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# THE IMPACT OF GEOPOLITICAL RISKS ON THE FINANCIAL STABILITY OF THE AGRICULTURAL SECTOR: A COMPARATIVE ANALYSIS OF UKRAINE AND THE COUNTRIES OF THE EUROPEAN UNION

*The object of the research is the financial resilience of the agricultural sector in Ukraine and selected European Union (EU) countries under geopolitical and macroeconomic risks generating uncertainty in agribusiness. The problem addressed in the article lies in the absence of a unified methodological approach to the quantitative assessment of agricultural financial resilience under geopolitical risks, as well as limited comparability of results between Ukraine and EU countries. The findings indicate a statistically significant negative impact of geopolitical risks, currency volatility, and debt burden on the financial resilience of the agricultural sector. A persistent structural gap between Ukraine and EU countries has been identified: the average integral financial resilience index for Ukraine is approximately 0.38, compared to about 0.54 in EU countries. The patterns revealed in the study are explained by external risks affecting Ukraine's agricultural sector. In contrast, higher financial resilience in EU countries is driven by a stable macroeconomic environment, diversified export structure, and institutional support mechanisms for agribusiness. A distinctive feature of the results is the integration of a balanced panel dataset with calculation of an integral financial resilience index based on normalized financial and institutional indicators. The practical application of the proposed index covers agricultural enterprises and financial management systems within the sector. The results are applicable under geopolitical risk conditions to assess financial resilience, evaluate risk impacts, and support informed managerial decisions.*

***Keywords:*** *financial stability, agribusiness, geopolitical risks, financial controlling, credit management, financial engineering.*

## 1. Introduction

Today has signs of a deep crisis, both international and domestic. This situation generates a significant number of risks, in particular financial, and has a critical impact on financial decision-making, in particular in the agro-industrial sector. The financial results and financial stability of agricultural enterprises directly depend on the impact of various negative factors, including military operations in the country, energy and currency crises. Since Ukraine currently has a significant share of agricultural enterprises and a significant share of agricultural exports, these processes generate additional risks for the financial security of these enterprises.

Scientists have several approaches to determining the financial stability of an enterprise, but basically financial stability is characterized as the ability to maintain the solvency and profitability of an enterprise in an unstable external and internal environment of the enterprise. However, most studies consider separately the impact of internal and external factors on the financial stability of agricultural enterprises, without taking into account the complexity of these processes and the possibilities of influencing them.

The scientific literature has fragmentarily highlighted the influence of geopolitical factors in managing the financial stability of an agricultural enterprise, taking into account such tools as credit management, financial controlling, and financial engineering. This problem is very important for agricultural enterprises, which activities are determined by high capital intensity, dependence on credit resources, and external markets. This requires the creation of a single analytical toolkit that will not only provide risk monitoring, but will also provide an assessment of adaptability and ensure effective management decisions.

The post-war recovery of the country, in particular its agricultural sector, will require a comparative aspect of financial stability with the countries of the European Union. These countries have a higher financial adaptability of the agricultural sector to the challenges of the external and internal environment through access to agricultural sector support programs and the introduction of developed financial management tools. Therefore, a comparative analysis between Ukraine and the countries of the European Union provides an opportunity to assess the impact of risks on the finances of the agricultural sector of the country, to implement those management decisions that will be effective.

That is why there is a need to form a comprehensive approach to assessing the financial stability of an agricultural enterprise, which is a synthesis of panel econometric analysis, integral indicators and financial risk management tools. This vision of financial stability allows to consider it as a dynamic characteristic of the financial condition of the enterprise, which takes into account the influence of all negative factors of the external and internal environment.

Within the framework of the research, it is important to clearly distinguish the levels of financial stability analysis. In the work, financial stability is considered at two interrelated levels: macroeconomic and microeconomic.

At the macro level, financial stability is defined as a comprehensive characteristic of the financial condition of the country's agricultural sector. It reflects its ability to maintain profitability, solvency and liquidity and develop under the influence of geopolitical and macroeconomic risks. It is this level that is analyzed using econometric analysis based on aggregated statistical indicators of the industry.

At the micro level, financial stability is determined by the ability of an individual agricultural enterprise to maintain solvency, achieve an optimal capital structure and adapt to external risks. In this context, the tools of financial controlling, credit management and financial engineering play a key role as mechanisms for forming financial stability in the agricultural sector in the long term.

Therefore, the research is based on a two-level methodological model that combines a macroeconomic assessment of the financial stability of the agricultural sector with an analysis of management mechanisms for ensuring it at the level of individual enterprises.

Today, there is no single approach among researchers regarding the essence of the concept of "financial stability of an enterprise". Supporters of the resource approach define financial stability as the ability of an enterprise to form and effectively use financial resources in order to ensure the continuous operation of the enterprise. Thus, in works [1, 2] the authors consider financial stability as a complex characteristic of the financial condition of an enterprise, which is formed under the influence of internal and external factors. Supporters of the balance sheet approach [3] focus on the ratio of own and borrowed capital, focusing on the sufficiency of own capital as the main factor ensuring the financial stability of the enterprise. In this context, it should be emphasized that the use of only financial ratios in assessing financial stability does not take into account the impact of risks, external factors and time dynamics. Supporters of the management approach interpret financial stability as the result of effective financial management and as a tool for achieving strategic goals in conditions of uncertainty. In [4], attention is focused on strengthening the role of uncertainty and external risks in forming an appropriate level of financial stability. It should be noted that this analysis is mainly descriptive in nature and does not determine cause and effect relationships. In [5], the authors argue about the feasibility of assessing the financial stability of the enterprise based on complex indicators. They emphasize the need to formalize indicators for assessing financial stability based on complex indicators, which requires the use of quantitative models that take into account the impact of macroeconomic factors. In [6] it is proposed to use balance sheet indicators to diagnose the financial stability of an enterprise. This approach is appropriate when conducting a basic assessment, but it does not take into account external macroeconomic risks. Similarly, financial stability as a prerequisite for sustainable development of business entities is considered in [7], focusing on conceptual analysis. Thus, the generalization of scientific approaches shows that when assessing financial stability, insufficient attention is paid to the dynamics of risks and external risks are not fully taken into account. Therefore, the limitations of factor-oriented models adapted to economic and geopolitical instability justify the feasibility of further research on the formation of approaches to assessing the financial stability of enterprises,

