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Methods of Evaluating the Efficiency of Innovations in Industrial Enterprises

Ernazarov Ortik Eshnazarovich
Samarkand State University.
E-mail: ernazarov1979@inbox.ru.

Abstract--- *The research is dedicated to the methods of evaluating the efficiency of innovations, which are one of the factors contributing to the increase in production of industrial enterprises, and the level of implementation of existing methods in practice.*

Keywords--- *Investment, Innovation, Efficiency, Economic Efficiency, Innovative Efficiency, Integral Efficiency, Discount Rate, Profitability, Cost Recovery Period, Innovation Profitability, Risk Ratio, Profitability of Innovations, Innovative Costs, Innovative Economy.*

I. INTRODUCTION

Based on the experience of ensuring sustainable economic development due to innovative factors in the world, increasing the innovative activity of modern industries and the competitiveness of products, the organizational and economic mechanism for improving the efficiency of innovations in production enterprises, classifying innovations and the features of innovative processes, methods for evaluating innovative projects and research problems in the conceptual directions of increasing the efficiency of innovation in high-performance sectors of science.Therefore, it is very important to study and implement methods for assessing the effectiveness of innovations in industrial enterprises. The right choice and rational use of methods for assessing the effectiveness of innovation in industrial enterprises will contribute to the further development of production.

II. LITERATURE REVIEW

Evaluating the effectiveness of innovations is a very complex process, and such research has been written by many scientists in their scientific works. Methods of evaluating the effectiveness of innovations in industrial enterprises, innovations, indicators of efficiency of innovations had been studied by Solou R. [1] , Santo B. [2] , Smith A. [3], Kuznets S. [4], Shumpeter J. [5], Sorokin P. [6], Draker P. [7], Tviss B. [8], Bogatyrev A. [9], Kondratev N. [10], Yakovets Y. [11], Fatkhutdinov S. [12], Vakhabov A.V. [13], Arabov N.U., Nasimov D.A.[14] and Karjavova Kh.A. [15].

III. RESEARCH METHODOLOGY

In this research, we used of methods of grouping, comparative and structural analysis, induction and deduction, analysis and synthesis, and monographic observations.

IV. ANALYSIS AND RESULTS

The general economic principle of evaluating the effectiveness of innovations is to compare the efficiency (result) and costs obtained from it. Performance and cost indicators can be expressed both in natura and in value size.

The problem of determining economic efficiency and selecting the most preferred innovation requires, on the one hand, an increase in the results of its use in relation to the cost of its development, preparation and implementation, and, on the other hand, a comparison of costs with the expected efficiency.

With the accelerated depreciation, which represents a reduction in the replacement time of existing machinery and equipment in industrial enterprises, the problem of evaluating the effectiveness of innovations suddenly becomes more urgent.

The method of calculating the effectiveness of innovations based on comparing results with costs involves making decisions about the appropriateness of innovations.

Typically, the following three groups of indicators are used to assess overall economic efficiency: integrated efficiency indicators; innovation profitability indicators; indicators of the payback period.

Here are the calculation options for this or that indicator from each group:

1. The integral effect (E) represents the amount of the difference between results and costs for a given period in a discount. Calculations based on such criteria are expressed as follows:

$$E = \sum_{t=0}^{T} (N_t - X_t) a_t, \quad (1)$$

T – the reporting year; N_t– result in years; X_t – t^{th} costs of innovation in the year; a_t – the discount rate.

2. Innovation profitability (R_i) represents the ratio of revenues to expenditures for a given period. Profitability is determined as follows:

$$R_i = \sum_{t=0}^{T} D_t a_t / \sum_{t=0}^{T} K_t a_t, \quad (2)$$

D_t – t^{th} income for the period; K_t – t^{th} volume of investments in innovations in the period.

The profitability of innovation is related to the integral efficiency. If the integral effect is positive, the yield is higher than a coefficient of 1 and vice versa. If the profitability is less than 1, then the innovative project will not be implemented.

The amount of income from innovation and the amount of investment required for a given period is determined on the basis of the following formula:

$$D = \sum_{t=0}^{T} \frac{D_t}{(1+a)^t}, \; K = \sum_{t=0}^{T} \frac{K_t}{(1+a)^t}, \qquad (3)$$

3. The payback period (T) is an indicator of sufficient information in assessing the effectiveness of innovations.

In general, the longer the payback period, the higher the risk. In a certain (short) period, innovations are self-sustaining, and in a given period, innovations called “covering innovations” may emerge that are able to offset the effects of previous innovations.

