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Agricultural enterprise economic security systems modelling

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Abstract. The research relevance was determined by the current conditions of economic instability and the growing influence of external factors on the economic activities of enterprises, understanding and effective management of economic security issues is becoming extremely important for ensuring the sustainability of agricultural enterprises. The study aimed to provide a comprehensive analysis of the economic security of an agricultural enterprise, focusing on identifying key aspects and their impact on the sustainability and viability of the enterprise. The study employed an analytical method, statistical method, functional method, system analysis method, deduction method, synthesis method and comparison method. This study focuses on the economic security of agricultural enterprises, considering the complex aspects of efficiency, risk protection and the ability to adapt to changes in the economic environment. The study defines economic security as a systematic approach to risk management and sustainability. Particular attention is devoted to responding to changes in the external environment, such as price fluctuations, climate anomalies and global market trends. Theoretical models, such as the risk system model, effective resource management, innovative development, and global competitiveness, which determine various aspects of economic security, were considered. The study focuses on the financial condition of the agricultural company Kernel, which proved to be dynamic and ambiguous in 2020-2023. The analysis includes factors such as the impact of geopolitical events and economic instability due to the war. The company implements strategies for global competitiveness, demonstrating flexibility, innovation, and diversification to ensure sustainability. Strategies are proposed to expand production diversification, improve risk management, and use innovative

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technologies to adapt to climate change. The practical application of this study lies in the possibility of using the results and recommendations developed on their basis to improve the economic security systems of agricultural enterprises

Keywords: financial risks; resource optimisation; innovative strategies; market challenges; adaptation to changes

INTRODUCTION

In the modern world, the agricultural sector is a crucial component of the economic structure. The relevance of studying the economic security systems of agricultural enterprises is extremely important in the face of growing challenges caused by market instability and the impact of external factors. Agrarian enterprises, performing an economic function, are a key element of the global economy and are inextricably linked to food security and rural development. Despite these important roles, agricultural enterprises face numerous challenges and economic risks arising from unforeseen circumstances. Climate change, geopolitical turbulence and rapid technological change pose serious challenges to their successful operation. In Ukraine, the main challenge facing agricultural enterprises is the war. Studying and optimising the economic security systems of agricultural enterprises in wartime is a strategically important task. This is necessary to ensure their sustainability and development in a changing economic environment, which is determined not only by economic instability but also by geopolitical and climate change. Issues related to economic security in the agricultural sector are becoming increasingly urgent, as global competition and the growth of new challenges, such as urbanisation and changing consumer trends, require careful study and development of appropriate management strategies. This approach opens up prospects for improving effective management strategies of agricultural enterprises, contributing not only to their stability but also to restoring the balance in the global agricultural sector.

N. Volkova *et al.* (2023), analysing the key aspects of economic security of agricultural enterprises, systematically revealed the impact of factors that determine the sustainability of these enterprises in a changing market environment. Their research focuses on the mechanisms of adaptation of enterprises to economic fluctuations, considering effective resource and risk management strategies. Determining the importance of economic security research for the successful functioning of agricultural enterprises, V.S. Lesyuk (2021) focuses on the development of methods for effective risk management. His work proposes specific strategies and approaches to ensure financial stability and competitiveness in a volatile market. The study by O. Pravdyvets (2023), in turn, aims to study innovative approaches to modelling the economic security of enterprises. It provides sound modelling methods that consider current trends and challenges, such as climate change and technological progress. N.Y. Drabchuk (2023) determined optimisation strategies for the use of economic resources of agricultural enterprises by considering the issues of resource management. His research examines the practical aspects of balanced use of resources, which affects the overall sustainability and efficiency of management. The study by O. Kubai and O. Zastavniuk (2022) also examines the economic security of agricultural enterprises through the lens of global trends. Their work thoroughly analyses the impact of climate change and geopolitical factors on the sustainability and development of the agricultural sector, contributing to an understanding of how these larger trends may shape the future of the industry.

In general, the results of these studies form a comprehensive approach to understanding the economic security of agricultural enterprises, providing valuable scientific grounds for further research and implementation of effective management strategies in this sector. However, the development of specific strategies for improving the economic security of agricultural enterprises was not sufficiently presented. The study aims to provide a comprehensive analysis to improve the economic security systems of agricultural enterprises to ensure the sustainability and efficiency of the industry in the current economic environment.