in particular the agricultural sector. It should be noted that existing approaches usually consider financial stability in a relatively stable macroeconomic environment, and in conditions of geopolitical instability, the analysis of external risks as a factor affecting the level of financial stability of an enterprise becomes key. Geopolitical risks are considered by scientists as events that change the established order and cause transformations in the economy, finance, trade, etc., causing crisis states. Geopolitical risks include military actions, political instability, energy crises, economic crises that affect the financial stability of a business entity. In this context, attention should be paid to the work [8]. In it, the authors proposed the use of a geopolitical risk index and proved that its growth is associated with an increase in investments, a decrease in business activity and financing.

The key work in this direction is the research in which the geopolitical risk index is proposed and empirically proven that the increase in geopolitical tension reduces investments, affects the decline in business activity and financial dynamics. In the work [9], political and economic uncertainty is considered as a separate direction of influence of geopolitical risks and it is proved that the increase in uncertainty leads to a reduction in investments, an increase in the cost of capital and an increase in the financial vulnerability of the enterprise. In the work [10], the influence of political conflicts and instability on financial decisions made by enterprise managers is studied. The authors prove that political risks increase risk; affect the increase in the cost of capital and a decrease in investor confidence. All this is negatively reflected in the level of financial stability of the enterprise. This is especially significant for entities in the agricultural sector due to their high export orientation, dependence on international logistics and sensitivity to currency and energy risks. The study [11] states that geopolitical conflicts and trade restrictions directly affect the financial stability of agro-industrial enterprises through increased costs, disruption of supply chains and reduced profitability. Therefore, based on the analysis of literary sources, it is possible to state that geopolitical risks are a powerful factor in the financial instability of business entities. At the same time, in the agricultural sector, the issues of assessing financial stability at the interstate level and quantifying key factors affecting its level are insufficiently researched. This justifies the feasibility of using panel econometric models.

The scientific literature presents an approach that focuses on the internal management mechanism of increasing the financial stability of the enterprise. Within the framework of this approach, special attention is paid to the tools of financial controlling, credit management and financial engineering, which are considered as tools for optimizing the capital structure, minimizing financial risks and increasing business adaptability in unstable economic conditions. Thus, in [12] the feasibility of implementing controlling mechanisms to increase the effectiveness of financial decisions based on a systematic analysis of the financial statements of the enterprise is substantiated. Within the framework of the enterprise risk management system, with an emphasis on the agro-industrial sector, in the study [13] financial engineering is considered as a tool for diagnosing financial risks. At the same time, in [14] financial engineering is considered as a tool for strengthening the financial security of the enterprise by increasing the efficiency of debt management and liquidity of the enterprise. In [15] prove that the implementation of financial controlling tools in the adaptive management system of the enterprise contributes to increasing the financial stability of enterprises. However, it should be noted that these studies are limited to the micro level and do not take into account the systemic impact of geopolitical and macroeconomic risks, and also do not take into account differences in the financial and institutional conditions of the functioning of the agricultural sector of different countries.

Thus, the analysis of literary sources indicates the existence of discrepancies between macroeconomic and geopolitical approaches to the analysis of financial stability and management concepts of financial

controlling, credit management and financial engineering. Also, the issue of the interaction of geopolitical risks and financial and managerial factors of the financial stability of the agricultural sector in the countries of the European Union remains insufficiently disclosed. In this context, this research combines the approaches of panel econometric analysis with the concepts of financial engineering and controlling. This allows to assess the key determinants of the financial stability of agribusiness in Ukraine and the countries of the European Union in the conditions of geopolitical risks and to formulate sound recommendations for increasing financial stability.

Thus, *the object of research* is the financial stability of the agribusiness sector of Ukraine and the countries of the European Union in the conditions of geopolitical and macroeconomic risks that form the uncertainty of the functioning of agribusiness. The subject of research is a set of financial, economic, macroeconomic and institutional factors that determine the level of financial stability of the agricultural sector, as well as management mechanisms for its provision.

*The aim of research* is to assess the impact of geopolitical risks on the financial stability of the agricultural sector of Ukraine and individual countries of the European Union.

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

1) identify the main types of geopolitical risks and determine their potential impact on the financial results of enterprises in the agro-industrial sector;

2) form a panel database of indicators of financial stability of the agricultural sector of Ukraine and EU countries for 2014–2024 and build an econometric model with fixed effects, which allows for a quantitative assessment of the key determinants of financial stability;

3) conduct a comparative analysis of the results obtained and propose a mechanism for increasing the financial stability of the agricultural sector of Ukraine.

## 2. Materials and Methods

The empirical basis of research is a panel database formed for the agro-industrial sector of Ukraine and five countries of the European Union, namely, Poland, Romania, Lithuania, Hungary and Bulgaria for 2014–2024. On its basis, an integral indicator of financial stability was calculated, which allows to assess the dynamics of the level of financial stability of the agricultural sector of a particular country and conduct a comparative analysis. The use of panel models with fixed effects allows to assess the impact of geopolitical and monetary and financial factors on the financial stability of the agricultural sector, to identify the role of compensatory management mechanisms in mitigating the negative consequences of such risks.

