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Yuliia Klius
Doctor of Economic Sciences, Professor,
Head of Department of Accounting and Taxation,
Volodymyr Dahl East Ukrainian National University
ORCID: https://orcid.org/0000-0002-1841-2578
Dmytrii Mykhalchuk
Postgraduate Student,
Volodymyr Dahl East Ukrainian National University
ORCID: https://orcid.org/0009-0001-2980-450X

INTERRELATION BETWEEN THE MANAGEMENT OF ECONOMIC SECURITY OF DEVELOPMENT AND THE STATE OF RESILIENCE OF THE ECONOMIC SYSTEM

The article explores the relationship between the management of economic security of development and the state of resilience of economic systems in the context of modern challenges. It is emphasized that economic security is a key element that ensures the sustainability of functioning and adaptation of economic systems to changing environmental conditions. The resilience of an economic system is considered as its ability to withstand internal and external threats, quickly recover from crisis situations and maintain its development potential. The article analyses the main factors that affect economic security, including financial stability, innovation activity, efficiency of management decisions and the ability to adapt to changes. Particular attention is paid to the risks arising in the process of functioning of economic systems, including threats of economic, social, political and environmental nature. It is determined that effective management of economic security contributes to strengthening the resilience of the system, reduces its vulnerability to external shocks and ensures long-term stability. In the process of managing innovative industrial risks, two stages can be distinguished: at the first stage, there is a struggle to maintain the system's performance (ensured by the level of system resilience), and at the second stage, there is a struggle for the successful completion of the task, despite the primary and secondary consequences of disturbing actions (carried out through the efficiency of the management system). The article proposes an approach to integration of economic security into strategic planning of economic systems. In particular, the expediency of using innovative methods of monitoring threats, implementing a risk management system and adapting management mechanisms to modern realities is substantiated. The role of digitalization, automation of processes and introduction of modern technologies in increasing the resilience of economic systems is considered. The results of the study are of practical importance for developing effective management strategies for enterprises operating in unstable conditions. The conclusions of the article contribute to the formation of a methodological framework for ensuring sustainable development and economic security of economic systems. The obtained results may be useful for scientists, practitioners and public managers dealing with issues of economic development and protection of economic systems from risks.

Key words: *economic security, risks, resilience, economic system, interconnection.*

Клюс Ю. І., Михайльчук Д. І.
Східноукраїнський національний університет імені Володимира Даля

ВЗАЄМОЗВ'ЯЗОК УПРАВЛІННЯ ЕКОНОМІЧНОЮ БЕЗПЕКОЮ РОЗВИТКУ ТА СТАНУ ЖИВУЧОСТІ ГОСПОДАРСЬКОЇ СИСТЕМИ

У статті досліджено взаємозв'язок між управлінням економічною безпекою розвитку та станом живучості господарських систем у контексті сучасних викликів. Підкреслено, що економічна безпека виступає ключовим елементом, який забезпечує стійкість функціонування та адаптацію господарських систем до змінних умов зовнішнього середовища. Живучість господарської системи розглядається як її здатність протистояти внутрішнім і зовнішнім загрозам, швидко відновлюватися після кризових ситуацій і зберігати потенціал розвитку. Проаналізовано основні чинники, які впливають на економічну безпеку, серед яких фінансова стійкість, інноваційна активність, ефективність управлінських рішень і здатність адаптуватися до змін. Особливу увагу приділено ризикам, що виникають у процесі функціонування господарських систем, включаючи загрози економічного, соціального, політичного та екологічного характеру. Визначено, що ефективне управління економічною безпекою сприяє зміцненню живучості системи, знижує її вразливість до зовнішніх шоків і забезпечує довгострокову стабільність. У процесі управління інноваційними промисловими ризиками можна виділено два етапи: на першому етапі йде боротьба за збереження працездатності системи (забезпечується рівнем живучості системи), на другому етапі – боротьба за успішне виконання завдання, незважаючи на первинні та вторинні наслідки збурювальних дій (здійснюється за рахунок ефективності системи управління). У статті запропо-

