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INNOVATION MANAGEMENT OF THE ENTERPRISE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

ABSTRACT

The article is aimed at establishing the features of the introduction of enterprise innovation management in the conditions of sustainable development and developing a new method for evaluating the effectiveness of the permanent innovation process (IP) under the dynamic nature of external influences.

General and special methods of knowledge used: comparative analysis to substantiate the difference between operational management of innovation implementation and strategic management of IP; structural analysis to substantiate that innovative management is the structure of the second level of SDP: quantitative and qualitative comparison was introduced to substantiate that structural nature of intangible assets is determined by the structure of production; scientific abstraction to substantiate that intellectual capital has a determining value for sustainable activity; mathematical formalization for the development of dynamic IP control model.

It is indicated that: the condition for effective provision of sustainable development is coordination of operational management innovations and strategic management of IP of the enterprise; innovative management is a second-level structure in view of the need for comprehensive implementation of SDP for effective long-term operation of enterprise; the structural nature of intangible assets is determined by the structure of production, peculiarities of supply and sales and is based on the totality of intangible assets of the enterprise; intellectual capital is of decisive importance for ensuring the sustainable nature of the impact innovations on the company's activities and as a condition for increasing the level of reliability of its competitive advantages; the systemic nature of the impact innovations on the company's activities requires the introduction of new methods of their evaluation.

A new method of evaluating the effectiveness of the extended innovation process, which forms the sustainable activity of the enterprise under dynamic conditions, was developed. The developed mathematical approach and the research results should be useful for the management of enterprises and for scientists dealing with the problems of innovative management.

Keywords: innovation management, enterprise, sustainable development, mathematical model

JEL Classification: D22, O32, Q56

INTRODUCTION

Innovative development is the only way to ensure competitiveness in global and local markets, but managing innovative development for the management of Ukrainian enterprises, when many enterprises are on the verge of survival under conditions of significant challenges and, lack of necessary resources (first of all, financial resources) even to maintain the main activity, is an extremely difficult task. It should also be taken into account that innovative development in other countries is complicated by the dynamic process of structural transformation of the world economy (Grynko et al., 2021; Zeynalli and Rahimli, 2022), but Ukrainian enterprises are placed in particularly tough conditions regarding innovative development due to the level of obsolescence of fixed

assets, due to constant economic crises, military actions (Danylyshyn, 2022; Koval et al., 2023), etc.

A significant level of various force majeure circumstances that create additional risks and open up new opportunities also determines the peculiarity of stimulating Ukrainian management to innovation and the relevance of the innovation process.

The success or failure of innovation implementation depends on the effectiveness of innovation management. The level of risk of the innovation process in Ukrainian conditions should not be underestimated - according to experts, only one out of seven innovation projects is successful (Demchenko, 2022; Svyrydenko and Revin, 2022; Sumets et al., 2022). The level of uncertainty of influence parameters and, even, uncertainty with a set of these parameters, the insufficient level of management awareness of risks in foreign markets significantly increase the risks of the innovation process. That is why management most often uses evolutionary tactics for the step-by-step modernization of the enterprise (Danylyshyn, 2022; Zayed et al., 2022c; Mainka et al., 2023) since this tactic allows to avoid significant losses in case of failure at a separate step of innovation implementation. In these difficult conditions, the management of Ukrainian enterprises faces the task of implementing such approaches to innovation management that are able to ensure a long-term competitive position in the market. This increases the importance of research into the peculiarities of innovative management in Ukraine and the development of such management measures that will ensure the sustainable development of enterprises.

LITERATURE REVIEW

In the scientific literature, sufficient attention is paid to operational innovation management (Chikán and Sprague, 2019) and strategic management (Kramarenko, 2020) of the innovation process. In particular, Chikán and Sprague (2019) detailed the project approach to the implementation of a separate innovation. Attention is paid to the need to identify, analyze and step-by-step planning of resource needs, the expansion of the use of which is due to the introduction of innovations, problems of changing logistics tasks due to the innovative development of the enterprise, etc. The concepts of MRP (material resource planning) and SCM (supply chain management) are proposed for resource planning.

Kramarenko (2020) indicated the priority of the innovation-investment development strategy to ensure competitive advantages. As the main factors of the implementation of the "strategy of innovation and investment development" "awareness (innovative receptivity)" and sufficiency of resources are indicated. These are, of course, important factors in the implementation of strategic innovation management, but, in our opinion, they alone are not enough for a successful innovation process. Kramarenko (2020) neglects operational management of the implementation of specific aspects of strategic plans. Kłosok-Bazan and Machnik-Słomka (2017), analyzing the implementation of individual innovations, do not even distinguish at which level of management they should be implemented.

The mentioned works do not consider the fundamental dichotomy of operational tasks of managing the implementation of innovations, which often implement a project approach and strategic management of the innovation process, where a separate innovation is only a segment in the general system of issues related to the implementation of innovation, the study of the importance of their implementation for the long-term policy of the enterprise. The problem is that the sustainability of development cannot ensure the implementation of individual innovations. These innovations are able to improve the competitive level of the enterprise only for a short time (Chikán and Sprague, 2019; Aleinikova et al., 2023). At the same time, the "integrated approach" proposed by the researchers (Prokhorova and Zalutka, 2021) and those similar to it in a tangential way determine the need to combine strategic management of the innovation process with operational management. In the article by Prokhorova and Zalutka (2021), it is also indicated that the introduction of an "integrated approach" is conditioned by the need to adapt to external challenges and to form a long-term competitive position in the market. This problem is significantly aggravated by the need to achieve the SDGs (Ghobakhloo et al., 2021) because the concept of "sustainability" contradicts the tactics of updating the technological process from time to time. The "sustainability" of development can only ensure permanent innovative improvement of the enterprise, which is not possible without strategic management of the innovation process as a whole.

