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Innovative tools for risk management of the production activities of agricultural enterprises in an institutional environment

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Abstract. The security of agricultural sector development is increasingly becoming a relevant issue in modern conditions, as the agricultural sector determines the sustainability of the economy and ensures the country's food security. Growing risks, such as climate change, economic difficulties and geopolitical conflicts, highlight the need to improve the security of agricultural production systems,

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which makes the study relevant. The study aimed to conduct a systematic analysis of innovative tools for managing the risks of production activities of agricultural enterprises and their impact on the formation of secure development in the agricultural sector of Ukraine. To achieve this goal, the method of analysis and modelling was used. Study results indicate that innovative approaches to risk management have a decisive impact on the sustainability and efficiency of agricultural production systems. To achieve a stable level of safe development of agricultural enterprises, it is necessary to focus on the implementation of key areas, such as maintaining the food base at a level sufficient to ensure a healthy diet, ensuring an adequate level of effective demand for the population and eliminating dependence on imports, aimed at protecting the interests of domestic producers of agricultural raw materials. The study demonstrated that institutional factors of risk management form an integrated system, where efficiency depends on the implementation of specific strategies for the development of agricultural institutions aimed at introducing innovative tools into the production cycle of agricultural enterprises. Furthermore, due to the accumulation of large amounts of production, financial, logistical and innovative potential of agricultural enterprises in the Forest-Steppe and Polissia regions, the level of safe development of agricultural enterprises is significantly increasing. This indicates their high capacity for sustainable reproduction of production and making a significant contribution to the agricultural sector of Ukraine. The study is of practical importance for agricultural enterprises, research institutions and government agencies, which can use the results to improve risk management strategies and increase the level of security of agricultural sector development

Keywords: risks of the production activity; business efficiency; financial stability; technological development; production system; institutes of agriculture

INTRODUCTION

In the modern economic landscape, where agriculture plays a strategic role in ensuring food security and economic resilience, the relevance of exploring innovative risk management tools for agricultural enterprises in an institutional context is becoming urgent. The growing instability of the economic and social environment, combined with the effects of climate change and global market fluctuations, causes a wide range of risks that directly affect agriculture. In this context, the study of innovative risk management tools becomes a strategically important task, as it aims to develop effective strategies and tools to help agricultural enterprises adapt to unpredictability and ensure stability in production processes.

An analysis of existing research indicates the need to improve risk management methods in agriculture. As such, A. Sudip and A. Khanal (2022) emphasised the importance of innovative approaches in addressing risk in agriculture. The authors emphasise that innovative tools can effectively contribute to the management of various aspects of production risks.

F. Capitanio (2022) highlights the need to consider risks in agriculture as a complex and multidimensional phenomenon. Innovative approaches address different dimensions of risk and develop comprehensive risk management strategies. S. Bai and X. Jia (2022) argue that innovative tools can serve as an effective tool for making informed decisions in risk management. This is especially important in the context of uncertainty and volatility in agriculture. S.V. Jansi Rani *et al.* (2022) believe that innovative methods can contribute to increasing the resilience of agriculture to various threats, such as climate change, market fluctuations and economic difficulties.

L.R. Deng *et al.* (2022) note a definite impact of innovative risk management approaches on the agricultural sector. These approaches stimulate technological development, which plays a key role in increasing the productivity and competitiveness of agriculture. The authors emphasise that the integration of the latest technologies, the development of agricultural technologies and the increase in production accuracy are the result of the implementation of innovative risk management strategies. This contributes not only to increasing the efficiency of farming but also to creating a sustainable agricultural sector that can withstand various external influences.

Furthermore, Z. Gao (2022) notes that the introduction of risk management innovations stimulates research and development activity, contributing to the emergence of new technological solutions and techniques. In general, innovative approaches not only improve current risk management methods in the agricultural sector but also create prospects for the future development of agriculture. According to O. Stashchuk *et al.* (2021), in the field of Ukrainian agriculture risk management, innovative approaches are important to stimulate technological development. Modern innovations can play a key role in increasing the productivity and competitiveness of agriculture in Ukraine.

In particular, M.P. Sychevskiy (2019) argues that the integration of the latest technologies, the use of modern agrotechnical solutions, as well as the application

of innovative risk management methods, can help improve the quality of production and optimise agricultural processes. This, in turn, will contribute to increased farming efficiency, higher farmers' incomes, and the competitiveness of Ukrainian agricultural enterprises on the international market. Understanding and active implementation of innovative risk management solutions is becoming a strategically important element for the sustainable development of Ukraine's agricultural sector.

D. Tretiak *et al*. (2023) also note that in the context of uncertainty and military conflict in Ukraine, a weakening of agricultural institutions is evident, which leads to alarming trends in the functional state of the production system. The modernisation of technological innovations in agriculture in the pre-war period showed that the interaction between the areas of innovative development of agricultural enterprises and the institutional platform for economic development of agriculture was manifested through the introduction of state regulatory instruments aimed at ensuring the result of the process of creating, disseminating and applying new rules and forms of production activities of enterprises and aimed at implementing innovative solutions for managing risks.

The institutional approach of the pre-war period was used to reduce threats and risks in the production system of agricultural enterprises through the processes of integration and unification of organisational technologies that ensured the transition from a disordered state to an orderly one through the joint, cooperative (synchronous) action of many subsystems (Shahini *et al.*, 2024). This is especially true for agricultural enterprises whose production conditions did not meet the norms and standards of the European market.

M. Sychevskiy (2019), O. Yatsukh *et al*. (2021) note that the production system unites agricultural institutions and determines the rules of their relations, as well as generates an innovative infrastructure of technologies in the production and technological process. However, the effectiveness of agricultural enterprises' development under the significant impact of martial law depends on innovative tools for managing the risks of production activities, which determine the pace of renewal, modernisation of fixed assets, creation and implementation of basic, improvement of technical, technological and information innovations to increase the competitiveness of products and guarantee the country's food security. However, reasonable steps are not always taken to address the problem of risk minimisation, and in some cases, they are limited by national guidelines for the economic development of agricultural enterprises. Therefore, conceptually, the institutional environment for innovation in agriculture should be implemented in a clear and unified systematic approach to risk management of agricultural enterprises' production activities with the identification of priority instruments for innovative development at the territorial level.

The solution to this problem is a complex multi-criteria task, which actualises the directions of overcoming various obstacles to the production activity of agricultural enterprises at different levels. Considering the existing research gaps, this study aims to review and develop innovative approaches to risk management of agricultural enterprises in the institutional environment. This approach will contribute to improving the sustainability of agriculture and ensure more effective risk management in this important sector of the economy.

MATERIALS AND METHODS

After a high-quality assessment of the risks of production activity, a quantitative study of its magnitude is considered; the numerical values of unit risks are calculated, taking into account the probable loss of the volume of production or resources; the final stage is the formation of a system of anti-risk events and the calculation of the value equivalent of risk in the institutional environment of safe development of agricultural enterprises. The quantitative measurement of the risk of production activity of agricultural enterprises is determined by the following indicators: the absolute level of losses (the amount of possible losses in material or cost form); relative to the level of losses (risk factor, K_r) (1):

$$K_r = \frac{E_p}{E_l}, \quad (1)$$

where K_r – risk coefficient; E_p – expected profit; E_l – expected profit.

The first method is presented in Table 1, and the second method of calculation (K_r) can be used to calculate how much income per 1 USD of loss. The most relevant today are the models that, based on the results of qualitative dispersion analysis, allow for mathematically evaluating the effectiveness of innovative tools for risk management of the production activities (ITMRPA) of agricultural enterprises. As one of the methods of quantitative assessment of the efficiency of ITMRPA of agricultural enterprises, an approach based on the analysis of Net Present Value (*NPV*) as a whole for a set of innovative production programs (projects), taking into account their changes depending on the functioning of ITMRPA of agricultural enterprises, is proposed. In the process of implementing innovative production programs (projects), agricultural enterprises face systematic and unsystematic risks. Non-systematic risks are those risks whose impact agricultural production entities can independently reduce by introducing more effective innovative tools for managing the risks of production activity.

