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MODEL OF ECONOMIC SECURITY MANAGEMENT FOR AGRICULTURAL ENTERPRISES UNDER MARKET CHANGES

ABSTRACT

The aim of this article is to develop a model for managing the economic security of agricultural businesses under market transformations, taking into account forecasting and modelling the development of each target market for the enterprise. The application of economic and mathematical models is proposed within the context of managing the economic security of the agricultural sector. This approach not only enables the analysis and forecasting of various economic processes but also facilitates the development of a well-founded strategy to minimise potential risks and exploit available opportunities.

It is demonstrated that the use of economic and mathematical models contributes to the objectivity of the decision-making process, ensuring high reliability and effectiveness. A mathematical apparatus for forecasting and modelling the development of each target market of the enterprise is proposed. It accounts for the influence of key factors on economic security within each of the target markets of an agricultural enterprise and evaluates the impact of each market on the overall economic security of the enterprise, thereby enabling the formulation of appropriate tactical measures.

To assess the current state of the core markets relevant to the enterprise and identify possible adaptation measures in the field of economic security for the year 2025, the proposed methodological approaches were used to evaluate trends in target markets. Growth coefficients were calculated for the financial market, sales market, labour market, and energy market for the enterprise LLC "Semenivsky Agroservice".

An analysis of the financial market's condition and trends indicates a deterioration in 2022 compared to 2020; however, in 2023–2024, all indicators began to gradually show a recovery trend. The analysis revealed that, overall, these factors led to a negative growth rate of the financial market coefficient.

It was also determined that LLC "Semenivsky Agroservice" exports a significant portion of its products abroad; therefore, the depreciation of the national currency cannot be unequivocally regarded as a negative factor. Methodological approaches have been proposed that when adapted to the specific conditions of the enterprise, may serve as indicators for revising planned targets, strategies, and tactics in the field of financial and economic security.

Keywords: economic and mathematical model, economic security, market changes, agricultural business, agriculture, express analysis, forecasting, modelling, relevant markets

JEL Classification: E20, H56, O10, Q10

INTRODUCTION

Today, the development of a model for managing the economic security of a business under conditions of market change is accompanied by a number of challenges caused by the instability of the external environment, global economic disruptions, and internal risks associated with entrepreneurial activity. The key problems in forming an economic security model for businesses include: constant changes in legislation, tax policy, financial markets, and the competitive environment, which complicate the creation of an effective business security management model; fluctuations in exchange rates, sanction

policies, international trade conflicts, and other factors that create instability and negatively impact the economic security of enterprises; high inflation rates, limited access to credit resources, and financial instability, which may lead to cash flow disruptions and the threat of bankruptcy; in the digital age, the protection of commercial and financial information has become critical to ensuring business stability; many companies lack well-developed crisis management strategies and mechanisms for rapid response to market changes, reducing their resilience to economic shocks; the use of outdated security management methods and the absence of integrated digital systems for risk analysis and threat forecasting decrease management efficiency.

"In today's world, business processes are becoming increasingly complex and require constant adaptation to changes in the environment. Financial uncertainty has become a standard that almost every economic agent has to face. Therefore, information and communication support, which helps companies to effectively diversify their business processes, becomes of key importance. The recovery of the Ukrainian economy requires a comprehensive approach in the context of creating favourable conditions for investments, ensuring access to loans and technical support for economic agents (logistics transformers)" (Petrushenko, et al. 2024).

In the context of digital technology development, the management of enterprise economic security can be optimised through mathematical digital models and the creation of appropriate software solutions. Based on the conducted research, a business economic security management model is proposed, which considers the influence of key external and internal factors on enterprise development and its economic security. This model is based on a process-oriented approach and involves identifying the key business processes of the enterprise (production, sales, finance, and resource support), which collectively shape economic security and simplify financial budgeting processes while considering external and internal opportunities and threats.

Thus, for the effective development of a business economic security management model, it is necessary to apply integrated approaches through the optimisation of mathematical models, incorporating digital transformation, strategic planning, crisis management, and the strengthening of financial monitoring mechanisms.

LITERATURE REVIEW

Military aggression has created unprecedented challenges that have significantly transformed the trajectories of socio-economic development of territorial communities and the business environment in Ukraine. In the context of martial law, there is a need to rethink traditional management paradigms and form innovative strategies to ensure the sustainable functioning and adaptability of business. The authors of the publication identify information and communication support as the main factor in diversifying business processes in conditions of financial uncertainty. Emphasising that in periods of instability, business, the public, and investors need clear, timely and reliable information. Information and communication support allows you to avoid panic, builds trust in institutions and helps maintain stability in the socio-economic environment (Petrushenko, et al. 2024).

The scientific article Yu. (2024) presents innovations in financial information management in a computer environment using a comparative analysis of two methods of trading in the securities market, which allows achieving efficiency in processing instructions in financial information management and increasing the financial and economic security of enterprises.

According to the authors, in the context of the war and post-war reconstruction, it is extremely important to define new strategic directions for economic revival, taking into account the needs of different sectors. At the same time, it is necessary to intensify economic activity, ensure broad access to resources, and provide tax and financial support to enterprises that have suffered significant losses as a result of hostilities. This will contribute to strengthening their financial stability and restoring the country's economic potential (Alekseyenko et al. 2024).

