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МОДЕЛЮВАННЯ ІННОВАЦІЙНОГО ПРОЦЕСУ ЯК НЕОБХІДНА УМОВА ФОРМУВАННЯ ЕФЕКТИВНОГО МЕХАНІЗМУ УПРАВЛІННЯ ІННОВАЦІЙНИМ РОЗВИТКОМ

Запропоновано процедуру моделювання інноваційного процесу як необхідної умови формування ефективного механізму управління інноваційним розвитком., проведено аналіз стратегічних ініціатив і моделей розвитку України в умовах структурно-інноваційних перетворень.

Ключові слова: *інноваційне підприємництво, економічний розвиток, трансформаційні етапи розвитку, інноваційний потенціал.*

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МОДЕЛИРОВАНИЕ ИННОВАЦИОННОГО ПРОЦЕССА КАК НЕОБХОДИМЫМ УСЛОВИЕМ ФОРМИРОВАНИЯ ЭФФЕКТИВНОГО МЕХАНИЗМА УПРАВЛЕНИЯ ИННОВАЦИОННЫМ РАЗВИТИЕМ

Предложена процедура моделирования инновационного процесса как необходимого условия формирования эффективного механизма управления инновационным развитием, проведен анализ стратегических инициатив и моделей развития Украины в условиях структурно-инновационных преобразований.

Ключевые слова: *инновационное предпринимательство, экономическое развитие, трансформационные этапы развития, инновационный потенциал.*

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MODELING THE INNOVATION PROCESS AS A NECESSARY CONDITION FOR THE FORMATION OF AN EFFECTIVE MECHANISM OF INNOVATIVE DEVELOPMENT

A procedure for modeling the innovation process as a prerequisite for the formation of an effective mechanism of innovative development, a analysis of strategic initiatives and models of Ukraine in the context of innovation and structural change is conducted

Keywords: *innovative enterprise, economic development, transformation stages of development, innovative potential.*

Problem and its connection with important scientific and practical tasks. Formation and development of market relations in Ukraine must radically change the system of state control of strategic innovations. In connection with the transition of the industry to the advanced program-oriented management and indicative planning have transformed accordingly and functions of government. In market economy should not be abandoned the methods of scientific planning, systems analysis, forecasting, optimization and programming, and conversely, significantly improve the quality of their application on all management levels and on all issues.

Analysis of recent publications on the problem. Issues of businesses functioning have long been the subject of research of scientists around the world: R. Hilferding, P. Drucker, R. Cantillon, A. Marshall, J.B. Say, Adam Smith, Y. Schumpeter and others. Since independence, Ukrainian scientists also issues payed attention to such issues, specifically: V. Boronos, L. Byriak, W. Vorotina, S. Dryga, V. Zbarskyy, A. Kvasovskyy, D. Knysh, A. Kovalyuk, M. Krupka, O. Kundytskyy, R. Larina, S. Lobozynska, V. Lyashenko, V. Plisa, G. Poplavska, S. Reverchuk, A. Horonzhyy, M. Hurasa and others.

The purpose of research is to study the methodological principles of forming the system of innovative development of business in Ukraine

The presentation of key findings and studies. The need for innovative changes in the national economy can be illustrated by comparing the structure of innovative economies of the developed countries. Thus, the Table 1 shows the structure of innovative economies (in terms of gross value added - GVA).

According to the analyzed data for the "Big Seven" common is to reduce the share of agriculture (0,1-0,8 percentage points (p.p.)) and industrial production (1,0-5,3 p.p.). At the same time, increasing the share of services, including financial and insurance (by 0,6-4,9 percentage points) and others, which primarily includes services for development of high-tech products, the introduction of modern technologies (at 0, 5-1,4 percentage points).

Table 1

Dynamics of the structure of GVA in six priority sectors of different countries, % [calculated on the basis of 2]