Therefore, *Hypothesis 1* was proposed: A condition for effective provision of sustainable development is the coordination of operational management of individual innovations and strategic management of the innovation process and related tasks of strategic management of the enterprise.

There are also many studies that assert the interrelationship between sustainable development and innovation (Kłosok-Bazan and Machnik-Słomka, 2017; Kuznyetsova, 2018; Mironova et al., 2022). Thus, in the work mentioned above, Kłosok-Bazan and Machnik-Słomka (2017) indicated that "innovation is at the centre of the problems related to the implementation of the idea of sustainable development" and that "innovation at the enterprise level should be considered as tools that

support the implementation of the strategy sustainable development". It is indicated that they strengthen the competitiveness of the enterprise.

Ghobakhloo et al. (2021) indicated the interconnection of the concept of Industry 4.0 and sustainable innovation. It is also indicated that Industry 4.0 forms the direction of the sustainable innovation process through its mutually coordinated functions, which are classified by Ghobakhloo et al. (2021). Also, the implementation of Industry 4.0 requires other innovative organizational norms "that promote sustainable innovation by promoting the constructive communication of sustainable development values" (Ghobakhloo et al., 2021; Sakun et al., 2021).

This led to **Hypothesis 2**: Innovation management is a second-level structure in view of the need for comprehensive implementation of the Sustainable Development Goals for the effective long-term operation of the enterprise.

In the articles of Pilarczyk (2018), Sytnyk et al. (2022) and Kalina et al. (2022) the formation of sustainable business models under the conditions of innovative development of enterprises is considered. The theoretical aspects of the use of tools for the implementation of sustainable innovative business models have been thoroughly studied. When researching the creation of value for the implementation of innovations, the structuring of intangible assets of the innovation process, which was used by the authors, is indicated.

The studies of Perevozova et al. (2019), Bondar-Podhurskaya et al. (2020) and Dvigun et al. (2022) dedicated to the scientific and methodological issues of evaluating the effectiveness of innovation management of machine-building enterprises in the context of sustainable development, an indicative evaluation approach is proposed, which is, in particular, based on the structure of intangible assets. It is indicated that this structure ensures a balance of "economic, social and environmental problems".

This led to the submission of **Hypothesis 3**: The structural nature of intangible assets is determined by the structure of production or provision of services, the peculiarities of supply and sales and is based on the totality of intangible assets of enterprises, which, accordingly, requires different approaches in innovative management to ensure the sustainability of the enterprise.

Sodomora and Yahelo (2021), Zayed et al. (2022a; 2022b), Mulcka et al. (2022), Phonthanukitithaworn et al. (2023) stated that intellectual capital is an important component in the "set of intangible objects" because of its "rapid growth in technologically advanced firms in the knowledge and management economy". It also states that "intellectual capital (IC) is critical for firms to achieve competitive advantage and growth." Phonthanukitithaworn et al. (2023) in the study assert the structural nature of intellectual capital and point to its components: relational capital, social and structural (organizational) capital, which are used in this article. Na-Nan et al. (2021) also indicated the structural nature of intellectual capital. Among its components, unlike (Sodomora and Yahelo (2021), Zayed et al. (2022a; 2022b), Mulcka et al. (2022), Phonthanukitithaworn et al., 2023), only relationship capital and social capital are highlighted. The importance of intellectual capital for ensuring a competitive position in the market is indicated. Zapata-Cantu and González (2021) also point to intellectual capital as a condition for ensuring competitiveness but limit it only to human capital. All mentioned researchers neglect such components of intellectual capital as "know-how", patents, and copyright and their importance for increasing the level of reliability of the company's advantages in the market, because other components can be quickly mastered and adopted by competitors, and the use of patents and copyrights is protected by legislation.

Therefore, **Hypothesis 4** was proposed: Intellectual capital is of decisive importance for ensuring the sustainable nature of the impact of innovations on the company's activities and as a condition for increasing the level of reliability of its competitive advantages.

Plakhotnik and González (2021), Yuldashev et al. (2022), Zayed et al. (2022d) and Semenets-Orlova et al. (2022) developed a mechanism for ensuring sustainable development to evaluate the effectiveness of the use of economic, social, scientific and technical indicators is suggested. Rosati et al. (2022) proposed a management six-phase approach to optimizing the contribution to the Central Bank, which allows for the formulation of innovative enterprise strategies. The methodology of this approach is based on the assessment of risks and the determination of ways to reduce them. Phonthanukitithaworn et al. (2023) proposed an evaluation of innovation efficiency using "structural equation modelling based on second-order factor analysis." Hrabchuk et al. (2022) proposed the efficiency coefficient of innovative development as an integral criterion, the calculation of which is based on expert indicators of profit growth, profitability level, payback period, discounted income, yield index and internal discount rate. All the mentioned methods are certainly useful, but the level of relevance of their forecasts is not sufficient for evaluating the effectiveness of strategic management of the innovation process and choosing the best strategy in a dynamic environment.

Therefore, *Hypothesis 5* is proposed: The dynamic nature and time extension of the innovation process, which forms the sustainable activity of the enterprise, requires the development of a new method of evaluating the effectiveness of the specified process.

