DOI: https://doi.org/10.32782/2524-0072/2025-82-52

UDC 330.341.1:658.011.4

MODERNIZATION OF TOOLS FOR MANAGING INNOVATION ACTIVITY OF ENTERPRISES IN CONDITIONS OF HIGH VARIABILITY OF THE EXTERNAL ENVIRONMENT

МОДЕРНІЗАЦІЯ ІНСТРУМЕНТІВ УПРАВЛІННЯ ІННОВАЦІЙНОЮ ДІЯЛЬНІСТЮ ПІДПРИЄМСТВ В УМОВАХ ВИСОКОЇ МІНЛИВОСТІ ЗОВНІШНЬОГО СЕРЕДОВИЩА

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The article is devoted to the study of theoretical and methodological foundations of modernization of tools for managing innovation activity of enterprises in conditions of high variability of the external environment. Based on system and process approaches, key factors influencing the effectiveness of innovation management are identified, in particular the level of adaptability, flexibility of management decisions, speed of response to external challenges and the ability to integrate new technological solutions. Methodological recommendations are proposed for the modernization of innovation management tools, in particular the introduction of digital technologies, the use of flexible planning models, expanding the use of analytical platforms for forecasting and assessing innovation risks. Opportunities for the formation of an adaptive management system are opened, which ensures an increase in the efficiency of innovative projects in conditions of instability.

Keywords: innovation activity, innovation management, modernization of tools, flexible planning, digitalization, adaptive management systems, variability of the external environment, innovation risks, competitiveness of the enterprise.

Стаття присвячена комплексному дослідженню процесів модернізації інструментів управління інноваційною діяльністю підприємств в умовах високої мінливості зовнішнього середовища. Показано, що сучасна економіка характеризується динамічністю, невизначеністю та посиленням впливу глобальних викликів, що значно ускладнює реалізацію інноваційних стратегій та потребує перегляду традиційних підходів до їх планування й організації. Наголошено, що ефективність інноваційного менеджменту визначається здатністю підприємств швидко адаптуватися до змін, формувати гнучкі управлінські моделі та активно інтегрувати цифрові інструменти у процеси розроблення, впровадження й комерціалізації технологічних новацій. Систематизовано чинники зовнішнього та внутрішнього середовища, що впливають на результативність управління інноваційною діяльністю, серед яких: інтенсивність технологічних змін, коливання ринкової кон'юнктури, нестабільність регуляторної політики, зростання інноваційних ризиків, рівень цифрової зрілості підприємства, а також якість організаційно-управлінських механізмів. На основі системного, процесного та інтеграційного підходів обґрунтовано необхідність упровадження сучасних інструментів управління, які дозволяють прискорити інноваційні цикли, підвищити точність прогнозування та мінімізувати ризики. Запропоновано методичні орієнтири модернізації інструментарію управління інноваціями, що включають: гнучке стратегічне планування, використання цифрових платформ для моніторингу ринку та аналізу Big Data, застосування моделей реального часу для оцінювання ефективності інноваційних рішень, упровадження інструментів інноваційного контролінгу, розвиток інструментів ризик-менеджменту та механізмів трансформаційного лідерства. Особливу увагу при-

ділено формуванню адаптивної системи управління, яка здатна забезпечити стійкість інноваційних процесів і підтримувати безперервність розвитку підприємства в умовах нестабільності.

Ключові слова: інноваційна діяльність, управління інноваціями, модернізація інструментарію, гнучке планування, цифровізація, адаптивні системи управління, мінливість зовнішнього середовища, інноваційні ризики, конкурентоспроможність підприємства.

Statement of the problem. Modern conditions for the functioning of enterprises are characterized by high variability of the external environment, which is manifested in the instability of market conditions, increased competition, rapid technological changes, increased uncertainty and growth of innovation risks. Under such conditions, traditional tools for managing innovation activities lose their effectiveness, as they do not provide adequate flexibility, responsiveness and adaptability of managerial decisions. This leads to a slowdown in innovation processes, a decrease in the effectiveness of innovation projects and a deterioration in the competitive position of enterprises.