Countries	Sectors					
	Agriculture	Industry	Construction	Transport and Trade	Financial and insurance services	Other services
Group of the "Big Seven"						
The arithmetic mean of the group	1,5	20,6	5,7	19,9	29,6	22,7
Group of leading countries in economic growth						
The arithmetic mean of the group	2,5	24,9	8,2	19,7	24,7	20,0
Group of successful transformation countries						
The arithmetic mean of the group	3,6	28,0	6,7	24,7	18,8	18,2
Group of new industrialized countries						
Korea						
2008	4,9	32,4	8,4	18,2	20,1	16,1
2015	3,0	30,5	8,9	16,9	21,6	19,1
Changes in 2015 to 2008	-1,9	-1,9	0,5	-1,3	1,5	3,0
Turkey						
2008	10,8	24,6	5,4	29,1	19,5	10,6
2015	8,7	22,2	5,6	31,7	20,2	11,6
Changes in 2015 to 2008	-2,1	-2,4	0,2	2,6	0,7	1,0
Russian Federation						
2008	6,7	31,4	6,6	32,7	4,6	18,0
2015	4,6	31,8	5,7	30,1	14,7	13,1
Changes in 2015 to 2008	-2,1	0,4	-0,9	-2,6	10,1	-4,9
Ukraine						
2008	17,1	33,6	3,9	23,9	7,7	13,8
2015	7,6	30,4	4,6	25,7	16,0	15,7
Changes in 2015 to 2008	-9,5	-3,2	0,7	1,8	8,3	1,9

Note that the relevant trends observed in leading countries of economic growth.

Slightly different is the specificity of structural changes in the transitional economies, which include Ukraine. There is also a decrease in the share of agriculture, but, apart from the service sector, the share of industry increases - namely, the production of high-tech and sophisticated products.

Countries that were part of the Soviet Union in the past by six sectors at present only data on the Russian Federation, where the share of financial and insurance services 10.1 p.p. and industry - by 0.4 p.p. by reducing the share of all other segments [1]. In countries such as South Korea and Turkey, the share of agriculture and industry fell by 1,9-2,4 p.p. by increasing the service sector. If you compile the data presented in Table 1, the main features that characterize the structure of national economies in the context of the six sectors, can be obtained averages of structures in groups (Table 2).

Table 2

Comparison of the national economy and the world in terms of gross value added in 2015, % [calculated by author based on 2,3]

Sectors	Countries "Big Seven"	Countries leading in economic growth	Countries with transformational economies	South Korea	Russian Federation	Ukraine	Deviations of Ukraine to countries				
							"Big Seven"	leaders of economic growth, p. p.	transformation, p. p.	Korea	Russian Federation
1. Agriculture	1,5	2,5	3,6	3,0	4,6	7,6	6,1	5,1	4,0	4,6	3,0
2. Industry	20,6	24,9	28,0	30,5	31,8	30,4	9,8	5,5	2,4	-0,1	-1,4
3. Construction	5,7	8,2	6,7	8,9	5,7	4,6	-1,1	-3,6	-2,1	-4,3	-1,1
4. Transport and Trade	19,9	19,7	24,7	16,9	30,1	25,7	5,8	6,0	1,0	8,8	-4,4
5. Financial and insurance services	29,6	24,7	18,8	21,6	14,7	16,0	-13,6	-8,7	-2,8	-5,6	1,3
6. Other services	22,7	20,0	18,2	19,1	13,1	15,7	-7,0	-4,3	-2,5	-3,4	2,6

Separately considered the comparison of the economic structure of Ukraine and the "Big Seven". It can be concluded that the largest differences observed in the agricultural sector; in addition, the indicators against the "Big Seven" share of industry 1.5 times higher, respectively, the share of services - less: financial and insurance - 1.9 times, others - in 1,5 times.

Note that not all differences in economic structure of Ukraine and developed countries show the inefficiency of the Ukrainian economy: so a significant proportion of Agriculture is due to historical and climatic features of Ukraine and, especially in the current global food crisis turns more on competitive advantage of Ukraine [1]. So you cannot argue about the appropriateness reduction of the agricultural sector, but rather an increase in value added in promising sectors.

Author considers the development of services, especially services for the development and implementation of modern technologies (engineering) and transfer of industry to innovation way of development.

According to the above analysis of the economic structure and the need for structural changes in accordance with the approach to the economic structure of developed countries, we can conclude the feasibility of the economic system of Ukraine towards innovative components. Further, in order to justify the economic feasibility of innovative development, the author proposes to develop a mathematical model that illustrate the feasibility of innovative development in view of the performance criterion - GDP [4].