Alekseyenko, Tulai, Ferens, Tsap, Tsokalo, & Artemenko (2024). In the context of the post-war reconstruction of the Ukrainian economy, the reinvestment method is gaining special importance as one of the main internal sources of financial support for enterprises. It involves directing part of the profits received not to consumption or dividends, but to the development of production capacities, renewal of fixed assets, digitalisation of business processes and development of new markets. Indeed, in conditions of a limited state budget and high risks for external investors, reinvestment becomes a realistic and effective strategy for the financial recovery of Ukrainian enterprises and the entire economy.

We share the authors' position that in modern conditions, the digitalisation of the economy is a key challenge for ensuring the financial security of the state. At the same time, it opens up new advantages and expands opportunities for the

development of the national economic system through the introduction of information and telecommunication technologies. The authors' comparative analysis of the level of application of innovations and digital solutions in Ukraine and in the world confirms the hypothesis they put forward (Onyshchenko et al. 2023).

The authors justify the feasibility of developing specialised software solutions for a comprehensive assessment of ecosystem assets of socio-economic systems (Veklych et al. 2024). This approach emphasises the important role of digital technologies in ensuring the economic security of business entities, as it allows not only to effectively track resources, but also to predict risks, optimise management decisions, and increase the level of business resilience to external threats.

Jin (2024) emphasises that the security of the economic sector is a matter of paramount importance. In this regard, he considers the use of blockchain technology as an effective tool for ensuring the protection of economic information and transactions. At the same time, the publication also outlines the potential risks associated with the implementation of this technology, which have been thoroughly analysed and systematised. We also believe that the need to use blockchain in the analysis of economic security is due to modern challenges such as cyberattacks, corruption, data falsification, and the opacity of financial flows.

Additionally, the use of decentralised finance (DeFi) applications and the role of stablecoins are important components of future digital ecosystems and potential economic security models. DeFi applications and stablecoins are important components of future digital ecosystems that have a direct impact on economic security models. DeFi and stablecoins are not just tools, but strategic components of digital sovereignty and financial stability. Their inclusion in economic policy can significantly strengthen national security (Puschmann, 2024).

We agree with the authors (Polinkevych et al. 2024) that developing a strategy for the sustainable development of digital business based on certain indicators of economic security of individual countries of the European Union and Ukraine is extremely important. Such an approach takes into account both objective macroeconomic conditions and specific national characteristics, which allows for the formation of a more effective, realistic and viable policy of digital development A successful digital transformation strategy must be multiscalar (cover different levels - from state to municipal), adaptive (able to respond to new challenges and technological changes) and inclusive (involve all groups of society). Particular attention should be paid to the local needs of regions and, at the same time, use positive European experience, in particular the best practices of EU member states in the development of the digital economy, the introduction of innovations, compliance with cybersecurity and digital rights.

That is why, when forming a modern model of economic security, it is necessary to take into account current global and regional trends, as well as challenges associated with digital transformation. In particular, we are talking about the rapid development of financial technologies (FinTech), decentralised finance (DeFi), digital trade, the Internet of Things (IoT), artificial intelligence (AI) and smart infrastructure.

These processes create new risk vectors associated with cyber threats, disinformation, digital inequality, data monopolisation, as well as increased dependence on global techno-platforms. At the same time, digitalisation opens up new opportunities for increasing the level of economic sustainability, transparency of management, efficiency of financial processes and strengthening digital sovereignty. Therefore, the integration of digital aspects into the architecture of economic security is not just expedient, but a necessary condition for the formation of a competitive and secure national economy.

AIMS AND OBJECTIVES

The aim of this article is to develop a model for managing the economic security of agricultural businesses under market changes, taking into account forecasting and modelling the development of each target market for the enterprise.

METHODS

In the current context of economic globalisation and increasing competitive pressure, the application of economic and mathematical models is becoming particularly relevant for managing the economic security of businesses. This approach makes it possible not only to analyse and forecast various economic processes but also to develop a well-founded strategy aimed at minimising potential risks and leveraging existing opportunities. The use of economic and mathematical models contributes to the objectification of the decision-making process, ensuring high reliability and efficiency.

To assess each factor and its impact on economic security, methodological approaches have been proposed, which include:

- identifying key factors influencing economic security across each of the enterprise's target markets;

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- developing a mathematical toolkit for forecasting and modelling the development of each target market of the enterprise;
- determining the impact of each market on the state of the enterprise's economic security and elaborating appropriate tactical measures.

Let us consider each of the identified factors in more detail.

1. The financial market for business is the domain where enterprises conduct financial operations and attract resources to support their activities. This market may include a variety of instruments and products that help companies manage their finances and implement their development strategies. For the purpose of assessment and modelling of various forecasts, we have selected key indicators, namely: the cost of capital, the level of taxation (corporate income tax rate), and the national currency exchange rate. These indicators can be supplemented as needed.

   The projected state of the financial market based on the indicators of capital cost, taxation, and exchange rate refers to a forecast or assessment of potential changes in these key financial market parameters in the future. Various factors that may influence these indicators are taken into account, such as macroeconomic trends, political developments, global market dynamics, and other economic factors.

   For instance, the forecast of the cost of capital may consider expected changes in central bank interest rates, inflation expectations, the level of demand for capital, and other factors affecting capital costs. The tax forecast may include an analysis of planned tax reforms, changes in legislation, and other factors that may influence the tax burden on businesses. The exchange rate forecast may depend on geopolitical events, trade balance, central bank interventions, and other factors affecting currency demand and supply.

   Forecasting these indicators helps managers, investors, and other market participants make informed decisions regarding investments, financial planning, and risk management. The accuracy of such forecasts may vary depending on the complexity and dynamics of the factors considered in their development.

