



Tatyana Kuzenko,
Valerii Bereza,
Inna Sabadash,
Kateryna Harbazi,ii,
Volodymyr Tsyupak,
Pavlo Matvieiev,
Serhii Selikhov

PRODUCTION POTENTIAL AS A DETERMINANT OF ECONOMIC SECURITY IN THE AGRO-INDUSTRIAL COMPLEX: THEORETICAL FRAMEWORK AND EMPIRICAL VERIFICATION

The object of research is the processes of ensuring the security of the agro-industrial complex of Ukraine in a competitive environment. The paper addresses the problem of insufficient development of the mechanism of the relationship between production potential, the level of competition and the financial stability of the industry. In addition, attention is focused on the lack of a quantitative assessment of the impact of production factors on the level of financial vulnerability of the agro-industrial complex. The research was aimed at providing a theoretical substantiate the conceptual foundations of a comprehensive model of ensuring the security of the agro-industrial complex and to quantitatively determine the impact of indicators of production capabilities on the share of unprofitable enterprises in the industry during 2016–2023. The results show that the average financial vulnerability of the industry was 23.75%, with a maximum value of 35.9% in 2022, which indicates high instability of financial results. The regression analysis revealed an inverse relationship between investment activity and the share of unprofitable enterprises, which was reflected in the coefficients at the logarithm of investments ($\ln(\text{Inv})$) – 50.64 for the base model and – 32.64 for the lag model). This confirms the fundamental economic laws regarding the stabilizing effect of the development of production potential. At the same time, the presence of a positive coefficient (1.63 and 2.10) in connection with yield indicators reveals a disparity between the level of physical productivity and financial stability of business entities. The defining characteristic of the results is the integration of a systemic conceptual model of ensuring the security of the agro-industrial complex with its empirical verification based on national statistical data and using multifactor regression analysis. The scope of practical application of the results covers the formation of investment policy, the development of mechanisms for modernization of production and instruments for strengthening the financial stability of the agro-industrial complex in conditions of heightened competition and potential geopolitical risks.

Keywords: security, agro-industrial complex, production potential, financial sustainability, competitive environment, productivity, financial security.

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1. Introduction

The agro-industrial complex (AIC) is one of the important components of the national economy. The AIC ensures food security, forms the export potential of the state, creates a significant percentage of jobs and generates foreign exchange earnings. The functioning of this sector of the economy is significantly influenced by the following factors: constant growth of global competition, significant price fluctuations, disruptions in logistics, the direct impact of climate change and geopolitical instability. It is the influence of these factors that determines the strategic importance of guaranteeing the economic security of the AIC.

The current conditions of the functioning of agricultural enterprises are experiencing a significant transformation of factors that affect competitive advantages. Traditional factors, such as production volumes and resource sufficiency, are supplemented by the following critically

important factors: innovative activity, the effectiveness of management decisions, rapid digitalization, environmental transformation and entry into global value chains.

The growth of production volumes in natural terms of agricultural enterprises does not always lead to the strengthening of the financial stability of enterprises. This is evidence of the universal relationship between production potential and economic security of agricultural enterprises.

In conditions of increased competition, production potential acts as the main resource base for agricultural enterprises. The impact of production potential on financial indicators is mediated through market mechanisms of price formation, cost of production, and availability of financial sources. The increase in the volatility of the external environment necessitates a quantitative assessment of the interdependence between production potential and the level of economic security of the enterprise.

Despite significant scientific research on the competitiveness of agricultural enterprises, the issues of a single concept of economic security of the agricultural sector, including the production, financial, and competitive environments, are not sufficiently theoretically substantiated and formalized. This problem is most acute for national economies that operate in conditions of significant structural transformations and under the influence of significant external risks.

Thus, an unsolved scientific problem has been identified, requiring theoretical understanding and systematization of the interpretations of competitiveness, production potential and economic security of agribusiness enterprises.

Scientific research on the competitiveness of agribusiness enterprises (AIC) demonstrates a transition from interpretation through productivity and cost indicators to a category that includes production potential, innovative development, financial sustainability, environmental component and sustainability of logistics networks.

Modern scientific approaches to understanding the security of the agribusiness sector define it as the ability of the system to maintain sustainable production and ensure financial stability, despite various external, climatic threats and global variability. The principles of adaptive sustainability and development of production systems are laid down as a basis.

Thus, in work [1] the creditworthiness of agribusiness enterprises is considered from the point of view of the interaction of productivity, profitability and modernization of activities. It is proved that the sustainability of family enterprises provides the basic economic stability of the industry, but a negative attitude towards the introduction of new technologies is possible. The model includes management, financing, marketing, new technologies, adaptation to climate change. This is what emphasizes the multifaceted nature of production potential.

Scientists argue that when considering the competitiveness of agricultural enterprises, in addition to production volumes, it is necessary to consider the efficiency of resource use and the adaptation of enterprises to external risks.

The study [2] demonstrates the assessment of the competitiveness of agricultural enterprises in the context of the production and export of Ukrainian wheat, in particular the analysis of the impact of sales channels and sales prices on economic efficiency in martial law. The paper proposes an approach to assessing profitability taking into account export activity and regional specifics of production. This made it possible for the first time at the level of a set of enterprises in the front-line region to identify the impact of pricing and sales channels on the profitability of wheat sales in conditions of prolonged martial law. Despite the complexity of the analysis, the study focuses mainly on the production, price and logistical aspects of the formation of the competitiveness of enterprises in the wheat market, which leads to a number of methodological and analytical limitations. In the paper [3], the environmental component is considered as a strategic factor of competitiveness. The authors prove that the green competitiveness of the agricultural sector is determined by compliance with environmental standards and the efficiency of resource use. The introduction of renewable energy, agrovoltatics and energy-efficient systems increases the autonomy of production. The development of a universal methodology for assessing green competitiveness for different levels of economic development remains out of focus, and the impact of energy autonomy on the overall level of economic security is uncertain.

In paper [4], the authors propose a multidimensional system for assessing the competitiveness of G20 countries. Research on export competitiveness confirms the importance of specialization and diversification. Researchers have not paid attention to the adaptation of the international system of indicators to the micro-level of enterprises.

In the study [5], the competitiveness of agricultural products was analyzed. It was determined that exports face problems of market and

exporter diversification. The RCA index confirms strong specialization in these products. The issue of limited market diversification and insufficient attraction of new exporters remains unresolved.

The macroeconomic dimension of the issue of production potential is presented in the study [4], which benchmarked the agri-food systems of the G20 countries. The results obtained demonstrate that leading countries combine a high level of innovation, environmental efficiency and trade balance. However, the proposed methodology does not allow directly identifying the contribution of individual components of production potential to the level of economic security at the micro level.

Scientists, studying the competitiveness of agricultural enterprises, came to the conclusion that factors such as resource efficiency and adaptation policies to external threats have a significant impact on the analysis of competitiveness. This is confirmed by the work [6], which identified a direct relationship between the following indicators in wartime conditions: production indicators, logistics indicators and profitability. The work analyzed the competitiveness of agricultural enterprises of different sizes and identified the main factors of influence: financial stability, efficiency of use of fixed assets and profitability. Unresolved issues include the problem of transforming production potential indicators into indicators of economic security.

Modernization of the industry and investment attractiveness of the agricultural sector are considered in [7]. The issues of assessing the impact of state support and the lack of a model of the relationship between production capabilities and economic security remain unresolved.

