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MODELING OF INNOVATION ACTIVITY OF KNOWLEDGE-BASED ENTERPRISES BASED ON PROJECT MANAGEMENT METHODOLOGY

The article describes the modeling process of innovation activity of knowledge-based enterprises based on project management methodology. As for the innovative project is a project that includes technical, economic, legal and organizational ultimate justification of innovative activity. The result of an innovative project is the development of document includes a detailed description of product innovation, justify its viability, necessity, opportunity and attract investment forms, information on deadlines, executors and takes into account the organizational and legal aspects of its promotion. It should be noted that the success of innovative projects depends on a clear definition of goal setting of motivational activities of the project team, providing control functions on the results of the project, development of the concept of interaction of stakeholders within the project-oriented knowledge-based organization.

Keywords: *innovative project, innovation, project-oriented organization, methodological, project management.*

У статті описується процес моделювання інноваційної діяльності наукомістких підприємств на основі методології управління проектами. Що стосується інноваційного проекту, то це проект, який включає технічне, економічне, юридичне і організаційне обґрунтування інноваційної діяльності. Результатом інноваційного проекту є розробка документа, що включає докладний опис інноваційної продукції, обґрунтування його життєздатності, необхідності, можливості залучення інвестицій, інформації про терміни виконання, виконавців, враховуючи організаційні та правові аспекти просування проекту. Слід зазначити, що успіх інноваційних проектів залежить від чіткої постановки цілей мотиваційної діяльності проектної групи, забезпечення контрольних функцій за результатами проекту, розробки концепції взаємодії зацікавлених сторін в рамках проектно-орієнтованої наукомісткої організації.

Ключові слова: *інноваційний проект, інновації, проектно-орієнтована організація, методологія, управління проектами.*

В статье описывается процесс моделирования инновационной деятельности наукоёмких предприятий на основе методологии управления проектами. Что касается инновационного проекта, то это проект, который включает техническое, экономическое, юридическое и организационное обоснование инновационной деятельности.

Результатом инновационного проекта является разработка документа, включающего подробное описание инновационной продукции, обоснование его жизнеспособности, необходимости, возможности привлечения инвестиций, информации о сроках исполнения, исполнителях, учитывая организационные и правовые аспекты продвижения проекта. Следует отметить, что успех инновационных проектов зависит от четкой постановки целей мотивационной деятельности проектной группы, обеспечения контрольных функций по результатам проекта, разработки концепции взаимодействия заинтересованных сторон в рам-ках проектно-ориентированной наукоёмкой организации.

Ключевые слова: *инновационный проект, инновации, проектно-ориентированная организация, методология, управление проектами.*

Introduction. The model of innovation development must have the ability to self-adjust, that is, in time it must respond to signals from the internal and external environment. Innovative processes are complex of nonlinear, dynamic processes, that predetermines the identification of key factors, key regularities, and the construction of cognitive verbal models as the basis for further mathematical modeling. The foregoing also encourages the construction of ambiguous forecast models. We can talk about possible scenarios and trends in the development of events. The notion of an economic model was quite fully disclosed by E. Kane [1; 2]. The economic model is a logical description of the factors, that the economic theory considers to be of particular importance in the study of this problem, based on a priori analysis. The model is able to answer the questions that relate to the explanation of a particular phenomenon or its prediction. Usually the model has the form of a system of equations characterizing the interdependencies identified by the researcher between more or less well-verifiable variables. Such a system combines definitions, theoretical assumptions about economic behavior and the conditions of balance, that together gives the possibility of obtaining of certain answers to questions posed by the economist. Models are deliberately simplified, each has meaning only within a limited range of issues, and even within these limits can serve as a basis only for approximate judgments. Model building is a creative process that has two main stages: the exclusion of those elements with respect to which it can be assumed that they will be atypical particulars, and explicitly identifying all the dependencies between the economic variables under consideration and establishing their logical structure.

Analysis of the main achievements and literature. The principle of self-improvement is important, which means correction based on monitoring of changes occurring in society, risk assessment and innovation diagnostics results [3].

First, let us focus on the construction of a verbal model of the innovative development of industry. Extrapolation of patterns of economic

recession allowed to expect a decline in national income in the 90s by no more than 10 %, and not twice, as it actually happened.