In this research, the integral indicator of financial stability (IFFS) reflects the aggregated sectoral financial position of the agricultural sector of the country and is not an indicator of the individual financial stability of an individual enterprise. The use of panel data allows to assess cross-country structural differences at the sectoral level.

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

– geopolitical risks have a statistically significant negative impact on the financial stability of agricultural enterprises in Ukraine;

– in EU countries, the impact of geopolitical risks on financial stability is less pronounced due to more developed mechanisms of financial intermediation and state support;

– export diversification, access to credit resources and the level of state support reduce the negative effect of geopolitical risks on the financial stability of agricultural enterprises.

The research methodology is based on a combination of theoretical and empirical methods, which allowed for a comprehensive assessment of the financial stability of the agro-industrial sector in conditions of geopolitical and macroeconomic instability.

The following methods were used in the research process. To systematize approaches to the interpretation of the financial stability of the agricultural sector, financial risk management and the role of state support in conditions of crisis risks - the method of analysis and generalization. Economic and statistical methods were used to assess the financial condition of the agricultural sector. Taxonomic and correlation-regression analysis methods – to identify determinants of financial stability and quantitative assessment of the impact of geopolitical, currency and financial factors. To verify the reliability of the results obtained, a diagnostic method was used. To compare the financial stability of the agricultural sector of Ukraine and the European Union countries and to substantiate practical mechanisms for its strengthening, methods of comparative analysis and economic interpretation were used.

The choice of research methodology is based on the use of official international statistical databases. The use of Eurostat data (national accounts and financial accounts of non-financial corporations) allowed the formation of the main indicators of the agricultural sector of the EU countries. These are the following indicators: indicators of financial results, the structure of assets and liabilities, capital autonomy and debt burden. The FAOSTAT and OECD databases allowed the systematization of information on the export of agri-food products and the level of state support. The use of the World Bank database made it possible to process indicators of currency volatility and macroeconomic conditions. The World Bank and Eurostat Labour Statistics statistical databases show data on employment and labor productivity in the agricultural sector. The event approach allowed to identify indicators of geopolitical risks by isolating periods of armed conflict. To form a balanced panel sample for 2014–2024, all indicators were normalized.

The use of the proposed methodological tools allowed to assess the financial sustainability of the agro-industrial sector and form an analytical basis for management decisions in the field of credit management, financial controlling and financial engineering in the context of post-war recovery and European integration.

## 3. Results and Discussion

### 3.1. Identification of the main types of geopolitical risks and their potential impact on the financial results of enterprises

In recent years, the agricultural sector has been operating in conditions of increasing geopolitical instability. Military conflicts, trade restrictions, currency and energy crises affect not only the production activities of business entities, but also the financial stability of the agricultural sector, in particular, profitability, liquidity and financial resources.

In scientific research, geopolitical risks are mostly considered as events of external influence that disrupt established economic ties and increase financial risks for enterprises. In particular, scientists [8] prove that the increase in geopolitical risk reduces investment activity, worsens financing conditions and increases uncertainty in financial markets. For the agricultural sector, these consequences are more noticeable due to its dependence on external markets, logistics infrastructure and the macro-financial environment.

The research identified four main types of geopolitical risks that have the most significant impact on the financial stability of the agricultural sector: military (political), trade, currency and energy risks.

Military and political risks cover a wide range of threats that affect all areas of activity. These include armed conflicts, sanctions regimes, political instability and restrictions on economic activity. These risks negatively affect the production activities of enterprises in terms of the supply of raw materials and sales of products and the financial activities of enterprises in terms of the formation and use of assets and financial resources. In studies [9, 10], scientists have proven that military and political risks negatively affect the volume of investments, the level of profitability and financial stability of a business entity.

As for the agricultural sector, it is it that is very sensitive to these consequences due to its dependence on exports, financial resources and the stability of the functioning of infrastructure systems. The research takes into account the impact of military and political risks through the geopolitical risk indicator, which allows assessing their impact on the integral indicator of the financial stability of the agricultural sector.

Trade risks arise as a result of the complication of the conditions for entering foreign markets, export restrictions and disruptions in the activities of international logistics. Since the agricultural sector is mainly focused on foreign markets, these factors directly affect the volume of foreign exchange earnings and narrow financing opportunities.

Studies [11, 16] show that countries with a high concentration of agricultural exports have a higher level of trade risks, which negatively affects the level of profitability and liquidity. Within the framework of the empirical model of the impact of trade risk, the variable is represented by the share of agricultural exports in total exports, which characterizes the share of agricultural exports in the total volume of exports of the country.

Currency risks manifest themselves through exchange rate instability, which creates increased financial risks for enterprises with foreign exchange liabilities or dependent on imported resources. In [17] note that exchange rate instability negatively affects the financial efficiency of business and inhibits investment activity. For the agricultural sector, currency risks lead to an increase in the cost of credit, complicate financial planning and cash flow planning. In this research, this effect is represented by the exchange rate volatility variable, which reflects the annual volatility of the exchange rate.

Energy risks associated with rising energy and fuel prices directly affect the financial stability of a business entity through increased costs and reduced operating profit. Research results [11, 16] show that a sharp increase in the cost of energy and fertilizers leads to a decrease in the profitability of agricultural producers, especially in countries with high energy intensity of production and limited opportunities to attract financial resources. For agro-industrial enterprises, the increase in fuel and energy costs increases the cost of agricultural products, which reduces operating profit and financial stability of enterprises. In the countries of the European Union, the negative impact of energy risks is reduced due to state support mechanisms within the Common Agricultural Policy, which confirms the stabilizing role of budgetary instruments in periods of macroeconomic and geopolitical instability.