They cover the cost of innovation in the short term. It is during this period that the market, prices, R&D and technology can change. In sectors of the economy where the contribution of R&D and new technologies is high, this effect is observed with significant accuracy.

When the risk is high in business, the payback period is an important parameter in decision-making in relation to innovation. However, the risk must compensate for self-coverage in the short term. In other words, projects need to be implemented quickly. Typically, such projects will have low fan capacity, but this does not mean that technological innovation is impossible. The payback period refers to the ratio of initial investment in innovation to discounting the average annual cash flow.

$$T = \frac{K}{D}, \quad (4)$$

where: K is the initial investment in innovation; D is the discounting of average annual cash inflows.

However, in our opinion, this indicator is suitable for assessing the effectiveness of innovations on an incomplete scale. This is due to the fact that it affects a wide range of agents in the creation and use of innovations. Investors, research, development, design organizations, manufacturers and consumers of innovative products are involved in the creation of innovations.

At the same time, the ultimate goal is to achieve good results compared to the implementation of technological innovations. Annual economic efficiency (E_a) from the introduction of new technological processes, mechanization and automation, labor and production is calculated on the basis of the following formula:

$$E_a = (d_{n1} - d_{n2}) \cdot M_2, \quad (5)$$

where: $d_{n1}$and d_{n2} – the share of costs per unit of product (work) produced, respectively, with the help of the base and technology;

M_2 is the annual volume of production (work) in natural units with the support of new technologies in the reporting year.

The cost-effectiveness of innovations is determined on the basis of the following indicators: the cost of mastering technological innovations; total costs of production and sale of products; revenue from the sale of products produced as a result of the introduction of technological innovations; profit from the sale of products resulting from the introduction of technological innovations; revenue from product sales; value of intangible assets; value of fixed assets; net profit; average annual number of workers.

These indicators provide for the construction of a system of interrelated multipliers for factor analysis: costs per unit of sales volume; profit from product sales; net profit.

The cost-effectiveness of innovations is characterized by: a decrease in the cost of the product; increase in the level of labor armament with funds; increase in labor productivity; increase in sales or sales; increase the profitability of sales, production and other financial indicators.

The contribution of pure product growth due to increased labor productivity in industrial enterprises D_{pp}:

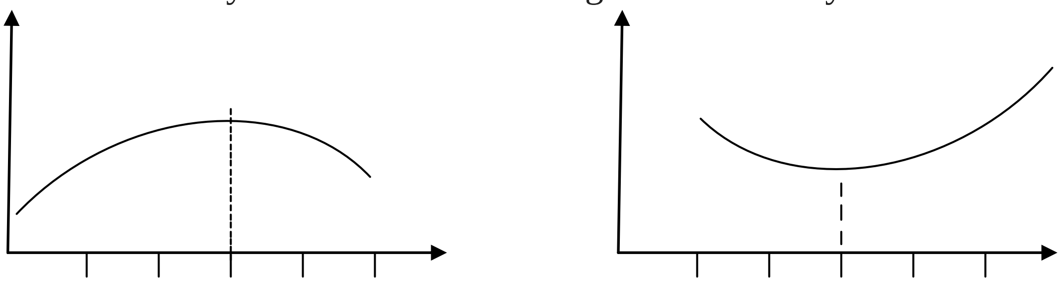
$$D_{pp} = \left(1 - \frac{\Delta G_w}{\Delta G_{pp}}\right) \cdot 100\%, \quad (6)$$

where: ΔG_w- growth rate of the number of workers in industrial enterprises%; ΔG_{pp} is the growth rate of pure product production%.

In our opinion, in order to assess the development efficiency of the innovation sector of the economy, it is necessary to use the following system of indicators that form a single system of measuring the innovative performance of any economic system (enterprise, large corporation, economic zone, macroeconomics) and apply in the innovation model monitoring system: the share of innovations (new products) in production; innovation costs and their share in total capital expenditures; fixed capital investments and their share in total investments; capacity of funds and level of armament with funds, energy capacity and material capacity in the economic system, technological efficiency; the share of R&D in the total capacity of science, the cost of innovations in total investment and the share of items in this area in the total number of items; TAT (turn around time) is a general indicator of innovation that is understood by the subject and measured at the time of the emergence of established needs until the time to fill the market with new goods. In terms of content, this figure is the best description of the competitors ’comparison; an indicator of technological intensity that determines the number of advanced technologies per worker.