The feasibility of economic and mathematical modeling due to the fact that the present state of economic potential, limits opportunities. Now Ukraine cannot fully implement any promising complex program of social development and economic growth because of the uncertainty of goals and means of achieving them, subject to the limitations that imposes the current socio-economic situation. You also need to create new organizational, economic, legal and institutional solutions, consistent state industrial, financial and tax policy with the policy of educational, scientific and technical innovations. If you make a complete transformation of the economic model in Ukraine innovative model based on building economic and mathematical model that would determine the parameters of the target and resource constraints, it will facilitate completion of structural changes in the national economy, accelerate economic growth. The purpose of the changes is to achieve the highest level of competitiveness of the domestic economy. It is necessary to increase the number of exported goods, including high-tech products. Provide scientific justification, supported by mathematical calculations, wisely use of the necessary resources, including physical, financial, natural and human [2]. As a key task of modeling, the author consider a mathematical analysis of statistical data and forecast formation

improving macroeconomic indicators, depending on the factors of influence. As the foundation of economic and mathematical analysis, we identified the factors and how they affect GDP.

As one of these indicators is investigated Δ_j - a factor which should provide an assessment of the impact of each factor on the level of innovation of their mutual influence on the resulting figure. Further, the values specified of the coefficient we present a range of innovative vectors (hereinafter - IV), as illustrated in Fig. 1. This right should be viewed as a polar coordinate system type, radius vector which acts as Δ_j - coefficient.

To ensure ease of comparison, all of the factors we consider as the radius vector which has an amount equal to - Δ_j coefficient:

$$\rho_j = \Delta_j \tag{1}$$

It is reasonable to accommodate these factors in increasing clockwise way which will result in IV.

From this angle φ_j - will be angle of each of radius vectors and will be:

$$\varphi_j = 2\pi / j \tag{2}$$

After step connecting of points $F_1, \ldots, F_j$ (point of the radius vectors), we received the innovation curve-trajectory:

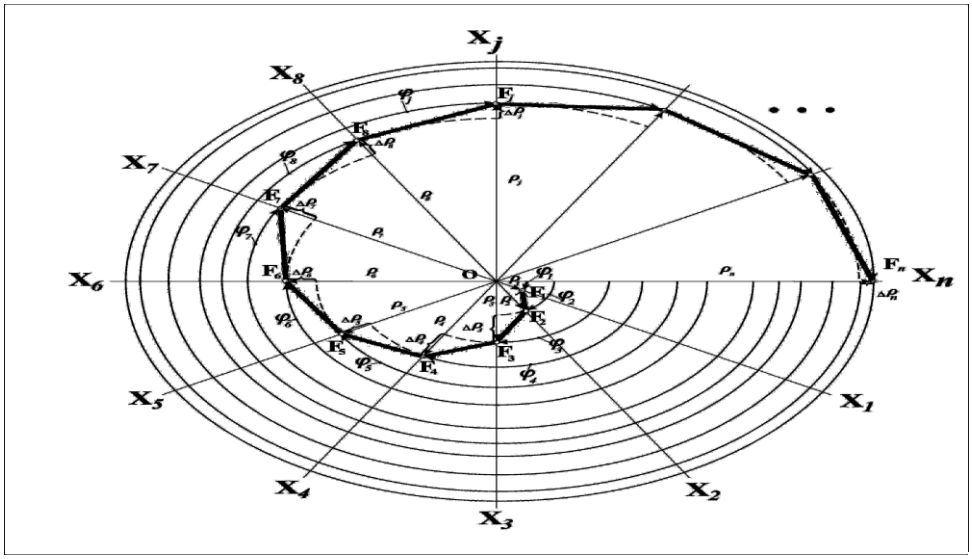


Fig. 1. Innovation curve trajectory in IV [calculated by Author with 4].

In the model, the following marks were used:

$\hat{y}$ – GDP; x_1 – FDI, mln. UAH; x_2 – investment in fixed assets, mln. UAH.; x_3 – the number of new technologies, units.; x_4 – the number of new technologies, units; x_5 – innovation financing, mln. UAH.; x_6 – the number of enterprises that implemented innovations, units.; x_7 – number of patents, units; x_8 – scientific personnel, thsd. people; x_9 – the volume of scientific and technological work, mln. UAH.

The equation of multiple dependence:

$$\hat{y} = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9 \tag{3}$$

For the analysis used the period of 8 years.