Within the framework of this research, this effect is taken into account using the SUB variable, which reflects the level of state support for the agricultural sector and allows to quantitatively assess its impact on the integral indicator of financial stability. Thus, each of the identified types of geopolitical risks affects the financial stability of the agricultural sector, which is represented in the corresponding variables of the econometric model. The proposed approach to identifying risks creates a conceptual basis for the formation of a panel database and further quantitative assessment of the determinants of the financial stability of the agricultural sector of Ukraine and the European Union countries. In order to summarize the identified types of geopolitical risks, the directions of their financial impact and the impact on the level of financial stability of the agricultural sector, Table 1 presents the relationship between the types of risk, the directions of financial impact and financial stability.

Thus, Table 1 summarizes the key types of geopolitical risks, their financial transmission channels and the expected direction of influence on the integral indicator of financial stability. The proposed scheme is the conceptual basis for building an econometric model with fixed effects and is the basis for hypotheses regarding the determinants of the financial stability of the agricultural sector.

**Table 1**

Types of risks and their impact on the financial sustainability of the agricultural sector

| Risk factors | Forms of impact | Nature of impact | Economic content of the impact |
|---|---|---|---|
| Military-political | Disruption of logistics routes, limited financial resources, increased production and credit risks | Negative | Decrease in profitability, loss of liquidity and solvency, decrease in investment attractiveness |
| Trade | Reduced export volumes, disruption of trade routes, reduced foreign exchange earnings | Negative | Decrease in foreign exchange income, increase in uncertainty of cash flows, deterioration of liquidity and financial stability |
| Currency | Increasing currency instability affecting the cost of imports and debt servicing | Negative | Decrease in predictability of cash flows and financial stability |
| Energy | Increasing production costs and the need for financial equalization | Negative | Increase in the cost of energy resources leads to a decrease in profitability and financial stability |
| Overall geopolitical risk | Combined negative impact on financial results, liquidity, enterprise value and investment attractiveness | Differentiated | The integral indicator of financial stability reflects the total financial impact on the level of financial stability |

**Note:** compiled by the authors based on [8, 11, 16, 17]

### 3.2. Formation of a panel database of indicators of financial stability of the agricultural sector and a fixed effects model

A meaningful comparative analysis of the impact of external risks on the financial stability of the agricultural sector requires an adequate panel database of the countries of the European Union and Ukraine. The countries were selected based on a similar structure of agricultural production, geographical location, and similarity of economies. These characteristics ensured the comparability of the indicators. According to these characteristics, the following countries were selected for comparative analysis: Poland, Romania, Lithuania, Hungary and Bulgaria.

In the course of the research during 2014–2024, three stages were formed, according to which the features of the functioning of the agricultural sector were considered:

– the first stage, the so-called pre-war period (2014–2021), which is characterized by the gradual growth of the agricultural sector and the beginning of integration into the European market;

– the second stage, the so-called crisis period (2022–2023) – characterized by a large number of military threats, disruptions in logistics and exchange rate fluctuations;

– the third stage, the so-called adaptation period (2024) – characterized by a partial restoration of production in the agricultural sector.

The econometric analysis was conducted on the basis of a set of observations (66 observations covering 6 countries and 11 years).

The sample of countries was formed on the basis of economic, structural and external factors, and this allows for an adequate comparative analysis of the financial stability of the agricultural sector.

The empirical analysis within the framework of this research is carried out at the macro level and is based on aggregated sectoral statistical data. Accordingly, the obtained estimates characterize the financial stability of the agricultural sector of the country as a whole and do not reflect the individual financial indicators of individual enterprises.

1. The selected countries have a significant share of the agricultural sector in the economy (from 5 to 12%), medium and large farms, oriented towards domestic and foreign markets, have similar technological models of agricultural production. These features are the basis for comparing financial stability indicators (integral indicator of financial stability, financial leverage, level of state support for the agricultural sector, share of agricultural exports in the country's total exports) within the same industry.

2. The selected countries have similar macroeconomic conditions, i. e. inflation rate, integration processes, currency dynamics. This geographical position is very important from the point of view of the process of adaptation to the influence of external threats, such as the war in Ukraine, the energy crisis, inflationary pressure. Ukraine is the only country in this list with a war economy. Therefore, the rest of the EU states are a reference group, with post-socialist economies that have overcome transformation processes and are integrated into the EU's common agricultural policy.

3. The selected countries have the following financial systems of the agricultural sector, which can be compared with each other: state programs to support farmers, lending to small and medium-sized enterprises in agriculture, openness to investment. All this makes it possible to assess both financial parameters and the level and effectiveness of state support for the agricultural sector.

4. Comparison with the selected countries will allow using the experience of adapting the country's agricultural sector to the requirements of the European Union, integration into EU financial programs, and the use of state support instruments in conditions of negative impact of external threats.

Accordingly, the selection of these countries will allow identifying and applying effective mechanisms for the post-war development of the agricultural sector of Ukraine.

The selected countries form a balanced panel, the features of which are:

– completeness of observations and balance of the panel;

– increasing the accuracy of model estimates;

– ensuring the geography of Eastern European countries in the context of global studies of the financial sustainability of the agricultural sector.

It is necessary to highlight the key principles that shaped the choice of the studied countries: the possibility of a structurally comparable agricultural sector, common economic dynamics, practical significance in the post-war policy of financial stability of Ukraine.