AIMS AND OBJECTIVES

To establish the peculiarities of the implementation of enterprise innovation management in conditions of sustainable development. To develop a new method of evaluating the effectiveness of the permanent innovation process under the dynamic nature of external influences.

METHODS

The presented scientific research was carried out using general and special methods of cognition. To substantiate the difference between the operational management of the implementation of innovations and the strategic management of the innovation process, the method of comparative analysis is applied. The method of logical generalization is used to substantiate Hypothesis 1.

The method of structural analysis was introduced to substantiate Hypothesis 2 regarding the fact that innovation management is a second-level structure in view of the need for comprehensive implementation of the Sustainable Development Goals for the effective long-term operation of the enterprise.

Quantitative and qualitative comparison methods were introduced to substantiate Hypothesis 3 regarding the fact that the structural nature of intangible assets is determined by the structure of production or service provision, the peculiarities of supply and sales and is based on the totality of intangible assets of the enterprise.

The method of scientific abstraction was used to substantiate Hypothesis 4 regarding the fact that intellectual capital is of decisive importance for ensuring the impact of innovations on the sustainable activity of the enterprise and as a condition for increasing the level of reliability of its competitive advantages.

The method of mathematical formalization is used to develop an adaptive approach to dynamic management of the integral indicator of the efficiency of the innovation process with the possibility of forecasting changes in this indicator due to the application of one or another set of management actions and, accordingly, evaluating and choosing the best of them.

RESULTS

Innovation management is an integral component of the general management system of the enterprise, which is integrated into all functional management mechanisms: production, investment, sales, logistics, etc. relations that are directly or indirectly related to the specified process.

In the scientific literature, the innovation process is often considered only within the framework of the implementation of a specific innovation or several innovations at once. At the same time, in order to acquire the appropriate level of competitiveness and achieve sustainable development of the enterprise, innovation management must be of a permanent nature.

The sustainable nature of development objectively cannot ensure the episodic implementation of individual occasional innovation projects. This requires the formation of a permanent innovation process, which should not only ensure the constant effective adaptation of the enterprise to the conditions of Economy 5.0 and the challenges of the global market but also, in an anticipatory manner, create the prerequisites for obtaining the appropriate level of competitive positions of the enterprise in promising areas of activity.

Therefore, for the implementation of sustainable development, it is necessary to provide systematic organizational measures for strategic management of the innovative process of the enterprise. At the same time, one of the main tasks of innovative management should be the identification and assessment of internal and external risks and the introduction of management solutions to reduce their negative impact. This is caused by the fact that the introduction of innovations increases risks for the enterprise, requires resources, first of all financial, can lead to significant fluctuations in the volume of production and sales of products or the provision of services, etc.

That is why, in order to reduce the level of risk, management often uses the tactics of step-by-step implementation of such innovations, which make it possible to obtain a certain result in a short time. It also allows to quickly recoup the

losses incurred during the implementation of innovations. Such innovations can be classified as innovations that improve the company's activities. Most often, these are product innovations - for example, the release of a new product or a product with new qualities, and process innovations - which allow improving the production process, for example, aimed at energy and resource conservation. The implementation of improving innovations makes it possible to avoid significant risks or, with the tactics of their step-by-step implementation, when faced with the impact of risks, to adapt to them and develop mechanisms of adaptation to their impact.

Such implementation of innovations often does not provide an opportunity to obtain a significant effect but protects against the risk of significant losses in case of not properly taking into account the negative effects of external and internal factors or not obtaining the expected result.

A significant effect can be provided by significant innovations that lead to a radical transformation of all spheres of the enterprise. The introduction of such innovations has a shock character for the enterprise and, if the corresponding result is obtained, for the competitive environment, as it gives the enterprise significant advantages in the competition (Kulikov et al., 2022). At the same time, innovations that lead to a radical transformation of production, if the challenges are not properly identified or managed ineffectively, the presence of risks of an uncertain nature can lead to catastrophic consequences. Therefore, the implementation of such innovations requires strategic management of the innovation process.

This determines the difference between the systems of organizing the operational management of the implementation of individual innovative projects and the long-term strategic management of the innovative restructuring of the enterprise. It should be noted that the permanent systematized implementation of improving innovations also requires thoughtful and coordinated operational and strategic management, in particular, because the impact of innovations on the enterprise as a single system has an emergent nature and causes changes in all areas of the enterprise.

Under such circumstances, a well-thought-out coordinated operational and strategic management of the innovation process allows to reduce the negative internal and external effects on the result and reduce the risk of failure of innovative activity.

This confirms the thesis that even with the use of tactics for the implementation of individual innovative projects, the strategic integration of innovations ensures an increase in the efficiency of the innovation process and the maximum use of the market opportunities it opens up. At the same time, the effectiveness of strategic management of the enterprise's innovation process is determined by its systemic nature, integrating the enterprise's production, financial, and intellectual capabilities to ensure sustainable development. This confirms Hypothesis 1.

A peculiarity of innovative management in modern conditions is the need for comprehensive implementation of the Sustainable Development Goals (SDGs). When forming the goals of enterprises and companies, the achievement of the SDG should not be considered only as a way to ensure the public good, because the achievement of the SDG is also necessary in view of narrow corporate interests.

The condition of achieving the SDG forms the goals of the enterprise and, thus, conditions the directions of its innovative development, if not directly, then, under any circumstances, the directions of the innovative development of the enterprise must be agreed with the SDG, because the path of development of the enterprise that contradicts the SDG is a dead end.