In [8], the strengthening of production through technological modernization is presented. The conclusion is that precision farming systems significantly increase yields and minimize climate risks. Similar conclusions are also drawn by research [9], which shows that the implementation of IoT, Big Data, and automation increases the efficiency of resource use and reduces transaction costs. However, there is no unified approach in the literature to assessing the economic effect of digitalization from the perspective of long-term enterprise security.

The scenario approach to the sustainability of agri-food systems is considered in [10], where four development trajectories were identified – from reducing fragility to transformational adaptation. However, the empirical criteria for the transition between scenarios remain insufficiently formalized.

The financial component of security is considered in [11], where it is proven that enterprises with high liquidity and profitability indicators demonstrate higher resilience to geopolitical shocks. However, the authors do not integrate financial indicators with technological and resource characteristics of production potential

In [12], the impact of production indicators, product prices and product sales channels on the competitiveness of enterprises was identified. The impact of external risks in martial law conditions, in particular logistical disruptions and price instability on world grain markets, was ignored.

In [13], the main components for the competitive development of the agricultural sector and ensuring food security were analyzed. The issues of costs, technological dependence of energy consumption of soilless farming based on IoT were left out of consideration.

In [14], technological progress in the agro-industrial sector was studied according to Web of Science data (1979–2025). The accelerated growth of digitalization, artificial intelligence, precision agriculture, and automation was substantiated. The unresolved issue lies in the area of technology transfer and stimulation of innovations in the agricultural sector.

In [15], the feasibility of implementing risk management and technological modernization was substantiated in order to increase the sustainability of agri-food chains. The disadvantage of this study is the lack of a mechanism for transition from operational stability to strategic adaptation.

In [10], the main directions of system development were identified, which include the following areas: increasing resilience, reducing fragility, adapting to risks, and transformation. The construction of development scenarios at the micro level requires further consideration.

According to the results of the literature analysis, the competitiveness and security of agribusiness enterprises have evolved from a narrow understanding through productivity and cost indicators to a systemic multi-faceted category. It includes production potential, financial sustainability, innovation, environmental safety and sustainability of supply chains. Research by scientists proves the importance of technological modernization, digitalization, investment activity and export orientation in the formation of a competitive agricultural sector.

In contrast, a significant number of works investigate individual aspects of the functioning of the industry without considering a holistic model of economic security. Scientists do not pay enough attention to the mechanism of transformation of production potential into indicators of financial sustainability of the enterprise under conditions of competition and external risks. The literature lacks quantitative studies that would illustrate the relationship between investment activity, profitability and the level of vulnerability of the agricultural sector in dynamics.

Thus, there is a need to combine resource, competitive and financial approaches within a single paradigm that would allow treating production potential as the main factor of economic security of the agro-industrial complex. Such a combination is the theoretical basis for building a conceptual model and its testing.

The object of research is the processes of ensuring the security of the agro-industrial complex (AIC) of Ukraine in a competitive environment.

Accordingly, *the subject of research* is the relationship between indicators of production potential and financial vulnerability of the agro-industrial complex as an indicator of its economic security.

The aim of research is to theoretically substantiate and empirically verify the impact of production potential on the financial vulnerability of the agro-industrial complex in a competitive environment. The level of sector security is assessed through the share of unprofitable enterprises as an aggregate indicator of its financial stability.

To achieve the aim, it is necessary to solve the following objectives:

1) within the framework of theoretical and conceptual analysis, substantiate the mechanism of the relationship between production potential, competitive environment and economic security of the agro-industrial complex;

2) within the framework of empirical research, carry out an econometric assessment of the impact of production potential indicators on the level of financial vulnerability of the agro-industrial complex and interpret the results obtained.

2. Materials and Methods

The empirical basis of research is the official statistical data of the State Statistics Service of Ukraine for 2016–2023, which characterize the financial results of the activities of enterprises of section A “Agriculture, forestry and fisheries” and indicators of the production potential of the agro-industrial complex.

Taking into account the tasks set in the research; the following hypotheses were formulated and empirically tested:

- the growth of the production potential of the agro-industrial complex has a negative impact on the share of loss-making enterprises as an indicator of the financial vulnerability of the sector;
- indicators of production efficiency and investment activity are statistically significant determinants of the financial stability of the agro-industrial complex.

The research methodology is based on a combination of theoretical generalization and econometric analysis, which allowed for a comprehensive assessment of the impact of production potential on the financial vulnerability of the agro-industrial complex in a competitive environment.

A set of theoretical and empirical methods was used in the research process. Methods of analysis and generalization were used to systematize approaches to the interpretation of production potential, competitiveness and economic security of the agro-industrial complex. Economic and statistical methods were used to assess the dynamics of financial results and production indicators of the sector. To identify determinants of financial vulnerability and quantify the impact of production potential indicators on the share of unprofitable enterprises, methods of correlation and regression analysis (the least squares method) were used. The statistical reliability of the results was checked using econometric diagnostics. The results obtained were interpreted from the standpoint of forming mechanisms for increasing the financial stability of the agro-industrial complex in competitive conditions.

The choice of research methodology is based on the use of official statistical data of the State Statistics Service of Ukraine. The use of indicators of financial results of enterprises in section A “Agriculture, forestry and fisheries” allowed the formation of an indicator of the sector’s financial vulnerability – the share of unprofitable enterprises. Statistical data on the volume of capital investments, production dynamics, productivity and resource structure made it possible to form a system of indicators of the production potential of the agro-industrial complex. To ensure the comparability of indicators over time for 2016–2023, methods of standardization and harmonization of statistical series were used. The formed database became the basis for building an econometric model for assessing the impact of production factors on the level of financial vulnerability of the sector.

The use of the proposed methodological tools made it possible to assess the impact of production potential indicators on the level of financial vulnerability of the agro-industrial complex. An analytical basis was also formed for making management decisions to strengthen its economic security in a competitive environment and structural instability.

3. Results and Discussion

3.1. Justification of the mechanism of the relationship between production potential, competitive environment and economic security of the agro-industrial complex

The modern understanding of the security of the agro-industrial complex (AIC) was formed as a result of the evolution of the economic theory of security and agrarian economics. Over the past decades, the term “security” has gone from a narrow, purely quantitative interpretation of food self-sufficiency to a system of characteristics that determine the viability of the sector. Today, the security of the agro-industrial complex is considered as the ability of the production and financial system to maintain stability and form the potential for development in conditions of competition and structural transformation.

The traditional approach to defining the essence of the security of the agrarian sector was based on the category of “food security”, which was introduced after the grain crisis of 1972–1973 at the UN General Assembly in 1974. It was then that the understanding of security as guaranteed access to the world’s food resources was laid down [16]. Over the following decades, this concept has expanded, in particular after the World Food Summit in 1996 and subsequent FAO reports, food security is considered as a complex of four components: availability, accessibility, use and stability of food. Modern conditions put forward deeper requirements: ensuring food security is impossible without guaranteeing the financial sustainability of agricultural producers and their ability to function in a competitive environment [17, 18]. At the current stage of development, the concept of resilience occupies a special place. Within its framework, agricultural systems are considered as complex adaptive structures characterized by stability (preserving their functions under the influence of external risks), adaptability (the ability of subjects to adjust internal processes) and transformation (readiness for radical changes) [19].

The results of empirical studies of European farms confirm that resilience is not an abstract category, but has a practical basis. In particular, in the work [20] it is proved that the ability of agricultural systems to function and develop is determined by the characteristics of production, access to resources and management efficiency.

The study [21] presents a more comprehensive approach to the problem. The researcher claims that the main factors influencing the future sustainability and adaptability of the agricultural system are climate change, geopolitical dynamics, and volatility of world prices. Therefore, the security of the agricultural sector is determined not only by indicators of production volume, but also by the system's ability to maintain economic sustainability and maintain a high level of competitiveness in a strategic perspective.