Table 1. *Methods of calculating the risk factor of production activity*

Calculation algorithm	Note
If there are losses	
K_r^L=PL/NV	PL – possible losses; NV – normative value of the coefficient
K_r^L=(EP-AP)/NV	EP – estimated profit; FP – actual profit
If there is a profit	
K_r^P=EP/NV	EP – excess profit
K_r^P=(AP-EP)/NV	AP – actual profit (loss)

Source: *constructed by the authors*

Let's consider the stages of ITMRPA assessment of agricultural enterprises, which are based on the analysis of Net Present Value (NPV).

Stage 1. The following analysis is performed for unsystematic risks:

– calculation of the risks of the innovative production program (project) in the absence of ITMRPA – P_i;

– calculation of new values of each type of risk P_i after the implementation of ITMRPA, which allows to reduce the risks of the innovative production program (project), i.e. P_i>P_i^*;

– calculation of the initial and final risk of the innovative production program (project) taking into account the weighting factors according to formulas (2-3):

$$P = P_1 \times K_1 + P_2 \times K_2 + P_3 \times K_3 + P_4 \times K_4, \quad (2)$$

$$P^* = P_1^* \times K_1 + P_2^* \times K_2 + P_3^* \times K_3 + P_4^* \times K_4, \quad (3)$$

where K_1, K_2, K_3, K_4 – coefficients.

The content of the constituent (2-3), as well as the general structure of the assessment of unsystematic risks, are shown in Table 2.

Table 2. *Estimates of unsystematic risks of production activity*

The type of risk of an innovative project of production activity	Risk assessment in the absence of ITMRPA	Control procedures	Risk assessment of the innovation program (project) of production activity when using ITMRPA	Conditions for the effectiveness of procedures
1	P_1	Procedure 1.1 Procedure 1.2	P_1^*	P_i>P_i^*
2	P_2	Procedure 2.1 Procedure 2.2	P_2^*	
3	P_3	Procedure 3.1 Procedure 3.2	P_3^*	
4	P_4	Procedure 4.1 Procedure 4.2	P_4^*	
n	*P*	-	*P**	

Source: *constructed by the authors*

Stage 2. Experts assess systematic risks ($P_{systemic}$), which form the environment for the operation of an innovative production program (project) and are not amenable to the management of agricultural enterprises. Systematic risks are determined by many factors (macroeconomic, legal and political), which have an equal level of influence on the implementation of an innovative production project.

Stage 3. According to the proposed approach to evaluating the effectiveness of the implementation of innovative tools for risk management of the production activity, the overall risk of the innovative production program (project) is determined (*r*). The total risk consists of the sum of unsystematic and systematic risk (4-5):

$$r = K_p \times P + K_{p_{systemic}} \times P_{systemic}, \quad (4)$$

$$r^* = K_p \times P^* + K_{p_{systemic}} \times P_{systemic}, \quad (5)$$

where P – the initial unsystematic risk of the innovative production program (project); P^* – final non-systematic risk of an innovative production program (project); K_p – specific weight of non-systematic risk of innovative production program (project); $K_{psystemic}$ – the specific weight of the systematic risk of the innovation program (project) of production; $P_{systemic}$ – systematic risk of the innovative production program (project); r – the initial total risk of the innovative production program (project); r^* – the final total risk of the innovative production program (project).

Stage 4. Modernize for purposes the calculation of the net present value of the innovative production program (project) (NPV) – the formula (6):

$$NPV = -I + \sum \frac{cf_t}{(1+d)^t}, \quad (6)$$

where *NPV* – Net Present Value of the innovative production program (project); *I* – the amount of investment in innovative production programs (projects); cf_t – the value of possible cash flow streams; *d* – discount rate; *t* – a period of time.

Stage 5. At the next stage, propose to calculate two discount rates: the first takes into account the risk of an innovative production program (project) in the absence of ITMRPA, and the second takes into account the implemented and functioning ITMRPA. A model CAMP (Capital Assets Pricing Model) is used to calculate the discount rate. According to CAMP, the discount rate (d) is calculated using the following formula (7):

$$d = R_f + \beta \times (R_m - R_f), \quad (7)$$

where R_f – the risk-free rate of return; β – the coefficient that determines changes in the price of assets of agricultural enterprises in comparison with changes in the prices of assets for all subjects of agricultural production in this market segment – the risk coefficient; $(R_m - R_f)$– risk premium; R_m– average market rates of return on the stock market.

It should be noted that the considered coefficient (β) is a measure of ITMRPA, and if assume that the obtained result of the ITMRPA qualitative assessment reflects the main risks of the innovative production program (project), then it can assume the following calculation of the coefficient (β) according to the formulas (8-9):

$$\beta = \frac{r}{100+1}, \quad (8)$$

$$\beta^* = \frac{r}{100+1}, \quad (9)$$

where *r* – total project risk is obtained as a result of the analysis.

Stage 6. Let's calculate two scenarios for calculating net present value with and without ITMRPA, using (6) and (10):

$$NPV^* = -I + \sum \frac{cf_t}{(1+d)^t}. \quad (10)$$

Stage 7. Finding the efficiency of ITMRPA implementation as the difference between the flows *NPV* and *NPV* be the formula (11):

$$ITMRPA_{ef} = NPV^* - NPV. \quad (11)$$

The simulation model "Activation of innovative tools for risk management of the production activity in the institutional environment of safe development of agricultural enterprises" is carried out according to the formula (12):

$$Q = (W, E), V = \{F_{zm1}, F_{zm2}, F_{zm3}, F_{zm4}, F_{zm5}, F_{zm6}, F_{zm7}, F_{zm8}, F_{zm9}, F_{zm10}, F_{zm11}, F_{zm12}, F_{zm13}\}, \quad (12)$$

where *W* – set of peaks of innovative tools that correspond to external and internal risk factors of production activity of agricultural enterprises; *E* – sets of arcs reflecting the direct influence of risk scenarios of the institutional environment on the parameters of the safe development of agricultural enterprises.

The interrelationship of parameters involves the construction of matrices of acceleration (deceleration) of leverage factors of innovative tools for risk managing of production activities, which have certain characteristics (Table 3). Thus, at a value of (+1), there is an increase (decrease) in the factor (*Fzmi, Fimi*), which leads to an increase (decrease) (*Fzmj, Fimj*); at a value of (-1), there is an increase (decrease) of the factor (*Fzmi, Fimi*), which leads to a decrease (increase) (*Fzmj, Fimj*); with the value (0), there is a weak or completely absent connection between the factors (*Fzmi, Fimi*) and (*Fzmj, Fimj*).

The intensity of the interaction is assessed on a point scale: 0.1 – no direct impact; 0.5 – weak influence; 1.0 – medium impact; 2.0 is a strong influence. Among the active peaks, lever factors of innovative tools for management of the risks of production activity were identified, which affect the safe development of agricultural enterprises, namely: F_{zm1} – Government programs for creating buffer stocks of agricultural raw materials of the grain and oil group; F_{zm2} – Futures contracts, F_{zm3} – Spots prices for agricultural products; F_{zm4} – manufacturing outsourcing; F_{zm6} – Blockchain, F_{zm7} – Digital financial technologies; F_{im8} – Contract farming.

RESULTS

The reason for the ambiguous perception of the methodology of risk management of production activity lies in the conservative approach of agricultural production entities to ensure the safety of the production cycle. The inability to quickly evaluate alternative scenarios of risk-indicative management of production resources limits agricultural enterprises in innovative development and accelerated economic processes following established innovative regulatory instruments, rules, and norms of agricultural institutes, which regulate the right to own land plots for agricultural land and ensure stable production cycle Summarizing the above, let's highlight the key institutional determinants of risk management of production activities of agricultural enterprises (Fig. 1).