The effectiveness of innovations is determined over time depending on the type of innovative outcome. If we distinguish, for example, innovations starting from fundamental discoveries (type A), innovations related to technical and technological changes (type B), innovations in the quality of improvement (type C), innovations in the sense of imitation (imitation) (not related to new technologies) (D type) and R - product innovations. To do this, we obtain an absolute curve with different curvatures depending on the efficiency measurement over time (Figure 1).

Short-term efficiency Long-term efficiency

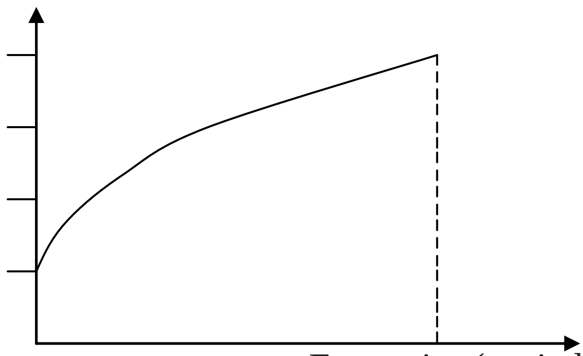


Type of innovation Type of innovation

Figure 1. Short-term and long-term effectiveness of innovation approaches.

The effectiveness of basic innovations based on fundamental discoveries is associated with a serious modernization of machinery and technology in a very short period of time, which is extremely short, often zero at all. The effectiveness of improvement (correction) and imitation as well as product (food) innovation is highly self-sufficient. It will have the opposite effect over a long period of time. Type C and D innovations are usually not available in such an interval, they can complete themselves much earlier. Over a long period of time, improvements (corrections) and imitation innovations with different efficiencies on each of them have time to occur more than once. The amount of capital system of innovations that are implemented also has a strong influence on some type of innovation or its more convenient type of system of "inclination". If this amount is too large, the possibilities for determining it and using the capital according to this amount will be wide (Figure 2).

Type of innovation



Enterprise (capital) size

Figure 2. The amount of innovation depending on the size of the system (enterprise, capital).

Innovations will also have a technological character. Conversely, confidence in the product (food) is high, and improvement (correction) and imitation innovations are appropriate for small businesses. At the same time, small businesses can successfully occupy a lower position in the R&D market in full view, but usually in such cases they will be sellers of manufactured technologies or new products and do not have the opportunity to master large batches.

On the other hand, there may be no need for products in such large batches.

As a final indicator, we take the cost per unit of sales volume to analyze the impact of the adoption of technological innovations on the cost of the product. The analysis of the factor model influences the cost of mastering innovations per unit of sales volume.

$$\frac{X}{T}=\frac{X_1}{T_1}\times\frac{X}{X_1}\times\frac{T_1}{T}, \quad (7)$$

Here, X – costs for production of sold products; T – revenue from sales of all products; X_1 –costs for mastering innovations; T_1 –revenue from the sale of products based on the application of innovations.

However, the proposed criteria for evaluating the effectiveness of innovations do not take into account the institutional conditions (costs) for the emergence of innovations. At the same time, efficiency does not take into account the gradual effect of packing innovations.

We introduce a function based on the ability of innovation to assess the potential of institutional costs. The analysis of the activities of enterprises with the support of the institutional function of change is based on the following formula:

$$Pi(t)=C(t), \quad (8)$$

Pi(t) – institutional change potential of the ith enterprise; *C(t)* –the costs required to change the internal obsolescence of an innovative enterprise and exogenous rules.

This function takes into account not only the institutional components of innovation, but also the specific costs associated with acquiring knowledge and behaviors that require deep knowledge-based skills, i.e., the introduction and implementation of innovation and the experience of its transformation. The total cost of innovation results consists of the transformation and transaction costs of the emergence of innovations, and the profitability of innovative institutions is equal to the total production costs of the institutionalization of innovations.

Based on the above, the change in profitability is shown in the Figure 3. Therefore, in our view, the strengthening (conservation) of organizational obsolescence leads to the emergence of both effective and ineffective institutions and rules of conduct that provide progressive and regressive innovation. Also, once they are in place, they can produce sustainable innovations that are inefficient or ineffective altogether. That is, the news does not yet indicate that the effectiveness of the proposed innovations is high.