Therefore, the modern understanding of the security of the agricultural sector involves the integration of structural components, the substantive characteristics of which are given in Fig. 1.

The security of the agricultural sector is always the result of the interaction of production resources, financial results and the competitive environment. To reflect this interaction, it is advisable to build a structural model that integrates the key components of sectoral stability and demonstrates the mechanism for transforming external challenges into financial results.

The systemic nature of the formation of the security of the agro-industrial complex is reflected in the conceptual model (Fig. 2), which demonstrates the presence of direct and feedback relationships between the production, financial and competitive components of the sector.

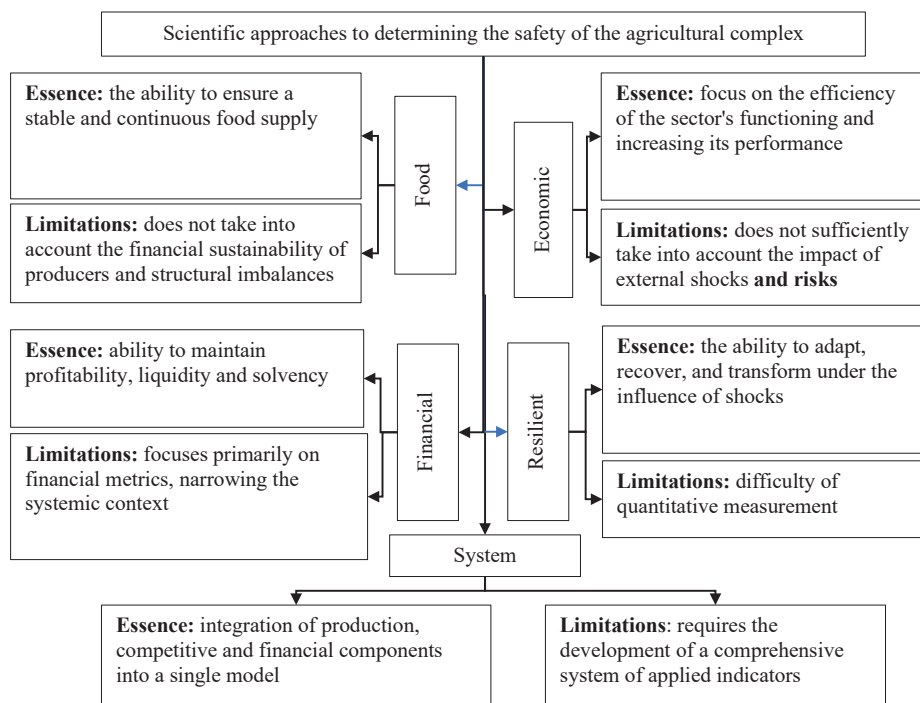


Fig. 1. Approaches to determining the security of the agro-industrial complex (compiled by the authors based on [16–21])

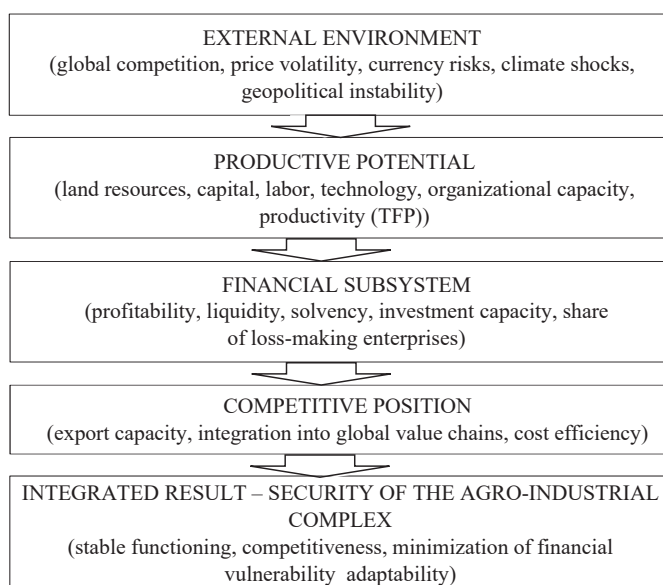


Fig. 2. System model of security of the agro-industrial complex (developed by the author on the basis of [17–20])

The security of the agro-industrial complex in the proposed model is considered as the result of the interaction of three components, namely, production potential, competitive environment and financial subsystem, which in the complex form the industry's resistance to external risks.

Exogenous risks, in particular price instability, currency fluctuations, climate change, geopolitical factors significantly affect the agro-industrial complex and increase the level of uncertainty of its development [21]. In such conditions, it is the production potential that plays an important role, which is formed on the set of labor, capital, land and technological resources. It is its level that is decisive in determining the positions of enterprises in the competitive environment and obtaining financial results [22, 23].

Through the mechanisms of market interaction, the competitive environment spreads external shocks to the internal structure of the industry. This creates a double effect. On the one hand, it stimulates efficiency, and on the other hand, it increases key financial indicators such as profitability, liquidity and solvency, financial stability [20]. The financial subsystem accumulates the results of the sector's functioning, reflecting the level of profitability, liquidity and solvency, which determine the degree of financial stability [20].

Integral security is formed as an aggregated state of the system and reflects its ability to operate stably and adapt in the long term. According to the concept of resilience of agrarian systems [19], security is dynamic in nature and assumes the presence of feedback: the achieved level of financial stability through the mechanism of reinvestment and modernization affects the further development of production potential.

Thus, the security of the agro-industrial complex is interpreted as the result of the systemic interaction of resource, market and financial factors in a competitive environment.

The defined system model of security of the agro-industrial complex allows to consider production potential as a basic structural prerequisite for the formation of financial stability and competitiveness of the sector. If integral security reflects the aggregated state of the system, then the production potential acts as its resource foundation, through which the adaptive and transformational capacity of the agricultural sector is realized.

Today, the production potential is increasingly understood as an integrated and dynamic system of interconnected resources, and not as their mechanical aggregate. This approach emphasizes that not only the availability of resources is of decisive importance, but also the effectiveness of their combination, which allows the industry to respond to external shocks and ensure competitiveness in the long term [19, 22, 23].

In this context, understanding the security of the agro-industrial complex requires a detailed consideration of the production potential as a systemic category, its internal structure and mechanisms of functioning in conditions of market competition.

Today, the production potential in the agricultural sector is considered as the ability of the agro-industrial complex to achieve economic results through the rational use of resources and the introduction of new technologies. Previously, within the neoclassical paradigm, the production potential was actually reduced to land, labor and capital, but modern approaches consider it much more broadly. In modern concepts, the resource theory of the firm and the idea of productivity are added to the factor approach, which allows to focus not only on the availability of resources, but also on their quality, competencies and capacity for innovation [22–24].

Research shows that the positions of producers in the market are directly related to their technical efficiency and overall level of productivity [22, 23]. The growth of total factor productivity means not only a more intensive use of resources, but also the willingness of enterprises to implement changes and improve production. Inclusion in global value chains is a factor in increasing productivity, as it provides access to modern technologies, new knowledge and international markets. However, such integration at the same time means greater dependence on the external environment and higher sensitivity to its fluctuations [25].

The peculiarities of the functioning of the agricultural sector are due to the influence of natural and climatic factors, the structural rigidity of land resources and increased vulnerability to price fluctuations. Therefore, it would not be enough to define production potential only by the volume of resources. First of all, production potential is characterized by the extent to which it provides high productivity and allows the sector to adapt to external changes.