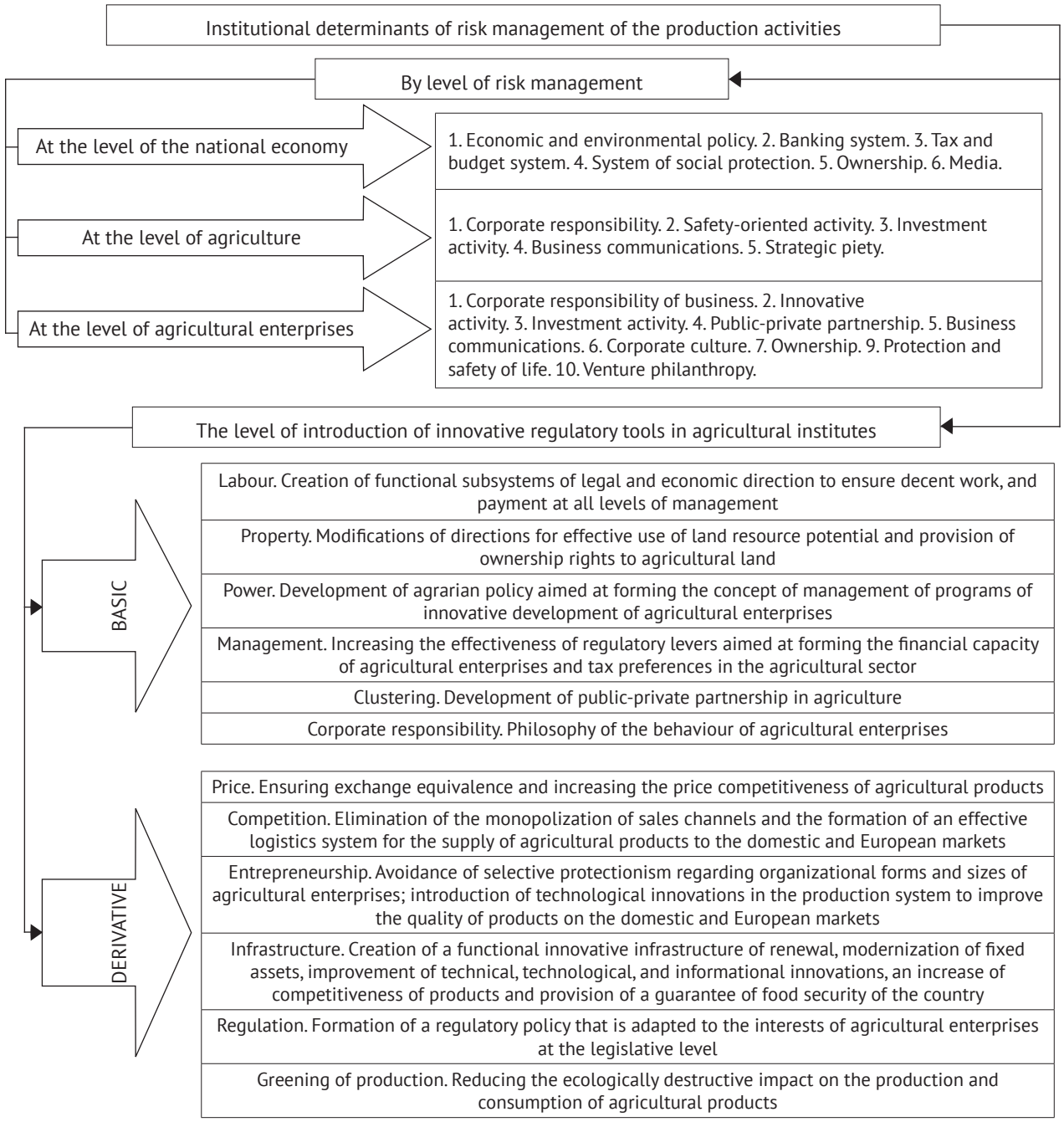

***Figure 1**. Institutional determinants of risk management of the production activities of agricultural enterprises*
***Source:** constructed by the authors*

Institutional determinants for risk management of the production activity of agricultural enterprises form a system, the effectiveness of which depends on the implementation of the relevant directions of development of agricultural institutes, focused on the introduction of innovative tools in the production cycle of agricultural enterprises. At the same time, the managerial function of neutralizing the risks of production activity is determined by the institutional and economic ability of agricultural enterprises to acquire, maintain and expand their share of product markets through the levers of market influence. The institutional and economic importance of agricultural enterprises in the national economy determines the need to increase their competitiveness in the country.

Valuable ideas for the formation of a new conceptual approach to risk-indicative management of the production activities of agricultural enterprises to activate the process of safe development in the institutional environment were offered by R. Zięba, who conducted an analysis of the breakdown of the quality standards of agricultural raw materials in the self-regulating contractual markets of various states. In his opinion, risks in agriculture occur due to the levelling of the interests of

subjects of agricultural production. These considerations are supported by the arguments of the new institutional theory, which is based on a set of elements that form the core of an innovative approach to the risk-oriented management of production activities of agricultural enterprises in the structure of an integral production system of agriculture with certain form-forming components of the institutional environment (Fig. 2).

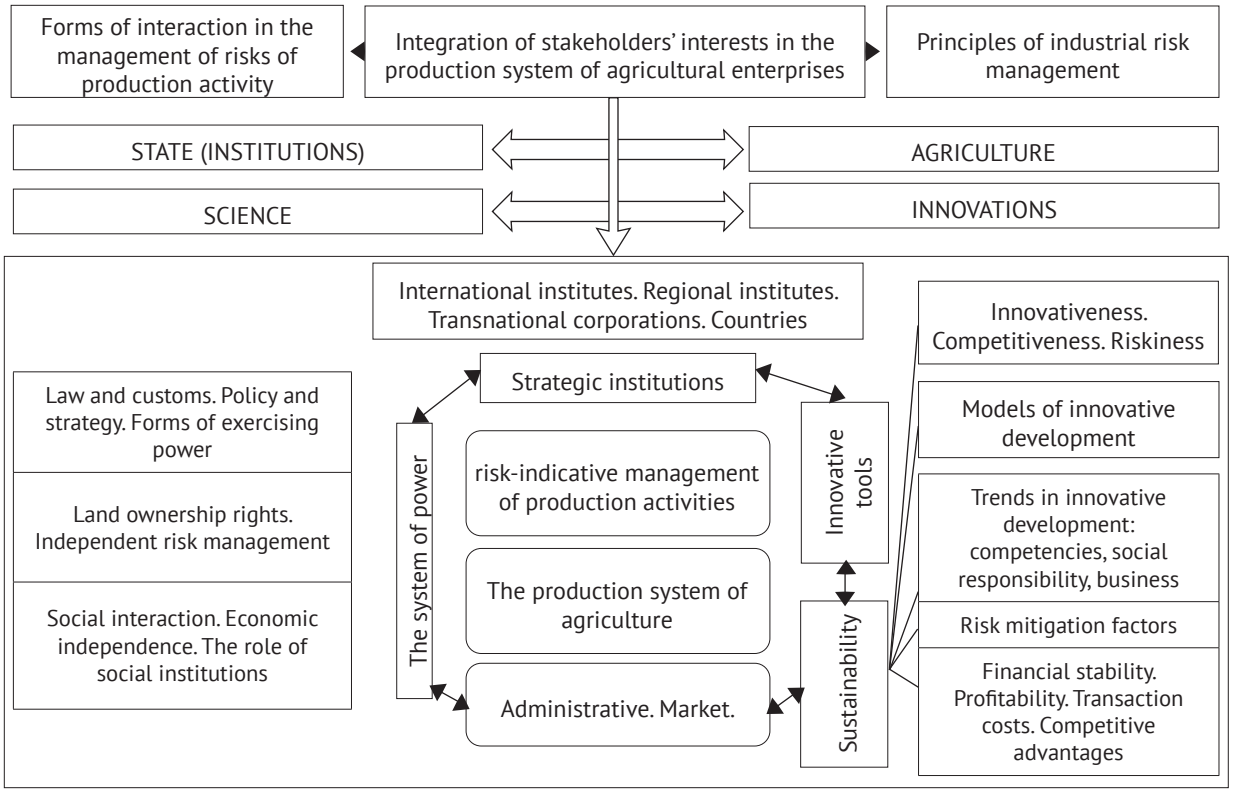

***Figure 2**. Innovative approach to risk-indicative management of production activities of agricultural enterprises in an institutional environment*