This will allow to make generalizations that are basic for the countries of Eastern Europe in view of modern external risks.

For the analysis, a final panel database was formed, which included the following variables:

*ROA* – return on assets (%);

*AC* – autonomy coefficient;

*FL* – financial leverage;

*LCR* – liability coverage ratio;

*SS* – level of state support for the agricultural sector (in shares of the industry's GDP);

*EHP* – share of agricultural exports in the country's total exports;

*VE* – exchange rate volatility;

*DI* – share of foreign direct investment in the gross value added of the agricultural sector;

*LPP* – labor productivity in the agricultural sector (in thousand euros per employee);

*IGR* – indicator of geopolitical risks (1 – years of war or sanctions, 0 – other years);

*IIFS* – integral indicator of financial stability.

The definition of the impact on IIFS financial stability by indicators is given in Table 2.

**Table 2**

Determination of the impact on the financial sustainability of the IIFS by indicators

| Variable | Value | Unit | Expected sign in the model |
|---|---|---|---|
| *IIFS* | Integral sustainability index: weighted average of normalized indicators | Index (0–1) | – |
| *ROA* | Return on assets | % | + |
| *AC* | Autonomy ratio | share | + |
| *FL* | Financial leverage | times | – |
| *LCR* | Liability coverage ratio | times | + |
| *SS* | State support to the agricultural sector/GDP of the agricultural sector | share | + |
| *FHP* | Share of agricultural exports in total exports | share | + |
| *VE* | Exchange rate fluctuations | index | – |
| *DI* | Share of agricultural sector in GVA | share | + |
| *LPP* | Labor productivity in the agricultural sector | thousands of euros/employees | + |
| *IGR* | External risks | 1 – years of war/ sanctions; 0 – the rest | – |
| $A_i$ | Fixed achievements of the country | – | – |
| $y_t$ | Partial fixed achievements | – | – |

The primary data were collected from open statistical sources [16, 18–22] and processed according to the unified classification NACE Rev.2/KVED A01 "Agriculture". In order to eliminate large differences between countries, all indicators were brought to a comparative format (shares, coefficients, indices). Currency values were converted into euros at the average annual exchange rate (ECB and NBU data).

After data collection, several stages of preparation were carried out:

– checking missing values and filling them in using the linear interpolation method (for 2.3% of observations);

– normalizing variables using the min–max method (0–1) to construct an integral financial stability index

$$z_{ijt} = \frac{x_{ijt} - x_j^{3/4}}{x_j^{\max} - x_j^{\min}}; \tag{1}$$

– removal of multicollinearity by checking variance inflation factors ($VIF < 5$);

– logarithmization of variables with large variation (*IIFS*, *EHP*, *VE*).

Calculation of the *IIFS* integral indicator as a weighted average estimate

$$IIFSit = 0.25 \cdot ROAit + 0.25 \cdot ACit + \frac{0.2}{FLt} + 0.1 \cdot LCRit + 0.05 \cdot SSit +$$

$$+0.05 \cdot EHPit + 0.05 \cdot (1 - VEit) + 0.03 \cdot DIit + 0.02 \cdot \left(\frac{LPPit}{100}\right), \tag{2}$$

where *i* – country; *t* – year.

The estimation was carried out using two specifications:

1) model with fixed effects at the country level

$$IIFSit = A_i + B_1 \cdot IGRit + B_2 \cdot VEit + B_3 \cdot EHPit +$$

$$+ B_4 \cdot FL + B_4 \cdot SSit + E_{it}; \tag{3}$$

2) two-factor model with fixed effects

$$IIFSit = A_i + y_t + B_1 \cdot IGRit + B_2 \cdot VEit + B_3 \cdot EHPit +$$
$$+ B_4 \cdot FL + B_4 \cdot SSit + E_{it}, \tag{4}$$

where $A_i$ – fixed effects of countries; $y_t$ – time fixed effects; $E_i$ – stochastic residual accumulating the influence of unaccounted factors.

The parameters were estimated by the least squares method using clustered standard errors by country. This allowed to take into account intragroup correlation and heteroscedasticity.

All six countries (Ukraine, Poland, Romania, Lithuania, Hungary, Bulgaria) had available observations for all years (2014–2024) of the research, which determined the balance of the panel base.

The following checks were performed:

Descriptive Validation: the check showed that all indicators have real limits of variation (*ROA*: 1–8%, *FL*: 1.0–2.5, *SS*: 5–20%, etc.).

Outlier Analysis: using the interquartile range method, it was confirmed that there were no statistical outliers that could negatively affect the regression results.

Correlation Analysis: confirmed that all pairs of variables do not exceed the multicollinearity threshold ($|r| < 0.7$).

Variance Inflation Factor: the result proved the absence of high correlation between the studied variables, since all values are <5.

The Hausman test was applied, which showed the feasibility of using the fixed-effects model.

The null hypothesis is that the estimates of the random effects model are efficient and consistent.

The alternative hypothesis is that the estimates of the random effects model are consistent, so a fixed effects model is used.

Test result

$$x^2(5) = 17.42, p = 0.007 < 0.05. \tag{5}$$

Since the null hypothesis is rejected, a country-level fixed-effects model was chosen as the most adequate for describing the panel data. This indicates that persistent differences between countries significantly affect the financial sustainability of the agricultural sector and should be taken into account in the modeling.

The purpose of the Broisch-Pagan test was to check for heteroscedasticity of the residuals, i. e., uneven error variances across countries.

The test result

$$LM = 12.38, p = 0.029 < 0.05. \tag{6}$$

Therefore, the hypothesis of homoscedasticity is rejected.