Given the complex structure of production potential, it is advisable to separately identify its main elements (Fig. 3).

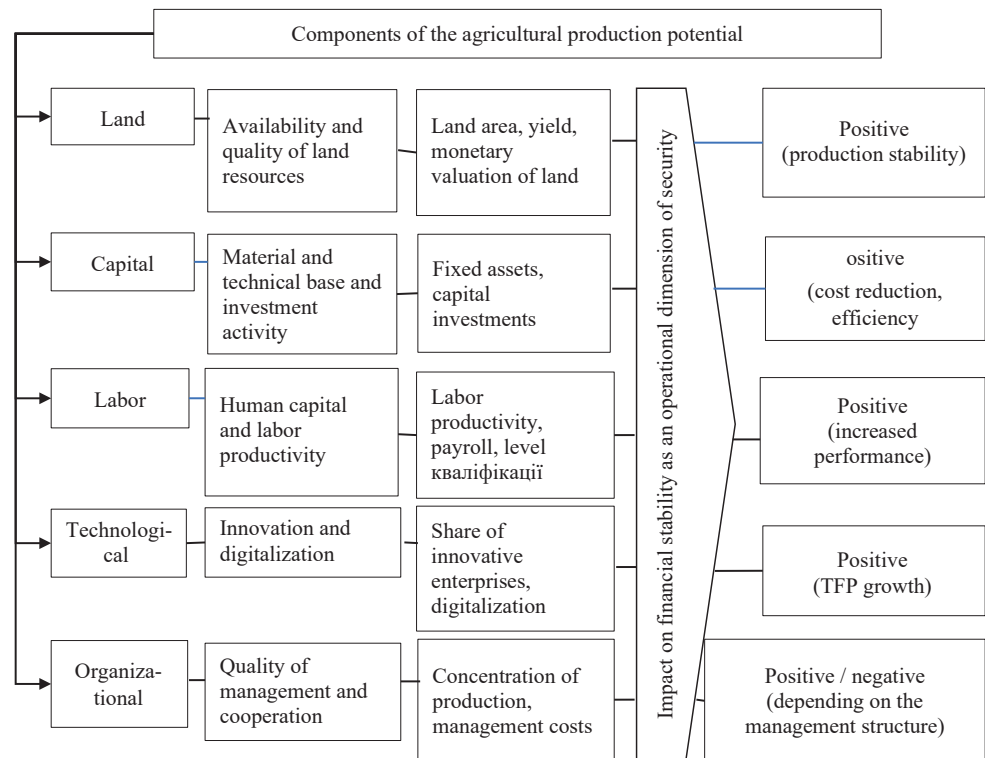


Fig. 3. Components of the production potential of the agro-industrial complex

Each of these components forms a separate dimension of efficiency, but only their interaction provides a systemic result. The technological level determines the intensity of resource use, organizational practices – management flexibility, and capital investments – the possibilities of modernization of production.

The logic of the implementation of the production potential is based on the consistent transformation of the resource base into productivity (total factor productivity, TFP, technical efficiency), which, in turn, determines the financial results and the level of sustainability of the sector.

The theoretical understanding of the production potential is carried out within the framework of several scientific paradigms (Fig. 4).

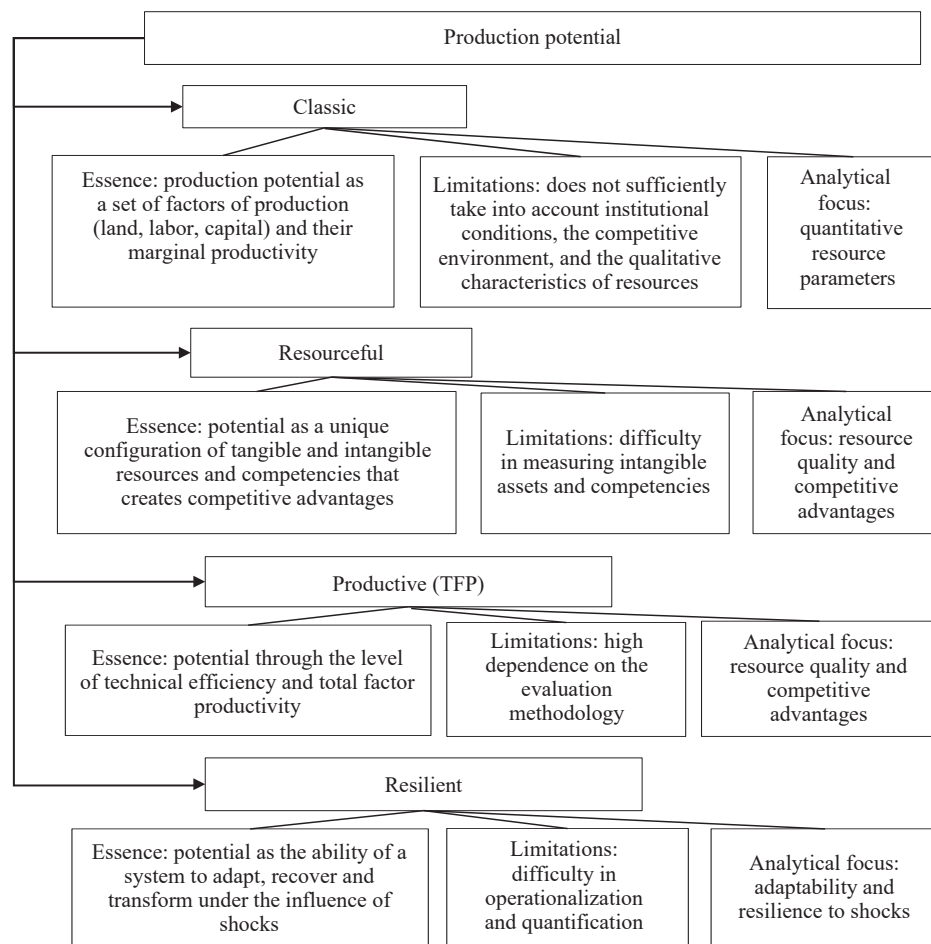


Fig. 4. Conceptual approaches to determining production potential (compiled by the author based on [19–22, 24])

Modern empirical research confirms that the level of total factor productivity (TFP) is a key determinant of the financial stability of agricultural producers [23, 24]. From the point of view of resource theory, it is the unique configuration of land, technological and managerial resources that forms a long-term competitive advantage [24]. At the same time, the resilience approach emphasizes the dynamic nature of potential, focusing on the ability of the system to adapt and transform under the influence of shocks [19].

In the system security model of the agro-industrial complex, production potential is the resource core through which the productivity and competitiveness of the sector are formed. Its impact on security is manifested through the mechanism of transforming productivity into financial results.

An increase in total factor productivity is reflected in the financial results of enterprises, improving their financial condition, liquidity and contributing to a decrease in the share of loss-making enterprises. All this has a positive effect on the overall level of security. In turn, an insufficient level of efficiency makes enterprises financially vulnerable in a competitive environment.

Therefore, production potential is not just a resource base of the agricultural industry, but also one of the key factors of its financial stability

and structural adaptability. It is the efficiency of the implementation of production potential that shapes the ability of the agro-industrial complex to provide an appropriate level of long-term security.

The integration of agricultural markets into the global space has significantly changed the nature of competition. It has ceased to be a local mechanism of market coordination and has become a systemic

factor in the structural transformation of the industry. Access to international markets expands the capabilities of enterprises to export manufactured products and integrate into international value chains. However, the dependence of producers' incomes on the world price situation and external shocks is increasing [17]. The agro-industrial complex is currently exposed to various types of risks, namely economic, climatic, institutional, geopolitical, which increases the instability of the market environment and affects the mechanisms of competition [21].