***Source:** constructed by the authors*

One of the directions for evaluating the effectiveness of the implementation of innovative tools for risk management of the production activity is the creation of a single model that would combine both qualitative and quantitative approaches for the calculation of various quantitative indicators. Therefore, the main ways of preventing the risks of production activity at the level of safe development of agricultural enterprises can be a justified approach to the choice of the sales market and the development of a price strategy based on spot prices for agricultural products, as a quickly realized asset of agricultural enterprises; compliance with the principles of fair competition and the main provisions of multilateral trade agreements, as well as government programs for the creation of buffer stocks of agricultural raw materials of the grain and oil group; thought out own marketing policy, taking into account strategic innovation programs and production projects, determining the behaviour of competitors on the market. Their prevention is also facilitated by systematic monitoring of factors and areas of production risk formation in trade contracts and contracts for consumer production of agricultural products. Therefore, the stimulus for predicting potential risks of production activity, as well as an effective innovative management of them, are model scenarios of excitation (activation) of innovative tools. At the same time, scenarios for the activation of innovative tools for managing the risks of production activity are aimed at the safe development of agricultural enterprises in an institutional environment with numerical impulses that strengthen the vertices of the simulation model and determine changes in the values of the vertices at the corresponding steps of the simulation model.

Institutional form-forming components within the framework of study single out key innovative tools for neutralizing the risks of production activity of agricultural enterprises, which, with a certain amplitude of resource provision of subjects of agricultural production, accelerate the protective functions of the production system of agriculture from uncoordinated decisions of formal and informal institutions, the principle actions of which are the structuring of mutual relations between subjects of agricultural production and stakeholders. Misalignment of their interests in making management decisions provokes dynamic fluctuations in the

production system of agriculture and discourages the coordination of production cycles of agricultural enterprises at different levels of influence of risk scenarios in the innovative development of agricultural production. This happens through a philosophical approach to riskology, as a science that singles out several axioms (axioms of generality, axioms of acceptability and axioms of non-repeatability).

The dialectic of the theory of development and the theory of systems provides an opportunity to consider innovations in the context of tools for the renewed development of production cycles of agricultural enterprises that change the production system of agriculture to a qualitatively new level. On this basis, the uncertainty and unrepeatability of production cycles of agricultural enterprises in the institutional environment are considered as a stage of using innovations as tools for managing the risks of production activity, as a percolation of the stages of the transition of the production system of agriculture from one state to another (Fig. 3).

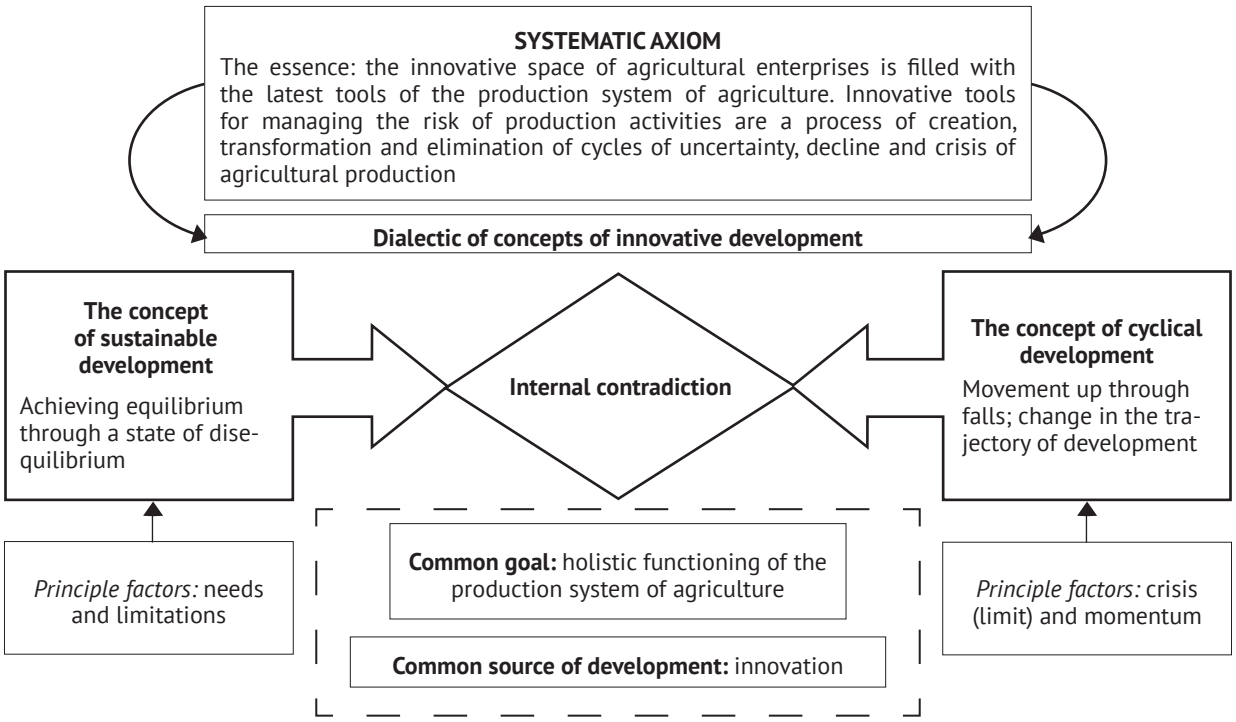

Figure 3. *Structural dialectical connection of the concept of innovative development of agricultural enterprises with sustainable and cyclical development of the production system of agriculture*

Source: *constructed by the authors*

Ensuring the innovative development of agricultural enterprises involves the activation of the functioning of the production system of agriculture in a new quality, while preserving its structural and functional integrity. This is possible only under the condition of the formation of a mechanism for the activation of innovative tools for risk management of the production activity, which can ensure a transformational transition to the safe development of agricultural enterprises and a new qualitative level of their capabilities in the institutional environment in the presence of innovative potential of enterprises, risk-oriented behaviour of enterprises; formation of a favourable innovation climate; modification of the structure of enterprise assets, in the direction of resource provision.

Strategic innovation programs and innovation projects at the level of the state and agricultural institutes belong to the innovative tools for risk management of agricultural enterprises. These programs and projects are formed with the help of levers and regulators (futures (option) contracts; spot prices for agricultural products; production outsourcing; agricultural technologies; blockchain; digital financial technologies; contract farming; trading contracts; government programs for creating buffer stocks of agricultural raw materials and oil group; insurance of agricultural raw materials; hedging and diversification of production systems, contracts of consumer production), which are implemented at the territorial level, and on which the dynamic fluctuation of production cycles of agricultural enterprises depends.

Production cycles are subject to the influence of different levels of risk, and their partial neutralization (minimization) depends on the time lag in the provision and use of resources for the production needs of agricultural enterprises. Processes of evaluation of factor events in addition to typical and repeated situations in the production activity of agricultural enterprises have

a limited number of possible results. At the same time, dynamic forecasting methods provide a more reliable result than static regularities and simple extrapolation dependencies. Extrapolation allows obtaining only a partial forecast, which reflects changes in individual components of the safe development of agricultural enterprises. Therefore, individual security parameters that do not have system properties are replaced by system-non-forecasting based on simulation technologies. It should be noted that the factors of change (modification) of the parameters of the macro- and microenvironment of agricultural enterprises in the institutional environment act as a risk factor.