   The projected state of the financial market based on the indicators of capital cost, taxation, and exchange rate is proposed to be calculated using the following formula:

$$FM^{t+1} = \left(\frac{K^t}{K^{t+1}} - 1\right) w_k + \left(\frac{T^t}{T^{t+1}} - 1\right) w_t + \left(\frac{V^t}{V^{t+1}} - 1\right) w_v \quad (1)$$

   where, FM^{t+1} – weighted growth coefficient of the financial market; K – cost of capital (interest rate on loans), %; T – corporate income tax rate, %; V – exchange rate (USD); w_k, w_t, w_v – weight coefficients.

2. The Sales Market is the sphere where producers sell their goods or services to end consumers or other businesses. The sales market is an essential component of the supply chain and includes all processes from finding buyers to completing sales transactions. The sales market has a significant impact on the economic security of an enterprise. Effective management of the sales market helps ensure the stability and success of the company's operations, while an improper strategy or issues within the market can lead to serious economic difficulties.

   The sales market is characterised by many indicators: the level of competition, market capacity, market growth, prices, market conditions, and business activity, among others. However, the most critical factors from a tactical response perspective are market growth and the average price of goods. To assess the impact of the sales market on economic security and its forecasting, the following formula is proposed:

$$SM^{t+1} = \left(\frac{Q^{t+1}}{Q^t}\right) w_q + \left(\frac{P^{t+1}}{P^t}\right) w_p \quad (2)$$

   where, SM^{t+1} – weighted growth coefficient of the sales market; Q – sales volume in the target market, UAH thousand; P – price of the product, UAH; w_q, w_p – weight coefficients.

3. The Labour Market is an important component of the economy where the demand for labour from businesses meets the supply of labour from employees. Its conditions significantly impact the economic security of enterprises for several reasons:

   - The availability of skilled labour in the labour market is crucial for business. A shortage of qualified personnel can limit the company's potential for development and the implementation of strategic projects.

- The market value of labour can change depending on the demand and supply in the labour market. Businesses must consider these dynamic changes when developing budgets and wage strategies.
- Changes in legislation and the regulatory environment can affect labour conditions and the company's expenses related to wages, social benefits, and other aspects of human resource management.
- The flexibility of the labour market can impact the company's ability to adapt to changes in production plans or market conditions.

All these aspects must be taken into account by enterprises when developing personnel management strategies, talent acquisition, ensuring labour supply, and creating conditions for stable and effective business operations.

To assess the development prospects of the labour market according to the proposed methodological approaches, the following indicators are suggested: labour market growth, i.e., the dynamics of the number of workers in the industry; labour cost, i.e., the average wage in the industry; and the level of competition in the labour market, i.e., how many applicants compete for a single job position.

For assessing the prospects of labour market development, the following formula is proposed:

$$LM^{t+1} = \left(\frac{E^{t+1}}{E^t}\right) w_e + \left(\frac{S^t}{S^{t+1}} - 1\right) w_s + \left(\frac{C^{t+1}}{C^t}\right) w_c \quad (3)$$

where, LM^{t+1} – weighted growth coefficient of the labour market; E – number of employees in the industry; S – average wage in the industry; C – workload coefficient per job position in the industry; w_e, w_s, w_c – weight coefficients.

4. The Energy Market has a significant impact on the economic security of an enterprise, and it is crucial for businesses to thoroughly study it and adapt their strategy to the changes in this market. Investments in energy efficiency, diversification of energy sources, and risk management strategies can help ensure the resilience of the enterprise in the face of changes in the energy market.

   The energy market influences the economic security of the enterprise in many ways:

   - Changes in energy prices, such as oil, gas, coal, or electricity prices, can significantly impact the enterprise's costs. Enterprises that rely on large volumes of energy may face substantial pressure on their expenses if energy prices rise.
   - Reliable access to energy is critical for the continuous operation of a business. Problems with energy supply, such as interruptions, can lead to production stoppages or reduced productivity, which can immediately affect the enterprise's economic activities.
   - High energy costs can be a significant factor limiting the profitability of a business. Investments in energy efficiency and the use of renewable energy sources can help reduce energy costs and make the business more competitive.
   - Changes in the energy industry, such as the development of new renewable energy technologies or energy storage solutions, can create new opportunities for businesses to reduce their energy costs or even become energy producers, providing an additional source of income.

   The assessment and forecasting of changes in the energy market are important elements of economic security management, and thus, this factor is reflected in the proposed model. To assess the forecasted or modelled state of the energy market and its impact on the financial and economic security of the enterprise, the following formulas are proposed:

$$EM^{t+1} = \left(\frac{O^{t+1}}{O^t}\right) w_o + \left(\frac{P^t}{P^{t+1}} - 1\right) w_p \quad (4)$$

where, EM^{t+1} – weighted growth coefficient of the energy market (in terms of key types of energy); O – supply volumes of energy resources on the market, units of measurement; P – price of energy resources on the market, UAH; w_o, w_p – weight coefficients.

The market state coefficients show the trends of changes that carry risks or opportunities for ensuring the economic security of an enterprise in the forecast period or when modelling scenarios. The level of pressure from the indicators of each market on the state of economic security and operational efficiency varies depending on the type of economic activity and the specific development characteristics of each enterprise. In this context, we agree with the opinion of O.V. Orlyk,

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who states that «to justify clear and effective ways to strengthen the economic security of enterprises, it is very important to highlight the most important contemporary dangers and threats. Therefore, when analysing the factors of economic security, priority should be given to destructive factors (threats). However, positive factors should not be overlooked, considering, on the one hand, their positive impact on the level of economic security, and on the other hand, their potential transformation into a negative direction» (Orlyk, 2015).