Competition should be considered in two aspects. On the one hand, it increases efficiency through optimization of resource allocation and productivity growth, on the other hand, it increases the sensitivity of the industry to fluctuations. Competitive pressure in the agro-industrial complex contributes to the introduction of innovations and increased technical efficiency, which is ultimately reflected in the growth of TFP [22, 23]. The sensitivity of the agro-industrial sector to fluctuations is determined by the level of its integration into global value chains. Such integration provides access to technologies and new markets, but at the same time increases sensitivity to external fluctuations [25].

Therefore, competition cannot be considered as an environment for the functioning of the agro-industrial complex. It is a mechanism through which production potential is transformed into certain financial results, determining the level of profitability, liquidity and financial vulnerability of enterprises.

Summarizing the above, it is worth considering the main directions of security transformation under the influence of competition (Table 1).

Table 1

Directions of the influence of competition on the security of the agro-industrial complex

Direction of influence	Mechanism of influence	Impact result
Price	Fluctuations in world prices	Increased financial vulnerability
Technological	Differentiation of technological level	Divided enterprises by level of efficiency
Resource	Fluctuations in the cost of capital	Increased financial risks
Logistics	Logistical failures	Increased operational risks

Within the framework of the concept of resilience, competition acquires additional importance. It is considered as a mechanism of market selection of competitive enterprises. Enterprises with high productivity, diversified activity structure and effective management are more adapted to market shocks [20]. At the same time, high competition can increase the vulnerability of enterprises with lower technical efficiency.

Thus, competition performs not only the function of increasing efficiency, but also the function of structural transformation. Its impact on the security of the agro-industrial complex is multi-vector and depends on the combination of production, financial and institutional characteristics. To generalize the systemic effects of competition in the formation of security, it is advisable to highlight its key functions (Table 2).

Table 2

Functions of competition in the formation of the security of the agro-industrial complex

Competition function	Function content	Mechanism of influence on the security of the agricultural complex
Stimulating	Contributes to increasing the efficiency of resource use	Productivity growth (TFP) → increased profitability → strengthening financial stability
Selection	Selection of more efficient producers	Displacement of low-performance enterprises → structural renewal of the sector → increased average stability
Transmission	The impact of external shocks on the internal structure of the industry	World price volatility → change in profitability → fluctuations in financial stability
Global Integration	Integration into global value chains	Access to technologies and markets → increased productivity; at the same time, increased dependence on external risks
Regulatory	Coordination of the interaction of production and financial parameters	Regulation of the impact of productivity on financial results

Note: compiled by the authors based on [17, 20–25]

Thus, competition should be considered as a factor that determines the degree and direction of the influence of production potential on financial stability and, accordingly, the overall level of security of the industry.

The generalization of scientific approaches gives grounds to assert that the modern understanding of the security of the agro-industrial complex is much broader than its interpretation within the framework of the food or financial approach. It is interpreted as a complex characteristic of the stable functioning of the agro-industrial sector, its competitiveness and financial stability in conditions of instability.

Within the framework of the developed model, the security of the agro-industrial complex is formed through the interaction of three interrelated components:

- production potential, which is the resource base of the system;
- the competitive environment, which ensures the transformation of productivity into activity results;
- the financial subsystem, which reflects the final results, efficiency and stability of the agro-industrial complex.

Production potential forms economic opportunities, but their implementation depends on the conditions of competition. Thus, the security of the agro-industrial complex is dynamic in nature and reflects the system's ability to adapt and recover. Thanks to the mechanism of reinvestment and modernization, a feedback loop is formed, when financial stability provides opportunities for the further development of production potential.

Summarizing the theoretical analysis, the following research logic can be formulated: production potential shapes productivity, competi-

tion determines the conditions for its implementation in financial indicators, and financial stability reflects the level of security of the sector.

In this context, it is advisable to assess the security of the agro-industrial complex through a system of quantitative indicators that reflect the financial vulnerability and structural features of the agricultural sector. This approach provides a transition from the conceptual level of analysis to the construction of an econometric model aimed at identifying the impact of production potential and the competitive environment on the financial stability of the agro-industrial complex.

The proposed theoretical construction forms a holistic methodological basis for further empirical research and allows integrating resource, competitive and financial dimensions of security into a single analytical system.

3.2. Assessment of the impact of production potential indicators on the level of financial vulnerability of the agro-industrial complex

The proposed theoretical framework is based on the transition from a conceptual understanding of the security of agro-industrial complex enterprises to its quantitative assessment. The research considers production potential as a condition for profitability and financial stability. Instead, competition is a factor that leads to the transformation of production results into financial indicators. The proposed provisions from the point of view of empirical verification have undergone an econometric analysis of the impact of production potential indicators on the degree of financial vulnerability of the agro-industrial complex of Ukraine for 2016–2023.

Ensuring the security of agro-industrial complex enterprises is carried out taking into account the indicator of the share of loss-making enterprises in section A "Agriculture, forestry and fisheries", which reflects the aggregated state of financial stability of the industry [26–28].

To empirically test the hypothesis regarding the impact of production potential on the level of economic security of the agro-industrial complex, an annual data panel for Ukraine for 2016–2023 was formed. The following indicators were also used: the share of loss-making enterprises in section A, indicators of investment activity and production potential. The obtained data are given in Table 3.

Table 3

Annual data set for Ukraine (2016–2023)

Year	Share of unprofitable enterprises, % (Y)	Capital investments in section A, million dollars (X ₁)	Yield of grain and legume crops, c/ha (X ₂)	Gross harvest of grain and legume crops, thousand tons (X ₃)
2016	23.6	1975.89	46.1	66088
2017	13.6	2366.22	42.1	61917
2018	8.5	2446.48	47.4	70057
2019	18.1	2288.31	49.1	75143
2020	28.9	1879.82	42.5	64933
2021	30.1	2563.21	53.9	86010
2022	35.9	1590.57	45.8	53864
2023	31.3	1789.23	55.2	59772

Note: dependent variable – share of loss-making enterprises in section A; X – indicators of production potential

During the period 2016–2023, the dynamics of the percentage of loss-making enterprises in section A is characterized by significant volatility and a significant deterioration in the financial condition in the second half of the period under review. The percentage of enterprises that suffered losses was 23.6% in 2016, but decreased to 13.6% in 2017 and 8.5% in 2018. This trend indicates an improvement in the financial results of enterprises in the agricultural sector.

In 2019, there were negative trends in the dynamics of this indicator: starting from 2019, the indicator demonstrated a stable upward trend, increasing from 18.1% in 2019 to 31.3% in 2023, with a peak value of 35.9% in 2022. This dynamics indicates a significant decrease in the financial stability of the sector in the face of growing internal and external risks, in particular military threats, logistical disruptions and pandemic restrictions.

Thus, if in 2017–2018 there was a temporary improvement in financial results, then in the subsequent period a trend towards increasing financial vulnerability was formed, which has signs not only of cyclical, but also of structural transformation of the economic security of the agro-industrial complex.

In order to visualize the trends in the financial vulnerability of the agricultural sector, the dynamics of the share of loss-making enterprises in section A for 2016–2023 was analyzed. The corresponding changes are shown in Fig. 5.