MATERIALS AND METHODS

The study is based on a comprehensive analysis of several materials, including theoretical sources, financial reports of agricultural enterprises, documentation on yields, sown areas, operational indicators, and statistical reports. For a detailed review of the economic situation in the selected sector, the financial reports of the agricultural enterprise Kernel for the last 4 years (FY2023 Annual Report, 2023) were used. Thus, trends and key financial indicators of the industry were identified.

The analysis of documentation covering aspects of yields, sown areas and operational indicators provided an opportunity to understand production efficiency and factors affecting the profitability of agricultural enterprises (Kernel – The profitability…, 2023; Kernel – Everything about…, 2023). The active use of open data and statistical reports related to the agricultural sector helped to contextualise the results and determine the place of the industry in the economic environment. Consideration and analysis of academic articles and research in the field of agricultural economics and the security of agricultural enterprises play an important role in expanding the theoretical basis of the study.

The analytical method was primarily used to study the financial performance of agricultural enterprises in recent years. The statistical method used to study data on yields, revenues and other agricultural indicators was useful. This method was employed to identify trends that define agriculture and to establish correlations between different variables, which contributed to a deeper understanding of the factors that affect the efficiency of the industry and improved the understanding of the dynamics of the agricultural sector. The functional method was used to identify key aspects of resource and risk management in agricultural enterprises. This approach was employed to focus on the efficiency of business processes and identify opportunities for further improvements.

The study of the interrelationships of the agricultural system using the system analysis method provided a comprehensive view of the factors that determine economic security. This method was used to connect various elements, such as production, financial management and risk management, to create a holistic picture of the industry. The identification of general principles for managing the economic security of agricultural enterprises based on the deduction method involved the study of specific cases and facts. This approach was used to identify fundamental principles that can be applied in a broader context.

The synthesis method was used to create a holistic view of the economic security system of agricultural enterprises. This method was employed to overcome limitations and to consider the sector as a single complex. The comparative method was used to compare management strategies, risks, and resources of agricultural enterprises, which helps to select effective tools for applying the optimal approach. This method was employed to identify best practices that can be used for adaptation to improve the efficiency of the sector. As a result, these measures were used to assess the effectiveness of resource and risk management in agricultural enterprises and to consider the feasibility of implementing specific recommendations to improve the system.

RESULTS

Economic security is a key aspect of modern enterprise management, as it determines their sustainability, viability, and ability to adapt to changes in the economic environment. This concept encompasses a comprehensive set of factors that ensure the efficiency of economic activity and protect against the negative impact of external and internal threats. When defining the economic security of enterprises, it should be seen as a systematic approach to risk management and sustainability (Kahler, 2004). One of the key aspects of this concept is the ability to respond adequately to changes in the external environment, such as fluctuations in commodity prices, climate anomalies and global market trends. Effective economic security involves a deep understanding and management of the financial, production and market aspects of an enterprise.

The aspect of economic security covers the definition of the basic principles and models that define its essence. The systemic approach involves considering economic security as an integral part of strategic planning, where resource endowment, financial sustainability and risk management interact to ensure long-term stability. The internal and external environment is an important aspect of understanding economic security. Businesses should be prepared for the impact of various factors, identify them, and develop adaptation strategies. However, in addition to measures, it is also important to consider proactive approaches, such as innovation and the use of industry best practices.

Several key theoretical models define different aspects of economic security. The first of these is the risk system model, which recognises economic security as a complex system with a variety of risks. This approach provides an opportunity to identify and manage risks through reactive, proactive, and strategic strategies. Reactive strategies are aimed at solving problems after they arise, proactive strategies involve preventing risks, and strategic strategies integrate risk management into strategic management, creating a comprehensive system of protection. This approach allows businesses not only to respond to challenges and dangers but also to actively work on their prevention and strategic management, ensuring full protection in all aspects of their activities. The integration of risk management into strategic management makes the system more efficient and flexible, allowing businesses to adapt to changes in the environment and achieve sustainability in a dynamic market environment (Settembre-Blundo *et al*., 2021).

The second model, focusing on effective resource management, aims to optimise the use of finance, labour, and other assets to ensure the efficiency of the enterprise. It incorporates the rationalisation of production processes, efficient inventory management and optimisation of financial flows as key strategies to achieve this goal. The introduction of efficient production processes is aimed at increasing productivity and optimising the use of resources. Efficient inventory management helps to avoid storage overruns and ensures that the necessary materials are available for continuous production. Optimisation of financial flows includes rational allocation of funds, effective budget management, and minimisation of financial risks (Pandey *et al*., 2022).