To eliminate the effect of heteroscedasticity, clustering of standard errors by country was applied, which ensures robustness of estimates and correctness of significance levels.

The presence of autocorrelation in panel data can cause deviations of standard errors, which leads to incorrect determination of coefficients. The results of the Wooldridge test indicate the presence of weak autocorrelation: $F(1,5) = 5.87$, $p = 0.056$, however, it is sufficient for the correlation of estimates. In order to take into account intragroup correlation and heteroscedasticity, standard error correction was used to ensure the accuracy of estimates by clustering them by country.

A number of additional tests were conducted to verify the results obtained. First, testing an alternative specification of the model by perturbing the integral indicator of financial stability on individual financial indicators (ROA, AC, FL), which did not lead to changes in the signs and directions of the influence of key indicators. Second, the application of the sequential exclusion procedure (sequential exclusion of individual countries) showed a negligible effect on the statistical significance of the variables (external risks, financial leverage, share of the export potential of the agricultural sector). Third, the research of the interaction effect between external risks and state support revealed that state support mitigates the negative impact of external risks on the financial stability of the agricultural sector.

The diagnostic tests conducted confirmed the adequacy and balance of the formed panel base, the reliability and validity of the constructed model with fixed effects, which allows to consider it representative for the agricultural sector.

**3.3. Comparative analysis of results and the mechanism for strengthening the financial stability of the agricultural sector of Ukraine**

The constructed database panel (2014–2024) allowed to conduct a comparative analysis of the integral indicator of the financial stability of the agricultural sector of Ukraine and selected countries of the European Union (Poland, Romania, Lithuania, Hungary, Bulgaria), Table 3. The purpose of the analysis was to identify the main differences in the dynamics of financial stability and to identify the factors that determine the difference in the levels of stability.

It is important to note that the integral indicator is formed on the basis of aggregated sectoral statistical data, therefore the results of the analysis characterize the financial stability of the agricultural sector at the macro level. The empirical model does not reflect the financial indicators of individual enterprises, but allows to assess general cross-country structural differences and the dynamics of sectoral stability.

At the micro level, the established trends are manifested through changes in the financial conditions of the functioning of agricultural enterprises, in particular their liquidity, capital structure and investment activity.

The results of the fixed-effects model allowed to determine that the average value of the integral indicator of financial stability in Ukraine is 0.38, while in the sample of EU countries it is 0.54. This indicates that Ukraine lags behind by approximately 30%.

Let's highlight the main determinants of the gap:

– the level of financial leverage – for Ukraine it is 2.05 versus 1.42 in EU countries. This indicates dependence on borrowed capital;

– lower autonomy coefficient – 0.31 versus 0.47, i. e. the share of equity in the assets of Ukrainian agricultural enterprises is significantly lower;

– higher level of currency volatility – 1.7 times higher than the EU average;

– low share of agricultural exports – 0.38 versus 0.52, which reduces the diversification of foreign exchange earnings;

– low level of state support – 0.10 versus 0.15, which reduces the anti-crisis potential of the agricultural sector.

**Table 3**

A fragment of the panel database: dynamics of the integral indicator of financial sustainability (IIFS) of the agricultural sector, 2014–2024

| Country | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bulgaria | 0.558 | 0.423 | 0.485 | 0.439 | 0.511 | 0.503 | 0.424 | 0.391 | 0.484 | 0.445 | 0.403 |
| Hungary | 0.444 | 0.548 | 0.443 | 0.393 | 0.488 | 0.487 | 0.490 | 0.421 | 0.596 | 0.483 | 0.419 |
| Lithuania | 0.459 | 0.373 | 0.438 | 0.461 | 0.507 | 0.440 | 0.449 | 0.450 | 0.430 | 0.504 | 0.469 |
| Poland | 0.371 | 0.399 | 0.487 | 0.550 | 0.414 | 0.374 | 0.516 | 0.532 | 0.477 | 0.409 | 0.411 |
| Romania | 0.409 | 0.457 | 0.475 | 0.522 | 0.42 | 0.366 | 0.483 | 0.455 | 0.476 | 0.476 | 0.471 |
| Ukraine | 0.452 | 0.396 | 0.367 | 0.514 | 0.379 | 0.432 | 0.494 | 0.366 | 0.451 | 0.476 | 0.428 |

**Note:** calculated by the authors based on the panel database [16, 18–22]

Fig. 1 shows the obtained results of the dynamics of the integral indicator of financial stability of the agro-industrial sector of Ukraine and the EU countries for 2014–2024.

The results show that until 2022, Ukraine demonstrated a gradual increase in the value of the integral financial stability indicator. With the beginning of the full-scale war in 2022, there is a sharp decrease in this indicator from 0.49 to 0.31, which is a very negative trend. In the studied EU countries, financial stability remained stable. Accordingly, it was concluded that external risks negatively affect the integral financial stability indicator.