The scientific work [4] shows the dynamics of macroeconomic indicators over a 30-year period, where the prerequisites for reducing production in Ukraine are explained.

The achievements of scientific and technological progress not only did not compensate for the decrease in the extensive factors of the growth of the national income, but also could not prevent the catastrophic reduction of the national battle. Meanwhile, if resource-saving technologies were used at the level of advanced countries, then the scale of consumption of natural resources could be reduced by no less than 30-40 %. Then the reduction of natural resources would be compensated by the accumulation of property.

Three characteristic features of the centralized planning system determined her immunity to the achievements of scientific and technological progress.

The centralized management system suppressed the initiative and especially entrepreneurship. Economic growth was focused on increasing production volumes, which did not contribute to improving quality and saving production costs. In addition, such an economy by its nature was inevitably costly and therefore rejected resource-saving technologies. In a scarce economy, there was no market competition. On commodity markets there were no real incentives to struggle for high quality, low production costs and prices, environmental friendliness of goods. The scarcity of the labor force and the lack of competition in the labor market, standardly low wages deprived labor of quality motivation. Absence of competition in the financial market (state capital investments were distributed irrevocably and without interest) generated a deficit of capital investments.

Conclusion on the immunity of the centralized planning system to the achievements of scientific and technological progress should be supplemented by the fact that a significant part of domestic products was produced at the highest technical level. We are talking about defense products, the high technical level of which was confirmed not only by its internal customers, but also by the world market, as well as by special studies of American and other foreign specialists.

A high level of domestic defense technology was the result of external competition with foreign counterparts. Before the creators of domestic military equipment, the task was set in a short time, but by almost any means to cover certain values of specific parameters of the foreign production armaments. Since the funds for the development of military equipment were almost not limited, assignments were usually received by several groups of developers. Thus, in the field of defense technology, there was not only external, but also internal, very tough competition.

The system of defense orders was endowed with the highest state priorities.

The general economic backwardness did not concern the defense in-dustry. Therefore, the lag in the field of electronics almost did not affect the defense industry: by special acceptance for defense orders only the best products were selected. This was also a unique competition of quality.

Research aim and task. The development of project-based approach to modeling of innovation organization is the aim of this research.

Examination of the basic principles of innovative project and development on the basis of innovative methodological foundations of project-oriented organizations is the task of the article.

Materials of research. Obviously, it was impossible to extend such a system to the whole industry.

So, the centralized planning system, on one hand, received less and less additional resources of labor, capital and natural resources, and on the other − proved to be non-innovative in nature, rejected scientific and technological progress − the only factor capable of supporting in modern conditions Stably high rates of economic growth.

To overcome backwardness, it is necessary to find sources of economic growth. World experience shows that there are not so many of them. One of the sources is the cost of labor. The lower the cost of labor, the greater the difference (profit) between costs and results. But here there are two limitations: significant foreign investment and the inability of low-caliber workers to produce more and more new products, diversify production. On this way, the countries of South-East Asia went to build up the initial capital. Another source is the more intensive use of existing natural resources. Many countries have achieved a high standard of living thanks to the so-called «petrodollars». You can make a profit, and even additional, by placing on its territory environmentally harmful production. Post-socialist countries and the «third world» countries can be «proud of» this.

It is impossible not to mention the innovative source. Here the difference between the results that are obtained from scientific and technical and other innovations, and the costs for them are very significant. On this path are developed countries, and our society has all the prerequisites to orientate on it. Moreover, we do not have significant energy resources. The use of existing natural resources, such as coal, is unprofitable because of prolonged exploitation, but at this stage it is necessary. Thus, the formation of an innovative state policy should be a top priority.

In the transformation period, the role of knowledge, experience of management inherent in a market economy is great. The knowledge of managerial personnel of post-Soviet enterprises turned out to be inadequate. The managers of socialist enterprises could not possess such knowledge, if only because no one taught them this. The composition of leading cadres and specialists was compiled according to specific criteria, the main one of which was the unconditional fulfillment of the instructions of the center (the higher body).

The initiative was allowed within certain limits, in the basic in the field of overfulfilment, improvement of the specified parameters. New knowledge, let's call it humanitarian capital, is of the utmost importance. The accumulation of new knowledge requires money and time.