The third model, focused on innovative development, focuses on the importance of innovation in ensuring competitiveness and adapting to changes in the economic environment. This approach is determined by the introduction of the latest technologies, stimulation of creativity and development of innovative thinking. The introduction of the latest technologies includes the

use of advanced scientific and technical developments to optimise production processes and improve product quality. This may include the automation of production, the use of artificial intelligence and other innovative tools. Stimulating creativity involves activating the creative potential of the company's staff. This may include providing creative training, creating a favourable environment for ideas and innovation, and recognising and rewarding creative achievements (Xu, 2021).

Last but not least, the global competitiveness model analyses economic security in the context of global market conditions. This model involves a systematic review of international trends and the competitive situation, and research on global supply and demand, which allows businesses to adapt to international standards and requirements. The analysis of international trends and competition involves an assessment of economic processes and business strategies on a global scale. The study of global supply and demand is aimed at understanding how an enterprise can meet the needs of the international market and ensure an efficient supply chain system (Bakator *et al*., 2019).

These theoretical models, using different approaches and strategies, identify the main directions for ensuring the economic security of agricultural enterprises. Given the complexity of the current economic environment, a combination of these models can be effective in achieving stability and successful adaptation to change. The role of economic security in the agricultural sector is to ensure sustainability, protect against financial difficulties and maintain the competitiveness of agricultural enterprises in changing market conditions. In the following, the economic security models will be considered in the context of the Ukrainian agricultural enterprise Kernel.

A review of the financial position of the agricultural enterprise Kernel can provide important insights into the efficiency and sustainability of the agricultural sector, as well as reflect the practical aspects of the role of economic security. The company specialises in the cultivation and processing of agricultural products holds a leading position in Ukraine and is known on the global market. Table 1 shows the financial position of the company.

Table 1. *Financial position of Kernel company, USD million*

Indicator	2020	2021	2022	2023
Revenue	4,107	5,595	5,331	3,455
EBITDA	443	806	220	544
Net profit	123	506	-41	299
Assets	3,165	3,996	4,185	3,885
Main items	1,634	1,713	1,662	1,443
Current assets	1,531	2,284	2,523	2,442
Inventories	555	709	1,116	489
Available funds	369	574	448	1,077
Owned assets	1,494	1,948	1,686	1,744
Debt	966	1,085	1,696	1,474
Operating cash flow	269	461	-305	716
Financial cash flow	226	-48	476	-216
Investments cash flow	-203	-205	-294	10

Source: *compiled by the authors based on FY2023 Annual Report (2023)*

Kernel's financial position proved to be dynamic and mixed during 2020-2023. During this period, the company saw an increase in revenue and net profit until 2021, which indicated its successful financial performance. However, in 2022, a decline was recorded in both revenue and net profit, and the latter even became negative. This is due to various factors, including the impact of geopolitical events and economic instability caused by the war. A further analysis of the financial indicators shows an increase in the company's debt and a loss in operating cash flow in 2022. This indicates increasing financial difficulties and the need for risk management. On the positive side, the company's cash flow is expected to increase in 2023, which could be a positive signal for overcoming financial difficulties in the future. Overall, the company may need to strategically manage risks and adapt to market changes to ensure sustainability and competitiveness in a challenging economic environment.

In the area of economic security, Kernel has a high level of research and analysis of potential risks that may affect its operations. The company identifies key factors such as fluctuations in agricultural commodity prices, changes in foreign exchange rates, political and regulatory changes, and uncertainty in production conditions. Market conditions in agriculture are highly vulnerable to external factors such as weather conditions and global production trends. In the context of the war

in Ukraine, this risk is exacerbated by uncertainty and possible changes in the production and transportation of agricultural products. The volatile environment may result in unpredictable currency fluctuations, which has a direct impact on the company's financial liabilities and production costs. Agricultural business conditions, such as yields and technical aspects, may be significantly affected in the conflict zone, leading to uncertainty in production volumes and prices.

Kernel has implemented and actively uses a risk management model. This system includes the use of various financial instruments designed to protect against the negative impact of fluctuations in foreign exchange rates. For example, in the face of changes in exchange rates, the company may use derivatives or other instruments to minimise financial losses. The company employs advanced agricultural technologies and monitoring systems to respond to weather anomalies promptly and minimise crop losses, as inclement weather or extreme weather conditions can result in reduced production potential. Table 2 shows the company's acreage and yield data.