A diagram of the average values of the integral financial stability indicator for the period 2014–2024 was constructed for the studied countries. Comparative analysis revealed a significant lag of Ukraine in terms of the average level of the IIFS (0.38) from the studied EU countries (Fig. 2).
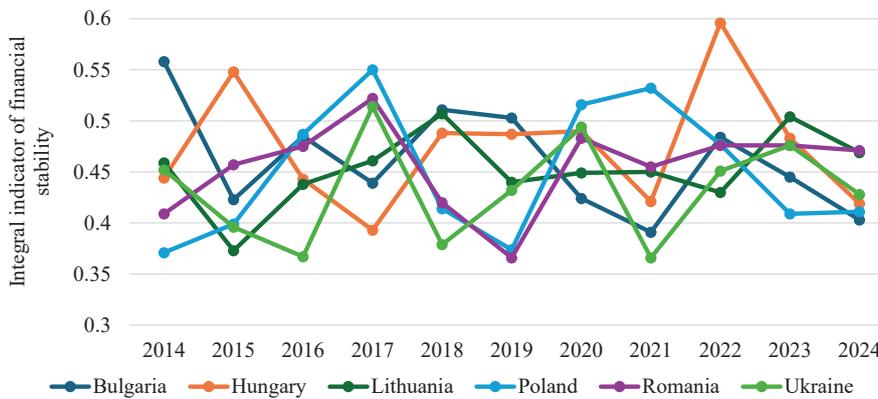
In contrast, countries such as Poland, Lithuania and Romania have a value of this indicator of 0.52–0.57. This situation has arisen due to high currency instability, significant debt burden and the absence or low level of state support. The high financial performance of EU countries in crisis periods is due to a stable financial infrastructure, well-established diversified exports and access to EU funds.

The graphical presentation of the results of the regression analysis made it possible to clearly identify the following main patterns:

1. The presence of a low IIFS level in Ukraine in 2022–2023, which is a consequence of the impact of military operations and currency risks.

2. The IIFS stability in EU countries is due to state support in the form of anti-crisis programs and financial reserves.

3. The gap in financial stability (0.15 points) between Ukraine and the average level of EU countries, which reflects the need for structural restructuring of the financial policy of the agricultural sector.

Table 4 provides generalized average values of key indicators of financial sustainability for 2014–2024.

The analysis shows that the financial stability of Ukraine is significantly affected by the debt burden, low level of state support and increased instability of the foreign exchange market. As for the EU countries under study, the key to financial stability is a stable macroeconomic policy, access to Common Agricultural Policy (CAP) programs and a system of financial support for farms.

Accordingly, credit management tools at the macro level, such as state guarantees for loans, interest rate compensation and debt restructuring mechanisms, play the role of financial stabilizers. They help to adapt to the negative impact of external risks on the financial stability of the agricultural sector.

In order to summarize the comparative results, Table 5 was formed, which displays the average values of the integral indicator of financial stability for 2014–2024.

Analysis of Table 5 revealed that the average values of the integral indicator of financial stability indicator (*IIFS*) indicate differences between countries in terms of the stability of the agro-industrial sector in 2014–2024.

The average *IIFS* level for the studied EU countries is approximately 0.54, while Ukraine lags behind the average European level by 30%.



**Fig. 1.** Dynamics of the integral indicator of financial stability (*IIFS*) of the agricultural sector of Eastern European countries, 2014–2024
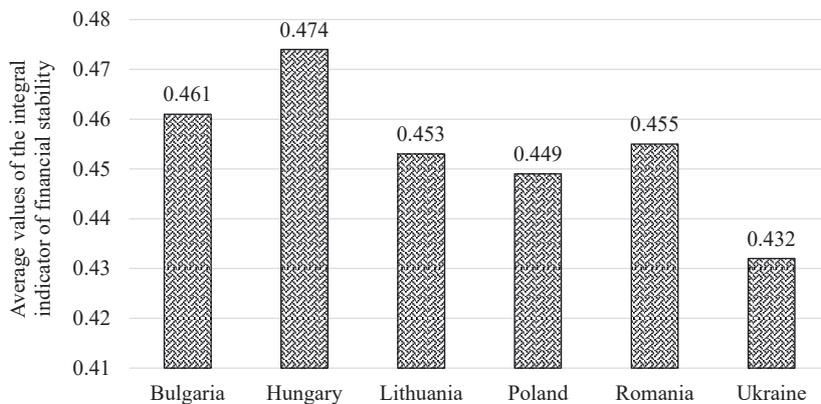


**Fig. 2.** Average values of the integral indicator of financial stability of the agro-industrial sector of Ukraine and EU countries, 2014–2024

**Table 4**

Comparative indicators of financial sustainability of the agricultural sector of Ukraine and EU countries (2014–2024)

| Indicator | Ukraine | Average in EU (5 countries) | Deviation, % | Impact on financial stability |
|---|---|---|---|---|
| IIFS (integral indicator) | 0.38 | 0.54 | −29.6 | weak stability |
| AC (autonomy coefficient) | 0.31 | 0.47 | −34.0 | limited equity |
| FL (financial leverage) | 2.05 | 1.42 | +44.4 | debt burden |
| EHP (export share) | 0.38 | 0.52 | −26.9 | low income diversification |
| SS (state support) | 0.10 | 0.15 | −33.3 | weak government buffer |
| VE (currency instability) | 0.11 | 0.07 | +57.1 | exchange rate risks |

**Note:** calculated by the authors based on data from [16, 18, 19, 21, 22]

**Table 5**

Average values of the integral indicator of financial stability for the agro-industrial sector of Ukraine and selected EU countries, 2014–2024

| Country | Average value | Min | Max | Deviation from average EU value (%) | EU country |
|---------|---------------|------|------|-------------------------------------|------------|
| Ukraine | 0.38 | 0.31 | 0.44 | −30.2 | – |
| Poland | 0.56 | 0.49 | 0.60 | +4.8 | + |
| Romania | 0.52 | 0.45 | 0.56 | −1.9 | + |
| Lithuania | 0.55 | 0.48 | 0.59 | +2.8 | + |
| Hungary | 0.53 | 0.46 | 0.57 | −0.5 | + |
| Bulgaria | 0.51 | 0.43 | 0.55 | −3.4 | + |

**Note:** calculated by the authors based on data from [16, 18, 19, 21, 22]

The highest average IIFS values are in Poland (0.56) and Lithuania (0.55). This is due to access to capital, developed *CAP* subsidy programs and low currency instability. Ukraine has an increased level of leverage ($FL > 2.0$) and significant dependence on borrowed capital, which negatively affects the integral financial stability indicator, despite positive trends in the export of agricultural products.