новано підхід до інтеграції економічної безпеки у стратегічне планування господарських систем. Зокрема, обґрунтовано доцільність використання інноваційних методів моніторингу загроз, впровадження системи ризик-менеджменту та адаптації управлінських механізмів до сучасних реалій. Розглянуто роль цифровізації, автоматизації процесів і впровадження сучасних технологій у підвищенні живучості господарських систем. Результати дослідження мають прикладне значення для розробки ефективних стратегій управління підприємствами, які функціонують у нестабільних умовах. Висновки статті сприяють формуванню методологічної бази для забезпечення стійкого розвитку та економічної безпеки господарських систем. Отримані результати можуть бути корисними для науковців, практиків і державних управлінців, які займаються питаннями економічного розвитку та захисту господарських систем від ризиків.

Ключові слова: *економічна безпека, ризики, живучість, господарська система, взаємозв'язок.*

Problem statement and its significance. By comparing the obtained value of the system's survivability state with the one required for the analyzed projects, the economic system can choose the best option for the existing conditions, which will increase the efficiency of innovation activities. It should be noted here that it is the resilience of the economic system that determines the minimum acceptable value of sustainability in order to maintain the integrity of the system at the point of bifurcation of innovation development. This means that the magnitude of the consequences of a potential complex of innovative industrial risks should not exceed its value, otherwise, as a result of innovative development, not only will the desired efficiency not be achieved, but the emergence of the economic system will be lost. At the same time, the complex of innovative industrial risks will determine the conditions for changing survivability, and the effectiveness of risk management will determine the quality of its change. In other words, the survivability of an economic system that is transformed when the complex of innovative industrial risks changes becomes a tool for choosing the direction of innovative changes and reflects the quality of changes in the management of innovative industrial risks.

The process of such interaction in time is represented by the following algorithmic sequence. Information about possible primary consequences of the implementation of innovation risks is fed into the system, which includes performance monitoring tools, emergency protection tools, reconfiguration and management tools. The implementation of the management system tools (based on the state of survivability) affects the development of primary consequences, and depending on the intensity of processes in the system, specific external conditions of functioning, and the effectiveness of risk management, the economic system eventually transitions to one of the possible states. By its nature, this transition process is stochastic. After that, the system assesses the primary consequences, as a result of which the system's state is classified into one of three classes: operable, inoperable or non-emergency, and emergency [3]. In the operable state, the system quickly returns to the task and the quality of innovation risk management is manifested in the system's ability to perform all functions to the fullest extent possible. If the state is inoperable, the system can return to the task after some recovery procedures that are implemented through the risk management system (creation of reserves, reduction of the scale of consequences, etc.) and should be implemented as soon as possible. At the same time, the transfer of the system to a new stable state does not complete the process of managing innovation risks, because in the course of further functioning until the task is completed, secondary consequences of disturbing actions may also be revealed.

They differ from the primary ones in that they are more distant in time from the moment of disruption of the normal course of the production process, but are no less dangerous than the primary ones and are associated with processes that are uncontrollable due to surprise. The speed of development of secondary consequences and the final result also significantly depend on the characteristics of the system itself and the level of its survivability.

Thus, in the process of managing innovative industrial risks, two stages can be distinguished: at the first stage, there is a struggle to maintain the system's performance (ensured by the level of system survivability), and at the second stage, there is a struggle to successfully complete the task, despite the primary and secondary consequences of disturbing actions (carried out through the effectiveness of the management system). Accordingly, two tasks are distinguished in the management of innovation activities: assessing the survivability and ensuring the effectiveness of industrial innovation risk management [3]. However, this is true only in cases where the action is a one-time event.

Analysis of recent research and publications. Ukrainian scientists are actively researching the relationship between economic security management and the state of resilience of economic systems, focusing on the challenges caused by economic crises, military operations and global instability. The works of A. Bazyliuk, J. Zalilo, A. Mazaraki and others consider models for assessing the resilience of systems, strategic risk management, as well as approaches to improving financial stability and adapting to changing conditions. Significant attention is paid to the digitalization of management processes, diversification of activities

and Ukraine's integration into the global economic space. The research results are aimed at developing mechanisms to ensure sustainable development of the national economy.

