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Innovative management of the production risks of agricultural enterprises

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The article examines the innovative infrastructure in the management of production risks of agricultural enterprises, which is related to the rules for evaluating alternative scenarios for reducing threats in the production system of agricultural production entities in order to obtain the desired result. A methodical approach to the assessment of factors-tools in the innovative management of production risks, which activate the process of economic development of agricultural enterprises in an institutional environment, is presented. It is proved that the institutional determinants that manage the production risks of agricultural enterprises form a system whose effectiveness depends on the implementation of the relevant directions of economic development of agricultural institutes focused on the introduction of innovations into the production cycle. The structural dialectic connection of the concept of innovative development of agricultural enterprises with the cyclical development of the production system is presented. A structural and logical diagram of a methodical approach to the implementation of the mechanism of innovative management of production risks of agricultural enterprises has been built. A mathematical toolkit for evaluating scenarios of innovative management of production risks of agricultural enterprises is defined. Stimulating and disincentive factors-tools in the innovative management of production risks and their impact on the economic development of agricultural enterprises are determined. In order to determine the optimal scenarios for neutralizing threats to the economic development of agricultural enterprises, models of acceleration (deceleration) of the action of stimulating and disincentive factors-tools in the innovative management of production risks were built. The integral index of the economic development of agricultural enterprises of the agro-climatic regions of Ukraine in the pre-war, war-conflict and post-war periods was calculated. It has been established that due to the accumulation of a significant amount of production, financial, material, technical and innovative potential, the level of economic development of agricultural enterprises of the agro-climatic zones of the Forest-Steppe and Polissia increases, which characterizes their ability to reproduce the production system of agriculture in Ukraine.

Keywords: Innovations, production risks, risk management, institutional environment, production system, agricultural institutes, agricultural enterprises.

INTRODUCTION

In the conditions of uncertainty and military conflict in Ukraine, the modernization of technological innovations in agriculture in the pre-war period showed that the interaction of the directions of innovative development of agrarian enterprises and institutions of agriculture as a whole was manifested through the implementation of state regulatory instruments that ensured the process of creation, distribution and creation of new rules and forms of conducting production activities of agricultural production entities and were aimed at the implementation of innovative solutions for managing the risks of production activities.

The institutional approach of the pre-war period made it possible to reduce threats and risks in the production system of agricultural enterprises through the processes of integration and unification of agricultural technologies, the action of which ensured the transition from a disordered to an ordered

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state of the technological process due to the synchronous action of many subsystems (Serskykh and Britchenko, 2019). This was especially true of agricultural enterprises whose production conditions did not meet the norms and standards of the international market.

The solution to this problem belongs to the type of complex multi-criteria tasks of overcoming obstacles to the functioning of agricultural enterprises, that is, to weaken the conservative model of risk management of production activity, to neutralize threats and restrictions in the external and internal institutional environment, and to accelerate the pace of adaptation of subjects of agricultural production to the norms and standards of modern innovative tools that manage production risks (Britchenko *et al.*, 2022). The presence of a large number of local regulatory documents in the production activities of agricultural enterprises sometimes contradict each other and lead to confrontation and conflicts between agricultural institutions and subjects of agricultural production. All this complicates the procedures of analysis, evaluation and management of risks of production activity, and therefore reduces the efficiency of business processes in the production system as a whole. To overcome these limitations, systematic improvement of production risk management processes using more effective innovative tools is necessary.

Scientific problems of innovative development of agriculture, management of innovative potential of agricultural enterprises, formation of effective innovation mechanisms, innovative and investment development of states and regions have become the subject of fundamental research by such scientists as Hodgson (2000), Jaffe, Lerner, & Stern (2005), Nelson (1993), Shchekovich (2009), Shkarlet, Dubina, & Tarasenko (2016), Shubravska (2010), Britchenko (Britchenko *et al* 2018), Shpykulyak, Kurylo & Suprun (2011), Yurchyshyn (2014). The issue of risk occupies the opinion of many researchers in various fields of activity, but much attention in the modern methodology of risk assessment is disclosed in the works of such scientists as Andriichuk, & Bauer (1998), Barry (1984), Berehovy (2010), Drucker (1997), Harrison (1999), Martynova (2016), Robinson, Barry, & Klibenstein (1984), Trusova, Hryvkivska, Tanklevska, Vdovenko, Prystemskyi and Skrypnyk (2019), Vitlinskyi, and Velykoivanenko (2004). However, the scientific paradigm of the institutional environment of innovation in agriculture can be activated only by providing an innovative infrastructure for the production of agricultural enterprises, which is connected with the rules for evaluating alternative scenarios for managing the risks of production activity and aimed at reducing threats in the production system and obtaining the desired result.

The priority direction of our research is the development of a methodical approach to the assessment of factors-tools of innovative management of production risk, which activate the process of safe economic development and reproduction of the agrosystem of agricultural enterprises.

The study results can be used to develop and implement new risk management methods by agricultural enterprises. It can help businesses identify, analyze, and manage risks more effectively which, in turn, will reduce losses and increase resilience to adverse factors.

METHODS AND MATERIALS

The methodology of innovative production risk management is formed on the basis of a comprehensive approach to ensuring the economic development of the production system of agricultural enterprises. Traditional scenarios of indicative management of production risks limit agricultural enterprises in innovative development and acceleration of economic processes in accordance with established innovative programs and projects presented by agricultural institutes, and which regulate ownership of agricultural land plots, as well as ensuring stable economic development. At the same time, state support for maintaining a stable size and volume of land-resource potential in conditions of cyclical downturns in the economy (unstable system of pricing and currency fluctuations or regulation of the profits of agricultural enterprises) should be carried out by using a system of methods (subsidies, subsidization of resource-saving eco-innovative instruments, increasing the employment of the rural population) and be formed exclusively through the development of new levers that harmonize the priority of the interests of the institutes of the development of rural areas in the interdisciplinary space of preserving the natural and ecological and economic elements of the land-resource potential of agricultural enterprises (Grigriev, 2015). Institutes for the development of rural areas are able to accumulate a significant amount of additional capitalized reserves and regulate cash flows from capital investment funds for the effective use of agricultural land while balancing the natural and ecological and economic elements of the production system of agricultural enterprises (Figure 1).

It is proposed to include "Priority of the amplitude of the efficiency of the use of the production system" as additional strategic areas of interaction between agricultural enterprises and institutes for the development of rural areas, i.e., the influence of institutes for the development of rural areas is aimed at determining the maximum level of state financing of capital investments, at stimulating the development of small and medium-sized businesses in the fields of rural farms, and their managers should become rural UTGs, which house agricultural enterprises with a high level of efficiency in the use of the production system, which have a stimulating effect on the growth of GDP, private investments, the accumulation of productive capital in technological objects of eco-innovative reproduction of agricultural lands, increasing the fertility of agricultural land for the purpose of obtaining profit

and (or) achieving another positive (social and environmental) effect.

The priority of the amplitude of the efficiency of the use of the production system of agricultural enterprises can be implemented by applying a wide range of regulatory ecological and economic tools for the development of rural regional cooperatives, which have a direct connection with the sectoral direction of agricultural producers, which, by the nature of the influence, are divided into national ones (applied equally to all regions without exception) and selective (applied selectively to individual regions, territories or their groups). The state-wide regulatory ecological and economic instruments of the amplitude of the efficiency of the use of the production system of agricultural enterprises are aimed at creating common prerequisites for the regional development of agriculture. The measures of this policy have a uniform impact on all regions of the country, forming a reproductive mechanism of safe land use and rational use of agricultural land, as well as increasing the productivity of agricultural land. Within the framework of the national policy, the limits of independent and joint actions between the rural regional government and the institutes for the development of rural territories are defined in relation to the distribution of powers and responsibilities in all areas of agriculture in the regions, taking into account the agricultural enterprises operating in their territories, with the establishment of national rules, procedures and norms for the distribution of ownership of land plots and recreation of natural resources.