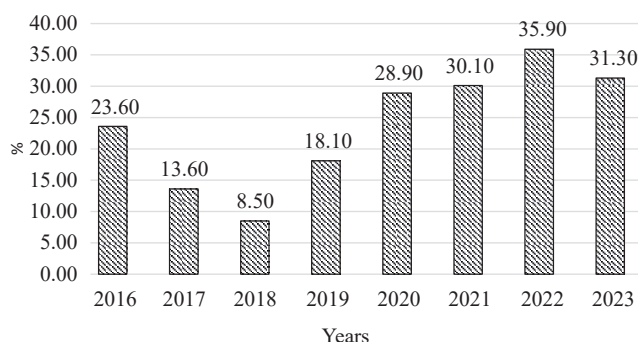


Fig. 5. Dynamics of the share of unprofitable enterprises in section A "Agriculture, forestry and fisheries" in Ukraine, 2016–2023, %

The growth of the indicator after 2020 reflects the impact of pandemic restrictions, disruption of logistics chains, as well as large-scale military risks in 2022–2023.

It should be noted that section A demonstrated some improvement in the financial results of agricultural sector enterprises, which affected the share of unprofitable enterprises, and in 2018 this indicator had the lowest value. This indicates a short period of stabilization, which preceded the deepening of crisis phenomena.

It should be noted that high overall productivity of some enterprises does not automatically translate into financial stability of the industry in a competitive environment, price instability and institutional constraints.

The dynamics of capital investments in section A were also unstable. In 2016, the volume of capital investments amounted to 1975.89 million USD, in 2017 there was an increase to 2366.22 million USD and 2446.48 million USD in 2018. This trend indicates an increase in investment activity in the industry. In 2020, this indicator is reduced to 1879.82 million USD, 2021 is characterized by growth - 2563.21 million USD, a decline in 2022 and growth in 2023 to 1789.23 million USD. Its graphic representation is shown in Fig. 6.

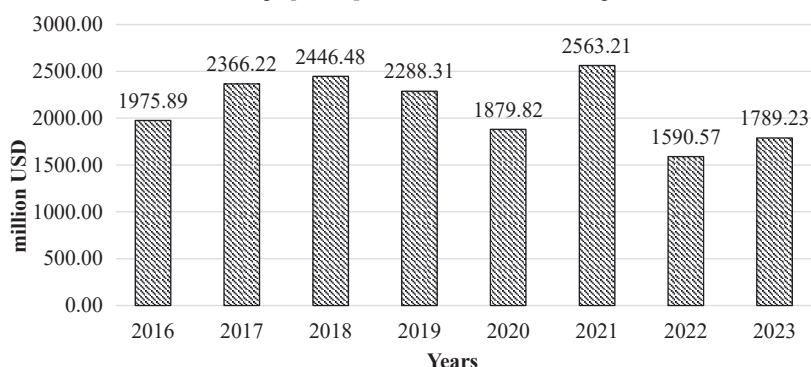


Fig. 6. Capital investments in section A, 2016–2023, million USD

The unstable dynamics of capital investments indicates the dependence of production potential on macroeconomic and geopolitical risks. In competitive conditions, the modernization of production capacities, the introduction of innovative technologies, and increasing the efficiency of resource use depend on investments. The consequence of negative downward trends is a reduction in the ability of enterprises to adapt to changes in market conditions.

When considering the dynamics of grain and leguminous crops yields in 2016–2023, an upward trend was detected with interannual fluctuations. The dynamics of the indicator indicates gradual growth, despite the results of 2017, when the value was at the level of 42.1 c/ha. Already in 2021 and 2023, there are the maximum values for the period under study of 53.9 c/ha and 55.2 c/ha, respectively. Compared to 2018, the yield increased from 47.4 to 55.2 c/ha, which indicates an improvement in production technology and rational use of resources.

However, the increase in the share of unprofitable enterprises during 2020–2023, combined with an increase in productivity, demonstrates discrepancies between production results and financial stability, which are influenced by external risks and the competitive environment.

Fig. 7 shows the dynamics of grain and legume yields in order to assess the technological efficiency of production.

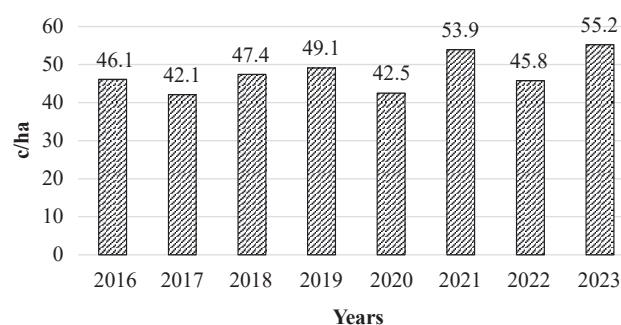


Fig. 7. Grain and legume crop yields in Ukraine, 2016–2023, c/ha

Analysis of the gross harvest of grain and legume crops in the analyzed period 2016–2023 showed significant volatility. The dynamics of this indicator was unstable: relatively stable volumes in 2016–2018 (66.1–70.1 million tons), in 2019 there was a significant increase (75.1 million tons), in 2020 a decline to 64.9 million tons was recorded. In 2021, this indicator reached its maximum value for the studied period and amounted to 86.0 million tons. In the following 2022, this indicator amounted to 53.9 million tons, which was a consequence of the first year of the military conflict. Already in 2023, the gross harvest volume increased slightly to 59.8 million tons, but this indicator has not yet reached the pre-war level.

The above dynamics confirm the structural limitations of the realization of production potential in conditions of significant instability and disruption of the logistics component. These factors affect the ability of the agricultural sector to transform production results into stable financial indicators.

The analysis of changes in the gross harvest of grain and leguminous crops was carried out in order to assess the scale of the realization of production potential. The data are shown in Fig. 8.

The simultaneous increase in yield and the presence of a large share of unprofitable enterprises indicates a discrepancy between productivity and financial results. This indicates a structural asymmetry of the competitive environment.

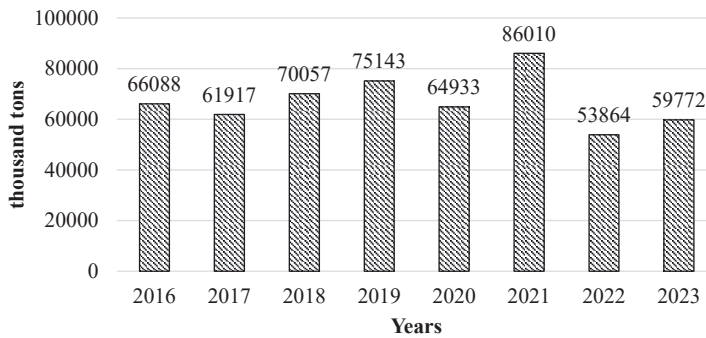


Fig. 8. Gross harvest of grain and leguminous crops in Ukraine, 2016–2023, thousand tons

The main statistical parameters were calculated in order to characterize the variation of indicators and the general structure of the formed sample. The research results are given in Table 4.

Table 4

Descriptive statistics of variables (2016–2023)

Variable	Mean	Standard deviation	Minimum	Maximum
Share of loss-making enterprises, %	23.75	9.70	8.5	35.90
Capital investments, million USD	2112.47	350.45	1590.57	2563.21
Yield c/ha	47.76	4.82	42.1	55.20
Gross grain harvest, thousand tons	67223.00	10391.87	53864.00	86010.00

Table 4 shows the average share of loss-making enterprises in section A for the period under study 2016–2023. The average value is 23.75%, which confirms the high level of vulnerability of the agricultural sector in the period under analysis. The standard deviation of the indicator was 9.70, which indicates significant interannual volatility of financial results. It should be noted that capital investments, yield and gross harvest (indicators of production potential) also have noticeable variability. This creates a statistical basis for further analysis of the impact of these indicators on the level of economic security of the sector. A correlation analysis was carried out to identify trends and statistical relationships between production potential and the share of loss-making enterprises. The results are presented in Table 5.