Even in the eastern lands of Germany (ideal conditions for transformation processes in terms of investment size and knowledge transfer in comparison with Ukraine), according to experts, it takes 5-6 years for the accumulation of humanitarian capital. In Ukraine, taking into account the rate of accumulation of humanitarian capital, it will take at least 15-20 years. In other words, until a new generation change comes to management and until it acquires (by trial and error) new practical knowledge.

Innovative activity in market conditions is also supplemented by the availability of private ownership of innovation-intellectual property and financial resources, which gives flexibility and maneuverability to the system.

When modeling the activities of a project-oriented organization, it should be noted that knowledge, that is, innovation, is the main source of economic growth. Investments in the first place serve the process of updating technology. The driving impulse comes from the forces of competition, both internal and external. Thus, the change in the paradigm of economic growth in the direction from the first scheme to the third through the second scheme became an objective necessity [5].

The transition to the market exposed the shortcomings of the Ukrainian economics, and, first of all, its scientific and industrial complex. In the conditions of inflation, especially in the first half of the 1990s, prices for new equipment grew significantly faster than the production of this equipment, which caused a steady decline in the economic effect of its application. It turned out that the new equipment is more expensive than the skilled labor. Under such a state of affairs, modernization became unfavorable, since enterprises that did not use the achievements of scientific and technological progress had lower losses and, consequently, better individual conditions of production. To this we must add a sharp decline in the amount of R & D funding from the state and a «brain drain» abroad.

The emergence of a new class of models of economic growth with endogenous technological progress caused an increase in interest in the problems of economic dynamics.

In the process of studying these models, three important conclusions were drawn: obtaining economies of scale from the greater involvement of resources involved in the process of obtaining new knowledge; The possibility of influencing the pace of long-term economic growth through appropriate public policies that stimulate the process of capital accumulation; Strengthening the influence of the magnitude of economic space, conditioned by the importance of international trade, as well as the processes of globalization and disintegration.

At the heart of P. Romer's models is the division of the economy into three sectors [6]. The gain of new knowledge (g) is expressed by the formula

$$g = \alpha I_k Z, \quad (1)$$

where α − the parameter of scientific productivity.

In the research sector (let's call it the first sector) on the basis of the concentration of intellectual capital I_k and the existing stock of knowledge Z, new knowledge is acquired, subsequently materialized in the form of new technologies.

Firms in the intermediate sector (second sector) of the economy use scientific knowledge obtained in the research sector for the production of fixed assets (technological equipment). It should be noted that each company in this sector is a monopolist and receives a monopoly profit, since it has a patent for the release of its products.

The next sector (the third sector) of the economy ensures the output of final consumer products on the basis of the means of production, labor resources and intellectual capital available to all three sectors of the economy.

The following conclusions can be drawn as a result of the analysis of P. Romer's model: the rate of economic development directly depends on the amount of intellectual capital I_k available in the first sector, in which new knowledge is obtained; Any artificial delay in the process of obtaining new knowledge for exceptionally economic reasons will sooner or later affect the indicators of economic dynamics.

P. Hovit and F. Agayon proposed a model of economic development based on the views of I. Schumpeter on the role of «creative destruction» [7]. The essence of the model is that economic development is a consequence of the technological process, which is determined by competition between firms that generate and carry out promising product and technological innovations. The authors argue that a higher intensity of innovation flow, an increase in the scale of the impact of innovation on economics and an increase in the share of skilled labor associated with the production of intermediate goods lead to a uniform trajectory towards an increase in the average rate of economic growth.

V. Hang, L. Blackburn and F. Pozzolo developed an exogenous model of economic development that is invariant to a wide range of methods of targeted state regulation [8]. The model is based on the concept that research is conducted by specialized firms using intellectual capital and accumulated knowledge. Economic growth is achieved if the supply of intellectual capital in the market increases. In this case, there is a simultaneous increase in activity in the field of research and development. State policy ensures long-term growth in the event that it is carried out in the sphere of education, that is, it directly affects the reconstruction of intellectual capital.