For these purposes, a differentiated approach should be implemented to create a balance of interests between rural UTC and institutes for the development of rural areas for the proportional distribution of budgetary resources for the reproduction of natural and ecological and economic elements of the production system of agricultural enterprises and its effective use in order to achieve optimal diversification of production. taking into account the implemented eco-innovative technologies for the protection of agricultural lands and ensuring social responsibility for land use in rural areas.

Stimulating levers of the economic interests of rural UTCs and institutes for the development of rural areas should encourage the use of the production system of agricultural enterprises under the conditions of innovation, using regulatory instruments that provide a kind of "circle of state support" capable of forming the prerequisites for mutually beneficial cooperation (Fedulova, 2013;Khomiuk, 2019). State support for agricultural enterprises, taking into account the adjustment of the mechanism of dating and subsidies, as well as state financing of eco-innovative technologies, should be provided through the targeted allocation of budget resources, expanding the forms and methods of influencing the safe and highly productive use of agricultural land by preserving the ecological and economic elements of the production system (Chychkalo-Kondratska, 2010; Khomiuk, 2019).

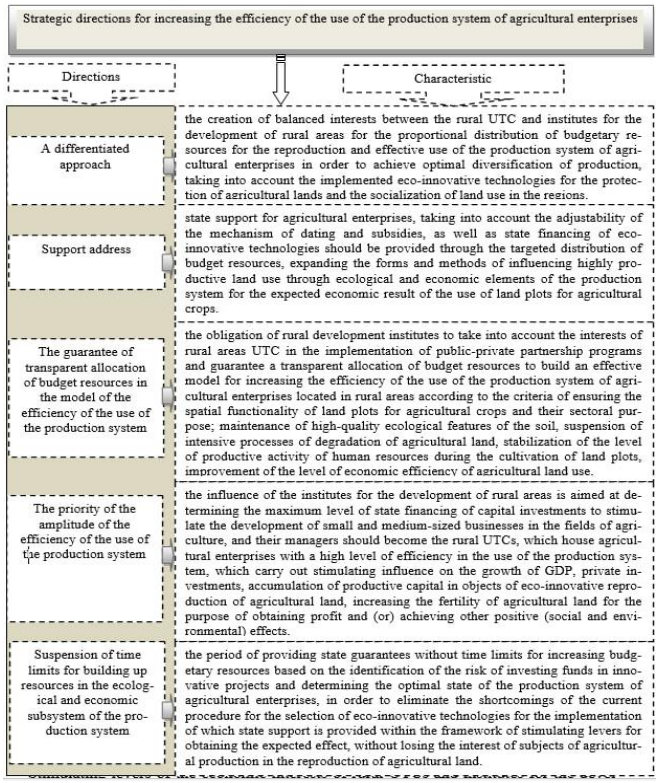


Figure 1. Implementation of strategic areas of improvement the efficiency of using the production system agricultural enterprises.

The guarantee of transparent allocation of budget resources for the construction of an effective model of the efficiency of the use of the production system of agricultural enterprises obliges the institutes for the development of rural territories to take into account the interests of rural local government organizations and to implement public-private partnership programs according to the criteria of ensuring the spatial functionality of land plots for agricultural crops of industrial purpose, maintaining high-quality ecological features soil, suspension of intensive processes of agricultural land degradation, stabilization of the level of productive activity of human resources in the cultivation of land plots, increase in the level of economic efficiency of agricultural land use (Antoniuk *et al* 2018). Thus, revision of the program-targeted approach to ensuring state support of agricultural enterprises, sustainable development of directions and vectors of effective use of their production system; the formation of appropriate legislative support on this basis will allow creating a favorable environment for sustainable economic growth through the implementation of the land market, the growth of the role of newly created united communities in rural areas and the

migration of economically active human resources to safer territories.

From the point of view of modernization of institutions for the development of rural areas in the post-conflict period of the country and ensuring the growth of innovative and technological shifts in rural UTCs, a key strategic direction of increasing the efficiency of the use of the production system of agricultural enterprises is proposed, aimed at "suspension of time limits on the increase of resources in the ecological and economic subsystem of the production system". This will make it possible to determine the period of providing state guarantees in the continuous period of increasing budgetary resources based on the identification of the risk of investing funds in innovative projects and determining the optimal state of the production system of agricultural enterprises, in order to eliminate the shortcomings of the current procedure for the selection of eco-innovation tools, for the implementation of which state support is provided in within the framework of stimulating levers to obtain the expected effect, without losing the interest of business entities in the reproduction of agricultural land.

Valuable ideas regarding the formation of a new conceptual approach to the innovative management of production risks of agricultural enterprises in order to activate the process of economic development in an institutional environment were proposed by Zięba (2000), who conducted an analysis of the violation of the quality standards of agricultural raw materials in the self-regulated contract markets of various states. In his opinion, risks in agriculture arise due to the leveling 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 oriented management of production risks of agricultural enterprises in the structure of an integrated production system with certain formative components of the institutional environment (Fig. 2).

It is worth noting that the new institutional approach to the innovative management of production risks of agricultural enterprises in order to activate the processes of economic development is multi-criteria. The methodological prerequisites of this approach are the identification of effective institutional determinants in the innovative management of production risks of subjects of agricultural production, which by its nature is quite complex and meaningful for the creation of hypotheses, axioms and theories of system analysis (Hlushko *et al* 2015; Hryshova and Fedorkin, 2017).

Institutional determinants in the innovative management of production risks 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 into the production cycle of agricultural enterprises (Hlushko *et al* 2015). At the same time, the managerial function of neutralizing production risks is determined by the institutional and economic capacity of agricultural enterprises with the help of levers of market influence, which expand their own share of commodity markets. The institutional and economic importance of agricultural enterprises in the national economy dictates the need to increase their competitiveness in the country (Dubina 2017).

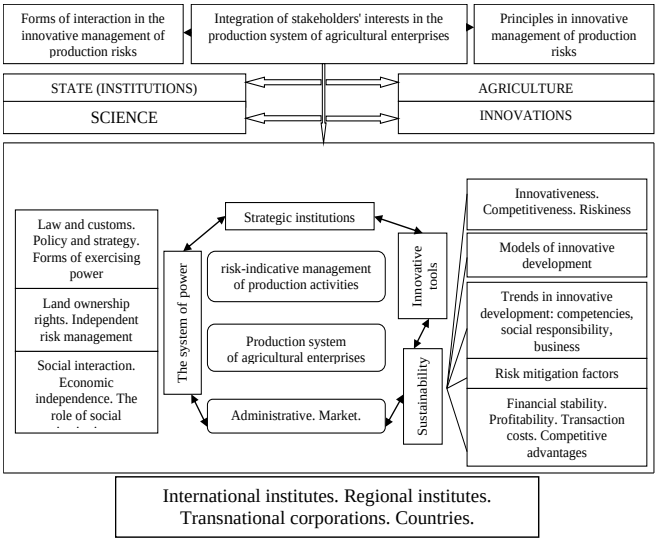


Figure 2. Innovative approach to oriented management of production risks of agricultural enterprises in the structure of an integrated production system with certain formative components of the institutional environment.