Table 2. *Kernel sown areas and yields*

Production	2020/2021	2021/2022	2022/2023
Corn			
Sown areas, ha	255,000	255,000	150,000
Yield, t/ha	8	9.3	8.5
Wheat			
Sown areas, ha	73,000	64,000	35,000
Yield, t/ha	4.9	6.1	4.5
Sunflower			
Sown areas, ha	149,000	154,000	130,600
Yield, t/ha	3	3	2.5
Overall land assets, ha	**510,000**	**500,000**	**363,000**

Source: *Kernel – The profitability of sunflower processing remains high (2023)*

These data show a decrease in the company's total land bank, as well as fluctuations in the yields of different crops during the period. The yields of corn, wheat and sunflower are lower in the 2022/2023 season compared to previous seasons. The decrease in the total land bank may indicate potential challenges related to resource constraints and land management. Fluctuations in the yields of different crops also have a direct impact on the financial performance of the enterprise, as yields determine the volume of production and, therefore, income. In the context of the economic security system, this information indicates the need to improve risk management strategies, adapt to changes in climate conditions and improve crop cultivation methods to ensure the stability and resilience of the enterprise in a changing environment.

Kernel is successfully implementing a global competitiveness model based on several key aspects: export page, flexibility and adaptability, innovations in production and marketing, quality system and consumer confidence, diversification, and vertical integration strategies. The company is actively expanding its export activities in Ukraine and internationally thanks to its high-quality products and innovative approaches. In the 2022/23 season, Ukraine's grain exports totalled approximately 49 million tonnes, up 1 million tonnes compared to the 2021/22 season. A significant portion of Ukrainian grain was shipped abroad via alternative routes, with only 55% exported through Ukrainian deepwater ports. This resulted in significant changes in the structure of exporters compared to previous years. Table 3 shows Kernel's operating performance.

Table 3. *Kernel's operational performance*

	2019	2020	2021	2022	2023
Sunflower processing, thousand tonnes	3,164	3,436	3,183	2,187	2,502
Sunflower oil sales, thousand tonnes	1,619	1,518	1,367	967	1,012
Grain exports, thousand tonnes	6,094	7,902	8,013	7,969	3,707

Source: *Kernel – Everything about the company, history, production, profits (2023)*

The indicators indicate fluctuations in the company's operations, which may be due to various factors, such as war, economic conditions, production circumstances and external factors. An important aspect is flexibility and adaptability, which allow Kernel to respond effectively to changes in market conditions and global challenges. A key element of global competitiveness is the innovations that the company implements

both in agricultural production and in product marketing. Technologies for growing and processing agricultural products improve the quality and competitiveness of goods on the global market. The company devotes much effort to the production quality system, compliance with international standards (ISO) and building consumer confidence. Strict adherence to safety and quality standards creates the basis for success in the global market. In addition, the company successfully uses diversification and vertical integration strategies to ensure stability and competitiveness. A wide range of products, from grains to oilseeds, makes Kernel less dependent on fluctuations in individual market segments.

In summary, all these measures allow Kernel to compete successfully in the global market, maintaining high global competitiveness and ensuring resilience in the face of complex challenges, such as global changes in market conditions or geopolitical factors. The kernel takes a comprehensive approach to ensuring economic security, using models such as the risk system to identify and manage risks, the efficient resource management model to optimise the use of finance and resources, the innovation development model to maintain competitiveness, and the global competitiveness model to adapt to international standards. To constantly control and monitor the situation, Kernel uses systems for analysing financial statements, performance indicators and risk reports. This allows the company to respond to potential threats promptly and make informed decisions to ensure business stability and sustainability. To improve the economic security system of agricultural companies, a specific strategy can be proposed that covers various aspects of the enterprise. Figure 1 shows several steps that can contribute to improving the effectiveness of the economic security system.