For agricultural enterprises, the danger of production activity risks is particularly significant, since the impact of macroeconomic fluctuations leads to a crisis of the microeconomic genesis of agricultural production. Accordingly, the combined influence of factors of the macro- and microenvironment of agricultural enterprises strengthens or weakens the process mechanism of assessing the safe development of agricultural production entities in the institutional environment. A comprehensive understanding of risk, as an element of managing the production activities of agricultural enterprises, contains an effective component – economic losses that threaten their competitiveness and the corresponding consequences for the country's agriculture. Risk, as "a deviation of a parameter of the production system of agriculture from a given target value by an amount that does not exceed the permissible deviation of this parameter", allows, on the one hand, to realize the economic interests of agricultural enterprises, and on the other – "to single out a threat to their competitiveness". From the point of view of the implementation of the integrated value of safety in the macro- and microenvironment of agricultural enterprises, risk factors in the system of protection of production activities are associated with the problems of implementing innovative tools for resource management and ensuring the needs of agricultural enterprises in the future.

Assessment of risk factors allows: first, to generalize threats and activate the safe development of agricultural enterprises; secondly, to identify risk events and develop optimal management solutions. Therefore, an important task is to identify and systematize the relationship between the manifestation of risk factors and their impact on the results of production activities of agricultural enterprises. The stages of evaluating the effectiveness of the implementation of innovative tools for risk management of industrial activity (ITMRPA) involve the determination of their number and the causes of danger. An important stage of innovative risk management of production activity is the assessment of the level of safety according to qualitative and quantitative parameters. Qualitative analysis of risks allows to determine in advance the sources of their occurrence. The advantage of this approach is that already at the initial stages, it is possible to assess the degree of risk when carrying out a particular activity. The matrix of acceleration and deceleration of innovative tools for risk management of production activities of agricultural enterprises was used (Table 3, 4).

Table 3. *Matrix of acceleration of the action of innovative tools for risk management of production activities of agricultural enterprises*

	F_{zm1}	F_{zm2}	F_{zm3}	F_{zm4}	F_{zm5}	F_{zm6}	F_{zm7}	F_{im8}	F_{im9}	F_{im10}	F_{im11}	F_{im12}	F_{im13}	Degree of interaction
F_{zm1}		1	1	1	0.5	1	1	0.5	0.5	0.5	0.5	0.5	0.5	126.4
F_{zm2}	1		0.5	0.1	1	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	128.8
F_{zm3}	1	0.1		2	1	1	0.5	2	2	1	0.1	0.1	2	161.6
F_{zm4}	1	1	0.5		1	0.5	0.5	0.5	0.5	0.5	1	0.1	0.1	149.9
F_{zm5}	1	1	0.5	0.1		0.5	1	0.5	0.1	0.1	0.5	0.5	1	62.3
F_{zm6}	0.5	2	0.5	1	2		2	1	1	2	2	0.5	0.1	155.8
F_{zm7}	0.5	0.5	0.5	0.5	1	1		1	1	1	1	0.5	0.5	162.4
F_{im8}	0.5	1	2	1	2	2	0.5		2	2	2	0.5	0.1	167.3
F_{im9}	0.1	1	0.5	0.1	1	2	1	2		2	2	0.1	0.5	136.1
F_{im10}	0.1	2	2	0.1	1	0.5	0.5	0.5	1		2	0.1	0.5	47.9
F_{im11}	0.1	2	0.1	0.1	1	1	1	0.5	0.5	1		0.5	0.1	28.5
F_{im12}	2	1	0.1	0.1	0.5	0.1	0.1	0.1	0.5	0.5	0.5		2	29.6
F_{im13}	0.5	2	0.5	0.5	1	0.5	0.5	0.1	2	1	1	0.5		95.6
Degree of activity	1	0.5	1.1	1.9	0.7	1.4	0.5	1.9	1.2	0.9	0.5	2.2	1.5	

Source: *constructed by the authors*

Table 4. *Matrix of slowing down the effect of innovative tools for risk management of production activity of agricultural enterprises*

	F_{zm1}	F_{zm2}	F_{zm3}	F_{zm4}	F_{zm5}	F_{zm6}	F_{zm7}	F_{im8}	F_{im9}	F_{im10}	F_{im11}	F_{im12}	F_{im13}	Degree of interaction
F_{zm1}		1	1	0.5	1	0.5	0.5	0.1	0.1	0.1	1	0.1	1	55.5
F_{zm2}	1		1	1	1	0.5	1	0.5	0.5	0.5	1	0.1	0.5	127.7
F_{zm3}	0.1	0.1		0.1	0.1	0.1	0.1	0.5	1	1	1	0.1	0.1	33
F_{zm4}	0.5	0.5	0.1		0.5	0.5	0.5	0.5	0.1	0.5	1	0.1	0.1	31.5
F_{zm5}	1	1	1	0.5		0.1	0.1	0.1	0.1	0.5	0.5	0.1	1	62.3
F_{zm6}	0.1	0.1	0.1	0.1	0.5		0.5	0.5	0.5	1	0.5	0.1	0.5	36.5
F_{zm7}	0.1	0.5	0.1	0.1	0.5	0.5		0.5	0.1	0.5	0.5	0.1	0.5	34.7
F_{im8}	0.1	0.1	0.1	0.5	0.1	0.5	0.5		1	1	0.5	0.1	0.1	43.7
F_{im9}	0.1	1	0.5	0.5	0.1	1	0.5	1		2	1	0.1	0.5	95.9
F_{im10}	0.5	1	0.5	0.5	0.1	1	0.5	2	2		2	0.5	0.5	152.5
F_{im11}	0.5	2	2	1	1	1	1	2	2	2		0.5	1	221
F_{im12}	2	2	0.5	0.5	2	0.1	1	0.1	0.5	0.5	1		2	26.7
F_{im13}	0.5	2	0.1	0.5	1	0.5	0.5	0.5	1	1	1	0.1		85.4
Degree of activity	1.1	0.7	0.6	0.8	0.8	0.7	0.6	0.5	0.8	1	1.3	2	1.1	

Source: *constructed by the authors*

Behaviour models of innovative tools for risk management of the production activities provide optimal and positive interaction of factors according to scenarios 1 and 12, which demonstrate the best results of safe development of agricultural enterprises. Important components in this process are public-private partnerships, as well as the presence of a regulatory price policy. Thus, according to Scenario 1, the momentum of the interaction of the factors of innovative tools for managing the risks of production activity is carried out in three vertices – F_{im8}=1, F_{zm4}=1, F_{zm2}=1 (the improvement of contract farming increases the level of production outsourcing and expands the volume of futures contracts). At the same time, there is an increase in all weighted coefficients of safe development of agricultural enterprises in the institutional environment (Fig. 4).

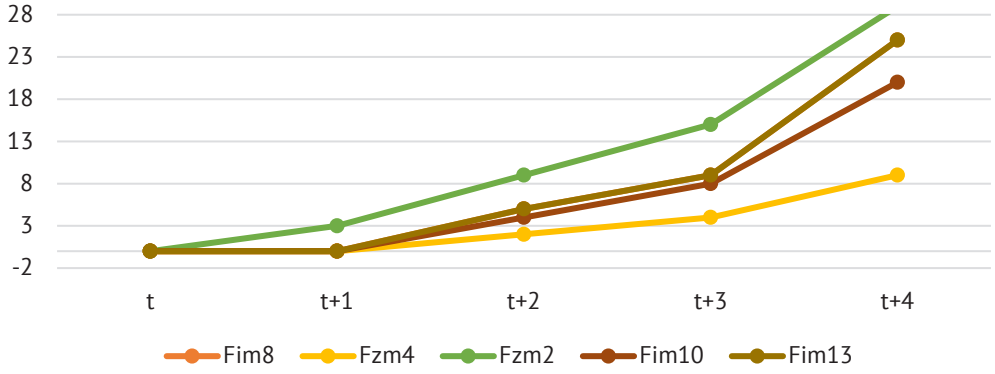

Figure 4. *Simulation model of the behaviour of innovative tools for risk management of the production activities of agricultural enterprises (Scenario 1)*

Note: *Scenario 1. The momentum of the interaction of innovative tools for managing the risks of production activities improves contract farming, increases the level of production outsourcing, and expands the volume of futures contracts to fix prices for agricultural enterprises. There is an increase in all weighted coefficients of safe development of agricultural enterprises in the institutional environment*

Source: *constructed by the authors*

Scenario 12 demonstrates the momentum of the interaction of four vertices – F_{im8}=1, F_{zm3}=1, F_{zm6}=1, F_{zm7}=1, (the state policy of regulating spot prices for agricultural products under rational contract farming, improves the logistics infrastructure of the agricultural market with the help of Blockchain technologies and

digital financial technologies). Sensing the state's interest in the implementation of modern digital innovations allows to optimize innovation potential, rationally use the available resource potential of agricultural enterprises and ensure their safe development based on public-private partnership (Fig. 5).