In general, Table 1 presents the suggested tactical measures that enterprises are recommended to take depending on the trends of changes in the coefficients.

Table 1. Tactical Measures in the Field of Economic Security of the Enterprise Depending on the State of Forecasted Coefficients for the Development of Target Markets.

Target Markets of the Enterprise	Change Coefficient	Tactical Measures
	0< FM ≤ 1	▪ diversification of the asset portfolio; ▪ attracting external financing under moderate terms; ▪ effective cost management and budget optimisation; ▪ business diversification.
Financial Market (FM)	FM ≤0	▪ reducing dependence on external financing; ▪ anti-crisis financial management; ▪ cutting costs and eliminating unnecessary expenses; ▪ protection against currency risks.
	1≤ FM	▪ expanding the investment portfolio; ▪ attracting additional funds for business development; ▪ investing in innovative development.
	0<SM≤ 1	▪ diversification of products; ▪ risk management; ▪ price optimisation; ▪ horizontal integration.
Sales Market (SM)	SM≤0	▪ development within a niche market; ▪ production downsizing; ▪ cost optimisation.
	1≤SM	▪ product and market development; ▪ expansion of geographic presence; ▪ product differentiation; ▪ development and implementation of innovations; ▪ activation of promotion and sales methods.
	0< LM ≤ 1	▪ development of human capital potential; ▪ measures to increase labour productivity; ▪ slight increase in labour motivation.
Labour Market (LM)	LM ≤0	▪ stimulating labour productivity; ▪ improving motivational programs; ▪ functional adaptation.
	1≤ LM	▪ numerical adaptation; ▪ raising staffing requirements; ▪ personnel marketing; ▪ diversification of the workforce.
	0< EM ≤ 1	▪ energy cost optimisation; ▪ energy conservation; ▪ energy reserves planning.
Energy Market (EM)	EM ≤0	▪ diversification of energy supply; ▪ exploring alternative energy sources; ▪ abandoning energy-intensive processes or production.
	1≤ EM	▪ diversification of production processes; ▪ expanding production; ▪ creating reserves.

The tactical measures outlined are not universal and primarily depend on the relationship between the partial indicators of each market and their direction, as well as the specifics of the enterprise's economic activity, its strategy, and internal resources. However, the methodological approaches, when adapted to the conditions of a specific enterprise, can serve as signals for revising planned indicators, strategy, and tactics in the field of financial and economic security.

RESULTS

In order to test the proposed model for managing economic security, we assessed the economic security of the enterprise LLC "Semenivsky Agroservice". This agricultural enterprise specialises in the cultivation of winter wheat, corn, sunflowers, and barley. LLC "Semenivsky Agroservice" is one of the most successful agricultural enterprises in the Mykolaiv region. The company has modern machinery and equipment and employs advanced agricultural technologies. LLC "Semenivsky Agroservice" is also an exporter of grains and oilseeds. LLC "Semenivsky Agroservice" is an operating enterprise and is successfully operating in the conditions of war in Ukraine.

The enterprise operates profitably and efficiently. At the studied enterprise, there has been significant growth in assets, particularly in non-current assets, which indicates the active investment strategy of the company. During the period of study, the company's assets grew by 71%, with fixed assets increasing by 25.6%. The reduction in the depreciation of fixed assets by 23% indicates capital investments in fixed assets, including the acquisition of new equipment for land cultivation and transportation. However, the analysis of financial statements showed the absence of intangible assets on the company's balance sheet, which suggests a low level of innovation activities at the enterprise.

The enterprise's assets consisted of 40.46% non-current assets, with the remaining 59.54% accounted for by current assets. The most significant elements of current assets were production stocks (14.03% of total assets), goods credits not formalised by promissory notes (accounts receivable for goods, works, and services) (40.89% of total assets). The main non-current assets during the year were fixed assets (39.03% of total assets).

During the study period, the structure of liabilities looked as follows: equity capital accounted for 75.14%, long-term liabilities - 0%, and short-term liabilities - 24.86%. The share of equity capital was very high. With a positive value for financial leverage, it is recommended to reduce this indicator. The main components of equity capital were the charter capital (65.84% of total liabilities) and retained earnings (9.3% of total liabilities).

The express analysis of the financial condition includes the calculation of several indicators that reflect various aspects of the enterprise's financial activity, such as liquidity, stability, profitability, business activity, etc. One of these indicators is the share of fixed assets in total assets. In 2020, this share accounted for 45.62% of the company's liabilities, indicating a high level of investment in fixed assets. In 2021, this indicator increased by 2.7% compared to the previous year, indicating further enhancement of the enterprise's production capacity. However, in 2022, we observed a negative growth in this indicator by -0.09% compared to the previous period. This is primarily due to the full-scale invasion of the Russian Federation into the territory of Ukraine, in which the enterprise is located in the Mykolaiv region, which was a zone of active hostilities. However, we see a gradual increase in this indicator in 2023-2024 by 0.08%.

Table 2. Express Analysis of the Financial Condition of LLC "Semenivsky Agroservice".