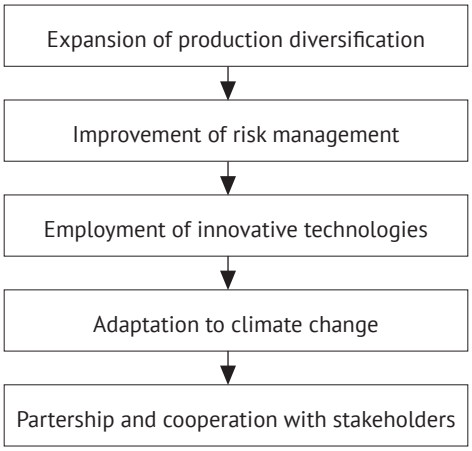

Figure 1. *Strategies for improving the economic security of agricultural enterprises*
Source: *compiled by the authors*

The strategy of expanding production diversification is key for companies. This includes developing organic production and expanding the range of crops grown. Organic products are becoming an important trend in agriculture, and companies can actively invest in this sector to ensure diversity and high demand for their products. For example, the development of organic production allows them to respond to the growing consumer demand for environmentally friendly products. In addition, expanding the range of crops grown reduces dependence on a particular type of agricultural product and allows for easier adaptation to changes in seasonal and market conditions. This strategy has a double effect: it not only broadens the company's market reach but also reduces its exposure to risks associated with changes in demand for specific agricultural products. The diversity of the product portfolio allows companies to manage risks more effectively and ensure stability in changing market conditions (Waha *et al*., 2018).

Risk management is the second key strategy for agricultural companies. In particular, they can use a variety of financial instruments, such as options or futures, to actively protect themselves from the negative impact of fluctuations in agricultural commodity prices. For example, the use of options and futures allows them to effectively minimise and control currency and price fluctuation risks. In the event of changes in exchange rates or agricultural commodity prices, companies can take timely action to protect their financial position. This makes them less vulnerable to unforeseen market conditions and ensures financial stability in changing economic circumstances. Employing innovative technologies to improve agricultural production is the third key strategy for companies. They can actively implement modern technologies, such as artificial intelligence systems, to accurately analyse climate conditions and predict risks in agriculture. For example, the use of artificial intelligence systems allows for detailed climate analysis and prediction of possible risks, such as adverse weather conditions or pests. This enables companies to respond to potential threats promptly and adapt their crop production

strategies. The introduction of innovative technologies contributes not only to risk reduction but also to increasing the efficiency and productivity of agriculture, which is an important element in ensuring the economic security of enterprises in a rapidly changing market environment (Emerick *et al.*, 2016).

Creating climate change adaptation strategies is the fourth important strategy for agricultural enterprises. As part of this strategy, companies can actively develop new plant varieties that are more resistant to extreme weather conditions. New varieties can be adapted to changing climatic conditions, which will help increase yields and reduce the impact of negative factors. In addition, innovative irrigation systems and other technologies can be introduced to ensure efficient crop production even in difficult climatic conditions. Ensuring high yields in extreme weather conditions is a key aspect of ensuring the economic security of companies, as it allows them to maintain production stability and respond to environmental challenges promptly. The last key strategy is to develop partnerships and stakeholder engagement. Businesses can actively cooperate with agricultural cooperatives, research institutions and other industry players to share resources, and experience and jointly develop new technologies. Cooperation with agricultural cooperatives can help improve production processes and optimise resource management. Scientific institutions can be valuable partners for the research and development of new technologies aimed at increasing the productivity and sustainability of crop production. In general, these strategies will help agricultural enterprises to ensure the sustainability and resilience of their economic condition in a changing business environment, increasing efficiency and reducing risks of their operations.

DISCUSSION

The results of the presented study of the economic security of agricultural enterprises reveal important aspects of the functioning of companies in the current economic environment. The main emphasis is placed on identifying and analysing the key aspects of economic security that determine the stability and viability of an enterprise. The research considers current trends and challenges in the economy and develops innovative methods for modelling economic security. This is an important aspect, as it allows us to adapt strategies to climate change, global market trends and technological progress in agriculture. Further analysis of key theoretical models, such as the risk system model, resource management, innovation development, and global competitiveness, reveals various aspects of economic security. The combination of these models creates a comprehensive approach to ensuring the sustainability of an agricultural enterprise in the face of change.

It is important to note the impact of the conflict in Ukraine on agriculture, in particular on harvests and production conditions. In addition, an important element is the active use of risk management by businesses, including the use of financial instruments to protect against the impact of exchange rate fluctuations and the use of advanced technologies to respond to weather anomalies and minimise crop losses. Strategies for improving the economic security system proposed for companies are identified as key components for ensuring sustainability and competitiveness. In particular, strategies to increase production diversification, improve risk management, use innovative technologies, and adapt to climate change are critical for the effective functioning of a company in a changing economic environment (Sahachko *et al.*, 2023).