Therefore, there is an objective need to rethink and modernize the tools for planning, organizing, monitoring and controlling innovation activities, which can ensure the sustainability and dynamism of enterprise development in a turbulent environment.

Analysis of recent research and publications. The problems of modernization of tools for managing innovation activities of enterprises in conditions of high variability of the external environment are actively studied in the works of domestic and foreign scientists. The publications Bezrukova N., Huk L., Chmil H., Verbivska L., Komchatnykh O., Kozlovskyi Y. [1] emphasize that digital platforms significantly expand forms of collaboration between businesses, universities, and startups, accelerating the commercialization of innovations and reducing transaction costs. Kaida I.F. [2] examines the methodology and approaches to innovation management taking into account the digitalization of business. Levytskyi V., Radynskyi S., Krupka A. [3] explore the role of IT tools, digital platforms, and information security. Haustov M. M., Bondarenko D. V. [4] focus on information systems/data that support innovation management processes: data sources, indicators, IT analysis tools. Savchenko S., Rogova A. [5] prove that digital technologies (data analytics, artificial intelligence, cloud services, IoT) significantly change the mechanisms for planning, monitoring and controlling innovation processes, ensuring their speed and accuracy even under conditions of increased turbulence of the market environment. Petrukha N., Zhmaiev A., Synkevych M. [6] emphasize that digital analytics contributes to the formation of new mechanisms of innovative controlling that increase the transparency and validity of managerial decisions. At the same time, the analysis of the literature revealed a number of scientific gaps. Specific mechanisms for transforming traditional management tools under the influence of digitalization, especially in industries with a significant level of regulatory and market instability, remain insufficiently studied. Models for assessing innovation risks in real time and mechanisms for their integration into flexible planning systems need to be clarified. There are practically no comprehensive empirical studies devoted to the adaptation of modern tools of innovation management to the conditions of Ukrainian enterprises operating in specific economic, institutional and security circumstances.

Highlighting previously unresolved parts of the overall problem. Modernization of innovation management tools is closely related to a number of topical scientific and practical tasks of modern management and innovation economics.

The study is aimed at solving the practical problem of increasing the effectiveness of innovative projects through the introduction of adaptive, flexible and digital management tools. Modernization of innovative tools is a key condition for strengthening the competitiveness of enterprises, their technological renewal and ability to sustainable development in an unstable environment.

This issue is in line with the strategic priorities of the state innovation policy aimed at stimulating innovation activity, removing barriers to technological development and forming a high-tech economy. The solution of the outlined problem is not only of great scientific importance, but also of a significant practical effect, providing the basis for the development of effective managerial decisions, innovative strategies and organizational and economic mechanisms for the development of enterprises, which was the reason for the choice of this research topic.

Formation of the objectives of the article (task statement). The article is aimed at theoretical substantiation and methodological development of approaches to the modernization of tools for managing the innovation activity of enterprises in conditions of high variability of the external environment, as well as the formation of practical guidelines for increasing the adaptability, efficiency and effectiveness of innovation processes in situations of growing instability.

Within the framework of this goal, it is envisaged to analyze the conceptual foundations and modern scientific approaches to the management of innovation activities in the context of turbulence and digital transformation. To summarize the key trends in the development of innovation management tools that are formed under the influence of technological, economic and market changes.

To develop methodological approaches and proposals for the modernization of innovation management tools aimed at increasing the flexibility and adaptability of management decisions. And to assess the possibilities of implementing the proposed solutions in the practice of enterprise management, taking into account the conditions of instability and the needs of strategic development.

Summary of the main research material. In modern realities, enterprises are forced to carry out economic activities in conditions of increased turbulence caused by the cumulative impact of hostilities, global economic crises, energy threats, pandemics and other force majeure circumstances.

Such extreme conditions significantly transform the environment of innovation activity, changing development priorities, cost structure, access to resources and human resources.

As a result, traditional approaches to innovation management and planning lose efficiency, which necessitates adaptation of innovation management tools to conditions of high uncertainty and risk.

In modern realities, enterprises are forced to operate in conditions of high turbulence – hostilities, global economic crises, energy threats, force majeure situations (Tab. 1-3).