However, the relationship between the management of economic security of development and the state of viability of the economic system is almost not studied by domestic scientists, so **the purpose of this article** is to establish it and study the prospects for its development.

Summary of the main research material. The current conditions of development of economic systems create the need for continuous implementation of innovation processes, but the state of domestic production and economic facilities is such that continuous innovation activity is implemented in the form of separate (discrete) innovation projects. Therefore, in essence, the process of managing innovative industrial risks is a discrete-continuous abstract model of risk management of innovative projects implemented at different speeds and according to different schemes, taking into account the internal characteristics of the economic system (state of viability) and the impact of the external environment. Accordingly, the nature of industrial innovation risk management should be unique, but carried out continuously in accordance with the above-mentioned development conditions. At the same time, innovation management should take into account all the features of innovative industrial risk to ensure effective innovative development of the enterprise. In this case, we can define management as a set of measures aimed at reducing the danger of a potential risk scenario and choosing an alternative to innovative development that will lead to effective and safe implementation of innovations.

The scheme becomes much more complicated when innovation processes are continuous and the consequences of various disturbances overlap, as in the case of cascading industrial risks. Under these conditions, the 'race effect' plays a significant role in the process of innovation implementation: the processes of development of the consequences of disturbing actions and the processes of struggle for security based on the resilience of the economic system take place simultaneously with the introduction of innovations (Fig. 1).

At the same time, the effectiveness of this struggle lays the foundation for the next level of development of the system elements, including the ability to manage the complex solution of simultaneously arising problems. Therefore, the scale of the consequences of emerging risks, the state and, ultimately, the existence of the system are largely determined by its capabilities, which are determined by the state of survivability and the quality of the system of innovative industrial risk management: efficiency and effectiveness. If the system has a level of survivability that provides a margin of efficiency due to the nature of the measures taken, it creates favorable conditions for timely decision-making. This allows, in turn, to limit the secondary consequences and maintain the system's performance, even with slightly worse technical characteristics.

In this regard, it is important to emphasize the following: in many cases, the management of innovative industrial risks takes place under conditions of acute time pressure in the context of continuous changes in the system itself, so the models of industrial risks of innovative activity of such systems should be dynamic, and the system of their management should be proactive and take into account the existing level of survivability of the economic system. The influence of the time factor can be disregarded and static models can be used in two extreme cases, when the speed of change processes accompanied by the growth of disturbing actions and

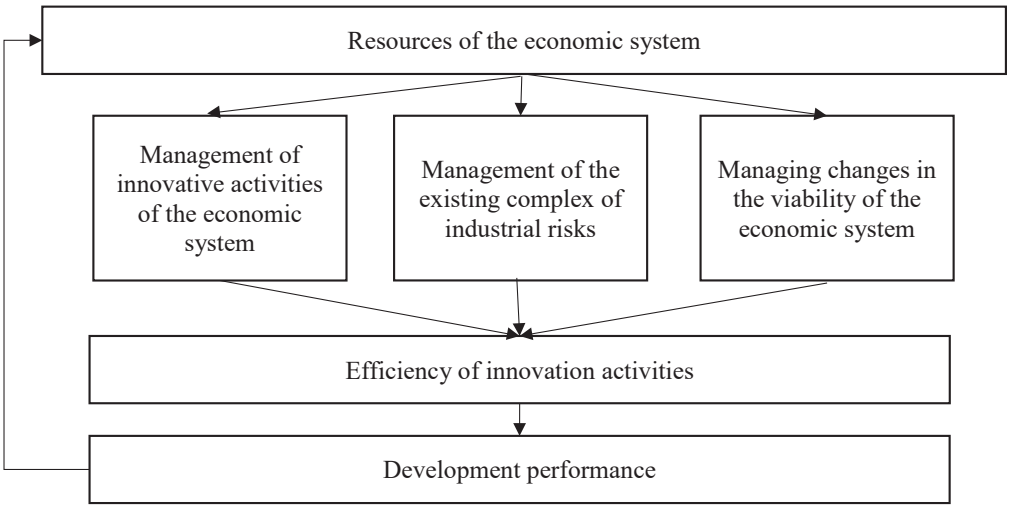

Figure 1. Scheme of innovation management taking into account the "race effect"

Source: compiled by the author

the achievement of economic system security differ significantly. In the first case (the speed of the control system is much higher than the speed of change), the control system has time to work out its algorithms and make the necessary shutdowns, switching and switching before interconnected failures begin to occur.