B. Derevyanko *et al.* (2021) analysed the role of economic security in modern enterprise management, highlighting its key impact on the stability and viability of enterprises. The results of the analysis covered various aspects of economic security aimed at ensuring efficient operation and considering possible risks, such as fluctuations in product prices, the impact of climate change and global market trends. The authors' conclusions relate to the importance of systematic risk analysis and management to ensure the efficiency of an enterprise in a changing market environment. The study provides information that can serve as a basis for developing risk management strategies and improving the efficiency of the economic security of enterprises. The results of the authors, as well as the present study, focus on the role of risk management and the use of innovative technologies to ensure the sustainability of enterprises in a changing economic environment. All of the authors' approaches identify specific strategies aimed at improving the efficiency of management processes and ensuring the sustainability of enterprises, but a full analysis of their interactions and possible limitations is required.

M.K. Shad *et al.* (2019) highlighted a systematic approach to risk management and sustainability in enterprise management. The authors note an important aspect of the study, which is to consider changes in the global economic environment and the ability of an enterprise to effectively adapt to them. The coverage of such phenomena as price fluctuations and market trends indicates the need not only for a reactive response to changes but also for the introduction of systemic planning and strategic management to ensure the sustainability and successful adaptation of the enterprise to new conditions (Musayeva *et al.*, 2024). The results of the study emphasise the relevance of implementing an integrated management approach to ensure the effective operation of an enterprise in a changing economic environment. Compared to the present study, it is possible to note that the authors have effectively focused on risk management and the use of financial instruments to protect against negative impacts in the agricultural sector. However, the authors' study could be even more detailed, including specific examples and

strategies for using advanced technologies to improve quality and productivity.

J. Clapp (2019) in his study examined in detail the basic principles and models of economic security, drawing attention to their importance in the context of strategic planning, in particular in the agricultural sector. He emphasised the importance of the interaction of three key components: resources, financial stability, and risk management to achieve long-term sustainability. The interaction of resources in the context of agricultural business may include optimising the use of land, labour and other assets. Financial stability is seen as a key element in ensuring the sustainability of an enterprise, while risk management is defined as a strategic approach to avoiding and mitigating potential threats (Cheremisina & Salo, 2023). The author's conclusions emphasise the importance of taking these components into account in strategic planning in the agricultural sector to achieve long-term sustainability, which makes his research relevant and useful for practical application in enterprise management. This approach was also considered in the present study, where the importance of these components in strategic planning was pointed out. However, innovative development and global competitiveness should also be considered, which can significantly affect the economic security of an enterprise.

D. Ciuriak and P. Goff (2021) analysed theoretical models of economic security and identified their key aspects and strategies. Focusing on theoretical aspects, they reveal the importance of innovative development, effective risk management, and global competitiveness. One of the key topics of the authors' research is innovative development. They view innovation as an important factor in ensuring economic security and competitiveness. The researchers show how innovations affect economic sustainability and how their implementation can reduce risks. Given the importance of concrete applications, especially in the current economic environment, it is important to combine theoretical models with concrete examples and analysis of real enterprises.

R. Vavrek *et al.* (2021) analysed the financial condition of agricultural enterprises in their study. The level of analysis and justification of potential risks that may affect the economic security of the enterprise under consideration is revealed. Key factors include fluctuations in agricultural commodity prices, changes in foreign exchange rates, political and regulatory developments, and uncertainty in the production environment. The volatility of the agricultural business, such as weather conditions and global production trends, can lead to unpredictable fluctuations in foreign exchange rates and commodity prices (Buka *et al.*, 2023). The authors should explore and consider aspects of risk management, identify specific financial instruments to protect against negative impacts and improve the consideration of advanced technologies to improve quality and productivity in the agricultural sector.

T.T. Duong *et al.* (2019) considered the practical experience of implementing a risk management system and using modern agricultural technologies to ensure economic security. The main focus of the study is practical examples of the use of financial instruments and monitoring systems to effectively respond to unforeseen circumstances. Financial instruments, such as financial derivatives, futures contracts, and monitoring of the company's financial position, can be used to effectively manage risks and ensure the economic security of agricultural enterprises (İsmayilov *et al.*, 2022). This approach allows for a better understanding of which tools and strategies can be applied in real agricultural business. The presentation of practical examples provides concreteness and helps to replicate successful risk management experiences to ensure economic resilience. However, it should be added that, in addition to identifying specific tools and strategies, an important aspect is to adapt these approaches to the specific conditions of each agricultural enterprise. Considering unique factors such as farm size, crop types, market conditions and regional peculiarities is crucial for the successful implementation of a risk management system (Oleksandrenko & Valchyshyna, 2023).