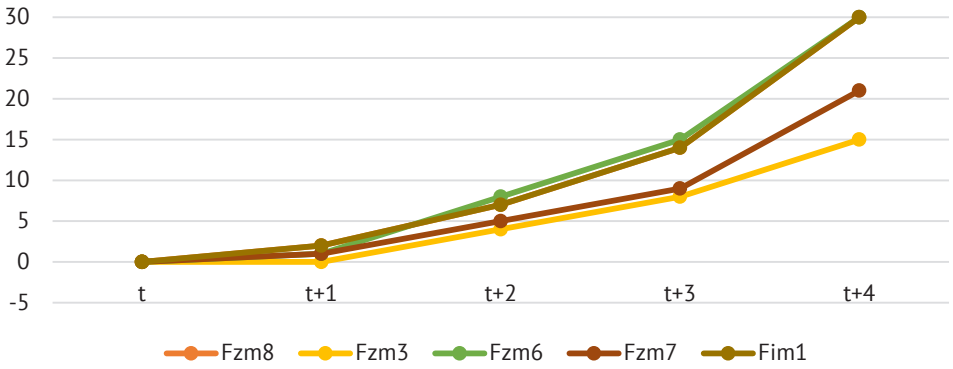

Figure 5. *Simulation model of the behaviour of innovative tools for risk management of the production activities of agricultural enterprises (Scenario 12)*

Note: *Scenario 12. The impetus for the interaction of innovative tools for managing the risks of production activity is provided by the state policy of regulating spot prices for agricultural products in rational contract farming; and improves the logistics infrastructure of the agricultural market with the help of Blockchain technologies and digital financial technologies; innovative and resource potential is optimized; the level of safe development of agricultural enterprises based on public-private partnership is increasing*

Source: *constructed by the authors*

Taking into account the state of war in Ukraine and the consequences of the destabilization of the production system of agriculture in the country (the extent of the loss of resources and production potential of agricultural production), based on the results of simulation modelling, the integral index of the safe development of agricultural enterprises was calculated (the calculation was made on average per subject of agricultural production) certain agroclimatic zone. The activation of strategic innovative tools for managing the risks of production activity in the institutional environment made it possible to single out the structural coefficients of the index of safe development of agricultural enterprises, which are listed in Table 5. Thus, the calculations revealed that a high level of coefficients of production, financial, logistical and innovative components of safe development per agricultural enterprise was recorded in the agro-climatic forest-steppe zone, Polissia zone and Western Zone. This is due to the rapid acceleration in the institutional environment of production outsourcing and futures contracts based on the government's creation of reserves of agricultural raw materials of the grain and oil group under food security programs in the country. The peculiarity of this trend was felt in 2021 and, despite hostilities in most regions of Ukraine, in 2022. During this period, the diversification of the production system of agriculture was intensified, and agricultural technologies, Blockchain and protective financial technologies were introduced, which have a huge potential for increasing productivity, income and food security in Ukraine.

Table 5. *Integrated index of safe agricultural development enterprises in agro-climatic zones of Ukraine for 2018-2023 (on average for one subject of agricultural production)*

Structural coefficients of safe development agricultural enterprises	Steppe zone	Forest-steppe zone	Polissia zone	Western zone
The level of costs per 1 ha of agricultural land	4.41	4.09	3.07	2.54
Fund return	0.22	0.94	0.97	0.62
Product profitability level	4.5	55.7	43.8	38.1
Productivity	51.6	123.5	148.2	111.7
Coefficient of production component of safe development	15.009	162.624	139.031	81.874
Solvency ratio	0.12	0.87	0.71	0.46
Liquidity ratio	0.171	0.358	0.347	0.342
Turnover ratio of current assets	0.19	0.58	0.54	0.41
Financial leverage ratio	0.06	0.76	0.74	0.58

Table 5. Continued

Structural coefficients of safe development agricultural enterprises	Steppe zone	Forest-steppe zone	Polissia zone	Western zone
Coefficient of the financial component of safe development	0.015	0.371	0.314	0.193
Profitability of sales	1.5	34.5	33.6	9.2
Product quality factor	8.1	12.1	13.1	12.4
The level of the ratio of the spot price to the sale price on the domestic market	1.07	1.86	1.2	1.13
Coefficient of stimulation of the logistics process	0.04	0.44	0.32	0.77
Coefficient of the logistic component of safe development	0.721	18.484	13.001	9.963
The volume of innovations in production	0.15	0.87	0.51	0.77
Innovative potential	19.6	90.1	38.04	39.4
The level of innovation	0.41	10.9	7.9	1.75
Coefficient of innovative component of safe development	1.097	29.234	12.399	7.286
Integral Index of Safe Development (Isd)	0.422	180.56	83.888	33.871
Interpretation of the level of safe development	Critical level	High level	High level	Sufficient level

Source: *constructed by the authors*

By 2022, the steppe zone of Ukraine had a high level of safe development of agricultural enterprises. However, due to the occupation of a significant territory of this zone by the aggressor country during 2022, a clearly expressed risk scenario of lost opportunities for agricultural production entities due to the deterioration of a significant amount of resources and assets is being followed. This affected the slowdown of the index of the production component of the safe development of agricultural enterprises. Such distribution increases the need for the reproduction of the process of activation of innovative tools for managing the risks of production activity after agricultural enterprises after the liberation of the occupied territory of the Steppe zone, and the reconstruction of residential, industrial, transport, logistic and agricultural infrastructure. In 2022, most of the agricultural enterprises of the Steppe zone, which is not occupied by the aggressor country, have limited resource capabilities, and face large fluctuations in yield and agricultural production due to the high frequency and probability of climatic shocks, which also increase the pressure on high food prices. In turn, this increases vulnerability and reinforces the importance of supporting supply so that markets can adjust to price fluctuations. It is believed that the implementation of agricultural technologies is critical for overcoming the risks of production activities.

In 2023, agricultural enterprises in the Steppe zone of Ukraine continue to face challenges arising from the difficulties associated with the loss of part of the territory due to the occupation, as well as from natural and economic factors. The occupation significantly limits the possibilities of restoring agricultural infrastructure and resources, which requires great efforts to restore and modernise them. The vulnerability of agricultural enterprises in this area is also increased by unstable climatic conditions that affect production. In particular, insufficient rainfall and rising temperatures are factors that increase the risk to productivity. In addition, climate change introduces uncertainty into crop production and can lead to difficulties in making decisions about technology choices. In the context of high food prices and price fluctuations, it is necessary to support the agricultural market and implement measures that contribute to its stabilisation. The introduction of agricultural technologies and innovative risk management methods remains a key element of the strategy to adapt to new conditions and maintain the competitiveness of agriculture in the face of the challenges of 2023. Indeed, the increase in climate variability in the Steppe zone of Ukraine, which has seen a decrease in annual precipitation and an increase in temperature over the past two decades, is harming agricultural productivity. In turn, factors such as yield variability and the risk of failure affect technology adoption decisions, especially in low-income contract farming. This limits agriculture in innovative approaches, and even more so, in increasing investment in agricultural technologies.