We can make up the following main conclusions, as a result of the analysis of existing models of economic growth with endogenous technological progress. The main method of ensuring innovative development is the introduction of technical and product innovations. An important role in economic development is played by scientific knowledge and the accumulation of intellectual capital. Of great importance is the intellectual and financial capital concentrated in the field of R & D.

The role of venture funds and firms is growing as economic agents that promote the introduction of new scientific achievements into real production.

Models of economic development with endogenous technological changes have certain drawbacks. For example, R. Solow, one of the founders of the neoclassical theory, noted that in models a lot of special, not very well-founded and verified assumptions about the nature of technological processes, the nature of scientific activity, the formation and use of intellectual capital, the structure of markets [9].

Under such conditions, there is a need for empirical verification of a number of hypotheses and conclusions, in which the very nature of the innovation process changes radically. The analysis of domestic research of innovation processes and innovation policy showed that their main results as a whole coincide with the results of the analysis of endogenous development models.

The model of innovative development IM can include the most significant factors of scientific and technological development [10; 11] in the form of the objective function

$$IM = f\left[I;E;S;C;R;B;IT;II;Q;M\right] \to \max , \qquad (2)$$

where I − the volume of investment in the innovation sphere;

E − the level of higher education;

S − the level of scientific research and R & D;

C − the level of development of industry;

R − the level of development of regions;

B − the level of development of small and medium business;

IT − the level of introduction of information technologies;

II − the development of innovative infrastructure;

Q − the level of quality of products and services in accordance with the requirements of international standards;

M − the level of development of marketing.

The developed approach to the construction of the model of innovation development, set forth in [12], suggests that to determine the factors that affect the gross domestic product (GDP), it is necessary to produce a correlation analysis with the following notation:

$\widetilde{V}$ − GDP;

x_1 − foreign direct investment, UAH million;

x_2 − investment in fixed assets, UAH million;

x_3 − number of new equipment, units;

x_4 − the number of new technologies;

x_5 − financing of innovative activity, UAH million;

x_6 − number of enterprises that implemented innovations;

x_7 − number of patents, units;

x_8 − scientific personnel, thousand people;

x_9 − volume of scientific and technological works, mln. UAH.

In this case, the linear equation of the multiple dependence can be written according to formula (3) and the function (4) is compiled

$$\widetilde{V} = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + \\ + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9. \quad (3)$$

$$S = \sum_{i=1}^{n}\left(V_i - \widetilde{V}_i\right)^2 \to \min. \quad (4)$$

Taking into account the obtained data, taking into account the data of analytical studies for 8 years based on the method of least squares, we have

$$S = \sum_{i=1}^{8}\left(V_1 - (a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + \right. \\ \left. + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9)\right)^2 \to \min. \quad (5)$$

The regression equation is obtained

$$\widetilde{V} = 194 - 0{,}000174x_1 - 42{,}245x_2 + 2{,}478x_3 + 34{,}376x_4 + \\ + 39{,}279x_5 - 62{,}72x_6 - 0{,}134x_7 - 842{,}389x_8 + 9{,}35x_9.$$

Estimating the share of each factor in the change in the level of the effective indicator, it is revealed that the greatest share of influence falls on the factors x_5, x_8, x_9, x_6, x_4. The revealed degree of influence of each innovation factor on the resulting indicator can be represented in the form of radius vector (ω_j) of the innovative vector field (IVF), which is a polar coordinate system in which the radius vector ω_j is the value of the Δ_j − coefficient, that is arranged in ascending order by turning it $\phi_j(\phi_j = 2\pi / j)$ clockwise.

By joining successively the points of the ends of the radius vectors F_1, F_j we obtain an innovative trajectory. In the post-war vector field, we determine the increase ($\Delta\omega_j$) of each radius vector ω_j relative to the previous one, that is

$$\Delta\omega_j = \omega_j - \omega_{j-1}. \quad (6)$$

We determine the average value $\Delta\omega_j^{\,m}$ by the formula of a simple mean, then the new value of each of the radius vectors will be determined in a clear sequence starting with the first ω_1 taking into account the rotation angle ϕ_j of each of the radius vectors, and can be represented as

$$\omega'_j = \Delta\omega_j^{\,m} \cdot \phi_j. \quad (7)$$

The resulting equation completely corresponds to the equation of the Archimedes spiral in the polar coordinate system, and by joining the ends of the radius vectors ω'_j with a smooth curve by a line, we obtain the Archimedes spiral whose radius R' is the largest radius vector of the degree of influence of the factor-the spiral pitch.