In general, the results indicate that effective economic security of agricultural enterprises requires a comprehensive approach that combines theoretical models, risk management strategies and practical experience in the use of modern technologies. Consideration of the changing market environment, as well as flexibility and innovation, are key factors for ensuring the sustainability and competitiveness of agricultural enterprises in the current economic landscape.

CONCLUSIONS

This study shows the key role of economic security in modern enterprise management, emphasising its impact on stability, viability, and adaptability to economic change. Several theoretical models defining economic security have been identified, each offering unique approaches and strategies. The risk system model considers economic security as a complex system that allows for the identification and management of risks through reactive, predictive, and strategic strategies. The resource management model optimises finances, labour, and assets, emphasising the rationalisation of production processes and efficient inventory management. Innovative development emphasises the importance of innovation for competitiveness, while global competitiveness considers economic security in the context of global market conditions.

Applying these models to agricultural enterprises, as in the case of Kernel, revealed a dynamic and mixed financial position during 2020-2023. External factors, including geopolitical events and economic instability due to the war, affected revenue and net profit. The

study highlighted Kernel's proactive approach to risk management, using financial instruments and advanced agricultural technologies to respond to market and environmental uncertainties. Kernel's global competitiveness model demonstrated effective strategies such as export diversification, innovation, quality assurance and vertical integration. In general, the company takes a comprehensive approach to ensuring economic security, using models such as the risk system, the efficient resource management model, the innovative development model, and the global competitiveness model to ensure that the company can meet its objectives.

To improve the economic security of agricultural enterprises, a strategy has been proposed that includes expanding production diversification, improving risk management, introducing innovative technologies, developing climate change adaptation strategies, and developing partnerships. These strategies are aimed at increasing the company's resilience to market fluctuations, climate risks and geopolitical instability. Further research could focus on improving the risk assessment methodology and developing innovative adaptation strategies for agricultural enterprises in a changing economic environment.

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CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

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Моделювання систем економічної безпеки аграрних підприємств

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Анотація. Актуальність проведення дослідження полягає в тому, що в сучасних умовах економічної нестабільності та зростаючого впливу зовнішніх факторів на господарську діяльність підприємств, розуміння та ефективне управління питаннями економічної безпеки стає надзвичайно важливим для забезпечення стійкості аграрних підприємств. Метою дослідження був комплексний аналіз економічної безпеки аграрного підприємства, зосереджений на виявленні ключових аспектів, їх впливу на стійкість та життєздатність підприємства. Серед використаних методів було застосовано аналітичний метод, статистичний метод, функціональний метод, метод системного аналізу, метод дедукції, метод синтезу та метод порівняння. Дане дослідження фокусувалося на економічній безпеці аграрних підприємств, розглядаючи комплексні аспекти ефективності, захисту від ризиків та здатності адаптуватися до змін у економічному середовищі. Робота визначає економічну безпеку як системний підхід до управління ризиками та забезпечення стійкості. Особливу увагу приділяється реагуванню на зміни зовнішнього середовища, такі як коливання цін, кліматичні аномалії та глобальні тенденції ринку. Були розглянуті теоретичні моделі, такі як модель системи ризиків, ефективного ресурсного управління, інноваційного розвитку, глобальної конкурентоспроможності, що визначають різні аспекти економічної безпеки. Дослідження стосується фінансового стану аграрної компанії Kernel, який виявився динамічним та неоднозначним у 2020-2023 роках. Аналіз включає фактори, такі як вплив геополітичних подій та економічної нестабільності внаслідок війни. Компанія реалізує стратегії глобальної конкурентоспроможності, демонструючи гнучкість, інновації та диверсифікацію для забезпечення стійкості. Пропонуються стратегії розширення диверсифікації виробництва, вдосконалення управління ризиками та використання інноваційних технологій для адаптації до змін клімату. Практичне застосування даного дослідження полягає у можливості застосування отриманих результатів та розроблених на їх основі рекомендацій для удосконалення систем економічної безпеки аграрних підприємств

Ключові слова: фінансові ризики; ресурсна оптимізація; інноваційні стратегії; ринкові виклики; адаптація до змін

Automation and robotisation of processes in the agricultural sector have brought about significant positive changes aimed at optimizing and improving production efficiency (Baierle *et al.*, 2022). The introduction of robots and automated systems has been a key factor in simplifying and accelerating various aspects of the agricultural process, leading to increased productivity (Abbasi *et al.*, 2022). One of the main benefits of automation is the increased efficiency of production processes. Robots and automated systems allow tasks to be performed faster and more accurately, which in turn reduces the time required for production cycles and contributes to an increase in overall farm productivity. In addition, automation ensures the stability and reliability of processes. Robots can work continuously and without losing productivity, which is especially important in the agricultural sector where time is a critical factor, especially during crop rotation and processing. An additional advantage is the reduced dependence on manual labour and the human factor. Robots can perform routine and time-consuming tasks, eliminating the possibility of human error. This increases the accuracy and consistency of tasks, reducing the likelihood of losses and improving product quality.