Indicators	2020	2021	2022	2023	2024	Absolute deviation, +, -	
						2024 to 2023	2024 to 2020
Share of fixed assets in assets	0.46	0.48	0.39	0.40	0.48	0.08	0.02
Depreciation ratio of fixed assets	0	0	0	0	0	0	0
Asset turnover (turnover), resource utilisation, trans-formation ratio	2.87	2.14	1.93	2.11	2.54	-0.33	0.43
Fund return	6.29	4.51	4.48	4.50	5.51	-0.78	1.01
Inventory turnover ratio (turnover)	0	0	0	0	0	0	0
Accounts receivable turnover ratio (turnover)	8.11	5.37	4.55	4.87	5.65	-2.46	0.78
Return on assets on net profit, %	16.4	6.28	2.06	3.05	3.98	-12.42	0.93
Equity payback period	4.58	9.92	26.27	19.97	12.08	7.5	-7.89
Ratio of own working capital provision of inventories	2.18	0.88	0.89	0.87	0.98	-1.2	0.11
Ratio of financial independence (autonomy)	0.75	0.56	0.53	0.54	0.58	-0.17	0.04
Ratio of financial stability	0.75	0.56	0.53	0.54	0.58	-0.17	0.04
Ratio of current liquidity (coverage)	1.79	1.16	1.27	1.14	1.45	-0.34	0.31
Ratio of absolute liquidity	0.01	0.03	0.06	0.04	0.04	0.03	0
Ratio of short-term receivables and payables	0.15	0.96	1	0.95	0.80	0.65	-0.15

In 2020, the financial condition indicators of the enterprise were quite high; in particular, the share of equity was 0.75, which indicated high financial stability. However, after the positive value of financial leverage, it is advisable to reduce this

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indicator. In 2024, the value of the indicator remained within the regulatory limits. However, by the end of the studied period, this indicator decreased to 0.53, which is below the regulatory level. The financial stability coefficient also decreased from 0.75 in 2020 to 0.58 in 2024, which indicates a decrease in the sustainability of the enterprise in the future. This was due to a decrease in the share of sustainable sources of financing.

Important indicators of financial security are liquidity indicators. The dynamics of liquidity of LLC "Semenivsky Agroservice" are shown in Table 3.

Table 3. Dynamics of liquidity indicators of LLC "Semenivsky Agroservice".

Indicators	2020	2021	2022	2023	2024	Absolute deviation, +, -		Relative deviation, %	
						2024 to 2020	2024 to 2023	2024 to 2020	2024 to 2023
Current liquidity ratio (coverage)	1.79	1.16	1.27	1.37	1.45	-0.34	0.08	-81.01	105.8
Quick liquidity ratio	1.43	0.98	0.97	1.05	1.23	-0.2	0.18	-80.39	1.17
Absolute liquidity ratio	0.01	0.03	0.06	0.03	0.02	0.01	-0.01	200	66.67
Short-term receivables to payables ratio	0.15	0.96	1	0.92	0,75	0.60	-0.17	500	81.52

The company's liquidity during the reporting period remained within normal limits, although it decreased slightly in 2024, but increased compared to 2022. The value of the liquidity indicator is within the regulatory limits at the beginning of the period under review, that is, the enterprise is able to repay all its obligations within the year. In 2023, for every hryvnia of current liabilities, there are UAH 1.37 of current assets. In 2024, liquidity was within the norm and for every hryvnia of current liabilities, there were UAH 1.45 of current assets. Absolute liquidity shows the ability of the enterprise to immediately repay its current liabilities. The value of this indicator increased over time, which indicates improved financial stability. Regarding the ratio of receivables to payables, in 2020-2021 and 2023-2024, this ratio was less than one, which indicated effective management of payables and receivables. However, in 2022, this situation changed, and the accounts payable and receivable management policy turned out to be ineffective.

Consequently, in 2022, the financial condition of the enterprise deteriorated compared to previous periods. The equity ratio decreased significantly to 0.53, which is below the regulatory level and indicates lower financial stability. In addition, the financial stability ratio also decreased to 0.56, which indicates a decrease in the stability of the enterprise in the future. Accounts payable and receivable management also became less effective, since the ratio of accounts receivable to accounts payable exceeds one. However, the liquidity of the enterprise remains within normal limits, and absolute liquidity is improving, which may indicate an increase in the ability to repay current liabilities. Overall, the financial condition of the enterprise in 2022 was less favourable compared to previous years, which is due to the consequences of the war. At the same time, positive dynamics of the main financial indicators are observed, which indicates a gradual recovery of activity.

An important indicator of the economic stability of an enterprise is the probability of bankruptcy. Bankruptcy is usually preceded by a period of financial difficulties, which leads to a deterioration in the financial condition of the enterprise. However, bankruptcy can be predicted in advance, and appropriate measures can be taken to prevent it.

There are many methods for predicting the financial condition of an enterprise regarding its possible bankruptcy. One of the main ones is the assessment of possible bankruptcy through a financial analysis of specific parameters of the enterprise's activities. These parameters characterise the financial condition of the enterprise and reflect the potential threat of bankruptcy in the future. The assessment is based on comparing the actual values of indicators with planned or regulatory ones, as well as calculating possible deviations in dynamics. If the analysis reveals an increase in negative deviations, this may indicate a threat of bankruptcy.

To assess the probability of bankruptcy of LLC "Semenivsky Agroservice", we used Altman's five-factor model (Sabadash & Kovalenko, 2012):

$$Z = 1{,}2X_1 + 1{,}4X_2 + 3{,}3X_3 + 0{,}6X_4 + 1{,}0X_5 \quad (5)$$

where, X_1 = return on equity (profit/equity); X_2 = liquidity (current assets / short-term liabilities); X_3 = efficiency of asset use (current assets / total assets); X_4 = production turnover (revenue / total assets); X_5 = financial stability (equity / total assets).