This condition creates additional requirements for the innovation process but also opens up new opportunities and prospects for the development of the enterprise. For example, taking into account the environmental Goals of sustainable development will allow the enterprise to produce innovative products that will give the opportunity to enter the market of the European Union countries since the products will meet the requirements of the "Carbon Border Adjustments Mechanism" (CBAM). Another example is the implementation of the SDG by creating the necessary social conditions for employees, which, in particular, will help to avoid the threat of a shortage of qualified personnel with a significant level of cross-border labour migration of the population of Ukraine, that is, it will also implement narrow corporate goals.

Thus, organizational measures for the implementation of strategic management of the innovation process, and first of all, a comprehensive analysis of the compliance of innovations with the requirements of the Central Bank, which must precede these measures, will in the future ensure the comprehensive efficiency of production activities and, in particular, competitiveness in prospective markets. This confirms Hypothesis 2.

In view of the need for innovation to meet the requirements of the CSD for the formation of the goals of the strategy of the innovation process, it is necessary to structure the intangible assets that are formed in the specified process into environmental, social, technical and technological, organizational components specified in the CSD.

The organizational component includes information about the infrastructure of relations with suppliers, intermediaries and consumers and, thus, this component contributes to the implementation of sustainable partnership and cooperation, which is one of the prerequisites for the sustainable development of the enterprise. Therefore, databases with information about counterparties and consumers are often the targets of industrial espionage and require the implementation of appropriate security measures.

The ecological component includes tools to protect the environment from the negative consequences of production activities, and mechanisms of reproduction of the natural environment. In many cases, these tools and mechanisms are formed in an adaptive way and form valuable experience, which is also a sign of intellectual capital and ensures the sustainable development of the enterprise.

The social component includes management relations with employees, conditions and peculiarities of providing social guarantees, etc. The importance of the social component of intangible assets for the effective implementation of the innovation process lies in the need for an appropriate level of team cohesion, unity in achieving the goal and, if necessary, a certain reduction in the level of social benefits without the accompanying loss of human capital, for example, to compensate for the lack of working capital of the enterprise for the implementation of innovations.

In general, the structural nature of intangible assets is determined by the structure of production or the structure of service provision, the features of supply and sales and is based on the totality of intangible assets of the enterprise.

For detailed coordination in the innovation process of the specified structures, intangible assets can be presented in accordance with "Provisions (of the standard) of accounting 8 "Intangible assets", approved by the order of the MFU dated October 18, 1999 No. 242. This includes rights: to certain types of activities, preferences, in particular, of an economic nature; on the use of natural resources; use of property; use of trademarks, names with signs of royalty, etc.; patents, commercial secrets (so-called know-how), etc. in accordance with the Law of Ukraine No. 3687-XII "On Protection of Rights to Inventions and Utility Models"; objects of intellectual property in accordance with the Law of Ukraine No. 3793-XII "On Copyright and Related Rights" (computer programs, databases, etc.).

Orientation to the implementation of an innovative process, which relies on intangible assets that correspond to the Law of Ukraine No. 3687-XII and the Law of Ukraine No. 3793-XII requires funding of research works in this direction. The determination of these costs by the structure of production or service provision can be seen in Table 1. In particular, the data presented in Table 1 indicate that management prefers research and development (R&D) performed by its own forces to R&D performed by other enterprises because this approach ensures a higher level of commercial secrecy. Also, these data confirm a significant difference in the shares of R&D expenses for enterprises of various types of activity and the difference in approaches to the formation of innovative strategies for them.

Thus, the most modern type of activity "Computer programming, consulting" is characterized by the lowest level of costs for R&D, as it is based on the purchase of the necessary innovative equipment and software without the costs of their development (see Figure 1, compiled using data from the State Statistics Service of Ukraine, 2022). The given data also indicate the formation of mutually directed time trends, for example, an increase in the share of expenditures on innovative R&D for "Transport, warehousing", "Computer programming, consulting" and a decrease in this share for "Production of chemicals and chemical products" and some other types of activity (Table 1).

Table 1. Costs for innovative R&D of enterprises by type of economic activity, in % of the total amount of costs for innovation by this type of activity. (Source: compiled using data from the State Statistics Service of Ukraine, 2022)

Type of economic activity	R&D performed in-house			R&D contracted out to others		
	2019	2020	2021	2019	2020	2021
Mining and quarrying	31,9	17,4	15,2	4,9	5,8	6,5
Production of food products	3,3	8,8	10,5	0,1	2,2	3,7
Production of chemicals and chemical products	65,4	64,6	59,8	1,0	0,9	1,2
Transport, warehousing, postal and courier activities	37,9	53,2	62,1	8,9	7,2	6,9
Computer programming, consulting and related activities	9,8	10,1	11,2	0,6	0,9	0,8
Scientific research and development	70,7	58,8	56,2	26,2	14,1	12,1

A comparison of the share of costs for innovative R&D of enterprises by types of economic activity (see Table 1) and the share of total innovation costs by areas of innovative activity of enterprises (Figure 1) indicates a significant difference in costs for R&D by types of economic activity from integrated data.