Institutional form-forming components within the framework of our study single out key innovative tools for neutralizing the production risks 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 (Fedulova, 2013). Misalignment of their interests in making management decisions provokes dynamic fluctuations in the production system, discourages the coordination of production cycles of agricultural enterprises at different levels of influence of risk scenarios in the innovative development of agricultural production (Vitlinskyi and Velykoivanenko, 2004).

Ensuring the innovative development of agricultural enterprises involves the activation of the functioning of the production system in a new quality, while preserving its structural and functional integrity (Myshchak, 2018). This is possible only under the condition of the formation of a mechanism for the activation of innovative tools for

management of the production risks, which is able to 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 behavior of enterprises; formation of a favorable 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 management of production risks of the 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 pro-grams 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.

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 (Kolodko, 2004). Therefore, 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 of the economic development of agricultural enterprises 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.

RESULTS

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" (Buzko *et al* 1996; Chychkalo-Kondratska, 2010).

The stages of evaluating the effectiveness of the implementation of innovative tools for management of the production risks (ITMPR) involve the determination of their number and the causes of danger. An important stage of innovative tools for management of the production risks 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.

After a high-quality assessment of the production risks, 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 production risks 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), (Andriichuk and Bauer, 1998; Buzko *et al* 1996; Donets, 2006).

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

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

Let's consider the stages of ITMPR 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 ITMPR, 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) (Granaturov and Litovchenko, 2005; Hetman and Shapoval, 2007; Yastremsky, 1983):

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

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

where, K_1, K_2, K_3, K_4 – coefficients.

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 management of the production risks, the overall risk of the innovative production program (project) is determined (*r*). The total risk consists of the sum of unsystematic and systematic risk (formula (4)-(5)) (Yastremsky, 1983; Yermoshenko *et al* 2004).

$$r = K_{\boldsymbol{p}} \times P + K_{\boldsymbol{p}_{systemic}} \times \boldsymbol{P}_{systemic}, \quad (4)$$

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

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); $K_{p_{systemic}}$ – 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. We modernize for our purposes the calculation of the net present value of the innovative production program (project) (NPV) – the formula (6) (Yastremsky, 1983; Yermoshenko *et al* 2004).

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

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

Step 5. Let's calculate two scenarios for calculating net present value with and without ITMPR, using formula (6) and formula (7) (Yastremsky, 1983; Yermoshenko *et al* 2004):

$$NPV^* = -I + \sum \frac{cf_t}{(1+d)^t}, \quad (7)$$

Step 7. We will find the efficiency of ITMPR implementation as the difference between the flows $NPV^*$and NPV for this we use the formula (8) (Yastremsky, 1983; Yermoshenko *et al* 2004):

$$ITMRPA_{ef} = NPV^* - NPV, \quad (8)$$

One of the directions for evaluating the effectiveness of the implementation of innovative tools for management of the production risks 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 behavior 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 in contracts for consumer production of agricultural products. Therefore, the stimulus for predicting potential risks of production activity, as well as 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 management of the production risks 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.

The simulation model "Activation of innovative tools for management of the production risks in the institutional environment of economic development of agricultural enterprises" is carried out according to the formula (12) (Yastremsky, 1983):

$$M = (G, S), W = \begin{Bmatrix} Xzm1, Xzm2, Xzm3, Xzm4, Xzm5, Xzm6, Xzm7, Xim8, \\ Xim9, Xim10, Xim11, Xim12 \end{Bmatrix}, \quad (9)$$

where, G– set of peaks of innovative tools that correspond to external and internal risk factors of production of agricultural enterprises;S– sets of arcs reflecting the direct influence of risk scenarios of the institutional environment on the parameters of the economic development of agricultural enterprises.

Leverage provides a potential opportunity to influence the income, profit and risks of agricultural production by changing the key factors, namely: a price, production volumes and a cost structure (ratio of fixed and variable costs). This feature makes the leverage attractive regarding price or cost management. Effective management of this ratio allows agricultural enterprises to exercise their positive influence on the amount of profit. The interconnection between the profit and the costs (productive and financial), which were incurred to obtain this profit, is characterized by the leverage as a component of the total risk of agricultural enterprises. As a key to success in the sector of agricultural production, it demonstrates the sensitivity of profit to changes in the sales volume. The leverage indicates how the profit of an agricultural enterprise will change with a change in income by 1%. In other words, the greater the share of fixed costs, the

greater the leverage, and, accordingly, the greater the risk of agricultural production. Given the positive dynamics of agricultural production, the high leverage degree accelerates the profit growth. However, with a decline in production, the high degree of leverage leads to losses and thus provokes risks. This factor facilitates the use of information about the dynamics of the leverage degree as a quality component of agricultural production risk management because it serves as an evaluation criterion, i.e., either maximizing profits or minimizing risks. In the current crisis conditions and martial law in Ukraine, most agricultural enterprises prefer to minimize the risks. Therefore, under such conditions, the lower the leverage degree, the better.

The positive impact of the operational leverage on the results of production activities of agricultural enterprises begins to appear only after the break-even point is overcome. This can be explained by the fact that agricultural enterprises are obliged to reimburse their fixed costs regardless of the specific sales volume because the break-even point of production activities is achieved later if the amount of fixed costs is increased, other factors being equal. As long as agricultural enterprises do not ensure the break-even point of their production activities, a high level of fixed costs will be an additional burden on the way to achieving a break-even production. Therefore, in order to reduce the agricultural production risks, enterprises should observe a decrease in the growth rate of fixed costs in net income; manage variable costs by reducing capacity, depreciation, and other operating costs. In addition, to increase further the net income, agricultural enterprises need to increase their business activities by enhancing the efficiency of working capital.

The interrelationship of parameters involves the construction of matrices of acceleration (deceleration) of leverage factors of innovative tools for management of the production risks, which have certain characteristics (Table 1). Thus, at a value of (+1), there is an increase (decrease) in the factor

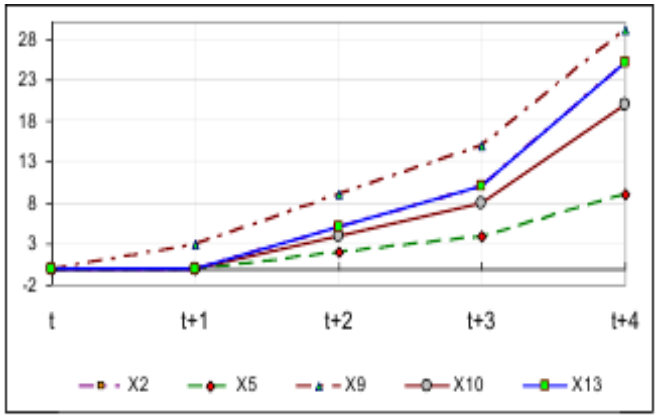
Table 1. Stimulating and disincentive factors-leverages of innovative tools for management of the production risks and their impact on the economic development of agricultural enterprises.