Ukraine's strong political commitment to strengthening agrarian policy and agricultural institutions will allow in the future (in the post-conflict period) restore the deployment of Blockchain-technology agricultural enterprises throughout the territory, to restore the infrastructure of logistical supplies of agricultural raw materials to the market under future contracts, and to improve the adaptation of agricultural technologies to farming in the conditions of climate change, to mitigate shocks and stability of the production system of agriculture. For example, improved varieties give higher and more stable yields, resistant to numerous stresses, and new technological packages (drought-resistant varieties of wheat and barley) in combination with integrated pest control increase yields and reduce production costs. Research centres in Ukraine are developing new varieties of crops and production technologies that help to ensure sustainable growth in the productivity of

the crop production industry in agricultural enterprises. In underdeveloped farms, taking into account the high variability of profits and (average) productivity growth of this industry is not a sufficient condition for the attraction and implementation of new technologies and agricultural innovations. New technologies must bring adequate and stable profits from year to year. There is no reason to introduce new technologies if small agricultural enterprises are exposed to price uncertainty due to the high volatility of food prices and frequent changes in agricultural policy, which increases uncertainty.

The main task of agricultural institutions is to ensure proper investment in agricultural research, and this is possible only with a favourable institutional environment, as well as increased government support for the introduction of technologies in small farms. The comprehensive reform of the irrigation system in Ukraine, which includes a new contractual land use of agricultural enterprises, provides a guarantee of ownership of agricultural land plots and full compensation of costs for innovative projects, which, with the help of production outsourcing, allow managing the production system of agriculture at the institutional level. This leads to an increase in the production and yield of crops of the grain and oil group, as export-oriented agricultural raw materials on the domestic and world markets. Under such conditions, there is a need to review the current production activity of agricultural enterprises, and, first of all, introduce diversification of the logistics component to ensure the safe development, stability and independence of agricultural production entities. This will make it possible to develop one's production base and fulfil relevant economic obligations to neutralize risks based on the above-mentioned innovative tools. At the same time, the predictive stability of the level of safe development of agricultural enterprises is of scientific and practical interest, which is determined comprehensively by calculating this index in the dynamic trend of the entire set of coefficients (production, financial, logistical and innovative components) in the long term. The calculated forecast integral index of safe development of agricultural enterprises by agro-climatic zones of Ukraine for 2024-2027 is presented in Figure 6.

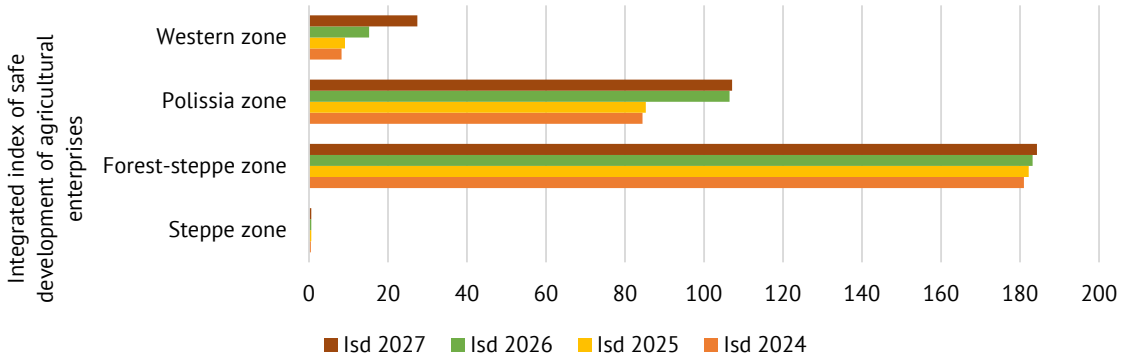

***Figure 6**. Forecast of the integrated index of safe development of agricultural enterprises for 2024-2027*
***Source:** constructed by the authors*

Thus, it is worth emphasising that the study results demonstrate that the accumulation of significant production, financial, logistics and innovation potential improves the secure development of agricultural enterprises in the Forest-Steppe and Polissia zones. This indicates their ability to reproduce the agricultural production system in Ukraine and determines their sustainability and competitiveness in the industry. By emphasising the importance of optimising production, financial and innovation capabilities, it is possible not only to support the sustainability of agricultural enterprises but also to contribute to the efficiency of the national economy. These results emphasise the importance of business and innovation potential for the development of the agricultural sector. Accumulation of production and financial resources, improvement of logistics processes and introduction of innovative approaches become catalysts for sustainable agricultural development.

DISCUSSION

Studies by many scholars, including A. Sudip and A. Khanal (2022) as well as the present study, confirm that the production activities of agricultural enterprises, unlike other areas of their activity, are closely related to the processes of their safe development in the institutional environment. Comparing the statements of scientists, it should be noted that the institutional environment of agriculture embodies formal and informal institutions that develop normative regulations for the production cycle of agricultural enterprises, enhance their economic opportunities and minimise potential risks in the market. The main formal institutions of agriculture that influence the resource provision and intensification of the production cycle of agricultural enterprises include the property institute, the state regulation institute, the entrepreneurship institute, the contract institute, the competition institute, and the knowledge institute. Informal institutions include peasant customs, traditions,

religious preferences, moral principles and views, stereotypes of agricultural behaviour. The basis of informal rules for the development of institutions is the cultural traditions and values of rural areas, which determine the worldview and behaviour of rural people. In rural areas, personalised exchange dominates (economic actors in agribusiness know each other directly), and therefore contractual agreements are often concluded formally; the resolution of conflicts over the provision and use of resources in the production activities of agricultural actors is often based more on local customs than on legal norms (Belgibayeva *et al.*, 2022).

At the same time, some authors may approach risk management from different perspectives and emphasise technological innovations. Thus, according to X. Liu (2022), Z. Ali *et al.* (2019) and others, in the process of managing the risks of agricultural enterprises' production activities, informal rules of conduct of economic agents interacting with agricultural institutions emerge. This is not just a part, but the most important component of risk-based resource management in the agricultural production system, which depends on a formalised description of innovative tools for risk-based management of agricultural enterprise development. While formal rules for managing the risks of agricultural enterprises' production activities change rapidly, informal rules tend to change gradually, but they set the vector for neutralising threats in production activities for innovative regulatory instruments (Horbal & Makarova, 2023). Informal rules and norms of risk management of agricultural enterprises are not created by the authorities, they often develop spontaneously and generate misuse of resources in the production system of the actors.

Scholars also identify different key risks for agricultural enterprises. Some may emphasise environmental risks, while others may focus on financial aspects. In this regard, X. Huang *et al.* (2021) argue that the imperfect institutional vector of agricultural institutions does not allow to fully neutralise risks in the production, social, human, financial and resource capital of agricultural enterprises, which is also highlighted in the present study. Accordingly, a new conceptual approach to the development of innovative tools for risk-oriented management of production activities of agricultural enterprises is needed to intensify the processes of their safe development in the institutional environment. On the one hand, it is necessary to constantly support the development of relevant agricultural institutions in the required direction (including their formation, development and training), and on the other hand, to stimulate this process by persuading agricultural producers to move forward and look for new standards of risk management of production activities, their systematisation in the organisational structure of risk management (Sinaj & Vela, 2022).

According to many authors, including B.M. Leybert *et al.* (2023) and O. Kotykova *et al.* (2020), social justice and trust institutions play a special role, being the main agro-industrial complex coordinators in the institutional environment. They establish conventional norms for all agricultural actors, formed from economic culture, value systems, habits and traditions, and mentality, and influence their behaviour when applying risk-based management in the institutional environment. They include the rules of social justice; mechanisms for ensuring and implementing the rules of social responsibility; and norms of behaviour of agricultural enterprises in economic relations.

M. Van Bergen *et al.* (2019), N.V. Trusova *et al.* (2019) and others, define that the norms of informal relations of agricultural enterprises in the institutional environment are based on economic relations and have a long period of development and are based on previous intergenerational relations in rural areas. They depend on the effective functioning of formal institutions (state, property, democracy, human rights, rule of law) and informal institutions (culture, religion, respect, traditions, customs, moral attitudes). In agriculture, these institutions are distorted, and the lack of stakeholder confidence in reducing transaction costs in the development of innovative tools for managing the risks of agricultural production leads to negative consequences and development risks, as demonstrated in the study. A key characteristic of the safe development of agricultural enterprises is the availability, possibility, stability and use of the production system, which largely depends not only on the growth of agricultural production but also on trade policy and the development of trade relations in agricultural raw materials markets, which can enhance these characteristics to a positive level (Penkova & Kharenko, 2023).