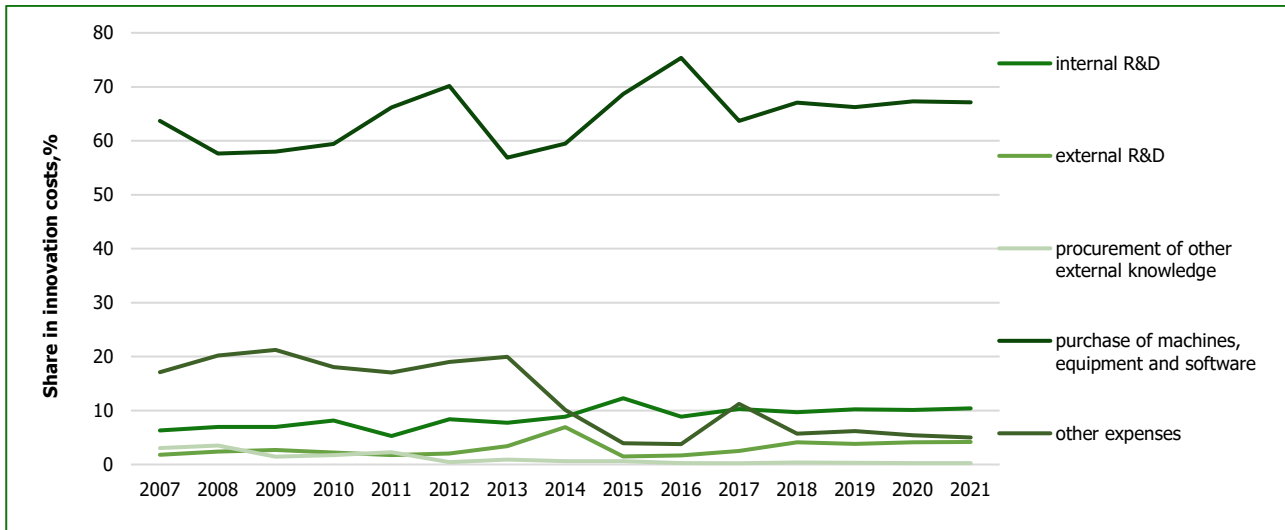


Figure 1. Share in total costs for innovation by areas of innovative activity of enterprises, %. (Source: compiled using data from the State Statistics Service of Ukraine, 2022)

This confirms Hypothesis 3: The structural nature of intangible assets is determined by the structure of production or provision of services, features of supply and sales and is based on the set of intangible assets of enterprises, which, accordingly, requires different approaches in innovative management.

Such an approach, in particular, is the coordination of the innovative strategy and the market strategy of the enterprise.

Different types of market strategies are possible to implement in the management of the enterprise's innovation process: aggressive capture of a significant share of the market; overcoming the lag behind the market leaders; expansion of market presence; transformation of forms of activity. The strategy of aggressively capturing a significant share of the market is often based on the release of a fundamentally new innovative product or service and is mainly used by companies without a significant previous background in the market. The strategy of overcoming lagging behind the market leaders is more often characteristic of companies that are already present on the market, occupying positions of outsiders, but thanks to the implementation of the innovation process, are able to gain more significant market positions. The strategy of expanding the presence in the market differs from the previous one in that the company's innovative policy allows it to enter other regional markets or even the global market. The strategy of transformation of forms of activity is aimed either at a change due to the innovation process of the main type of activity to another, or at all at the transformation into a new type of organization.

The innovative process of Ukrainian enterprises often relies not on their own "know-how", but on the introduction of products, processes, technologies, and methods that are already used by other enterprises, primarily by enterprises of developed countries (Bilyk, 2019), which is confirmed by the example mentioned above, regarding the activity type "Computer programming, consulting".

This allows Ukrainian enterprises to increase their competitiveness in foreign markets but also forms a "catch-up" nature of development. This nature of development does not provide the appropriate level of advantages compared to competitors and does not ensure the appropriate level of sustainability of enterprise activity. The appropriate level of benefits and the appropriate sustainable nature of development can only provide one's own intellectual capital or a special nature of access to resources. Moreover, intellectual capital to increase the level of reliability of competitive advantages should not be concentrated on one intangible asset, but, preferably, should be based on a set of these assets.

This confirms Hypothesis 4: Intellectual capital is of decisive importance for ensuring the sustainable operation of the enterprise and as a condition for increasing the level of reliability of its competitive advantages.

Strategic management of the innovation process requires the fulfilment of some prerequisites. And these prerequisites include, first of all, the availability of stable financing of innovative activity, even if this activity is significantly prolonged in time. The situation with providing long-term innovative processes with financial resources in the modern conditions of Ukraine is complicated by the lack of cheap financial resources in the market of financial and banking services and by the reluctance of financial institutions to provide loans for the implementation of long-term innovative processes due to their risky nature.

Nowadays, under the conditions of large-scale, high-intensity hostilities, a significant number of enterprises have problems with the financial support of their activities. However, according to the data of the State Statistics Service of Ukraine (2022), even in the previous 20 years, investment in innovative activity mostly had neither a sustainable nature nor sustainable external sources of financing (Figure 2).