Leverage factor	Interpretation of the factor
X_{zm1} – Government programs to create buffer stocks of agro-raw materials of the grain and oil group	At the studied stage, this factor is developed, the system exerts an influence on its transformation, the factor itself has a strong influence on the change in the security level of the development of agricultural enterprises. It is possible to note the strengthening of the effect on the system when it is activated. The absence of government programs for buffer stocks of agricultural raw materials of the grain and oil group will significantly affect the production activity and competitiveness of agricultural enterprises. The factor can be used as an indicator.
X_{zm2} – Futures contracts	Changing the factor is the goal of innovative risk management of production activity. The factor has a high degree of interaction and is influenced by other factors. Futures (option) contracts are an indicator of the safe development of agricultural enterprises.
X_{zm3} – spots prices for agricultural products	The factor is strongly interconnected with innovative risk management of production activities. It can be used as an indicator for monitoring and the state of security of the development of agricultural enterprises. The interaction of the factor with the security of the development of agricultural enterprises is stronger in the matrix of acceleration of the influence of the macro environment.
X_{zm4} – Manufacturing outsourcing	The factor influences the innovative management of risks of production activity. Its growth leads to the growth of other factors, greatly accelerates the safe development of agricultural enterprises. The factor can be used as a lever of innovative risk management of production activity. The more actively production outsourcing is implemented, the higher the level of safe development of agricultural enterprises.
X_{zm5} – Agricultural technologies	The change of the factor falls under the influence of other elements of innovative risk management of production activity and safe development of agricultural enterprises.
X_{zm6} – Blockchain	The factor actively affects the safe development of agricultural enterprises, which makes it a lever of innovative risk management of production activities. However, the activity of the factor in the deceleration matrix is lower than in the acceleration matrix.
I_{zm7} – Digital financial technologies	The factor has a strong effect on changing the security level of the development of agricultural enterprises, it is currently active. The factor can be used as an indicator.
X_{im8} – Contract farming	The factor actively acts to change the level of security of the development of agricultural enterprises, which makes it a lever of innovative management of risks of production activity. However, the activity of the factor in the deceleration matrix is lower than in the acceleration matrix.
X_{im9} – Trade contracts	The factor has a high degree of interaction with the level of security of the development of agricultural enterprises and is influenced by other factors of innovative management of risks of production activity.
X_{im10} – Insurance of agricultural raw materials	The factor actively affects the safety of the development of agricultural enterprises, which makes it a lever of innovative risk management of production activities. However, the activity of the factor in the deceleration matrix is lower than in the acceleration matrix. This is explained by the fact that when the insurance of agricultural raw materials is reduced, the innovative management of the risks of production activity is limited.
X_{im11} – Asset hedging	The factor does not have a high degree of interaction with the security of the development of agricultural enterprises and is influenced by other factors. Changing the factor is the goal of innovative risk management of production activity.
X_{im12} – Diversification of production systems	Changing the factor is the goal of innovative risk management of production activity. The factor comes under the influence of many other factors. Can be targeted.
X_{im13} – A potential innovative tool	Changing the factor is the goal of innovative risk management of production activity. Can be targeted.

($Izmi, Iimi$),which leads to an increase (decrease) ($Xzmj, Ximj$); at a value of (-1), there is an increase (decrease) of the factor ($Xzmi, Ximi$),which leads to a decrease (increase) ($Xzmj, Ximj$); with the value (0), there is a weak or completely absent connection between the factors ($Xzmi, Ximi$) and ($Xzmj, Ximj$). 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.

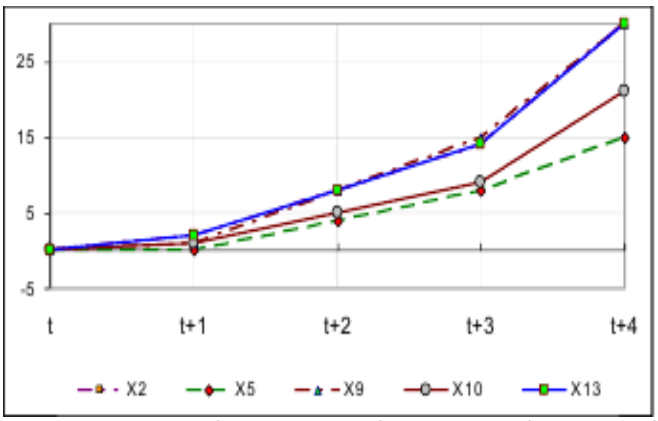
Among the active peaks, lever factors of innovative tools for management of the production risks were identified, which affect the safe development of agricultural enterprises, namely: X_{zm1} – Government programs for creating buffer stocks of agricultural raw materials of the grain and oil group; X_{zm2}– Futures contracts, X_{zm3} – Spots prices for agricultural products; X_{zm4} – manufacturing outsourcing; X_{zm6} – Blockchain, X_{zm7} – Digital financial technologies; X_{im8} – Contract farming, (Table. 1).

Behavior models of ITMPR provide optimal and positive interaction of factors according to scenarios 1 and 9, which demonstrate the best results of safe development of agricultural enterprises. Important components in this process are public-private partnership, as well as the presence of a regulatory price policy. Thus, according to Scenario 1, the momentum of the interaction of the factors of ITMPR is carried out in three vertices – X_{im8} =1, X_{zm4} =1, X_{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. 3a, Fig. 3b).



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

Figure 3a. Simulation model of the behavior of innovative tools for management of production risks of agricultural enterprises (Scenario 1).



Scenario 9. The impetus for the interaction of innovative tools for managing of production risks is provided by the state policy of regulating spot prices for agricultural products in rational contract farming; 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 on the basis of public-private partnership is increasing.

Figure 3b. Simulation model of the behavior of innovative tools for management of production risks of agricultural enterprises (Scenario 9)

Scenario 9 demonstrates the momentum of the interaction of four vertices – X_{im8} =1, X_{zm3} =1, X_{zm6} =1, X_{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 on the basis of public-private partnership.

Taking into account the state of war in Ukraine and the consequences of the destabilization of the production system of the country's agriculture (scales of losses of resource and production potential of agricultural production), based on the results of simulation modeling, an integral indicator of the safe economic development of agricultural enterprises was calculated (the calculation was carried out on average per subject of agricultural production) certain agro-climatic zone. The activation of strategic innovative tools in the management of production risks made it possible to single out the structural coefficients of the index of safe economic development of agricultural enterprises, which are shown in Figures 4-8 (calculated by the authors based on the data State Statistics Service of Ukraine (2023)).

Thus, the calculations revealed that a high level of coefficients of production, financial, material and innovative components of safe economic development per agricultural enterprise was recorded in the agro-climatic zone of the Forest Steppe, Polyssia and Western Zoya.

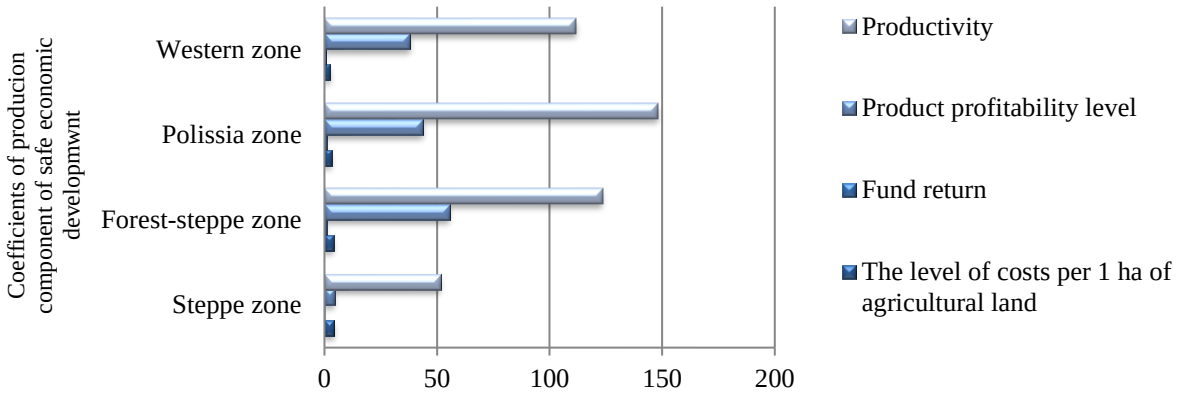


Figure 4. Coefficients of production component of safe economic development of agricultural enterprises on average for 2018-2022.