In the second case, the system does not have time to intervene in the development of the primary consequences of rapidly occurring impacts, and the transition to a new steady state occurs without its intervention. Only later will risk management-based security measures affect the secondary consequences and recovery processes, and in both cases, the role of stochastic factors is reduced. This means that in this case, the quality of resilience will be manifested in the independence and speed of the system's response and recovery.

Each model of innovative industrial risks is created for a specific purpose and, therefore, is unique. Theoretically, many types of models and their classification features are considered in relation to technological and biological objects [2]. From the point of view of the study, we are interested in models grouped into the following classification groups based on the following features:

the nature of the object being modelled;

the nature of the processes taking place in the object;

method of model implementation.

Classification of models and modelling based on the nature of the object being modelled. The use of this approach provides for a comprehensive study of innovative industrial risks of the economic system and allows identifying the characteristics of the modelled object to build an effective management system. This helps to increase the level of security in the process of innovation and improve its efficiency, which leads to an increase in the sustainability of the economic system.

This is the initial stage in building a comprehensive model of innovative industrial risks, which revealed that in the course of implementation of innovative activities by modern economic systems in the form of projects, there are disturbing actions (innovative industrial risks) that negatively affect the safety of innovative development of the system. This made it possible to identify the reasons for its change in the course of innovation activity and to form a block for managing innovative industrial risks based on the level of survivability existing in the economic system.

In the course of the identified interrelation of the dynamics of the quality of the system's survivability in the process of its innovative development and the nature of innovative risks, it has been found that innovative industrial risks of an economic system, acting as an object of modelling, can be described by the structure of a complex of risks arising in the process of modernization of the system's production potential in the course of its innovative activity. In this case, this whole complex of risks is determined not only by internal innovative industrial risks arising in the course of innovative development of the production potential components, but also by the risks caused by inconsistency of innovative changes in the production potential components among themselves.

This approach to modelling innovation risks makes it possible to determine the initial impetus for their development and identify the most effective instruments

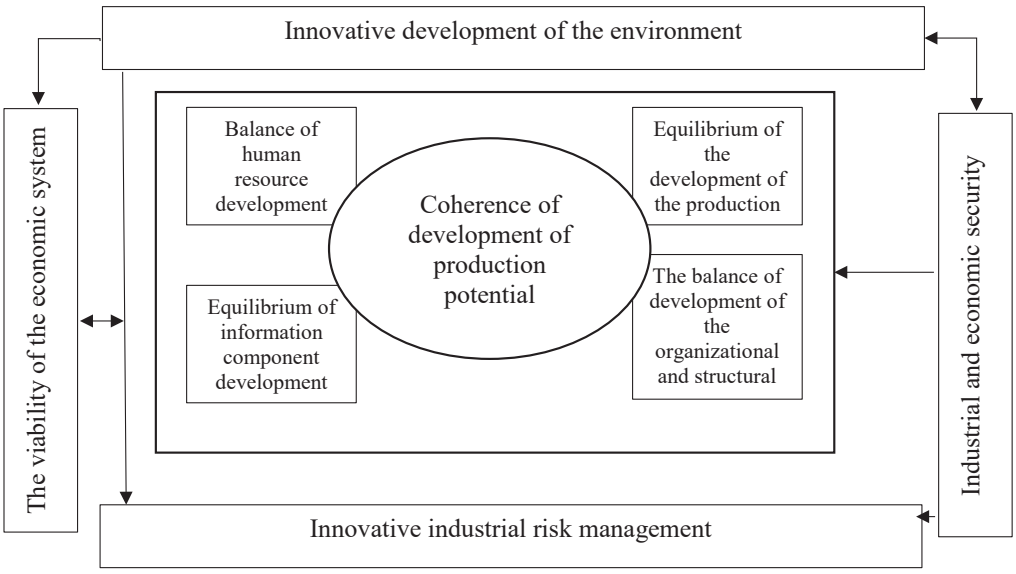

Figure 2. Scheme of innovative risks of production and economic systems with regard to the management regulator