Parameters of the regression line are estimated using the least squares method:

$$S = \sum_{1}^{n} (y_i - \hat{y}_i)^2 \to \min \tag{4}$$

Hereafter:

$$S = \sum_{i=1}^{8} (y_1 - (a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9))^2 \to \min \tag{5}$$

Necessary conditions for extremum function of variables $\frac{\partial S}{\partial a_i} = 0\left(i = \overline{0,9}\right)$provide a system of normal equations:

$$\begin{cases}
8a_0+a_1\sum x_i+a_2\sum x_i+a_3\sum x_i+a_4\sum x_i+a_5\sum x_i+a_6\sum x_i+a_7\sum x_i+a_8\sum x_i+a_9\sum x_i+a_{10}\sum x_{10}=\sum y_i \\
a_0\sum x_i+a_1\sum x_i^2+a_2\sum x_ix_i+a_3\sum x_ix_i+a_4\sum x_ix_i+a_5\sum x_ix_i+a_6\sum x_ix_i+a_7\sum x_ix_i+a_8\sum x_ix_i+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_i^2+a_3\sum x_ix_i+a_4\sum x_ix_i+a_5\sum x_ix_i+a_6\sum x_ix_i+a_7\sum x_ix_i+a_8\sum x_ix_i+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_ix_i+a_3\sum x_i^2+a_4\sum x_ix_i+a_5\sum x_ix_i+a_6\sum x_ix_i+a_7\sum x_ix_i+a_8\sum x_ix_i+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_ix_i+a_3\sum x_ix_i+a_4\sum x_i^2+a_5\sum x_ix_i+a_6\sum x_ix_i+a_7\sum x_ix_i+a_8\sum x_ix_i+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_ix_i+a_3\sum x_ix_i+a_4\sum x_ix_i+a_5\sum x_i^2+a_6\sum x_ix_i+a_7\sum x_ix_i+a_8\sum x_ix_i+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_ix_i+a_3\sum x_ix_i+a_4\sum x_ix_i+a_5\sum x_ix_i+a_6\sum x_i^2+a_7\sum x_ix_i+a_8\sum x_ix_i+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_ix_i+a_3\sum x_ix_i+a_4\sum x_ix_i+a_5\sum x_ix_i+a_6\sum x_ix_i+a_7\sum x_i^2+a_8\sum x_ix_i+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_ix_i+a_3\sum x_ix_i+a_4\sum x_ix_i+a_5\sum x_ix_i+a_6\sum x_ix_i+a_7\sum x_ix_i+a_8\sum x_i^2+a_9\sum x_ix_i=\sum yx_i \\
a_0\sum x_i+a_1\sum x_ix_i+a_2\sum x_ix_i+a_3\sum x_ix_i+a_4\sum x_ix_i+a_5\sum x_ix_i+a_6\sum x_ix_i+a_7\sum x_ix_i+a_8\sum x_ix_i+a_9\sum x_i^2=\sum yx_i
\end{cases}$$

Counting represents a system of equations::

$$\begin{cases}
8a_0+136a_1+92a_2+87a_3+104a_4+57a_5+88a_6+53a_7+101a_8+59a_9=122,5 \\
136a_0+352a_1+47a_2+95a_3+125a_4+35a_5+146a_6+107a_7+104a_8+31a_9=228,2 \\
92a_0+47a_1+406a_2+35a_3+99a_4+98a_5+98a_6+147a_7+102a_8+96a_9=38,5 \\
87a_0+95a_1+35a_2+170a_3+168a_4+213a_5+163a_6+160a_7+139a_8+139a_9=122,3 \\
104a_0+123a_1+99a_2+168a_3+155a_4+274a_5+134a_6+162a_7+176a_8+217a_9=135,9 \\
57a_0+35a_1+98a_2+213a_3+274a_4+165a_5+222a_6+139a_7+188a_8+191a_9=210,8 \\
88a_0+146a_1+98a_2+163a_3+134a_4+222a_5+178a_6+151a_7+152a_8+194a_9=132,6 \\
53a_0+107a_1+147a_2+160a_3+162a_4+139a_5+151a_6+352a_7+144a_8+108a_9=84,7 \\
101a_0+104a_1+102a_2+139a_3+176a_4+188a_5+152a_6+144a_7+102a_8+184a_9=152,1 \\
59a_0+31,2a_1+96a_2+159a_3+217a_4+191a_5+194a_6+108a_7+184a_8+338a_9=265,9
\end{cases}$$