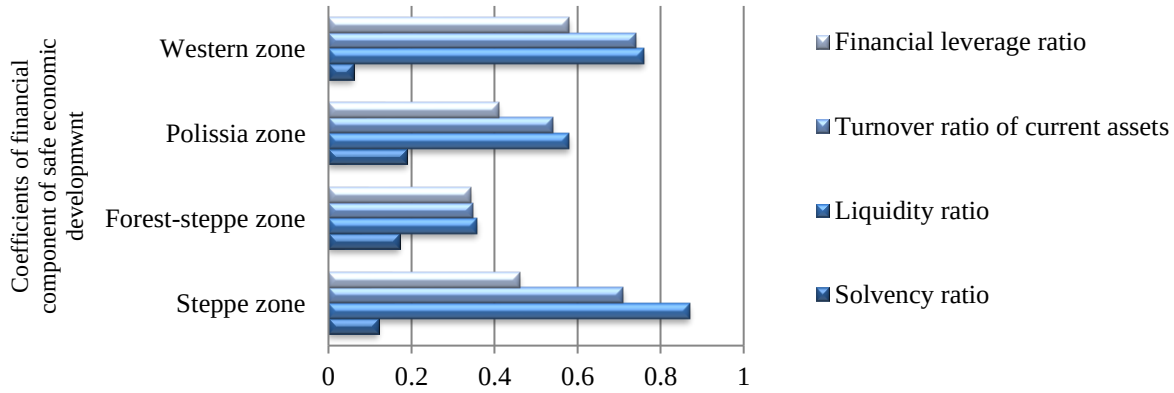


Figure 5. Coefficients of the financial component of safe economic development of agricultural enterprises on average for 2018-2022.

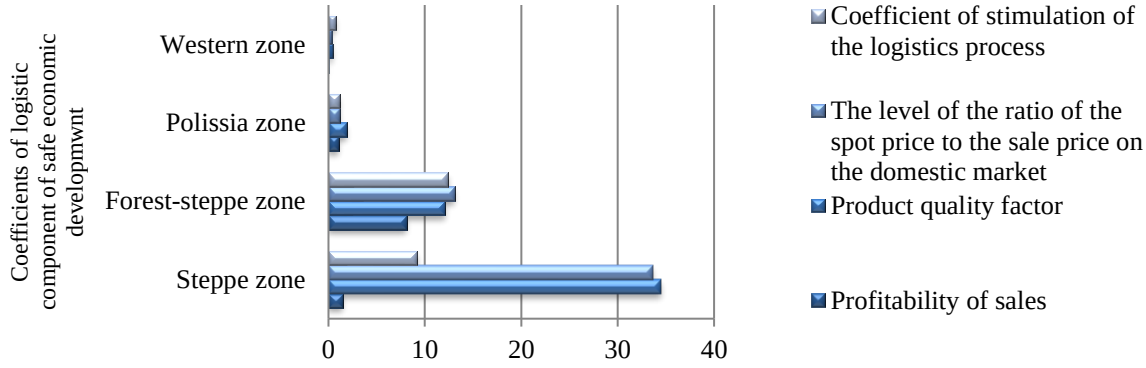


Figure 6. Coefficients of the logistic component of safe economic development of agricultural enterprises on average for 2018-2022.

This is due to the rapid acceleration in the institutional environment of production outsourcing and futures contracts based on the government's creation of stocks of agricultural raw materials of the grain and oil group as part of the country's food security programs. The peculiarity of this trend was felt in 2021 and, despite hostilities in most regions of Ukraine, in 2022. During this period, the processes of diversification of the production system of agricultural enterprises were intensified, agricultural technologies, Blockchain and protective financial technologies were introduced. These

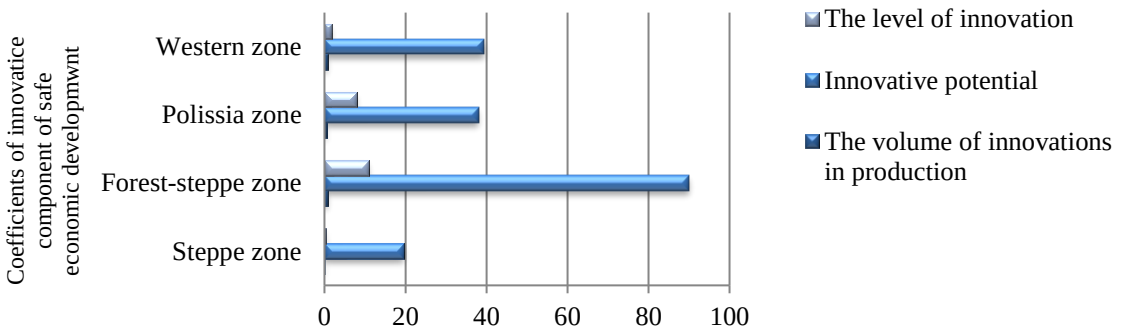


Figure 7. Coefficients of the innovative component of safe economic development of agricultural enterprises on average for 2018-2022.

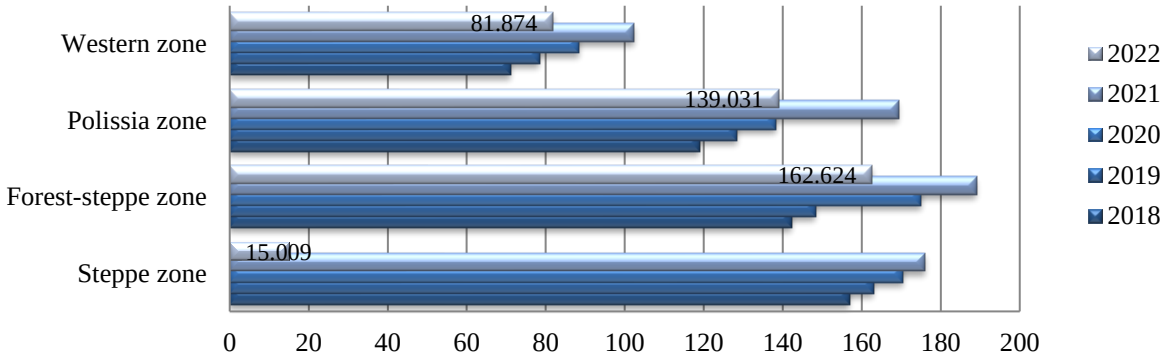


Figure 8. Integral index of safe economic development of agricultural enterprises on average for 2018-2022.

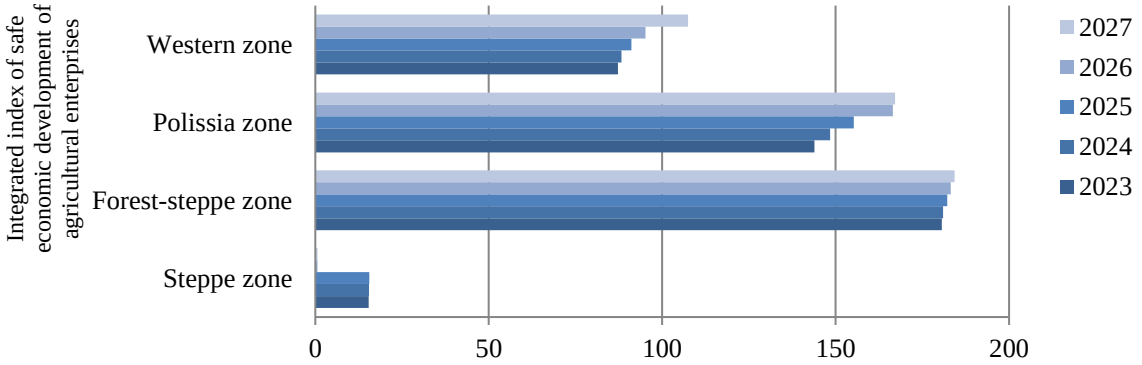


Figure 9. Forecast of the integrated index of safe economic development of agricultural enterprises on the 2023-2027.

innovative tools have significant potential for reproducing the ecosystem of agricultural enterprises and the security of rural areas of Ukraine.