According to the assessment results, we will obtain a Z value, which is interpreted as follows: a Z value of more than 2.99 indicates high financial stability of the enterprise; a Z value from 1.8 to 2.99 may indicate moderate financial risk; a Z value less than 1.8 may indicate high financial risk and the possibility of bankruptcy of the enterprise.

Using financial reporting data, an assessment of the probability of bankruptcy of LLC "Semenivsky Agroservice" was carried out:

- 2020 year: $Z = 1{,}2 * 0{,}6 + 1{,}4 * 0{,}16 + 3{,}3 * 0{,}22 + 0{,}6 * 1{,}14 + 1 * 0{,}6 = 2{,}9$
- 2022 year: $Z = 1{,}2 * 0{,}6 + 1{,}4 * 0{,}16 + 3{,}3 * 0{,}03 + 0{,}6 * 0{,}24 + 1 * 0{,}6 = 1{,}78$

Thus, in 2020, the value of the Altman coefficient showed that the enterprise was not threatened with bankruptcy. However, in 2022, the probability of bankruptcy increased. This is due, among other things, to the beginning of the war in Ukraine, which created significant threats to the economic security of all enterprises, and agricultural enterprises in particular.

To assess the state of the main ones for the enterprise and possible measures for adaptation in the field of economic security in 2025, the proposed methodological approaches to assessing trends in target markets were used. Table 4 shows the calculation of the growth coefficients of the financial market, sales market, labour market and energy market for the enterprise LLC "Semenivsky Agroservice".

Table 4. Calculation of the coefficients of the state of relevant markets for an agricultural enterprise. *(Source: generated and calculated by the author based on data from the National Bank of Ukraine, the Ministry of Finance of Ukraine, the Agrarian Exchange, and the State Statistics Service of Ukraine)*

Indicators	wi	Indicator values			Partial coefficients with weighting	
		2020	2022	2025 (forecast)	2022	2025 (forecast)
Financial market (FM)						
Cost of capital (interest on loan), %	0.4	16.0	25,0	15,0	-0,14	0,27
Profit tax, %	0.3	18.0	18,0	18,0	0,00	0,00
Exchange rate, UAH/USD	0.3	27.0	36,4	40,7	-0,02	-0,09
Weighted financial market growth rate (FM)					-0.22	0.18
Sales market (SM)						
Sales volumes in the target market, million tons:						
sunflower	0.1	13.5	12,0	11,0	0,09	0,09
wheat	0.2	20.0	18,0	17,0	0,18	0,19
barley	0.2	7.0	6,0	6,5	0,17	0,22
Price, UAH/t:						
sunflower	0.1	14000.0	22000,0	25000,0	-0,04	-0,01
wheat	0.2	6000.0	8500,0	9000,0	-0,06	-0,01
barley	0.2	5000.0	7000,0	7500,0	-0,06	-0,01
Weighted sales market growth rate					0.29	0.46
Labour market (LM)						
Number of people employed in the agricultural sector, million people	0.2	4.1	3,7	3,5	0,18	0,19
Average wage in agriculture, UAH	0.4	10000.0	12000,0	14000,0	-0,07	-0,06
Load per workplace in agriculture, people	0.4	2.5	2,0	1,8	0,32	0,36
Weighted labour market growth rate (LM)					0.43	0.49
Energy market (EM)						
Supply volumes (diesel fuel), thousand tons	0.4	7.5	6,0	6,5	0,32	0,43
Price (diesel fuel), UAH/l	0.6	28.0	50,0	45,0	-0,26	0,07
Weighted energy market growth rate (EM)					0.06	0.50

Analysing the state and trends of the financial market, it can be noted that in 2022, the trends worsened compared to 2020. Thus, the refinancing rate increased significantly from 16 to 25%, which limits the ability to attract credit funds for the development of enterprises and increases the riskiness of investments. The devaluation of the national currency from UAH 27 per USD 1 to UAH 36.4 in 2022 also has a negative impact. Taken together, these factors led to a negative growth

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in the financial market coefficient. At the same time, LLC "Semenivsky Agroservice" exports a significant part of its products abroad; therefore, in this context, the devaluation of the national currency cannot be considered unambiguously as a negative factor. The National Bank of Ukraine predicts an improvement in the growth rate of the financial market in 2025 due to a decrease in the refinancing rate. Comparative growth indicators of target markets are shown in Figure 1.