For solving the system, the matrix method was used:

$$X = \begin{cases}
8 \quad 136 \quad 92 \quad 87 \quad 104 \quad 57 \quad 88 \quad 53 \quad 101 \quad 59 \quad 122,5 \\
136 \quad 352 \quad 47 \quad 95 \quad 125 \quad 35 \quad 146 \quad 107 \quad 104 \quad 31 \quad 228,2 \\
92 \quad 47 \quad 406 \quad 35 \quad 99 \quad 98 \quad 98 \quad 147 \quad 102 \quad 96 \quad 38,5 \\
87 \quad 95 \quad 35 \quad 170 \quad 168 \quad 213 \quad 163 \quad 160 \quad 139 \quad 139 \quad 122,3 \\
104 \quad 123 \quad 99 \quad 168 \quad 155 \quad 274 \quad 134 \quad 162 \quad 176 \quad 217 \quad 135,9 \\
57 \quad 35 \quad 98 \quad 213 \quad 274 \quad 165 \quad 222 \quad 139 \quad 188 \quad 191 \quad 210,8 \\
88 \quad 146 \quad 98 \quad 163 \quad 134 \quad 222 \quad 178 \quad 151 \quad 152 \quad 194 \quad 132,6 \\
53 \quad 107 \quad 147 \quad 160 \quad 162 \quad 139 \quad 151 \quad 352 \quad 144 \quad 108 \quad 84,7 \\
101 \quad 104 \quad 102 \quad 139 \quad 176 \quad 188 \quad 152 \quad 144 \quad 102 \quad 184 \quad 152,1 \\
59 \quad 31,2 \quad 96 \quad 159 \quad 217 \quad 191 \quad 194 \quad 108 \quad 184 \quad 338 \quad 265,9
\end{cases}$$

$$a = \begin{pmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \\ a_7 \\ a_8 \\ a_9 \end{pmatrix}$$

$$y = \begin{pmatrix} 1272,15 \\ 28258,24 \\ 38,45 \\ 18229,3 \\ 1825,49 \\ 2916,88 \\ 1825,56 \\ 8474,37 \\ 152,21 \\ 2786,39 \end{pmatrix}$$

Calculate the inverse matrix:

$X^{-1} =$ [illegible]

This system solution:

$$a = \begin{cases} 132 \\ -0,000185 \\ -48,759 \\ 3,202 \\ 37,433 \\ 43,349 \\ -53,81 \\ -0,122 \\ -793,129 \\ 10,87 \end{cases}$$

The regression equation:

[illegible]

Correlation Index calculated by the formula:

$$i = \sqrt{1 - \frac{\sum_{j=1}^{8} (\hat{y}_j - y_j)^2}{\sum_{j=1}^{8} (y_j - \bar{y})^2}} \qquad (6)$$

$\hat{y}_j$ – regression;

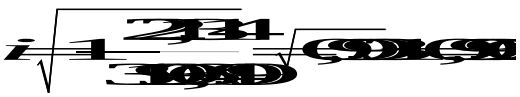
y_j - value of effective signs;

$\bar{y}$ – the average value of effective signs.

Dispersions and empirical values obtained constitute:

$\sum (\hat{y}_j - y_j)^2 = 221{,}314$

$\sum (y_j - \bar{y})^2 = 31996{,}499$



Some elastic coefficients indicate how the average, in %, y varies with changes of factor X by one percent:

$$Э_j = a_j \frac{\bar{x}_j}{\bar{y}} \quad (7)$$

a_i – regression coefficients with j factor.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β_j - coefficient indicates which proportion of standard deviation σy will change the dependent variable if you change the factor x_j on the value of its standard deviation (σj).

$$\beta_j = a_j \frac{\sigma_j}{\sigma_y} \quad (8)$$


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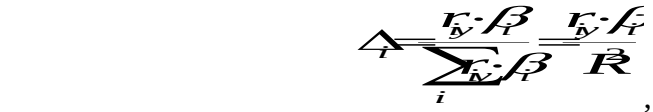
Next, to assess the impact of each factor in the amount, will calculate Δ_j - coefficient:


, (9)

$$r_{xjy} = \frac{\frac{1}{n}\sum_{i=1}^{n} x_{ij} y_i - \bar{x}_i \bar{y}}{\sigma_{xj}\sigma_y}, \quad (10)$$