Ukraine's strong political commitment to strengthening agrarian policy and agricultural institutions will allow in the future (in the post-conflict period) to 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 futures 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 (Berehovy, 2010). 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 (Kotykova *et al* 2020; Sychevskyi, 2019). 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, by introducing diversification of the logistics component in order to ensure the safe development, stability and independence of agricultural production entities. This will make it possible to develop one's own production base and fulfill 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 economic development of agricultural enterprises is of scientific and practical interest.

The calculated forecast integral index of safe economic development of agricultural enterprises by agro-climatic zones of Ukraine on the 2023-2027 is presented in Figure 9.

It was established that as a result of the accumulation of a significant amount of production, financial, logistics and innovation potential, the level of safe economic development of agricultural enterprises in the Forest-Steppe and Polissia zones increases, which characterizes their ability to reproduce the agrosystem in Ukraine.

DISCUSSIONS

The production activity of agricultural enterprises, unlike other spheres of their activity, is closely related to the processes of their safe economic development in the institutional environment. The institutional environment of agriculture embodies formal and informal institutions that develop normative regulators of the agrosystem of agricultural enterprises, activate their economic opportunities and minimize potential production risks (Ciccullo *et al* 2019; Hodgson, 2000). The formal institutions of agriculture that influence the activation of the agricultural system of agricultural enterprises include: the institution of ownership, the institution of state regulation, the institution of entrepreneurship, the institution of contract (agreement), the institution of competition, and the institution of knowledge. The basis of informal rules for the development of institutions are the cultural traditions and values of rural areas, which determine the worldview and behavior of the subjects of agricultural production (contractual agreements are often concluded formally; the resolution of conflicts regarding the provision and use of resources in production activities is often based on local customs than on legal norms) (Gupta *et al* 2015; Khomiuk, 2019; Zięba, 2000).

At the same time, in the mechanism of innovative management of production risks, such a component as risk-oriented management of resources in the agrosystem of agricultural enterprises depends on the formalized description of innovative tools. If the formal rules of production risk management of agricultural enterprises change quickly, then the informal ones, as a rule, change gradually, but they set the vector of neutralization of threats in production activities for innovative tools. Informal rules and norms of production risk management are not created by the authorities, they often develop spontaneously and generate abuse of resources in the agricultural system of subjects (Gupta *et al* 2015; Khomiuk, 2019).

In this regard, Kolodko claims that the imperfect institutional vector of the development of agrarian institutes does not provide an opportunity to completely neutralize risks in the production, social, human, financial and resource capital of agrarian enterprises. Accordingly, a new conceptual approach to the introduction of innovative tools in the management of production activities of agricultural enterprises is needed in order to activate the processes of agrosystem development in an institutional environment. On the one hand, it is necessary to constantly support the development of relevant institutes of agriculture in the necessary direction (which includes their formation, formation and training), and on the other hand, to stimulate this process by convincing agricultural enterprises to look for new standards of production risk management for the restoration of the agricultural system (Kolodko 2004).

The key characteristic of the safe economic development of agricultural enterprises is the availability, possibility and stability of the use of the agrosystem, which largely depends not only on the production of agricultural products, but also on the trade strategy and trade relations (Vasylkivskyi, 2015). At the same time, the following should be considered the main characteristics of innovative tools in the agrosystem of agriculture (Strashynska and Gretska, 2011): 1) the ability to produce, ensure storage and promotion of products to the final consumer in the required volumes; satisfy the regulatory needs of all social groups; 2) equality for all subjects of agricultural production in the use of agricultural technologies, balanced productivity and high quality of agricultural raw materials; 3) adaptability of the production system to fluctuations and limitations of growing agricultural products; 4) stable promotion of production outsourcing at the level of regions of the country regardless of agro-climatic zone; 5) balanced development of the national market of agricultural raw materials in the mode of diversification of agrotechnology, reproduction of the assortment of varietal composition of seeds for the production of export products.

Balancing the quantitative and qualitative parameters of the production activity of agricultural products, determining the criteria for the neutralization of production risks at the local level allows to ensure the reproduction of the agricultural system in rural areas where the subjects of the oilseed group are located (Tomilin, 2012). The reproduction of the agricultural system leads to an increase in the potential of the

production system of agricultural enterprises, which, in turn, stimulates the introduction of innovations in the logistics chains of grain and oil products through Blockchain technologies (Sychevskyi, 2019).

This approach expands the range of products of the grain oil group in accordance with the scale of its consumption while differentiating the price policy and within the regional market, stimulating international trade and export of agricultural products. This is confirmed by Kotykova, Babich, and Krylova, who emphasize that for the highest guarantee of the security of the economic development of agricultural enterprises, with the constant introduction of innovations in the agricultural system, spot prices for agricultural products of the grain and oil group are necessary on mutually beneficial terms (Kotykova *et al* 2020).

In this aspect, the agrosystem, which forms the relationship between the environment and society in the process of production activity, must ensure the conditions of preservation and effective use of the production system of agricultural enterprises. In view of this, it is necessary to evaluate not only land resources, but the entire inseparable agricultural system of a specific territory. And the conditions for the preservation of agriculture as a whole depend on the extent to which the economic interests of agricultural enterprises are aligned with the economic requirements for the risk-free use of agricultural land.

With the interconnection of land and other resources exploited in the production process (natural, material and labor), thanks to risk-free production activity, scenarios of the use of land plots placed under crops are determined, demarcated by latent signs of an economic and innovative-technological nature. That is, the determination of the limit on the average reproduction interval of the effective use of the production system of agricultural enterprises will allow to predict options for possible changes in the distribution (redistribution) of agricultural lands between land users and landowners.

Modeling of complex innovative processes in the management of production risks and the efficiency of the use of the production system of agricultural enterprises, with the interaction of various factors of reproduction of the agrosystem, make it possible to make forecasts: the yield of agricultural crops at different levels of anthropogenic load; the quality of the products obtained under different farming systems; changes in soil fertility under different fertilization systems; the development of economic and mathematical models for the optimization of a safe ecological and economic direction for the needs of agricultural production; to reveal the trends of economic processes operating in the united territorial communities of rural areas, in particular in the demographic, innovative and social spheres with natural requirements for the needs of economically active human resources, as well as the reproduction and use of resources for the future (Fig. 10).