Table 5

Pearson correlation coefficient matrix

Indicators	Y Share of loss-making enterprises	X ₁ Investment	X ₂ Yield	X ₃ Gross collection
Y: Share of loss-making enterprises	1.000	-0.284	0.214	-0.176
X ₁ : Investment	-0.284	1.000	0.618	0.552
X ₂ : Yield	0.214	0.618	1.000	0.360
X ₃ : Gross yield	-0.176	0.552	0.360	1.000

The correlation analysis revealed a weak negative relationship between the share of unprofitable enterprises and the volume of capital

investments ($r = -0.284$) and between the share of unprofitable enterprises and the scale of production ($r = -0.176$). Such indicators partially confirm the assumption about the stabilizing influence of investment activity and production scale in ensuring the financial stability of the agricultural sector. However, the strength of the relationship does not confirm an unambiguous dependence.

The relationship between yield and the share of unprofitable enterprises is positive, but weak and is $r = 0.214$, that is, it indicates the complexity of the interaction of physical indicators of productivity and financial results. This is due to the fact that increasing yield cannot guarantee a decrease in the financial vulnerability of the enterprise, if the price situation, costs and institutional environment are not taken into account.

The obtained correlation indices between investments and yield ($r = 0.618$) and investments and gross harvest confirm the relationship of individual components of production potential. This indicates the feasibility of further multivariate regression analysis to assess their partial impact.

The level of correlation does not indicate critical multicollinearity, despite the relationship between regressors. For example, the relationship between investments and yield is small and below the threshold values. Usually this indicates significant distortions of parameter estimates.

As a conclusion, it can be stated that the results of the correlation analysis indicate the presence of statistical relationships between indicators of production potential and the level of financial security of the agro-industrial complex. Correlation coefficients do not allow assessing the impact of several factors simultaneously and determining their significance in the formation of the level of economic security, this requires the use of a multivariate regression model.

Checking the stability of the obtained results and assessing the impact of the temporal nature of production potential requires the use of two model specifications.

To assess the current impact of production indicators on the share of loss-making enterprises in the corresponding year, model 1 was selected

$$Y_t = \alpha + \beta_1 \ln(Inv_t) + \beta_2 Yield_t + \beta_3 \ln(Output_t) + \varepsilon_t, \quad (1)$$

where Y_t – the share of loss-making enterprises in year t ; Inv_t – capital investment; $Yield_t$ – the yield of grain and legume crops (t/ha); $Output_t$ – the gross harvest of grain and legume crops (thousand tons); ε_t – the random error.

The use of logarithms of the variables “capital investment” and “gross harvest” helps to reduce the scale effect, increase the stability of the dispersion, and interpret the coefficients as semi-elasticities.

Using model (2), the hypothesis of the delayed effect of investment and production activity on the financial results of agricultural enterprises was tested

$$Y_t = \alpha + \beta_1 \ln(Inv_{t-1}) + \beta_2 Yield_{t-1} + \beta_3 \ln(Output_{t-1}) + \varepsilon_t. \quad (2)$$

Such a specification is based on the assumption that investment decisions, changes in production efficiency and production scale are transformed into financial results with a certain time delay, due to the inertia of economic processes and the peculiarities of the production cycle in the agricultural sector.

The obtained correlation estimates allow to draw preliminary conclusions about the directions of the relationship between variables, but do not allow to assess their simultaneous influence and relative significance. For this purpose, multivariate regression models were constructed, the evaluation results of which are presented in Table 6.

Table 6

Results of evaluation of regression models

Variables	Model 1	Model 2 (lag)
$\ln(\text{Inv})$	-50.64 (-1.64)	-32.64 (-0.78)
<i>Yield</i>	1.63 (2.00)	2.10 (1.73)
$\ln(\text{Output})$	-15.95 (-0.63)	-3.37 (-0.10)
<i>Constant</i>	679.68 (2.04)	321.33 (0.33)
<i>N</i>	8	7
R^2	0.337	0.459
<i>Adjusted R²</i>	0.246	-0.082
<i>F</i>	0.847	0.832
<i>p-value (model)</i>	0.393	0.558

Note: coefficient estimates are given by the method of least squares (OLS); in parentheses – *t*-statistics

The parameter estimates in the two specifications demonstrate consistency in the direction of influence of key variables.

The coefficient for $\ln(\text{Inv})$ in the two models has a negative value (-50.64 and -32.64, respectively), which confirms the hypothesis of the stabilizing role of investments in reducing the financial vulnerability of enterprises in the agricultural sector. This proves that the increase in investment activity is associated with a decrease in the share of loss-making enterprises, despite the fact that the statistical significance of the estimates is limited.

The coefficient for the yield indicator showed a positive value in two models (1.63 and 2.10), which indicates the structural features of the agricultural sector, according to which the increase in physical productivity does not guarantee an improvement in financial results. This result is consistent with the assumption of the influence of price conditions, logistics costs and institutional constraints on the financial sustainability of agricultural enterprises.

The coefficient of determination in the basic model is $R^2 = 0.337$, in the lag model $R^2 = 0.459$. The adjusted coefficient of determination in the lag model has a negative value (-0.082), which is due to the small sample size ($N = 7$) and the number of regressors. The ability to make precise cause-and-effect relationships is limited, since none of the specifications is statistically significant according to the *F*-criterion ($p > 0.10$).

Despite this, the preservation of the directions of influence of key variables in the two specifications confirms the economic logic of the relationship between investment activity and the financial sustainability of the sector. The lag model partially supports the assumption of time inertia of the transformation of production potential into financial results of enterprises.

Given the features of the empirical base and assessment methodology used, it is advisable to outline the main limitations of the research that may affect the interpretation of the results obtained.

Checking the relationships between the regressors showed a moderate correlation between the components of production potential (Table 6), which can potentially affect the accuracy of parameter estimates in the multivariate model. At the same time, the level of interdependence is not critical for interpreting the directions of influence of key variables.

In general, the results confirm the presence of a negative association between investment activity and the financial vulnerability of the agricultural sector, and also indicate a possible time inertia of the influence of production potential.

However, the obtained values can only be indicative due to the limited observation horizon.

Considering the peculiarities of using the empirical base and research methodology, it is necessary to note the main limitations of the research that can influence the interpretation of the results obtained.

The limitation of research is, firstly, the small sample size (2016–2023), which reduces the statistical value of the assessment and affects the value of the adjusted coefficient of determination. Secondly, it is limited in the ability to take into account the intra-industry heterogeneity of the use of aggregated data at the country level without a regional breakdown. Thirdly, the absence of institutional and price changes that can play a significant role in the formation of financial results.

The results obtained allowed to form the following practical conclusions regarding the management of enterprises in a competitive market and the formation of state economic policy:

1. Reducing the financial vulnerability of an enterprise is based on investment stability. The presence of a negative value of the coefficient $\ln(\text{Inv})$ in two models allows to conclude that it is advisable to develop long-term financing mechanisms for the modernization of agricultural enterprises. In this case, it is necessary to develop investment lending, guarantee instruments and access to capital.

2. Physical productivity does not fully provide financial security. The obtained positive yield coefficient indicates that the growth of economic efficiency cannot fully ensure the improvement of financial results without taking into account the market and institutional environment.