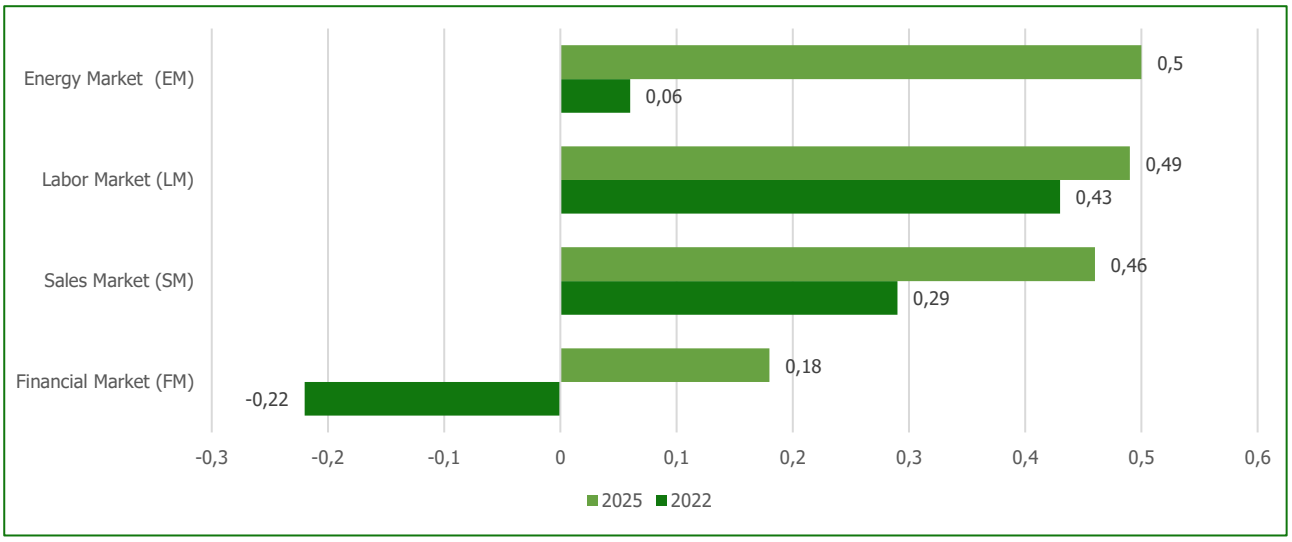

Figure 1. Growth rates of relevant markets for an agricultural enterprise.

In 2025, according to the forecast data developed by the Cabinet of Ministers of Ukraine and the National Bank of Ukraine, the growth dynamics of target markets, despite the continuation of the war, are expected to be more positive than in 2022. This is primarily due to the adaptation of the economy to new conditions. However, the forecast indicators do not take into account the further escalation of military operations, changes in global markets and possible restrictions on foreign aid.

The proposed model of managing the economic security of an enterprise and methodological approaches to its formation are not a universal tool for financial planning. At the same time, the use of individual elements of the model and their implementation in the system for monitoring external factors affecting economic security will increase the level of adaptability of financial management at the enterprise and will contribute to increasing economic security in changing environmental conditions.

Despite the approximately positive forecasts, the enterprise LLC "Semenivsky Agroservice" needs to take measures to save energy resources, diversify sales markets and sources of financing and adapt personnel policy in conditions of reduced supply on the labour market.

The importance of the processes of forming models for managing the economic security of a business in conditions of market changes is determined by the reasons for their necessity:

Adaptability to change: The market environment is characterised by a high level of uncertainty and dynamism. Economic security management models help companies quickly adapt to changes, identify potential risks and develop strategies to minimise them.

1. Protection from external and internal threats: Effective models allow you to predict and prevent potential threats that may affect the financial position and reputation of the company, including financial crises, technological failures, competitive challenges or data loss.
2. Ensuring stability and development. Reliable economic security mechanisms provide the enterprise with the stability necessary for long-term planning and investment in development. This includes expanding into new markets, introducing innovations and attracting capital.
3. Resource optimisation. Management models help identify and effectively allocate the resources necessary to protect the business, while optimising costs and increasing profitability.

4. Increasing the trust of investors and partners. The economic security indicator and the company's ability to effectively manage risks inspire greater confidence among investors, creditors, partners and customers, increasing its investment attractiveness.
5. Ensuring legal protection. Managing economic security includes compliance with legislative and regulatory requirements, which reduces the risks of legal violations and associated financial losses.
6. Supporting corporate culture. Forming a culture of economic security in a company helps to foster a responsible attitude towards resources, information and processes among employees. This increases overall awareness of potential risks and ways to avoid or minimise them, creating a safe and productive working environment.
7. Increasing competitiveness. Companies that effectively manage their economic security often stay ahead of their competitors due to their ability to quickly adapt to changes, reduce costs and improve the quality of their products or services.
8. Strengthening market positions: Stability and security allow a company not only to survive in difficult conditions but also to effectively expand its market presence, attracting new customers and expanding the range of products or services. Economic security becomes the foundation for growth and expansion, which allows you to use market opportunities as effectively as possible.
9. Promoting innovation. Strong economic security and stability create favourable conditions for investing in research and development. Companies that have a strong foundation are more inclined to experiment and innovate, which can lead to breakthrough solutions and product improvements.

The formation and application of effective models of business economic security management in conditions of market changes is not only the key to survival in the short term, but also the key to long-term success and sustainable development. It is important to remember that such models must be flexible and adaptive, able to respond quickly to changes in the external environment in order to ensure the best use of resources and maximum risk reduction.

DISCUSSION

Shtangret (2024) in her scientific research improved the model of the subsystem of information support for the development of the economic security system of the enterprise, which differs from those known in science and practice in structural elements (organisational restructuring, technological changes, technical renewal, personnel reinforcement, economic support), the filling of which with specific information allows determining the content of those changes that need to be made in connection with the digital transformation of the economy and the enterprise and the results of security activities, as well as informationally supporting the implementation of the development program.

Most scientific research is aimed at improving a separate block of the economic security management subsystem model (information, organisational, legal, economic support, etc.) or using the design thinking approach, which is why, in modern conditions, it is more effective to use a process approach to improving models (Pavlenko et al., 2023).