The model of the structure of the agrosystem, which is included in the production system of agricultural enterprises, subordinate to the "goods – market" relationship, includes: land resources (Q_1^e), economically active human resources (Q_2^{hr}), basic material resources (Q_3^{fa}), circulating material resources (Q_4^{cmr}), financial resources (Q_5^{fr}), eco-innovation resources (Q_6^{eir}). The set of these components determines the reproductive processes of the production system ($RPAS$), which can be represented by a functional dependence of the form (Herasymenko & Zhemoida, 2009):

$$RPAS = f(Q_1^e, Q_2^{hr}, Q_3^{fa}, Q_4^{cmr}, Q_5^{fr}, Q_6^{\text{eir}}), \quad (10)$$

Based on the agrosystem model, which is included in the production system of agricultural enterprises as an object of satisfying the economic interests of land users and landowners, it represents a complex modification of sets with interconnected structural elements that perform the functions of reproduction and use of production and natural resources for the purpose of obtaining agricultural products in the environment of constant dangerous ecological and economic

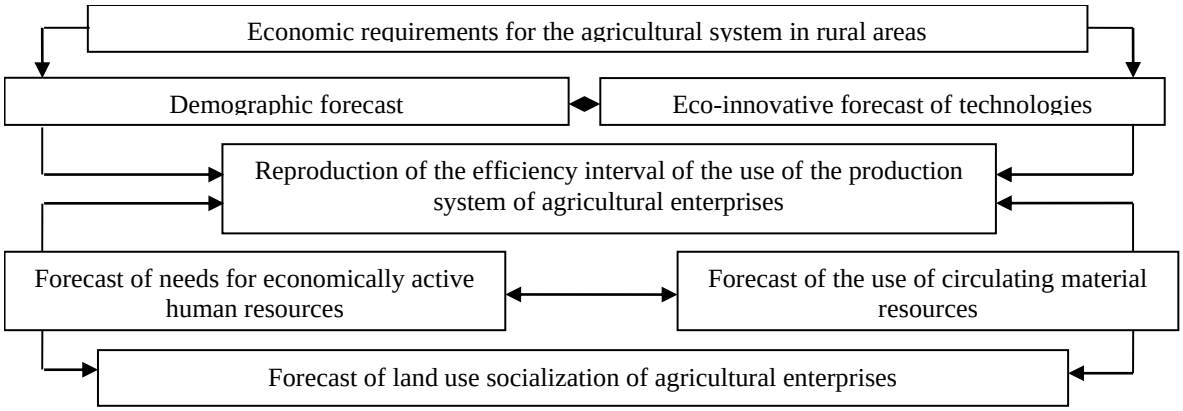


Figure 10. The structure of forecasts for reproduction of the efficiency interval of the use of the production system of agricultural enterprises.

disturbances. At the same time, the interrelationship of economic and mathematical models of reproduction of the agricultural system, which is included in the production system, covers the commodity strategy during the rational exploitation of natural resources, taking into account the eco-innovative technological capabilities of agricultural enterprises (Fig.11).

However, in the conditions of multi-criteria selection, there is always uncertainty due to the comparison of different evaluations according to different criteria. In contrast to previously developed approaches, all initial prerequisites are formulated in terms of resources, which requires increased requirements for the applied eco-innovative technologies of agricultural production. The eco-innovation-technological sequence chain at the G-th production when forming the yield of individual crops is written in a simplified form as follows:

$$r_{1S} \to r_{2S} \to r_{3S} \to r_{4S} \to r_{5S} \to r_{6S} \to v^G, \quad (11)$$

where, r_{1S} – the phase of field preparation (plowing, harrowing, loosening, cultivation, etc.) in the *s*-th enterprise; r_{2S}– the phase of the process of sowing agricultural crops (improvement of sowing and physical qualities of seeds, carrying out sowing in optimal terms); r_{3S} – the phase of application of organic and mineral fertilizers in optimal doses; r_{4S} – the phase of providing and using the eco-innovation-technological process with the necessary conditions for growth and development (vegetation, watering, fertilizing, etc.); r_{5S} – the phase of protection of agricultural plants from diseases, weeds, and pests; r_{6S} – the phase of optimal organization of the collection of agricultural crops (beginning, duration, etc.); v^G – volume of agricultural products.

The yield of agricultural crops as an object of mathematical modeling of the agrosystem, which is included in the production system of agricultural enterprises, can be considered as a function of a complex of factors with different directions of influence. In addition, the simultaneous forecasting of both the level of productivity and the volume of circulating material resources for its acquisition, according to constant and variable direction, as well as according to local action with a positive or negative result, allows you to purposefully reproduce the logistic flows of production resources and methods their use in order to obtain a high yield.

The application of the proposed approach to the assessment of the integral index of the safe reproduction of the agrosystem of agricultural enterprises located in the united territorial communities (UTC) of the countryside allows for their ranking on the example of the Kyiv region of the Polissia zone of Ukraine (as a territory that was not occupation during military operations by the country-aggressor) and determine predictive criteria for the effective use of agricultural land, which minimize production risks with their rational use (Fig. 12).

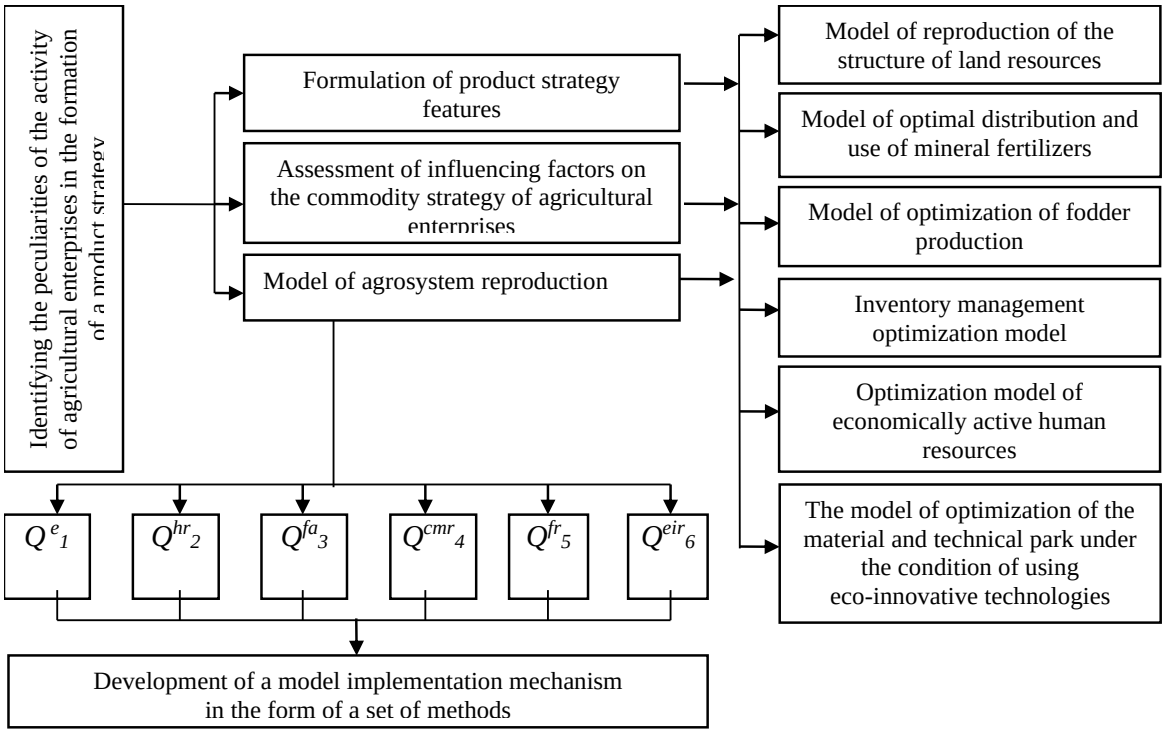


Figure 11. **Interrelationship of economic and mathematical models of agro-system reproduction and effective use of the production system of agricultural enterprises on the basis of the implementation of the commodity strategy.**