Another confirmation of the study is the results of R. Sharma *et al.* (2020), X. Li and Y. Sun (2022) as authors emphasise that the problem of introducing innovative tools for managing the risks of agricultural enterprises' production activities and ensuring the state's food security on their basis is complex and complex, and therefore its solution should be considered from the point of view of different hierarchical levels. The basis for the allocation and classification of such levels can be considered the specific interests of a separate group of subjects of each particular level. J. Gascón and K. Mamani (2022) and R. Finger (2023) also note that the national level of implementation of innovative tools for managing the risks of agricultural production activities and ensuring the food security of the state on their basis is achieved through government programmes that create a sustainable potential of the agricultural production system and determine the directions for improving the quality of grain and oilseed products.

A similar opinion is expressed by D.K. Deng-Kui Sii *et al.* (2021), according to which the specifics of managing production risks with the help of innovative tools at the national level are determined by the differences in economic and political interests of countries.

Thus, countries with the most developed agricultural production have natural advantages in agricultural production. However, F. Ciccullo *et al*. (2019) believe that countries with less favourable natural conditions for agricultural production are limited by agricultural production resources or emerging markets. The concept of innovative development of agricultural enterprises at the national level does not mean self-sufficiency in food. It implies that a country should produce enough food for its needs, but if comparative advantages prevent this, innovative tools for strengthening the food supply should be introduced.

Balancing the quantitative and qualitative parameters of agricultural production, and defining the criteria for neutralising risks at the local level allows for ensuring food security of the territories where the grain and oilseeds group entities are located. Consumer demand growth due to the intensification of production cycles leads to an increase in the potential of the agricultural production system, which, in turn, stimulates the introduction of innovations in the supply chain of grain and oil products through Blockchain technologies. It is worth noting that technological innovations in the agricultural production system ensure the reproduction process of territories and support the food security of the region (country) as a whole (Salo *et al.*, 2023). This approach expands the range of products of the grain and oilseed group following the scale of their consumption with differentiation of pricing policy and within the regional market, stimulating international trade and export of agricultural products. This is confirmed by W. Bai *et al*. (2022) and A. Burliai *et al*. (2021), who emphasise that the highest guarantee of food security of the state, with the sustainable introduction of innovations in the production system, requires spot prices for agricultural products, which in the logistics chain of planning and forecasting transport services for grain and oilseed products ensure the availability of long-term agreements for the supply of agricultural raw materials to countries of the world on mutually beneficial terms.

Thus, the discussion on the research of various authors in the field of innovative tools for managing the risks of production activities of agricultural enterprises in the institutional environment and the results of the study confirms that the study of innovative tools for managing the risks of production activities of agricultural enterprises and their impact on development security indicates the importance of both formal and informal institutions in agriculture. A key characteristic of the safe development of agricultural enterprises is the existence of a sustainable and efficient production system, which depends on a comprehensive approach to risk management. Technological innovations, such as the introduction of Blockchain and other advanced technologies in supply chains, play a key role in maintaining food security by stimulating international trade and securing long-term agreements for the supply of agricultural raw materials. In summary, innovative approaches to risk management are a necessary element for achieving sustainable and secure agricultural development in an institutional environment.

CONCLUSIONS

Sustainable development of agricultural enterprises in the institutional environment is focused on ensuring agro-economic capabilities without resorting to food imports from other countries. Achieving a stable level of sustainable development of agricultural enterprises should involve the implementation of the following key areas: maintaining the food supply at a level sufficient for a healthy diet; ensuring an adequate level of effective demand of the population; eliminating dependence on imports and protecting the interests of domestic producers of agricultural raw materials.

From the perspective of the sectoral approach, Blockchain technologies as innovative tools for managing the risks of production activities in cities where agricultural enterprises are located and located at short distances from logistics centres should be fully involved in the model of safe operations. Development of agricultural production entities to expand the segment of agricultural raw materials on the world market. The introduction of innovative tools for managing production risks should be transferred to a new doctrine of innovation of production and technological standards of regional development. This will facilitate the state's influence on the reproduction of an integral agricultural production system, creating the sustainability of the production system's potential in the country, ensuring the greening of agricultural raw materials and shaping the new behaviour of agricultural enterprises to ensure the security of their production system. This approach promotes cooperation with other stakeholders, strengthening interaction in the field of agricultural policy and ensuring national security in the production of agricultural raw materials.

The study results indicate a high level of security for the development of agricultural enterprises in Ukraine, which was assessed using integral indices. These indices consist of various components that reflect the level of costs, financial stability, productivity, logistics and innovation in the agricultural sector. Based on the calculations, the study found that the agro-climatic zones of the Forest-Steppe, Polissia and Western zones have the highest level of security in agriculture. Despite the difficult conditions of the military conflict in Ukraine, these regions have shown resilience and adaptability through the successful implementation of innovations such as blockchain technologies and financial instruments. The practical implications of the findings are that successful strategies for sustainable agricultural development include maintaining the food supply, creating an adequate level of effective demand, and eliminating dependence on imports. It is also important to use innovative tools, such as blockchain technologies,

which provide risk management and increase the resilience of production systems. Further studies should detail specific measures to implement innovations, as well as study the impact of such strategies on the socio-economic development of regions.

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None.

CONFLICT OF INTEREST

None.

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Інноваційні інструменти управління ризиками виробничої діяльності сільськогосподарських підприємств в інституційному середовищі

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Анотація. Безпека розвитку аграрного сектору стає все більш актуальним питанням в сучасних умовах, оскільки аграрний сектор визначає стійкість економіки та забезпечує продовольчу безпеку країни. Зростаючі ризики, такі як зміна клімату, економічні труднощі та геополітичні конфлікти, підкреслюють необхідність підвищення безпеки систем сільськогосподарського виробництва, що обумовлює актуальність дослідження. Метою дослідження було проведення системного аналізу інноваційних інструментів управління ризиками виробничої діяльності сільськогосподарських підприємств та їх впливу на формування безпечного розвитку в аграрному секторі України. Для досягнення поставленої мети використано метод аналізу та моделювання. Результати дослідження свідчать, що інноваційні підходи до управління ризиками мають вирішальний вплив на стійкість та ефективність систем сільськогосподарського виробництва. Для досягнення стабільного рівня безпечного розвитку сільськогосподарських підприємств необхідно зосередитися на реалізації ключових напрямів, таких як підтримання продовольчої бази на рівні, достатньому для забезпечення здорового харчування, забезпечення належного рівня платоспроможного попиту населення та усунення залежності від імпорту, спрямованих на захист інтересів вітчизняних виробників сільськогосподарської сировини. Дослідження показало, що інституційні чинники управління ризиками формують інтегровану систему, ефективність якої залежить від реалізації конкретних стратегій розвитку аграрних інституцій, спрямованих на впровадження інноваційних інструментів у виробничий цикл сільськогосподарських підприємств. Крім того, завдяки накопиченню значних обсягів виробничого, фінансового, матеріально-технічного та інноваційного потенціалу сільськогосподарських підприємств Лісостепу та Полісся, рівень безпечного розвитку сільськогосподарських підприємств значно підвищується. Це свідчить про їх високу спроможність до сталого відтворення виробництва та здійснення вагомого внеску в аграрний сектор України. Дослідження має практичне значення для сільськогосподарських підприємств, науково-дослідних установ та державних органів, які можуть використовувати отримані результати для вдосконалення стратегій управління ризиками та підвищення рівня безпеки розвитку аграрного сектору

Ключові слова: ризики виробничої діяльності; ефективність бізнесу; фінансова стійкість; технологічний розвиток; виробнича система; інститути сільського господарства