$$R^2 = 1 - \frac{\begin{vmatrix} 1 & r_{1y} & r_{2y} & r_{3y} & r_{4y} & r_{5y} & r_{6y} & r_{7y} & r_{8y} & r_{9y} \\ r_{y1} & 1 & r_{21} & r_{31} & r_{41} & r_{51} & r_{61} & r_{71} & r_{81} & r_{29} \\ r_{y2} & r_{12} & 1 & r_{32} & r_{42} & r_{52} & r_{62} & r_{72} & r_{82} & r_{92} \\ r_{y3} & r_{13} & r_{23} & 1 & r_{43} & r_{53} & r_{63} & r_{73} & r_{83} & r_{93} \\ r_{y4} & r_{14} & r_{24} & r_{34} & 1 & r_{54} & r_{64} & r_{74} & r_{84} & r_{94} \\ r_{y5} & r_{15} & r_{25} & r_{35} & r_{45} & 1 & r_{65} & r_{75} & r_{85} & r_{95} \\ r_{y6} & r_{16} & r_{26} & r_{36} & r_{46} & r_{56} & 1 & r_{76} & r_{86} & r_{96} \\ r_{y7} & r_{17} & r_{27} & r_{37} & r_{47} & r_{57} & r_{67} & 1 & r_{87} & r_{97} \\ r_{y8} & r_{18} & r_{28} & r_{38} & r_{48} & r_{58} & r_{68} & r_{78} & 1 & r_{98} \\ r_{y9} & r_{19} & r_{29} & r_{39} & r_{49} & r_{59} & r_{69} & r_{79} & r_{89} & 1 \end{vmatrix}}{\begin{vmatrix} 1 & r_{21} & r_{31} & r_{41} & r_{51} & r_{61} & r_{71} & r_{81} & r_{29} \\ r_{12} & 1 & r_{32} & r_{42} & r_{52} & r_{62} & r_{72} & r_{82} & r_{92} \\ r_{13} & r_{23} & 1 & r_{43} & r_{53} & r_{63} & r_{73} & r_{83} & r_{93} \\ r_{14} & r_{24} & r_{34} & 1 & r_{54} & r_{64} & r_{74} & r_{84} & r_{94} \\ r_{15} & r_{25} & r_{35} & r_{45} & 1 & r_{65} & r_{75} & r_{85} & r_{95} \\ r_{16} & r_{26} & r_{36} & r_{46} & r_{56} & 1 & r_{76} & r_{86} & r_{96} \\ r_{17} & r_{27} & r_{37} & r_{47} & r_{57} & r_{67} & 1 & r_{87} & r_{97} \\ r_{18} & r_{28} & r_{38} & r_{48} & r_{58} & r_{68} & r_{78} & 1 & r_{98} \\ r_{19} & r_{29} & r_{39} & r_{49} & r_{59} & r_{69} & r_{79} & r_{89} & 1 \end{vmatrix}}$$

The values:

$$F := \begin{pmatrix} 1 & 0.97 & 0.34 & -0.57 & 0.98 & -0.78 & 0.75 & -0.93 & 0.99 \\ 0.97 & 1 & 0.23 & -0.43 & 0.988 & -0.76 & 0.81 & -0.86 & 0.994 \\ 0.34 & 0.23 & 1 & -0.54 & 0.22 & 0.17 & 0.35 & -0.47 & 0.22 \\ -0.57 & -0.43 & -0.54 & 1 & -0.47 & 0.57 & -0.17 & 0.79 & -0.46 \\ 0.98 & 0.988 & 0.22 & -0.47 & 1 & -0.80 & 0.79 & -0.90 & 0.998 \\ -0.78 & -0.76 & 0.17 & 0.57 & -0.80 & 1 & -0.37 & 0.76 & -0.80 \\ 0.75 & 0.81 & 0.35 & -0.17 & 0.79 & -0.37 & 1 & -0.66 & 0.78 \\ -0.93 & -0.86 & -0.47 & 0.79 & -0.90 & 0.76 & -0.66 & 1 & -0.89 \\ 0.99 & 0.994 & 0.22 & -0.46 & 0.998 & -0.80 & 0.78 & -0.89 & 1 \end{pmatrix}$$

$$G := \begin{pmatrix} 1 & 0.996 & 0.98 & 0.38 & -0.55 & 0.98 & -0.74 & 0.80 & -0.93 & 0.986 \\ 0.996 & 1 & 0.97 & 0.34 & -0.57 & 0.98 & -0.78 & 0.75 & -0.93 & 0.99 \\ 0.98 & 0.97 & 1 & 0.23 & -0.43 & 0.988 & -0.76 & 0.81 & -0.86 & 0.994 \\ 0.38 & 0.34 & 0.23 & 1 & -0.54 & 0.22 & 0.17 & 0.35 & -0.47 & 0.22 \\ -0.55 & -0.57 & -0.43 & -0.54 & 1 & -0.47 & 0.57 & -0.17 & 0.79 & -0.46 \\ 0.98 & 0.98 & 0.988 & 0.22 & -0.47 & 1 & -0.80 & 0.79 & -0.90 & 0.998 \\ -0.74 & -0.78 & -0.76 & 0.17 & 0.57 & -0.80 & 1 & -0.37 & 0.76 & -0.80 \\ 0.80 & 0.75 & 0.81 & 0.35 & -0.17 & 0.79 & -0.37 & 1 & -0.66 & 0.78 \\ -0.93 & -0.93 & -0.86 & -0.47 & 0.79 & -0.90 & 0.76 & -0.66 & 1 & -0.89 \\ 0.986 & 0.99 & 0.994 & 0.22 & -0.46 & 0.998 & -0.80 & 0.78 & -0.89 & 1 \end{pmatrix}$$