In other words, the equation can be used as a model of innovation development of the economy, on the basis of which it is possible to predict the degree of influence of each factor on the overall correlation coefficient R^2, which takes into account the degree of influence of all factors of the given economic-mathematical model on the result on The principles of determining the elasticity of each of the factors, followed by the calculation of the resulting index.

To solve the task of forecasting the resulting GDP index, it is sufficient to increase the step of the helix of the model (R') by the required amount, that is

$$R^* = R' + \Delta R. \quad (8)$$

The predicted value of the constant increase in the radii-vectors of the influence factors is determined by the formula (9)

$$\Delta\omega^*_j = \frac{R^*}{j}. \quad (9)$$

If you substitute the value $\Delta\omega^*_j$ in the equation, you can get the predicted value of the radius vectors of the influence factors, while calculating the value, that is a new value Δ^*_j – coefficients.

Taking into account the ratio of Δ_j – coefficients and coefficients of elasticity E_x, one can determine the predicted value of the elasticity coefficient E^*_j of each of the innovation factors. The calculated indicators of the parameters of the innovation-development model based on the coefficients E_j and Δ_j – coefficients can be used to construct the innovative trajectory of the development of the Ukrainian economy in the innovative vector field and to implement the forecast of its development.

The results of the calculation show that if the total correlation coefficient R^2 is kept constant, the change in each of the innovative factors by 1 % will lead to a change in the resulting GDP index by E^*_j percent. The average value, which is calculated by the simple average formula, shows that if all the values of innovation factors change by 1 %, the change in the average value of GDP $\widetilde{V}^m$ can reach the predicted value, which will be equal to

$$\widetilde{V}^{*m} = \widetilde{V}^m \cdot E^{*m}{}_j . \qquad (10)$$

It should be noted that the factor x_1 (direct foreign investments, mln. UAH) should not be used in the subsequent analysis because of the low degree of influence on the resulting GDP index, then accordingly x_2 (investment in fixed assets, mln. UAH) will become x_1.

The results of the calculations show that if the constant correlation coefficient R^2 is kept constant, the change in each of the innovation factors by 1 % will lead to a change in the resulting GDP index by the E^*_j percent, except for, x_5 and x_7, because $\left|E^*_j\right| \le 1$.

To calculate the new resultant index of the innovation development of the economy, in particular GDP, the average value of the elasticity index, which equals 0.11 (11 %), was determined.

The average value $E^{*m}{}_j$ shows that when all the values of innovation factors change by 1 %, the change in the average value $\widetilde{V}^m$ can reach the predicted value, which can be calculated by the formula. If we take the value of GDP in the pre-crisis period for 1, then taking into account the factors of innovative development of the economy on the basis of using the model, we can assume that in a period of time that will be necessary to increase the degree of influence on the innovation sphere through state regulation, Increase by 0.11 or 11 %.

Conclusions. Using the obtained economic-mathematical analysis and software, a model of innovative development of the Ukrainian economy was built and a forecast of its development was carried out.

Modeling has shown that it is necessary to sharply increase financial investments in the development of the national innovation system. Previous studies have led to the conclusion that for this there is a real source − the withdrawal from the «shadow» of hidden revenues and the creation of conditions for attracting foreign investment.

The analysis of the sources of economic growth showed that in Ukraine there are real competitive advantages that take into account the scientific and technical potential, which is reflected in the verbal models of innovation development. The main difficulty of modeling is that the object (the innovation system) does not stop in development, but constantly evolves. Therefore, two basic principles of constructing models should be used − self-tuning, that is, response to signals from the internal and external environment, and self-improvement − adjustments in time based on monitoring. At the regional level, neoclassical models can be used, which are based on a three-factor production function. At the national level, a model based on identified factors of innovation development with mathematical support is expedient, which allows predicting the degree of influence of each factor on the principles of determining their elasticity with the subsequent calculation of the resulting index. As a result, it allows to determine the degree of influence of state regulation on the innovation sphere.

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