Kudelya (2016) for the first time developed a system of a comprehensive system for assessing economic security based on a mathematical model, which, unlike existing ones, takes into account a set of grouped indicators regarding the influence of important factors on the level of profitability of agricultural enterprises, taking into account the degree of financial risks, which will allow increasing the level of production efficiency of agricultural enterprises in modern economic conditions. Cherep, O. G., & Bekhter, L. A. (2018) substantiated the feasibility and necessity of forming a system to ensure the economic security of agricultural enterprises. Veklych et al., (2024) hypothesised that there is an urgent need to develop a package that will allow standardising source data, quickly conducting assessments, starting from the local level, increasing the reliability of the results obtained, and stimulating the widespread implementation of ecological and economic accounting in national statistical and accounting systems while creating models for managing economic security at the mesolevel.

In the dynamic world of finance, the introduction of generative artificial intelligence (GAI) to financial forecasting is considered a game-changer, potentially increasing the accuracy and reliability of forecasts. GAI differs from conventional forecasting methods in its ability to learn unsupervisedly and its flexibility in dealing with chaotic and nonlinear market conditions (Kumar et al., 2025). Castelló et al. (2024) emphasize that the learning process carried out using machine learning (ML) models and their evolution through large language model (LLM) interfaces based on natural language processing (NLP) systems should be considered in the interests of preserving rights and promoting competition. The role of the legislator in the protection of personal data in the EU Member States is a challenge of an economic and competitive

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nature and may limit the development of state-of-the-art models, which may affect the competitiveness of the region compared to other economic areas, such as the United States or China.

Graphical, analytical research methods (determination of specific gravity and structural particles), parameterisation methods using a matrix approach and linear functional dependence, and the method of strategic SWOT analysis were applied.

Kapliar et al. (2024) analysing the opportunities and threats in neobanks' resistance to risks against the backdrop of digitalisation of companies, they applied graphical and analytical research methods (determination of specific gravity and structural fractions), parameterisation methods using a matrix approach and linear functional dependence, and the method of strategic SWOT analysis.

CONCLUSIONS

In the context of the development of digital technologies, the management of the economic security of an enterprise can be optimised using mathematical digital models and the creation of appropriate software. Based on the research conducted, a model of business economic security management has been proposed, which takes into account the influence of key external and internal factors on the development of the enterprise and its economic security. The model is based on a process approach and provides for the allocation of key business processes of the enterprise (production, sales, finance, resource provision), which together form economic security and simplify the processes of financial budgeting, taking into account external and internal opportunities and threats. The proposed model of business economic security management takes into account the main risks, as well as opportunities for ensuring the sustainable functioning of the enterprise, and creates the prerequisites for making preventive tactical decisions based on direct monitoring of the processes of production, sales and budgeting, as well as reactions to external signals.

In order to test the proposed model of economic security management, we assessed the state of economic security of the enterprise LLC "Semenivsky Agroservice". Despite the relatively positive forecasts, the company LLC "Semenivsky Agroservice" needs to take measures to save energy resources, diversify sales markets and sources of financing, and adapt personnel policy in the face of a reduction in supply on the labour market.

Prospects for further research into the justification of the mechanism for implementing the model of economic security of agricultural enterprises in conditions of war and post-war recovery.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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МОДЕЛЬ УПРАВЛІННЯ ЕКОНОМІЧНОЮ БЕЗПЕКОЮ БІЗНЕСУ СІЛЬСЬКОГОСПОДАРСЬКИХ ПІДПРИЄМСТВ В УМОВАХ РИНКОВИХ ЗМІН

Метою дослідження є процес формування моделі управління економічною безпекою сільськогосподарського бізнесу в умовах ринкових змін з урахуванням прогнозування й моделювання розвитку кожного цільового ринку для підприємства. Запропоновано застосування економіко-математичних моделей у контексті управління економічною безпекою сільськогосподарського бізнесу, що дозволяє не лише аналізувати й прогнозувати різноманітні економічні процеси, а й формувати обґрунтовану стратегію дій із мінімізації потенційних ризиків і використання існуючих можливостей. Доведено, що використання економіко-математичних моделей сприяє об'єктивізації процесу ухвалення рішень, забезпечуючи їх високу надійність та ефективність. Запропоновано математичний апарат прогнозування й моделювання розвитку кожного цільового ринку підприємства, що враховує оцінку впливу ключових чинників на економічну безпеку на кожному з цільових ринків сільськогосподарського підприємства та впливу кожного ринку на стан економічної безпеки підприємства й розроблення відповідних тактичних заходів. Для оцінки стану основних для підприємства і можливих заходів для адаптації в царині економічної безпеки 2025 року використано пропоновані методичні підходи оцінки тенденцій на цільових ринках. Здійснено розрахунок коефіцієнтів зростання фінансового ринку, ринку збуту, ринку праці та енергетичного ринку для підприємства ТОВ «Семенівський агросервіс». Аналізуючи стан і тенденції фінансового ринку, можна відзначити, що 2022 року тенденції погіршилися порівняно з 2020 роком, однак протягом 2023-2024 років усі показники поступово відновили тенденцію до зростання. У процесі аналізу визначено, що разом ці чинники призвели до від'ємного зростання коефіцієнта фінансового ринку. Визначено, що ТОВ «Семенівський агросервіс» значну частину продукції експортує за кордон, відповідно, девальвацію національної валюти не може розглядати однозначно як негативний чинник. Запропоновані методичні підходи при їх адаптації до умов конкретного підприємства можуть слугувати своєрідними сигналами для перегляду планових показників, стратегії й тактики в царині фінансово-економічної безпеки.

Ключові слова: економіко-математична модель, економічна безпека, ринкові зміни, сільськогосподарський бізнес, сільське господарство, експрес-аналіз, прогнозування, моделювання, релевантні ринки

JEL Класифікація: E20, H56, O10, Q10