	X_1	X_2	X_3
Y	1			
X_1	0.997125	1		
X_2	0.99996	0.997687	1	
X_3	0.926894	0.92874	0.928852	1

In the analysis of the matrix of the pair correlation coefficients for the Anglo-American model, it is found that the result variable Y (the number of STZ) has a close relationship with the factor variables X_1, X_2 and X_3, since the correlation coefficients approach one. The density of connections in the model is significant, however, there are relations between the factor variables themselves, for example, the correlation coefficient between the variables X_1 and X_2 is 0.9976, and between the variables X_2 and X_3 is 0.9228. Thus, a high level of multicollinearity is observed in the model among the factor indices themselves.
The results of the regression analysis of the Anglo-American model are listed in Table 6.

Table 6. The results of the pair regression analysis of trends of the impact of investment in innovation, GDP volume and number of universities on the number of scientific and technical zones according to the Anglo-American model

Indicator	Investment in innovation	GDP volume	Number of HEIs
Form of the regression equation	$y = 1.4998x+140.88$	$y = 0.0431x+107.72$	$y = 0.2085x+52.155$
Determination coefficient, R^2	0.9999	0.9943	0.8591
F-Fisher criterion	12.1819	24.9378	15.9186
t-Student's criterion	6.0577	8.3695	6.8166
p-value	0.0090	0.0035	0.0064

Based on the data of the Table 6, it should be noted that with an increase in investment for innovation by one billion dollars, the number of scientific and technical zones should increase by 1.5, the volume of GDP – by 23.201 billion dollars, the number of HEIs – by 5 units. The study of the adequacy of models with the help of the Student's and Fisher coefficients suggests a high degree of probability of the influence of factor variables on the outcome one – number of STZ.

In all versions of the Anglo-American model, the form of the regression equation is linear and the coefficients are positive, which indicates the direct dependence of the number of scientific and technical formations on the selected factors in the studied countries.

The value of the determination coefficient R^2 for investment in innovation is 0.9999, for the volume of GDP – 0.9943, for the number of HEIs – 0.8591. If we compare the Anglo-American model with the general one, there is a correlation between them. That is, the governments of the countries belonging to this model adhere in their innovative strategy to global trends, namely: the financial potential of innovative development –

investment for innovation is of great importance; concerning the attitude of the country's leadership to the innovative development of the economy, it is expressed through the volume of GDP and its redistribution among business entities that make innovations. The scientific and intellectual potential in these countries is quite significant and the dependence of the outcome factor on this variable is significant.

Consequently, there is a need to make prediction calculations of the number of scientific and technical zones according to the general and Anglo-American models in relation to Ukraine and to compare them with the existing number of such formations at the moment. To do this, we need to substitute absolute values in the obtained linear regression equations, by solving which, we obtain the estimated values of the result index.

The results of such calculations are given in Table 7.

Table 7. Predicted values of the number of STZ in Ukraine according to the general and Anglo-American model

Name of the model	Investment in innovation	GDP volume	Number of HEIs	Number of existing STZ
General	47	16	184	147
Anglo-American	43	14	176	147

Based on the calculations, it should be noted that in Ukraine today there is such a number of STZ, which does not meet the objective conditions. However, it is necessary to take into account the fact that today there are about 40-50 STZ in Ukraine which are really working and profitable, and others are either not working or unprofitable. This is due to the state's lack of financing of the innovative component of the economy, the field of fundamental research and the field of higher education, as well as the weak involvement of private investors, which leads to negative dynamics of the development of venture financing.

In terms of the number of HEIs, that is, intellectual potential, Ukraine, like the Russian Federation, the USA, occupies a rather high place due to the traditional approach of the state regarding the training of scientific personnel and the powerful, historically determined tendency of priority development of technical, economic and natural sciences. Therefore, in the model of dependence of the number of STZ on the number of higher education institutions, which can be conventionally called “intellectual potential”, such a result was obtained – 176-184 scientific and technical formations.

But in reference with the abov it should be noted that the state and institutional investors today are not able to finance such scientific innovative formations. Therefore, the necessary requirement at the present stage of formation and development of scientific and technical zones is the development and introduction of a fundamentally new approach to investments in the innovation sphere. In the model “investment potential” there are predicted values for the number of STZ in Ukraine in the range of 43-47, indicating that about 100 existing innovative formations can not receive sufficient funding.

Concerning the model “economic potential” (number of STZ – volume of GDP), the difference in fluctuations between the predicted values to the number of innovation zones is not significant - from 14 to 16.

Today in Ukraine 16 technological parks are officially functioning, the number of which corresponds to the Anglo-American model, according to which Ukrainian is trying to build an innovative infrastructure.

Conclusions

So, after analyzing the predicted values, it is necessary to draw the following conclusions:

- Ukraine should adhere to the Anglo-American model in its strategy for the formation and development of innovative zonal formations;
- in the direction of the development of innovation infrastructure it is necessary to take into account the experience of the countries included in the indicated model: the USA, the Russian Federation and Great Britain;
- in order to optimize the number of existing STZ today, it is necessary to determine the specialization of the scientific and technical zone on the basis of analysis of the composition and structure of scientific staff, volume of regional gross product and volume of investment in innovation, taking into account the main provisions of the “Strategy of Ukraine's Innovation Development for 2010-2020 in the context of globalization challenges” and regional development strategies;

- optimal number of innovative scientific and technical formations, based on the calculations and correlation-regression analysis, is the interval within 15-18 zonal formations;
- there is a low level of innovation financing in the country, therefore, it is necessary to apply new approaches and strategies in this direction.

Conducted researches give us the opportunity to conclude that in order to substantiate and determine the number of STZ it is necessary to take into account such factors as economic potential of the country (GDP volume), financial (volume of investment in innovation) and intellectual (number of HEIs) potentials.

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