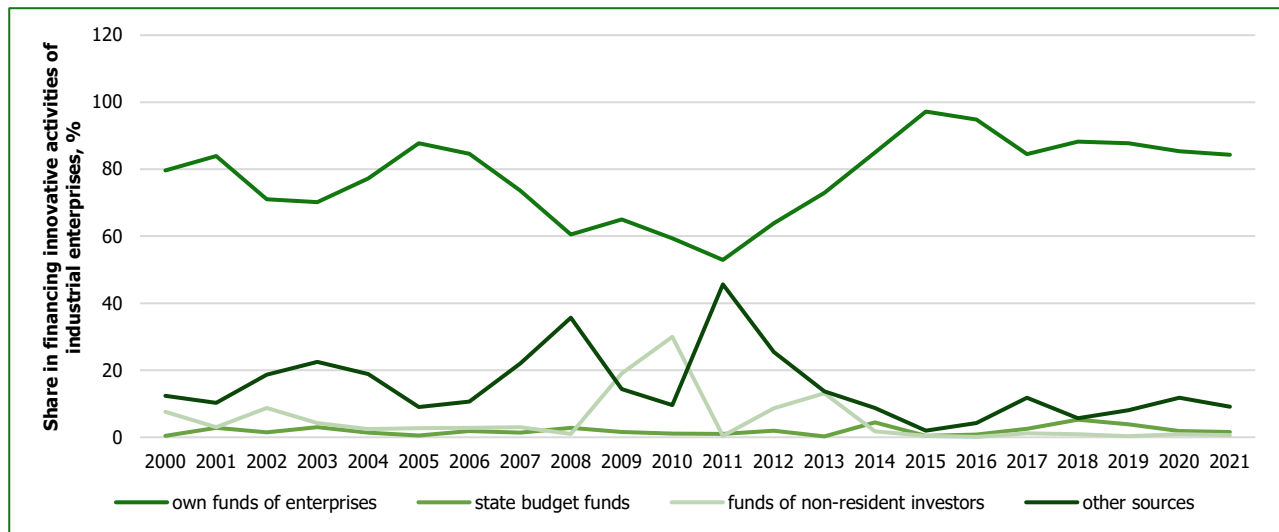


Figure 2. The share in the financing of the innovation process for industrial enterprises, % of the total amount of expenses. (Source: compiled using data from the State Statistics Service of Ukraine, 2022)

This conclusion is confirmed by calculations made using the data of the State Statistics Service of Ukraine (2022) and is shown in Table 2. Thus, fluctuations in the ratio of the average deviation of financing volumes to their average value by types of financing sources in 2021 acquired values from 56% to 111%.

Table 2. Average annual deviations and average annual values of the volume of financing of the innovative process of industrial enterprises by types of sources for the time period in 2021. (Source: calculations made using the data of the State Statistics Service of Ukraine, 2022)

Parameter	Own funds of enterprises, million UAH	State budget funds, million UAH	Funds of non-resident investors, million UAH	Funds from other sources, million UAH
Average value	7304.6	180.1	395.3	17171.4
Average deviation	4108.41	128.28	437.24	1205.99
The ratio of the average deviation to the average value, %	56	71	111	68

The lack of stability of financial resources today makes the strategic duration of the innovation process impossible, except for enterprises belonging to financial and industrial groups and enterprises whose investment in innovative activities is carried out by non-residents of Ukraine. At the same time, the need to ensure stable financing of strategic innovation programs with appropriate mobilization of resources and certain time gaps regulated by these programs can mobilize part of the enterprises to introduce the specified programs into production activities.

The factors that complicate the implementation of strategic management of the innovation process also include the outdated material and technical base of enterprises, the absence of their own scientific and technical structures that create their own innovative know-how; lack of a market for innovative developments; venture mechanisms; the unpredictability of the long-term tax policy, which does not stimulate investment in the implementation of innovative developments; significant dynamism of the market balance of demand and supply for domestic products, which does not make it possible to assess the payback of innovations with sufficient reliability; the management's desire to stabilize production activity under the existing risks and the prediction of possible destabilization of this activity when introducing risky long-term innovative processes, etc.

The conditions that ensure high-quality innovation management are: balancing the interests of all parties that directly or indirectly affect the result of the innovation process; consistency with the general organizational, technical and technological, financial and other tools of enterprise management; a comprehensive approach to the development and implementation of decisions regarding innovation management; dynamic response of management to the complications of the

innovation process; variability of innovation management methods and measures; implementation of material and non-material stimulation measures for employees who implement the innovation process; proper information provision of the innovation process; implementation of relevant analytical mechanisms and formation of forecasts regarding the innovation process as a whole and regarding the results of its stages; operational transformation of the types of enterprise activities indirectly related to the innovation process (Khromushyna, 2020; Kuznyetsova, 2022; Melnyk et al., 2022).

The tasks of managing the innovation process include research of the market environment and identification of promising directions for its development; identification and assessment of the market for innovative products or services of the enterprise; identification and assessment of the level of risk to obtain the proper result of the innovation process; identification of external and internal factors influencing the effectiveness of innovative activities; assessment of available resources for the implementation of innovations and organization of operational management of the specified resources; formation of an organizational structure for managing the innovation process and a production structure for the implementation of innovations; formation of variable management plans for the innovation process and preparation of decision trees for problem points of these plans.

This determines the need to improve traditional methods of evaluating innovations and introduce an integral indicator of evaluating the effectiveness of a dynamic and prolonged innovation process according to Hypothesis 5 of this study.

Methods of taking into account the integral indicator of the evaluation of the innovation process in scientific studies often relied on additive methods of their calculation taking into account the "weight" of individual criteria in this indicator (Tso, 2020) and other methods of multi-objective optimization using coefficient analysis. This did not provide the possibility of a relevant definition of the specified integral indicator, in particular, due to the failure to take into account the synergistic effects of the interaction of individual criteria and the length of time of the innovation process. In addition, scalar methods did not allow to determine the direction and rate of change of the integral indicator of the extended innovation process, which to a large extent also made it difficult to implement an adaptive approach to dynamic management of the integral indicator with the possibility of forecasting its changes due to the application of one or another set of management actions and, accordingly, evaluation and choosing the best of them.