Table 1 reflects the key extreme factors (military events, economic shocks, pandemics), typical events that accompany them, and also demonstrates their double impact on the innovation activity of enterprises.

On the one hand, such factors stimulate the development of adaptive, digital and resource-saving innovations, on the other hand, they lead to a reduction in investments, a decrease in innovation teams and a postponement of long-term R&D.

In such conditions, traditional methods of management and planning of innovation activities lose their effectiveness.

This necessitates the revision and adaptation of the tools of innovative planning and organization to extreme conditions.

Table 2 summarizes the impact of extreme conditions on the innovation activity of Ukrainian enterprises by industry in 2022–2024.

The analysis shows that the IT sector, logistics and education demonstrated the greatest adaptability, while industry and the agricultural sector suffered the greatest losses, but at the same time became an environment for the emergence of bottom-up innovations focused on survival and recovery.

We see that IT, logistics and education have demonstrated the highest adaptability. Industry and the agricultural sector are the most vulnerable, but this is where bottom-up innovations (independent initiatives) arise.

Despite the general decline in innovation activity in 2022, the recovery trend is recorded already in 2023-2024, thanks to the adaptation of management models.

Table 3 systematizes the positive and negative effects of the impact of extreme conditions on innovation processes.

Table 1

Extreme factors and their impact on innovation activity

Factor	Events	Impact on innovation activity
Military events	Destruction of infrastructure, mobilization of employees, relocation	Accelerating adaptive innovation Reducing investments and teams
Economic shocks	Hyperinflation, scarcity of resources, currency devaluation	Funding Limitations Incentive for technological savings
Pandemics	Lockdowns, social isolation, logistical disruptions	Innovations in online services, digitalization Delays in R&D

Source: grouped by authors

Table 2

Impact of extreme factors on innovation activity by industry in Ukraine for the period 2022–2024

Industry	War	Economic shocks	Pandemic (long-term consequences)	Type of Innovative Response
IT sector	Relocation, infrastructure losses	Cost growth	Growing demand for remote services	Cloud solutions, cybersecurity, e-government
Industry	Destruction of production, mobilization	Energy crisis, inflation	Disruption of logistics	Energy efficiency, automation, repair innovations
Agricultural sector	Mining fields, shortage of equipment	Rising resource prices	Export problems	Precision farming, agro-drones
Logistics	Blocking routes	Rising transportation costs	Supply disruptions	Drone delivery, tracking systems, automation
Medicine	The need for evacuation, mobile points	Lack of funding	Burden on the healthcare system	Telemedicine, mobile pharmacies, digital records
Education	Destruction of schools, relocation of students	Increase in the cost of training	Switching to online	Distance learning platforms, VR/AR content

Source: Ukrainian Innovation Index (2024, assessment based on surveys) and [2; 4-5]

The positive consequences include the intensification of "fast" innovations, the acceleration of digital transformation and the strengthening of intersectoral interaction, while the negative ones include an increase in uncertainty, personnel losses, a reduction in strategic research and an increase in the risks of loss of intellectual capital.

Thus, the analysis of the impact of extreme conditions on the innovation activity of enterprises indicates not only the growth of restrictions and risks, but also the formation of new opportunities for adaptive development. Under such circumstances, innovations cease to be exclusively a tool for long-term growth and are transformed into a key mechanism for survival and stabilization of activities.

This necessitates rethinking and systematizing the main tools of innovation management that can ensure flexibility, speed of reaction and effective use of limited resources in extreme conditions.

The results obtained demonstrate that traditional models of innovation management are not effective enough in conditions of high turbulence and systemic shocks.

Changing the nature of innovations – from strategically oriented to adaptive and anti-crisis – requires the use of specialized management tools focused on rapid decision-making, decentralization and increasing organizational resilience.

In this context, it is advisable to consider the main tools of innovation management used by enterprises in extreme conditions.

Under martial law, economic instability, and limited access to finance and resources, traditional approaches to innovation management are ineffective. Enterprises need a prompt response, minimizing costs and adapting strategies to new realities (Tab. 4).