Source: developed by the author

of managerial influence in order to increase the level of security of the economic system in the course of its innovative development. In the study, to reflect the relationship between the innovation risk management system and resilience, the authors propose a scheme of innovation risks of production and economic systems based on their resilience (Fig. 2). As can be seen in Fig. 2, the existing level of survivability of the economic system (management) determines the assessment and selection of effective management measures to influence the industrial risks of innovation activity, since it determines the ability of the system in this period of development to withstand the influences that disturb it.

Since a decrease in survivability leads to a loss of internal properties of the system and the emergence of new constraints (resource, time, etc.), this changes the conditions for the development of the risk management system and reduces its quality. This, in turn, will have an even more significant impact on the economic security and resilience of the economic system, and their further negative mutual influence may lead to the destruction of the system in the long run. It is also noted that the source of resilience formation is the management of the coherence of innovative development, both of the production potential itself and its components, which is reflected in the formation of resilience of economic systems in two directions: functional and structural.

In this regard, the level of sustainability is increased by effective management of innovation risks and forms the basis for further development of the system of economic security management of innovation processes. Therefore, the priority for modern economic systems in the course of implementation of innovation activities is its economic security along with efficiency. In addition, when choosing impacts on innovative industrial risks, the system should take into account the pace and quality of environmental change in the field of innovative development and economic security.

The proposed scheme also reflects that the mutual influence of the state of economic security of the components of the production potential and the coherence of their innovative development in relation to each other under the influence of environmental factors can lead to different consequences, which can be characterised by the probability and scale of consequences, which should be taken into account by the management system. This gives the scheme of innovation risks stochastic features and requires alternative and adaptive measures in the process of their management.

When forming a management system for the studied complex of risks of economic systems, which are complex socio-ecological and technological systems, dynamic models are used, since in modern conditions the task of managing innovation activity is to achieve its efficiency while maintaining the state of economic security of development through the management of innovation risks of the system. Static models are considered in the analysis of the most optimistic and pessimistic scenarios [6].

The complexity of the analysis in this case lies in the fact that economic systems in domestic practice have the features of singular systems, which include dynamic systems with processes occurring on different time scales. The variables of such a system are divided into two classes: 'fast' and "slow" variables. The rate of change of "fast" variables in almost all points of the phase space is much faster than the rate of change of "slow" variables. The trajectories of such systems consist of alternating sections of slow "drift" and fast "breaks". Fast-slow systems describe various physical and other phenomena in which the gradual evolutionary accumulation of small changes over time leads to an abrupt transition of the system to a new dynamic regime [3]. This explains the delayed nature of many disturbing actions (innovation risks) and the presence of primary and secondary consequences from them.

In other words, in the process of implementing an innovative project, as a result of disturbing actions, the system transitions to a state in which, in the event of a negative scenario, it may suffer significant damage or cease to exist as a result of innovative risks. In an optimistic scenario, the system can move to a new qualitative level of development due to the level of survivability created at the previous stage of innovation development through the management of innovation risks and the effect of innovation achieved through the management of innovation. The importance of this transition is growing for technologically and industrially interconnected economic systems, since the first alternative can cause a phenomenon called a cascade of bifurcations (Feigenbaum sequence) in an interconnected set of production and economic objects (which are modern integrated associations representing most industries) [2].

It implies one of the typical scenarios of transition of complex systems from order to chaos, from a simple periodic mode of change of system indicators to a complex aperiodic one with an infinite doubling of the effect of actions that disturb it. This will lead to a chain-like uncontrollable sequence of loss of quality of interdependent subsystems of integrated associations with different degrees of integration (including territorial, technological and economic ties). Therefore, in the process of innovative development, building a system of innovation risk management based on their dynamic model should seek to optimise it and form a preventive nature of managerial influence.