DISCUSSION

In contrast to the scalar additive methods proposed in other works, in particular, in the article by Demchenko (2022), the method of taking into account the result of the innovation process, determining the direction of its implementation and a set of management actions for this, a vector approach has been developed, which consists of the following.

It is proposed to evaluate the effectiveness of the innovation process not only from the point of view of its direct economic benefits and costs: profitability of products, turnover of assets, necessary resource (in particular, financial support) innovations, capital intensity of updating the technical and technological base (Khromushyna, 2020) or using traditional evaluation criteria efficiency of innovations: Net Present Value, Internal Rate of Return (relying only on those proposed by Tso (2020)) and others. These indicators are certainly important for evaluating the implementation of individual innovations, the results of which characterize the effectiveness of achieving individual operational goals.

At the same time, the achievement of strategic goals is more significant for the enterprise, since the innovation process should also provide new qualities and new opportunities to the enterprise, for example, reducing the risk of negative effects of external and internal factors; entering the global market or new local markets; acquiring a qualitatively new competitive position on the market, etc. Achieving such goals can be considered in the strategic planning of the innovation process, and then the result should be evaluated by forecasting the level of its approach to the planned goal.

Given the above-mentioned formalized mathematical definition of the efficiency vector of the innovation process, it can be represented in the coordinates of individual objective functions, the choice of which depends on the type of enterprise activity; product nomenclature; the markets to which it is supplied; external and internal factors of influence, etc.

Such a model allows real-time monitoring of changes in the value of the innovation process efficiency vector and the application of necessary management actions with an assessment of both their likely effectiveness and taking into account the cost of resources for their effective implementation, i.e., the specified approach allows to promptly adjust management actions on the selected strategic way.

For the single-target task of innovation management, this can be represented as follows:

$$\vec{F} = (\vec{F}_{ac} - \vec{F}_{pl}) / \vec{F}_{ac}$$

where \vec{F} is the efficiency vector of the innovation process; \vec{F}_{pl} is the planned result; \vec{F}_{ac} is the achieved result.

Such presentation provides an opportunity to evaluate the result in relative, not absolute values, which allows the owners and managers of the enterprise to understand the level of deviation from the planned value without special explanations.

When finding the efficiency vector, it is advisable to calculate the distance $(\vec{F}_{pl} - \vec{F}_{ac})$ as the length of a segment in multidimensional space.

For a multi-objective problem, there is a need to coordinate individual goals, since their extrema in real conditions do not coincide.

$$\vec{F} := \bigcup_i \left(\frac{(\vec{f}_{nac} - \vec{f}_{npl})}{\vec{f}_{nac}} \rightarrow opt \right) \rightarrow opt$$

where $\vec{f}_{i\text{noc}}$ and $\vec{f}_{i\text{inn}}$ are achieved and planned values of individual objective functions; $i = 1, 2, 3 \dots n$ is the ordinal index of the objective function.

Using the approaches of set theory, a relation is formed:

$$\vec{F} \in R^n | A\vec{f}_i \leq \vec{b}_i, \vec{f}_i \neq \emptyset$$

where A is the set of vectors \vec{f}_i ; \vec{b}_i are interval values of the approach of each of the objective functions to its extreme value.

The best value of the efficiency vector of the innovation process, if it is necessary to agree on the best values for a group of goals, is an option that takes into account the achievement of results with a different level of approximation of each of them to its extreme value in a compromise way. Interval values of the approach of each of the objective functions to its extreme value are set by management. Using the method of successive approximations, the range of parameter values for which there is a compromise solution for the best value of the efficiency vector of the innovation process is determined.

Selective attention to the implementation of only one of the objective functions, for example, the one that ensures the predominant development of the economic component, and neglecting other tasks of SDGs - social, environmental, etc., is strategically losing, since the postponed tasks will require a solution, making it difficult to achieve economic goals. In order to carry out the postponed tasks in the future, significantly more resources and, even, economic losses due to the need to rebuild technological processes, logistics chains, etc. may be required.

In general, the proposed method of mathematical formalization allows the realisation of the requirement of Hypothesis 5 of this study.

CONCLUSIONS

It is proposed to distinguish operational management of the implementation of individual innovations from the innovation process, which such implementation can be a part of. This made it possible to formulate the definition of innovation management as an integral component of the general enterprise management system, which is integrated into all functional management mechanisms: production, investment, sales, logistics, etc. and is aimed at ensuring the effectiveness of both the implementation of individual innovations and the implementation of the innovation process as a whole settlement of all types of relations directly or indirectly related to the specified process.

It is indicated that the steady nature of the enterprise's development cannot ensure the implementation of individual innovative projects from time to time. This requires the formation of a permanent innovation process, which should not only ensure constant effective adaptation of the enterprise to challenges but also, in an anticipatory manner, create prerequisites for obtaining the appropriate level of competitive positions of the enterprise in promising areas of activity.

This requires systematic organizational measures of strategic management of the innovation process. As an alternative option of innovation management, the tactic of step-by-step implementation of improving innovations is indicated, which reduces the risk of implementation but does not have a significant effect. It is indicated that even the permanent implementation of improving innovations also requires a well-thought-out and coordinated operational and strategic management because the impact of innovations on the enterprise as a single system has an emergent nature and causes changes in all spheres of the enterprise.