Summarizing the impact of extreme factors – wars, economic shocks, pandemics and logistical destruction – we will propose the concept of innovative antifragility of the enterprise, which is considered as the ability of the organization not only to maintain functionality in crises, but also to increase its innovative potential under the influence of stressful events. Unlike the classic "resilience", which involves a return to the previous state, antifragility means an improvement that comes from a combination of adaptive, digital and organizational-architectural innovations.

Generalization of the influence of extreme factors on the innovation activity of enterprises and analysis of innovation management tools in conditions of high turbulence indicate the need for a systematic approach to ensuring

Table 3

Positive and negative effects of extreme conditions on innovation

Positive	Negatives
Activation of "fast" innovations (low-cost, digital)	Curtailment of long-term strategic R&D
Formation of new business models that are focused on survival and adaptation	High staff turnover, departure of specialists
Accelerating digital transformation	High level of uncertainty, inability to plan
Strengthening intersectoral cooperation (business + science + state)	Risk of loss of intellectual property due to relocation and legal instability

Source: grouped by authors

Table 4

The main tools of innovative management in extreme conditions

Tool	The essence and benefits of application	Example of use in an enterprise
Lean Startup	Quick testing of ideas without significant investment	"Releaf Paper" (Ukraine) – creating paper from leaves: pilot products were tested on the market before scaling.
Agile approach	Adaptive planning and short implementation cycles	"Ajax Systems" (Kyiv) – innovations in security systems are implemented through short sprints.
Canvas business model	Business model visualization and quick adjustment	"PetCube" (Lviv) – using Canvas to build a new business model during relocation.
Foresight analysis	Predicting scenarios for the development of innovations	"Ukravit" (Cherkasy) – formation of strategies in agrochemistry taking into account global trends.
Scenario planning	Preparation for possible events and risks	"Nova Poshta" – the use of scenarios in case of logistics interruptions.

Source: grouped by the authors by [1; 5-6]

their sustainable development. In the conditions of war, economic shocks, pandemics and logistical failures, enterprises can no longer limit themselves to reactive adaptation, but need such management decisions that allow not only to maintain functionality, but also to strengthen innovation potential under the influence of external shocks. In this context, it is advisable to form a structural model of innovative antifragility of the enterprise, which reflects the logic of transforming extreme challenges into a source of development. The proposed model is based on a combination of key mechanisms of innovative antifragility – modular business models, diversification of risky R&D and processes, accumulation of digital competencies and the formation of innovation-sustainable clusters. Their interaction ensures the strengthening of the innovative capacity of the enterprise and, as a result, the growth of its competitiveness in extreme conditions. Thus, the structural model of innovative antifragility acts as an analytical tool that allows systematizing managerial decisions aimed at increasing the ability of the enterprise not only to withstand crisis influences, but also to use them as a catalyst for innovative development. An anti-fragile enterprise is able to transform extreme conditions into sources of development through: modular business models that provide rapid re-profiling of production or services; diversification of risky processes (supply, sales, R&D), which reduces dependence on external shocks; accumulation of digital competencies as the basis for process autonomy and minimization of losses; formation of innovation clusters of resilience – associations of enterprises, research institutes, IT platforms and government agencies for the exchange of technologies and joint response to crises. Together, these mechanisms form a dynamic system that makes the innovative development of the enterprise self-reinforcing even in the most difficult external conditions.

Based on the above, we will group in (tab. 5) and provide recommendations for the introduction of innovations in an unstable environment.