In the study, for a comprehensive study as an object of management, innovation risks are considered from the standpoint of a model of system behaviour in the event of a disturbance in the process of innovation development (Fig. 3).

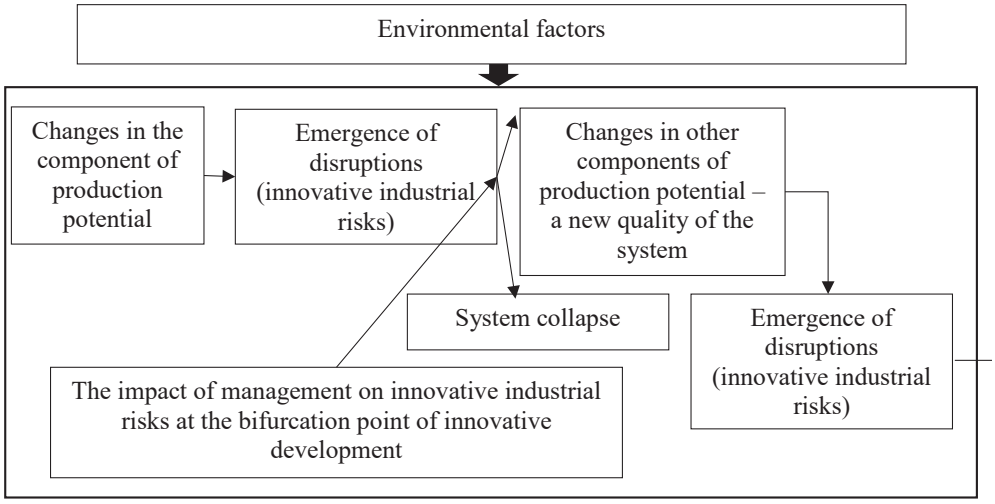

Figure 3. Scheme of development of innovative industrial risk of an economic system in the process of its innovative development

Source: compiled by the author

Based on this scheme (Fig. 3), it is clear that in the process of innovative changes in the economic system at different stages of its implementation, there is an alternative to the transition at the bifurcation point to a new qualitative level, and the task of the management system in this case is to choose such influences that would lead to the required development scenario. In this case, survivability acts as a functional part of the economic system, since it is with its help that it is possible to determine the perception of the system of the controlling influence of changes in its dynamics in accordance with them. It does not perform decision-making functions, i.e. it does not form or choose alternatives to its behaviour, but only reacts to external (controlling and disturbing) actions, changing its level in a predetermined manner.

As an object of management, innovative industrial risk consists of two functional parts – sensory and executive [2]. The sensory part is formed by a set of mechanisms (probability and scale of emerging innovative industrial risks), the direct cause of changes in the states of each of which is the corresponding controlling influences [3]. The executive part is formed by a set of material objects (production potential of the economic system), all or individual combinations of states of which are considered as target states of the technical system, in which it is able to independently perform the consumer functions provided for by its design. In this case, the direction of change in survivability can be considered as a special regulator of the innovative industrial risk management system, which allows monitoring the state of the object of management as a system and generating control signals for it. Regulators are a tool for responding to changes in the controlled parameters of the object of management using control algorithms in accordance with the Bellman optimality principle [6].

The point is that optimal control is built gradually. At each step, the control of that step is optimised. At the same time, at each step, the control is chosen taking into account the consequences, since the control optimises the objective function of this step only, which can lead to a suboptimal effect of the entire process. The control at each step should be optimal from the point of view of the process as a whole [8]. This is the basic rule of dynamic programming, which requires the formation of industrial risk management of innovation activities for a comprehensive analysis with the help of the regulator to make the management system comprehensive.

Consideration of innovative industrial risk as an object of management would be incomplete without analysing the factors that determine it. They can be divided into three groups based on their functional characteristics.

The first group includes factors that characterise adverse effects. The area of influence of a disturbing effect can be a point (technological unit, element, etc.) or their combination, united by means of links (structural element). The area of influence of the disturbing action can be specified by listing the system elements and their functional connections.