It is indicated that even with the use of tactics for the implementation of individual innovative projects, the strategic integration of innovations ensures an increase in the efficiency of the innovation process and the maximum use of market opportunities that it opens up. At the same time, the effectiveness of the strategic management of the enterprise's innovation process is determined by its systemic nature, which integrates the enterprise's production, financial, and intellectual capabilities to ensure sustainable development. This confirms the proposed Hypothesis 1: "A condition for effective provision of sustainable development is the coordination of operational management of individual innovations and strategic management of the innovation process and related tasks of strategic management of the enterprise".

It is indicated that a peculiarity of innovative management in modern conditions is the need for comprehensive implementation of SDG. This condition creates additional requirements for the innovation process but also opens up new opportunities and prospects for the development of the enterprise, therefore, it confirms Hypothesis 2: "Innovation management is a second-level structure in view of the need for comprehensive implementation of the SDG for the effective long-term operation of the enterprise".

Comparison and analysis of statistical data made it possible to confirm Hypothesis 3: "The structural nature of intangible assets is determined by the structure of production or provision of services, the features of supply and sales and is based on the totality of intangible assets of enterprises, which, accordingly, requires different approaches in innovative management to ensure the sustainability of the enterprise." It is indicated that an example of such an approach is the coordination of the innovative strategy and the market strategy of the enterprise.

It is indicated that the proper level of competitive advantages and the proper sustainable nature of development can be provided only by one's own intellectual capital. Moreover, intellectual capital to increase the level of reliability of competitive advantages should not be concentrated on one intangible asset, but, preferably, should be based on a set of these assets.

This confirms Hypothesis 4: "Intellectual capital is of decisive importance for ensuring the sustainable operation of the enterprise and as a condition for increasing the level of reliability of its competitive advantages".

It was established that the lack of conditions for sustainable financing is a significant obstacle to the permanent innovation process in Ukraine. This is confirmed by the establishment of significant fluctuations in the ratio of the average deviation of financing volumes to its average value, which took on values from 56% to 111% by types of financing sources in 2021. Other factors that complicate the implementation of strategic management of the innovation process are also specified.

The conditions that ensure high-quality management of innovations are specified: balancing the interests of all parties that affect the result of the innovation process; consistency with the general organizational, technical and technological, financial and other tools of enterprise management; a comprehensive approach to the development and implementation of decisions regarding innovation management; dynamic management response to challenges to the innovation process; variability of innovation management methods and measures; implementation of employee incentive measures; information provision of the innovation process; operational transformation of the activities of the enterprise indirectly related to the innovation process, etc.

The tasks of management of the innovation process are also specified and it is indicated that their complexity and dynamic conditions determine the need for a new mathematical approach to evaluating the effectiveness of the innovation process extended over time. The proposed approach makes it possible to determine the direction and rate of change of the integral indicator of the innovation process extended over time, which provides the possibility of choosing effective management actions and, in general, allows the realization of the requirement of Hypothesis 5 of this study: "The dynamic nature and extension over time of the innovation process, which forms the sustainable activity of the enterprise requires the development of a new method of evaluating the effectiveness of the specified process".

The developed mathematical approach and the research results should be useful for the management of enterprises and for scientists dealing with the problems of innovative management.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally

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УПРАВЛІННЯ ІННОВАЦІЯМИ ПІДПРИЄМСТВА В КОНТЕКСТІ СТАЛОГО РОЗВИТКУ

Метою цього дослідження є встановлення особливостей упровадження управління інноваціями підприємств в умовах сталого розвитку та розроблення нового методу оцінювання ефективності перманентного інноваційного процесу (ІП) за динамічного характеру зовнішніх впливів.

Використані загальні й спеціальні методи пізнання: порівняльного аналізу – для обґрунтування різниці між оперативним управлінням упровадженням інновацій і стратегічним управлінням ІП; структурного аналізу – для обґрунтування, що інноваційний менеджмент є структурою другого рівня від Цілей сталого розвитку: кількісного та якісного порівняння, запроваджено для обґрунтування, що структурний характер нематеріальних активів обумовлюється структурою виробництва; наукового абстрагування – для обґрунтування, що інтелектуальний капітал має визначальне значення сталої діяльності; математичної формалізації – для розроблення моделі динамічного управління ІП.

У дослідженні вказано, що: умовою ефективного забезпечення сталого розвитку є узгодження оперативного управління окремими інноваціями й стратегічного управління ІП підприємства; інноваційний менеджмент є структурою другого рівня з огляду на необхідність комплексної реалізації Цілей сталого розвитку для ефективної довгострокової діяльності підприємства; структурний характер нематеріальних активів обумовлюється структурою виробництва чи надання послуг, особливостями постачання й збуту та спирається на сукупність нематеріальних активів підприємства; інтелектуальний капітал має визначальне значення для забезпечення сталого характеру впливу інновацій на діяльність підприємства та є умовою збільшення рівня надійності його конкурентних переваг; системний характер впливу інновацій на діяльність підприємства потребує впровадження нових методів їх оцінювання.

Розроблено новий метод оцінювання ефективності подовженого в часі інноваційного процесу, який формує сталу діяльність підприємства за динамічних умов. Розроблений математичний підхід, результати дослідження мають бути корисними для менеджменту підприємств і для науковців, які займаються проблемами інноваційного менеджменту.

Ключові слова: інноваційний менеджмент, підприємство, сталий розвиток, математична модель

JEL Класифікація: D22, O32, Q56