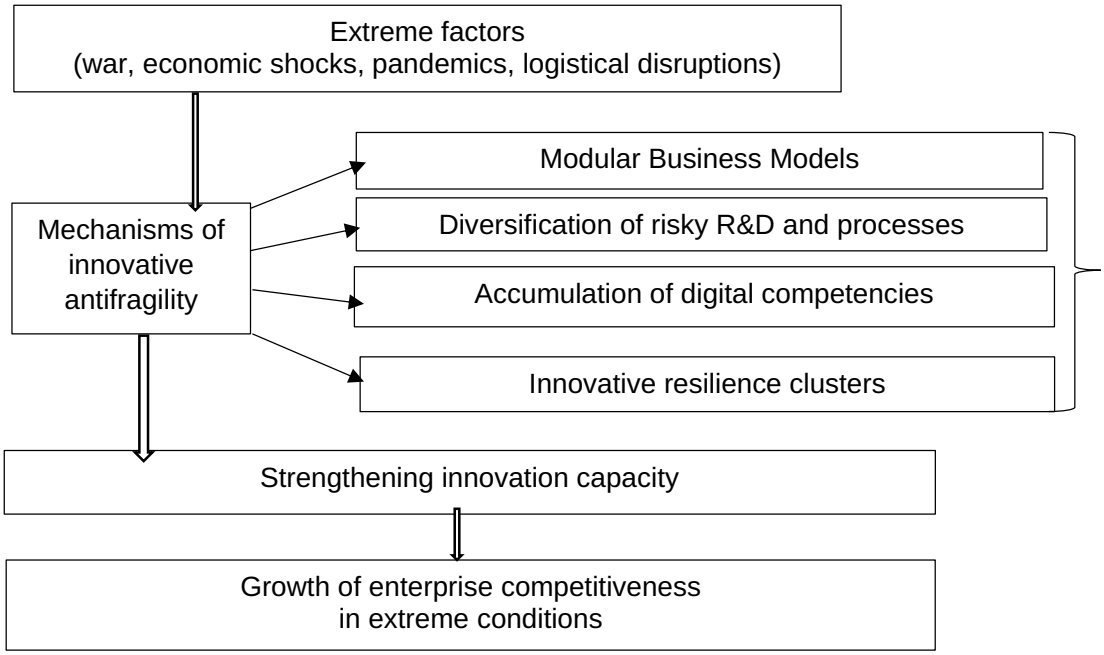

Fig. 1. Structural model of innovative antifragility of enterprise

Source: developed by the authors

Recommendations for various industries indicate that in conditions of high instability (war risks, destruction of infrastructure, disruption of supply chains, relocation of personnel, shortage of resources), adaptive, digital and resource-saving innovations that provide flexibility, continuity of activities and quick response to changes in the external environment become key. All industries demonstrate common vectors of innovative development:

1. Digitalization as the main tool for survival. The use of digital platforms, control systems, IoT, AI and remote technologies is a universal way to reduce dependence on physical infrastructure and human resources. This is manifested through: Smart Manufacturing in industry; digital agricultural platforms and precision farming systems; navigation and API solutions in logistics; telemedicine in healthcare; EdTech in Education.

2. Localization and autonomy of processes. In the face of damaged logistics routes and supply risks, enterprises are moving to a model of maximum autonomy, including: localization of warehouses and production; creation of their own mini-logistics and processing centers (especially in the agricultural sector); autonomous transport and technical solutions (drones, robotics).

3. Reduction of resource dependence and energy independence. In industry, the agricultural sector and logistics, energy efficient and renewable energy sources, resource optimization technologies, innovative methods of storage and processing of products are gaining more and more importance. This minimizes the risks of supply disruptions and increases the sustainability of production.

4. Flexibility of organizational structures and working models. The IT, education, and healthcare industries demonstrate that in conditions of instability, the key role is played by: agile remote teams (remote-first); mixed work and study models; mobile medical units and remote consultations. This solution allows you to maintain the quality of services regardless of geographical restrictions.

5. Seeking international support and partnerships. Industry, IT, medicine and education are actively focused on: partnership with European innovation programs (Horizon Europe, ERASMUS+); grant funding; integration into global markets and networks. This provides access to finance, technologies and competencies.