The use of 5G technologies in the agricultural sector opens up new perspectives and significant opportunities, especially in remote areas, where a stable Internet connection is identified as a key factor for the implementation of precision technologies (Tomble & Smuts, 2023). One of the key benefits of 5G is the provision of a stable and fast Internet connection anywhere, including remote agricultural areas, opening up access to a large amount of data and resources critical to the implementation of a number of precision technologies in agricultural production. The use of 5G technologies facilitates the implementation of precision agriculture. Fast and stable Internet connections enable the use of drones and sensors to collect data from fields in real time. These capabilities make it possible to analyse the condition of crops, identify problems and make prompt decisions to optimize production processes.

The introduction of 5G also helps to develop automation and IoT systems in the agricultural sector. A stable and high-speed connection allows for the connection of numerous devices and sensors, which enables monitoring and control of various aspects of agricultural activities. For example, automated irrigation systems or monitoring the condition of machinery. Additionally, 5G expands the possibilities for implementing artificial intelligence technologies in the agricultural sector. By providing high data transfer speeds, 5G creates the conditions for the implementation of advanced analytical systems, predictive models and other AI solutions that contribute to more accurate and efficient management of agricultural production. The use of precision farming systems, in particular the Global Positioning System (GPS) and related technologies, opens up great opportunities for optimizing the allocation and use of resources in the agricultural sector (Sridhar *et al.*, 2023). Technology has become a key tool for improving the efficiency and sustainability of agriculture.

The use of GPS allows accurately determining the geographical coordinates of each point on the field, which allows creating detailed mapping materials, including maps of soil and planted crops. This approach provides farmers with important information for making field management decisions. Precision farming systems allow adjusting the supply of resources, such as water, fertilizers and pesticides, depending on the actual needs of the plants. Optimizing the use of resources, reducing costs and increasing production efficiency. Using GPS, farmers can precisely control irrigation and spraying systems, directing them to where they are needed. This approach allows for efficient use of water and chemicals, providing an optimal environment for plant growth. GPS and precision farming systems allow for the creation of automated navigation systems for agricultural machinery. Tractors, combines and other machines can automatically control their movement on the field, ensuring precision and uniformity of work. Precision farming systems provide the ability to collect a large amount of field data in real time. This includes data on soil moisture, plant health, uniformity of resource distribution, and much more. This data is important for analysing and making detailed management decisions.

A survey was conducted among target groups to assess the usability of innovative approaches. Based on the results, a histogram was drawn up and the results of the survey are shown in Figure 1.

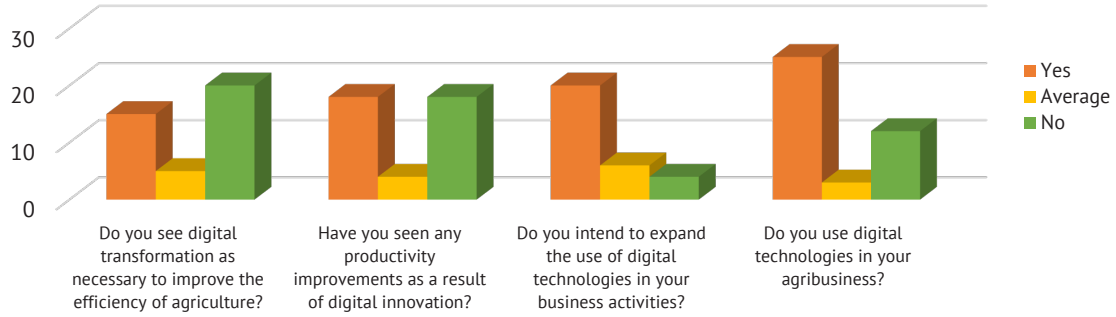

Figure 1. *The results of the survey on target groups*

Source: *compiled by the authors*

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