Profitability of innovations

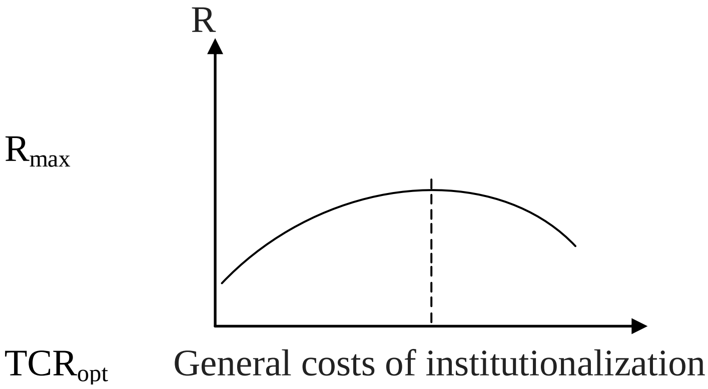


Figure 3. Profitability of innovations depending on the scale of institutionalization

The following is the utility function of Innovations:

$$U(X) = 1 - e^{-kx}, \quad (9)$$

k - the risk ratio(If this ratio is higher, the agent risk will be lower);
x – the intended amount of agent capital.

We consider it necessary to evaluate it, given the growing importance of innovation activity in enterprises. Indicators of these indicators are the level and stability of competitiveness, investment attractiveness of enterprises, the development of innovative infrastructure.

Therefore, the system of evaluation of the effectiveness of innovations in enterprises should be based on a database of integrated indicators of a size that does not depend on the scope, organizational and legal form of activities, areas of activity. At the same time, it is necessary to take into account the internal and external factors that affect its innovative activity. If the intellectual potential of the enterprise is considered in a complex way, along with the indicators of innovation efficiency, then the comparison of the assessment for a particular period of work shows the real dynamics of innovative development of the enterprise.

The constituent elements of intellectual potential are the intelligence of the staff (level of knowledge, erudition, experience, creative abilities and skills, qualifications, professional level).

The main directions of work in the field of innovation in industrial enterprises, the purpose and main content of the work (table 1).

Table 1: Areas of innovative activity in manufacturing enterprises

Areas of work in the implementation of innovative activities	The purpose of the work	The main content
Decrease in product cost	Ensuring competitiveness and	Introduction of new technologies and equipment; decrease in

	profit growth	material and energy capacity; reduction of labor capacity
Improving the management system	Operationality, adherence to contract rules, corporate culture	Changes in the organizational structure, optimization of the technological chain, staffing, improving the quality of the organizational system, labor motivationand others
Expansion of external relations cooperation	Product quality, cost reduction	Informatization of the material and technical supply, logistics, production and management processes
Optimization of the tax system	Financial stability	Optimization of Investments, accounting policy and financial system
Changes in corporate content	Getting investments	Increasing the efficiency of use of funds and investment attractiveness
Modernization of manufactured products	Market stratification	Introduction of new materials, achievement of new quality
Assimilation and development of new types of products	Development of new markets	Planning and implementation of R&D on new directions. Searching for new looking products.

In many cases, the introduction of old technologies is strongly associated with the creation of new technological equipment. As a clear example, enterprises producing special technological equipment can work together for electronic machinery, vacuum, nuclear engineering, etc., which require networks over time. The merger of enterprises and organizations was an active innovative activity aimed at creating new technologies and special technological equipment for their effective implementation.

V. CONCLUSION/RECOMMENDATIONS

The development of science-capacity high technologies in different countries has a common negative feature with all the existing differences: instability over time given the market prospects, high costs for innovation, unpredictability of the consequences. Typically, innovations lead to high commercial risk and a reassessment of expected outcomes. A typical example of such an innovative market is the market for special technological equipment.

The same problems arise for inventors and manufacturers of modern special technological equipment:

1. Selection of promising areas of high-tech development for the creation of special technological equipment;

2. Search for ways to optimize the innovation and investment activities of enterprises in order to reduce risk and achieve the desired financial results;

3. Inequality of workload with available capacity and intellectual potential.

In our opinion, an effective solution to the above problems depends on:

- The level of development of high technologies (namely, science provides employment in high-capacity industries) is directly related to the competitiveness of the country's economy;
- Ultimately, their solution will ensure the ultimate success or the enterprises themselves will lose in the fight against competitors in the market of special technological equipment.

In the current context of commercialization of the results, it will be very difficult to overcome the problems posed by the future development of enterprises and the correctness of making forward-looking decisions. Businesses are forced to choose the only right path of guaranteed development that leads to the best results.

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