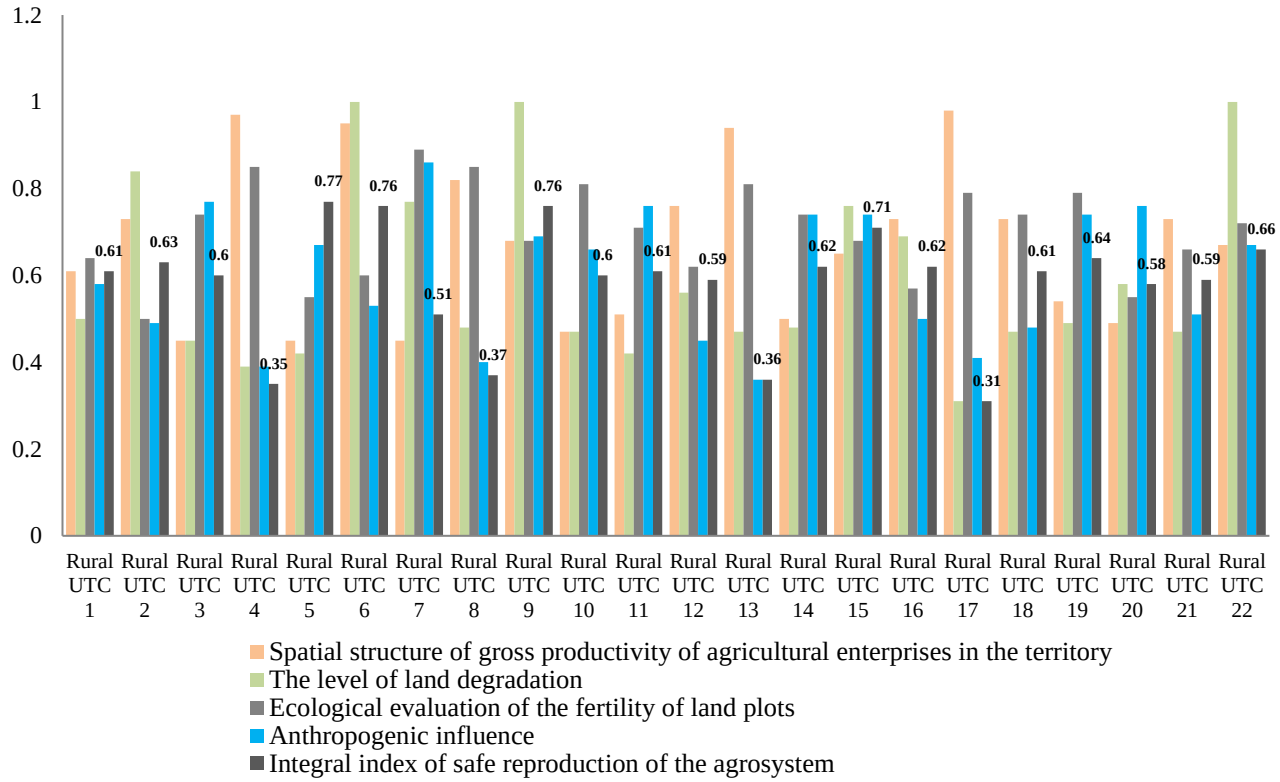


Figure 12. Integral index of safe reproduction of the agrosystem of agricultural enterprises of the Kyiv region of the Polissia zone of Ukraine for 2023-2025.

The results of the analysis of Fig.12 testify that among the rural UTC the highest level of safe use of the agrosystem of agricultural enterprises is characterized by UTC 4 (integral index 0.35), UTC 8 (integral index 0.37), UTC 12 (integral index 0.36) and UTC 17 (integral index 0.31). The indicator is somewhat lower in UTC 20 (integral index 0.58) and UTC 21 (integral index 0.59) and UTC 7 (integral index 0.51), which also have an average level of sustainability according to the criteria of manifestation of ecological and economic threats and risks. Other rural UTCs of the Kyiv region are classified as territories with a pre-crisis level of safe use of the agrosystem of agricultural enterprises. At the same time, it is worth noting that there are no territories where the integral index is at the crisis level among the UTC of the Kyiv region. In general, taking into account the calculations, it is possible to determine the appropriate directions for maintaining the balance of agricultural lands of agricultural production entities, which are based on the properties of the resource base. It will include economically active human resources, circulating material resources and sources of their financing with the use of innovative tools of Fintech technologies and Blockchain technologies, which will allow to assess the future possibilities of preserving ecological and ecological elements of the production system of agricultural enterprises as a whole.

Conclusions: Thus, the safe economic development of agricultural enterprises in an institutional environment is focused on ensuring own agro-economic capacities, without resorting to food imports from other countries. It is a criterion for the quality of strategic products of agricultural production, it is a guarantee of nutrition of products of the grain and oil group in sufficient quantity at the level of justified norms. At the same time, the key position of agricultural institutes regarding innovative management of production risk allows to focus on the agrosystem of agricultural production entities, which are able to independently provide the country with the necessary volume and range of products. Accordingly, achieving a stable level of safe economic development of agricultural enterprises should involve the implementation of the following main directions: 1) maintaining food supply at a level sufficient for healthy nutrition; 2) ensuring the appropriate level of solvent demand of the population; 3) eliminating dependence on imports and protecting the interests of domestic producers of agricultural raw materials. From the point of view of the industry approach, Blockchain-technologies as innovative tools for management of

production risks in urban areas where agricultural enterprises are located and which are located at small distances from logistics centers should be fully involved in the model of safe economic development of agricultural entities with the aim of expanding of the agricultural raw material segment on the world market. Only under this condition can one count on an effective process of the management of production risk of agricultural enterprises and form quantitative and qualitative resource components of simple or extended reproduction of production cycles in an institutional environment; to ensure a smooth process of innovative development of agricultural production entities. Restoration of the quantitative and qualitative resource component of the production cycle based on the implementation of the amplitude of innovation opportunities of agricultural enterprises of the grain and oil group, which is activated at the expense of Blockchain-technologies in order to select strategic innovation programs and projects in the business environment, will make it possible to have a stimulating effect on the growth of capital investments, accumulation of productive capital in objects of technological innovation for the purpose of obtaining profit and (or) achieving a positive effect. The application of new risk management methods can facilitate an increase in the agricultural enterprises' competitiveness. Moreover, the effective risk management will allow enterprises to adapt better to changes in the external environment and respond faster to harmful factors. In addition, the risks reduction and the production efficiency improvement can positively affect the agricultural enterprises' financial sustainability. As a result, this can attract additional investments, reduce costs, and increase revenues.

At the same time, the process of introducing innovative tools for management of production risks in the institutional environment should be transferred to a new doctrine of innovation of production and technological standards of regional development with the strengthening of the influence of the state on the reproduction of the integral production system of agriculture. This will positively affect the sustainability of the potential of the production system in the state, ensure the greening of agricultural raw materials, and also allow forming new behavior of agricultural enterprises to ensure the safety of their own production system, by stimulating cooperation with other stakeholders, in order to find a reliable supplier of seeds of the grain and oil group and careful planning diversification of agricultural technologies. In addition, an effective state policy should deter-mine the safety parameters of agricultural raw material production, its economic availability, reliability and resistance to external barriers and restrictions, both according to national and European standards; coordinate them with the main macroeconomic parameters of the country's development and be responsible for the implementation of the state agrarian policy.

***Ethical approval*:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

***Authors Contributions*:** Authors' contributions are equal.

***Availability of data and materials*:** Data will be available on request.

***Consent to participate*:** Informed consent was obtained from all individual participants included in the study.

***Consent for publication*:** All individual participants agreed to be included in the study.

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