Then $R^2 = 1 - \frac{|G|}{|F|}$

[illegible]

Δ_j - coefficient equals:

[illegible]

;

[illegible]

;

[illegible]

;

[illegible]

;

[illegible]

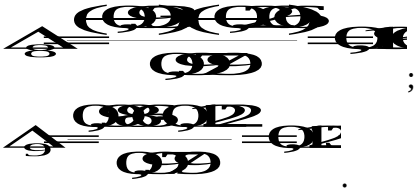
;

[illegible]

;

[illegible]

;



Increase of each ρ_j denotes relative to the previous one - ρ_{j-1} i.e.:

$$\Delta\rho_j = \rho_j - \rho_{j-1} \tag{11}$$

The formula to determine the arithmetic mean value of $\overline{\Delta\rho_j}$

$$\overline{\Delta\rho_j} = \frac{\sum_{j=1}^{n} \Delta\rho_j}{j} \tag{12}$$

In this case, the values of the radius vector will be determined in sequence, starting with the first ρ_1, and at the same time taking into account the angle of rotation φ_j.

$$\rho'_j = \overline{\Delta\rho_j} \cdot \varphi_j \tag{13}$$

The resulting broken curve and its equation correspond to Archimedean spiral. If you connect the end of the radius vector curve ρ'_j - you will get a spiral with a radius R' that is equal to the radius vector of greatest impact factor. Thus, the equation can be used as a model of innovative development, which will predict how each factor affects the correlation R2. This correlation takes into account the total impact of the factors considered in the model on its outcome. Therefore, the result of the application of the model is to determine the elasticity factors.

To predict the target gross domestic product the model steps forward to the desired value of ΔR:

$$R^* = R' + \Delta R \tag{14}$$

In turn, if divided by R^* the corresponding number of factors that influence the innovative development of (*j*), we get the forecast of increasing in the radius vector of influence factor:

$$\Delta\rho_j^* = \frac{R^*}{j} \tag{15}$$

Further, using the above equation, it is easy to get estimates of the radius vector of factors, which require the calculation of ρ_j^* which is the new value of ratios Δ^*_j

Based on correlation of Δ^*_j coefficients and elasticity, becomes possible the predictive calculation of elasticity of each factor affecting the innovative development.

$$Э_j^* = \frac{Э_j \cdot \Delta_j^*}{\Delta_j} \tag{16}$$

Research shows that if the correlation coefficient R2 remains unchanged, the change in the innovation factor of 1% would, on the basis of calculation of elasticity change the target index by $Э_j^*$ %.

The arithmetic mean $э_j^*$, which can be calculated using the following formula is needed to calculate the index of innovation development of economy:

$$\overline{Э_j^*} = \frac{\sum_{j=1}^{n} Э_j^*}{j} \tag{17}$$

$\overline{Э_j^*}$ shows that in conditions of change of all values of innovation factors by 1%, the average rate of innovation (GDP) could reach the projected size::

$$(\overline{ВВП})^* = \overline{ВВП} \cdot \overline{Э_j^*} \quad (18)$$

Next, is to determine model parameters. Point ends of vectors labeled from F1 to F8

Subsequently, a factor of direct investment is not considered because the impact on GDP is negligible.

According to a number of factors, the number of the radius vectors make 8, and the angle of each of the vectors will amount = π/4 (Table 3).

Table 3

Parameters of the model based on coefficients $э_j$ and Δ_j

	The coefficients		Ranking factors in the model		Coefficient value		Ranking factors in the model
	$э_j$	$\rho_j = \Delta_j$			$э_j$	$\rho_j = \Delta_j$	
x_1	0,008	0,01	2(X_2)	x_5	-0,503	0,11	5(X_5)
x_2	0,274	0,096	3(X_3)	x_6	-0,004	0,005	1(X_1)
x_3	0,354	0,107	4(X_4)	x_7	-0,629	0,196	7(X_7)
x_4	0,537	0,567	8(X_8)	x_8	0,131	0,123	6(X_6)

Thus, by connecting the ends of vectors, we get an innovative trajectory that will be based on statistical data.