Depending on the nature of the adverse impact, one or more impacting factors can be distinguished. In the case of innovative industrial risks, there may be many such factors, so the degree of their impact is reduced to one conditional equivalent on the basis of the monetary equivalent. This helps to characterise its intensity in different scenarios. On the other hand, the intensity of the factors' impact may change over time, in which case reduction algorithms are used.

In terms of the duration of exposure, all disturbances can be divided into impulsive (with almost zero duration) and intermittent. This factor plays a role in the severity of the primary and secondary consequences of risks. The longer the period of exposure to the factors, the faster the degradation of resilience and the greater the likelihood of chain and cascading effects of risks.

The second group consists of factors that characterise the system and its individual elements and subsystems in terms of resilience. The resilience of elements characterises the ability of elements to withstand adverse impacts, preventing destruction, disruption or deterioration. For business systems, it is primarily related to the condition and characteristics of the elements themselves. The impact of the system topology and its individual elements is related to the fact that adverse impacts have spatial intensity characteristics, and therefore the degree of impact will depend on the size of the elements and how they are located in space. The larger the elements and subsystems of the economic system, the lower its overall survivability, and the higher the requirements for managing emerging innovative industrial risks. First of all, the efficiency of the control system in this case can be increased by means of spatial dissipation. Resistance to the development of the consequences of disturbing influences of a certain type is also an internal characteristic of elements and subsystems and depends on the length and quality of their connections and the increase in the intensity of element failures. The timeliness and completeness of the actions of the industrial innovation risk management system is one of the main factors taken into account when assessing and ensuring the safety of innovative development of economic systems.

A distinction should be made between internal management measures built into the system and external means that are created to service many systems of similar purpose ("rescue services") and are connected upon request as needed. The main areas of security control provided by internal management tools are timely notification of the danger of occurrence and results of disturbing actions, effective redundancy, and recovery. In addition to the means of restoring operability, recovery tools also include means of localising and eliminating secondary consequences of failures, and means of restoring technical characteristics that ensure the required level of survivability to move to a new quality level.

The third group includes factors that characterize external means of ensuring the effectiveness of innovative industrial risk management: the presence of operational and reliable means of communication of the system with external means of ensuring the safety of the economic system, the possibility of timely and effective intervention of external management measures in the management of innovative industrial risks of the system. Their functions are performed by rescue services and mobile centralized reserve funds used for the duration of restoration work.

To assess the role of factors, the possibility and methods of their accounting in models of innovative industrial risks, it is important to know their nature, the source of initial data on their characteristics and the methods of obtaining them. The choice of model and analysis method depends on whether the factor is stochastic or deterministic, what information can be obtained about the characteristics of this factor. It is worth noting that some factors are stochastic in nature, and their full accounting is possible only with the help of probabilistic models of innovative industrial risks. Other factors are deterministic, and their accounting is carried out using deterministic models. Taking into account all factors requires a combination of probabilistic and deterministic models.

Many data in the game model are obtained using expert assessments. Despite the significant successes of game theory, it is usually difficult to directly apply its results to the task of managing innovative industrial risks due to the great variety and complexity of scenarios, as well as the fact that the innovative processes that generate this group of industrial risks develop over time and require diverse solutions [3]. However, with the adoption of some restrictions and the use of statistical tools, a general approach related to taking into account the uncertainty factor can be used.

Conclusions. Thus, innovative industrial risk as a complex object of management requires a new integrated approach in the process of development of an economic system based on innovations, which includes building a dynamic model with consideration of its stochastic features in the course of discrete innovative development of production and economic objects. This model reflects the interconnectedness of management of economic security of development and the state of viability of the economic system, which allows to determine the bifurcation point in the course of its innovative development and to choose the optimal alternative of managerial influence on the emerging innovative industrial risks in order to minimise the negative consequences of the uncoordinated implementation of innovations and to achieve a new quality level by the system.

In addition, in the process of forming the behavioural model, it was found that the level of viability of the economic system and the quality of modernisation of its production potential are the determining parameters in the choice of managerial impact on the complex of industrial risks of innovation activity. And the efficiency of the system for managing innovative industrial risks is one of the regulators for forming an algorithm for managing the economic system in order to achieve the efficiency of its development.

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