6. Emphasis on fast, practical and low-cost innovation. In many industries (especially agriculture and logistics), micro-innovations that do not require large investments, but significantly increase efficiency, become key: biofertilizers, short-cycle varieties; route optimization; autonomous technical solutions; lightweight digital services. All industries are

Table 5

Recommendations for the implementation of innovationsin an unstable environment

Industry	Problems	Recommendations
Industry (mechanical engineering, metallurgy, manufacturing)	destruction of production facilities, shortage of components, energy risks.	Introduction of energy-efficient technologies (modernization of equipment, use of renewable energy sources). Localization of supply chains (creation of warehouses closer to places of consumption). Digital production management (Smart Manufacturing). Use of the "Industry 4.0" model with elements of automation and IoT. Search for technology partners through industrial parks or European programs (e.g. Horizon Europe).
Agricultural sector	mining of fields, reduced yields, blockade of exports.	Introduction of precision farming (GPS, drones, sensors). Innovations in agrologistics: storage, drying, on-site processing. The use of agricultural platforms for online trade. Micro-innovations: varieties with a short growing season, biofertilizers, autonomous machinery. Attracting financing through green agricultural business (GreenAgroFunding).
Logistics and transport	destruction of infrastructure, transportation risks, delays.	Implementation of drone delivery and autonomous solutions. Route optimization through digital platforms and real-time navigation. Adaptation of warehouses to "flexible zones" for unloading and transshipment. The development of Last Mile Delivery technologies, especially in frontline areas. Using API systems to synchronize supply chains.
IT Sphere	Team relocation, cyber threats, personnel shortages.	Building flexible remote commands (remote-first + time zone sync). Investing in cyber protection and data backup systems. Adaptation of the business model to SaaS /PaaS products with global scaling. Expansion of the customer base outside Ukraine (export of digital services). Use of Upwork, Clutch, AngelList platforms for international presence.
Health care	lack of resources, evacuation of doctors, overload of the system.	Mass adoption of telemedicine and mobile consultations. Development of AI assistants for preliminary diagnosis. Distance training of staff through certified online platforms. Attraction of grants for innovative medical startups (exoskeletons, portable diagnostics). Integration of eHealth solutions with patient databases.
Education and science	relocation of students and teachers, shortage of technical resources.	Building a hybrid model of education (offline/online). Use of EdTech platforms (Moodle, Canvas, Prometheus, Coursera). Creation of educational startups in cooperation with the IT field. Implementation of AR/VR training for special disciplines (medicine, technology). Strengthening international cooperation (double diplomas, exchange of experience, ERASMUS+).

Source: grouped by the authors

adapting to volatility through a combination of digital technologies, resource-saving solutions and organizational agility. Innovation is aimed at increasing the resilience, autonomy and ability of enterprises to respond quickly to threats. Integration into international innovation ecosystems, which provides access to technology, knowledge and finance, becomes a critical success factor.

Conclusions. Based on a comprehensive analysis of the impact of extreme factors on the innovation activity of Ukrainian enterprises in 2022–2024, it is substantiated that innovation development under high instability acquires the features of an adaptive-reactive model. Its key characteristics include minimization of resource dependence, rapid decision-making, short innovation cycles and fragmented investments. This approach complements classical innovation models by incorporating the specifics of war and force majeure conditions. The sectoral analysis made it possible to identify three groups of innovations: adaptive innovations focused on rapid response; autonomizing innovations aimed at reducing external dependencies; and strategic survival innovations that form new business models capable of functioning in unstable environments. This classification reflects the transformation of innovation priorities under extreme conditions and represents a novel contribution to Ukrainian innovation research. It is proven that under high uncertainty, flexible management tools such as Lean Startup, Agile, Canvas modeling, foresight and scenario planning are the most effective, expanding their traditional role from optimization to adaptation instruments. The results confirm that IT, logistics and education demonstrate the highest adaptability, while industry and agriculture remain the most vulnerable, with innovative sustainability determined by digitalization, resource autonomy, workforce mobility and international partnerships. Intersectoral vectors of innovative development are identified, including digitalization, production and logistics autonomy, energy efficiency, flexible organizational models, international integration and the development of low-cost innovations. It is substantiated that enterprises can strengthen competitiveness in extreme conditions through modular business models, diversification of risk processes, accumulation of digital competencies and the formation of innovative resilience clusters. These findings constitute a theoretical contribution to innovation management and can be applied in enterprise strategy and public policy.

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Дата надходження статті: 07.12.2025
Дата прийняття статті: 17.12.2025
Дата публікації статті: 29.12.2025