Thus, we get the following values (Table 4).

Table 4

Change of the radius vector

Factors of innovative changes	$\Delta\rho_j$	Factors of innovative changes	$\Delta\rho_j$
X1	0	X_5	0,003
X_2	0,005	X_6	0,013
X_3	0,086	X_7	0,073
X_4	0,011	X_8	0,371

Using the arithmetic mean: $\overline{\Delta\rho_j} = 0{,}07$ we get (Table 5).

Table 5

Value of the radius vector

Value ρ'_j	Кут φ_j							
	φ_1	φ_2	φ_3	φ_4	φ_5	φ_6	φ_7	φ_8
	$\pi/4$	$\pi/2$	$3\pi/4$	π	$5\pi/4$	$3\pi/2$	$7\pi/4$	2π
	0,7854	1,5708	2,3561	3,1415	3,9269	4,7123	5,4977	6,2831
ρ'_1	0,0550							
ρ'_2		0,1100						
ρ'_3			0,1649					
ρ'_4				0,2199				
ρ'_5					0,2749			
ρ'_6						0,3299		
ρ'_7							0,3848	
ρ'_8								0,4398

Using formula 17 for determining the values of the radius vector, which will be shown in sequence ρ_1 based on the angle φ_j of each radius vector. As a theoretical model, connecting one end of the curve provides a vector trajectory of the economic system of Ukraine. Next, we move to implement the main task of forecasting the GDP. For this, we increase step model to the desired size for example - 0.7.

Because the formula 3.24 we get the predicted value R^* respectively as being equal to 0.7. Hence, as the number of impacts is 8, using 3.19 predictive value of the radius vector of factors of influence on the innovative development will be $\Delta\rho_j^* = 0{,}0875$.

For further calculations Δ^*_j - coefficient will be used in formula 17 with value $\Delta\rho_j^*$ (Table 6).

Table 6

Calculation of Δ^*_j - of coefficients on the basis of parameters of vectors

Δ^*_j	φ_j							
	φ_1	φ_2	φ_3	φ_4	φ_5	φ_6	φ_7	φ_8
	$\pi/4$	$\pi/2$	$3\pi/4$	π	$5\pi/4$	$3\pi/2$	$7\pi/4$	2π
	0,7854	1,5708	2,3561	3,1415	3,9269	4,7123	5,4977	6,2831
Δ^*_1	0,0687							
Δ^*_2		0,1374						
Δ^*_3			0,2062					
Δ^*_4				0,2749				
Δ^*_5					0,3436			
Δ^*_6						0,4123		
Δ^*_7							0,4810	
Δ^*_8								0,5498

Finally, using the formula 4 we can calculate the impact of each factor on GDP target by changing the value of the target factor by 1% (Table 7).

Table 7

Determining the impact of changing innovation factors on target

Indicator	Coefficients		Indicator	Coefficients	
	$Э^*_j$	Δ^*_j		$э^*_j$	Δ^*_j
X_1	0,05496	0,0687	X_5	-1,5712	0,3436
X_2	0,39216	0,1374	X_6	-0,3298	0,4123
X_3	0,68219	0,2062	X_7	-1,5436	0,481
X_4	0,26036	0,2749	X_8	0,58556	0,5498

Thus, if the correlation coefficient remains unchanged, all factors except the X5 and X7, with a change of 1% will result the change by a certain amount. Our calculation lets to result of innovative development, which is calculated by the formula 5 (average value), which is equal to 0.11, or 11%. Therefore, if one of the factors of innovation will change by 1%, the average change in GDP could reach 11%. Thus, the model used justifies structural changes in the economy towards innovative business development.

Conclusions and recommendations for further research

The results of the study are the following problem areas of organizational methods as unfounded promising areas of innovation; lack of time and financial balance of the current and strategic innovation; lack of methodological support planning and evaluation of innovative activity. Developed management process of methodological support of the development through balancing current and future innovation.

The technique involves managing sustainable innovation development in two directions: development of promising innovations and the benefits achieved. To plan the development of promising innovations developed model of innovation portfolio. Implementation of portfolio of innovative projects developed using the proposed models of planning innovation activity. For the planning of the benefits achieved (depending on the type of strategy, implemented) by the proposed method are formed and calculated parameters of innovation activity.

Analysis of the implementation effect of methodological provision leads to the conclusion that it has a direct impact on reducing the time, cost, and enhances the competitiveness of products.

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