3. Investment decisions have a prolonged effect in time. Accordingly, the higher explanatory power of the lag model indicates the inertia in time of the transformation of production potential into financial results, which indicates the strategic orientation of innovation policy.

4. Risk management mechanisms at agricultural enterprises are actualized by the high volatility of the sector.

Thus, the economic security of agro-industrial complex enterprises is formed under the influence of production potential. The influence is realized through access to financial resources, a competitive market and an institutional environment. The results obtained form the directions of further research using panel data and are of indicative value.

3.3. Discussion of the research results on the security of the agro-industrial complex in competitive conditions

The obtained results demonstrate the complex and nonlinear nature of the relationship between production potential and the security of the agro-industrial complex in a competitive environment.

Firstly, the relatively high average level of the share of unprofitable enterprises in the sector (23.75%) combined with the significant volatility of the indicator ($\sigma = 9.70$ pp) indicates the structural instability of the financial subsystem of the agro-industrial complex. The peak value in 2022 is especially indicative – 35.9%, which reflects the increased sensitivity of agricultural production to external economic and geopolitical shocks. The obtained results are consistent with approaches to the analysis of the resilience of agricultural systems [19, 20]. The security of the sector is determined not only by the level of productivity, but also by the ability of the system to adapt to multidimensional risks and maintain stable functioning in conditions of external instability.

Secondly, the results of the regression analysis showed a stable negative sign of the coefficient for the variable $\ln(\text{Inv})$ (-50.64 in the base model and -32.64 in the lag model), which is economically consistent with the hypothesis of the stabilizing role of investment activity. At the same time, the statistical significance of the models remains limited ($p = 0.393$ and $p = 0.558$), which indicates that production potential is not an isolated factor in the formation of the financial security of the sector. The explanatory power of the models indicates that from 33% to 46% of the variation in financial vulnerability can be associated with production potential indicators. Instead, the rest is determined by other factors, such as institutional, price and logistical.

Third, the positive coefficient for yield (1.63 and 2.10) indicates the existence of a gap between physical productivity and financial results. Even with an increase in yield to 55.2 c/ha in 2023, the share of loss-making enterprises remained at 31.3%. This demonstrates that an increase in total factor productivity does not automatically translate into financial sustainability. This conclusion is consistent with studies of the impact of global price volatility and integration into value chains [25], which emphasize that a competitive environment simultaneously promotes productivity growth and increases financial risks.

Therefore, the results obtained confirm the systemic interpretation of the security of the agro-industrial complex. Production potential is a necessary but insufficient conditional factor of financial stability. Competition acts as a moderator that determines the ability of the sector to convert productivity into profit.

On the other hand, the results obtained should be analyzed taking into account the methodological limitations of the research. When interpreting the research results, it is necessary to take into account certain limitations of the methodology used. The small sample size ($N = 7-8$) reduces the statistical power of the assessment and partially explains the value of the adjusted coefficient of determination (Adjusted $R^2 = -0.082$ in the lag model). The use of aggregated data at the national level does not reflect the internal heterogeneity of agricultural producers, and the absence of variables related to price, institutional and logistical factors in the model limits the possibilities of explaining the financial vulnerability of the sector. At the same time, these factors do not eliminate the economic logic of the results obtained, but only determine the boundaries of their interpretation. The preservation of the same direction of influence of variables in the two specifications of the model may indicate the presence of a reasonable relationship between investment activity and financial security of the agricultural sector. Further research should be directed at expanding the database and including additional factors of the market and institutional environment.

4. Conclusions

1. Within the framework of theoretical and conceptual analysis, the mechanism of the relationship between production potential, competitive environment and economic security of the agro-industrial complex is substantiated. It is proved that production potential acts as a resource basis of the system and forms the productivity of the sector, while competition acts as a moderator of the transformation of production results into financial indicators. The financial subsystem accumulates the results of this interaction through profitability indicators and the share of unprofitable enterprises. The proposed system model confirms that the economic security of the agro-industrial complex is dynamic in nature and is formed through the interaction of resource, market and financial components with the presence of feedback through the reinvestment mechanism.

2. As part of the empirical study, an econometric assessment of the impact of production potential on the level of financial vulnerability of the agro-industrial complex of Ukraine for 2016–2023 was carried out. The average value of the share of loss-making enterprises was 23.75%, with a maximum of 35.9% in 2022, which confirms the high volatility of the financial stability of the sector. Regression analysis showed a stable negative sign of the coefficient at $\ln(\text{Inv})$ (-50.64 in the base model and -32.64 in the lag model), which confirms the hypothesis of the stabilizing role of investment activity. The explanatory power of the models is $R^2 = 0.337$ and 0.459 , respectively. Although the statistical significance of the estimated models is limited ($p > 0.10$), the results obtained demonstrate an economically justified direction of dependencies, which is consistent with theoretical provisions and the results of previous studies.

The results obtained confirm the complex and nonlinear nature of this interaction, forming an analytical basis for the development of

mechanisms to support the industry. Given the identified feedback between investment activity and the vulnerability of the sector, the strategic vector of macroeconomic policy should be aimed at institutional support for the modernization of production. This will allow forming an integral shield against exogenous shocks, which is critically important for preserving the reproductive potential of the entire agro-industrial sector.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, including financial, personal, authorship or other, which could affect the research and its results presented in this article.

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Data availability

The manuscript has no related data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

Authors' contributions

Tatyana Kuzenko: Conceptualization, Methodology, Verification, Writing – review and editing, Project administration; **Valerii Bereza:** Conceptualization, Methodology, Verification, Writing – review and editing, Project administration; **Inna Sabadash:** Conceptualization, Methodology, Formal analysis; **Kateryna Harbazi:** Conceptualization, Methodology, Investigation; **Volodymyr Tsyupak:** Conceptualization, Methodology, Formal analysis, Writing – original draft; **Pavlo Matvieiev:** Conceptualization, Methodology, Investigation; **Serhiy Selikhov:** Conceptualization, Methodology, Investigation.

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✉ **Tatyana Kuzenko**, PhD, Associate Professor, Department of Finance and Credit, Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine, e-mail: kol-dis@ukr.net, ORCID: <https://orcid.org/0000-0003-3013-9487>

Valerii Bereza, PhD, Livestock Farming Institute of the National Academy of Agrarian Sciences of Ukraine, Kharkiv, Ukraine, ORCID: <https://orcid.org/0009-0006-6698-2889>

Inna Sabadash, PhD, Livestock Farming Institute of the National Academy of Agrarian Sciences of Ukraine, Kharkiv, Ukraine, ORCID: <https://orcid.org/0009-0001-5267-9153>

Kateryna Harbazihi, PhD, Associate Professor, Department of Trade Entrepreneurship, Commodity Science and Business Management, Odesa National University of Technology, Odesa, Ukraine, ORCID: <https://orcid.org/0009-0001-3059-3623>

Volodymyr Tsyupak, PhD, Livestock Farming Institute of the National Academy of Agrarian Sciences of Ukraine, Kharkiv, Ukraine, ORCID: <https://orcid.org/0009-0001-3886-6673>

Pavlo Matvieiev, Doctor of Economic Sciences, Associate Professor, Director, LIMITED LIABILITY COMPANY "ZEMINFORM", Kharkiv, Ukraine, ORCID: <https://orcid.org/0000-0003-0194-6909>

Serhii Selikhov, PhD, Livestock Farming Institute of the National Academy of Agrarian Sciences of Ukraine, Kharkiv, Ukraine, ORCID: <https://orcid.org/0009-0009-4040-2235>

✉ Corresponding author