Ukraine has a significant deviation from the average level of EU countries (from −28% to −32%), but the remaining member states have fluctuations within ±10%. This indicates that the Ukrainian agricultural sector is more sensitive to external risks, namely currency and political risks. But Ukraine has growth potential provided that a financial stabilization mechanism is applied, i.e. increased state support, development of hedging instruments and attraction of financing.

According to the results of Table 5, there is agreement with the econometric conclusions of the model, confirming the systemic difference in financial stability between Ukraine and EU countries and the need to implement European experience at agricultural enterprises in the conditions of post-war recovery.

The research results allowed to assert that the financial stability of the agricultural sector is formed under the influence of internal and external risks. This serves as the basis for synthesizing the results of panel econometric analysis with the tools of financial controlling, credit management and financial engineering. This combination will allow creating effective mechanisms to increase the financial stability of enterprises in the agricultural sector of Ukraine.

Based on the research conducted, a system of mechanisms to increase the financial stability of the agro-industrial sector was developed, covering all levels of management.

At the macro level – state policy (state mechanisms):
– creation of an agro-industrial stabilization fund to compensate enterprises for losses in conditions of military and currency crises;
– introduction of a currency hedging system through the use of derivatives or guarantee instruments of the NBU, expansion of subsidy programs, as well as integration with European programs to attract long-term capital.

At the meso level, industry mechanisms should be implemented: creation of regional financial associations for joint liquidity management and development of programs for adaptation to risks. It is important to develop the AgriRisk Hub platform, which identifies and analyzes financial risks in real time. It is also necessary to widely involve insurance programs to cover all types of risks in cooperation with international insurance companies.

At the micro level, emphasis should be placed on corporate finance. This includes optimizing the capital structure by minimizing short-term debt, increasing the share of equity, expanding export markets, and building domestic foreign exchange reserves.

The use of digital financial controlling systems, such as ERP, BI analytics, AI risk analysis models, will enable effective cash flow management. The use of financial controlling and financial engineering methods at the level of an agricultural enterprise contributes to the optimization of cash flow management, capital structure, and ensures the adaptation of agricultural enterprises to currency and debt risks. The implementation of such approaches in Ukraine is relevant and can significantly strengthen the level of financial stability of agricultural enterprises.

The implementation in Ukraine of mechanisms that have proven themselves positively in EU countries will allow:
– to reduce the instability of financial flows;
– to improve the investment attractiveness of the agricultural sector;
– to increase the resilience of enterprises to all types of external risks.

The results obtained indicate that increasing the financial stability of agricultural enterprises in the face of external threats requires a combination of macroeconomic instruments with the tools of credit management systems, financial controlling, and financial engineering at the enterprise level.

In the future, this will allow creating architectonics of financial security of the agrarian sector, which will become the foundation for the gradual development of the Ukrainian agrarian sector in the post-war period.

### 3.4. Discussion of the research results on the financial stability of agribusiness in the conditions of geopolitical risks

The results of the analysis of the panel model with fixed effects indicate the influence of geopolitical, currency and financial factors on the financial stability of the agribusiness sector. In particular, a change in the geopolitical indicator has a statistically significant negative effect (−0.04 at $p < 0.1$). Thus, war and other geopolitical risks associated with it reduce the ability of agribusiness enterprises to ensure the appropriate level of profitability, liquidity and stability.

The research results confirmed the conclusions of the work [8], which argued that an increase in external risks significantly reduces investment activity, narrows financing conditions and negatively affects the level of business activity of the enterprise. Similar conclusions were drawn in [9], where it is stated that military and economic risks lead to an increase in the cost of borrowed capital and reduce the financial stability of enterprises. These challenges are especially acutely felt by enterprises in the agro-industrial sector due to their significant dependence on exports and logistics. This is consistent with [11], which proves a direct relationship between military conflicts and trade restrictions, an increase in production costs against the background of the loss of sales markets. The empirical verification proves that the vulnerability of enterprises in the agricultural sector of Ukraine to external threats was highest in 2022–2023. It was at this time that the combination of military actions, export restrictions and inflationary processes led to a decline in the profitability of the agricultural sector. Such trends confirm the results of panel modeling on the hypothesis put forward regarding the direct negative impact of geopolitical factors on the level of financial stability of the agricultural sector.

The negative value of the regression coefficient for the currency fluctuation indicator (−0.02 at $p < 0.1$) indicates the instability of the exchange rate and negatively affects the financial stability of enterprises.

The results obtained are fully correlated with the position of scientists in the work [17], where it is proven that sharp changes in the exchange rate negatively affect financial results, reduce investment activity and business efficiency as a whole. A statistically significant negative impact was also revealed by the financial leverage indicator (–0.06 at $p < 0.1$). The result obtained indicates a decrease in the financial flexibility of enterprises in the event of excessive dependence on borrowed capital. Similar conclusions can be seen in the study [23], where it is proven that enterprises with a high level of debt burden have difficulty adapting to macroeconomic and financial impacts. The authors emphasize that a high debt burden limits the strategic flexibility of business entities and increases financial vulnerability in an environment of uncertainty, which corresponds to the results of the panel model for the agricultural sector of Ukraine. Thus, the level of financial leverage of agricultural enterprises in Poland and Romania is 30–40% lower than in Ukraine, which is one of the factors of higher financial stability of agricultural enterprises in these countries in 2022–2024. The analysis showed that the financial stability of the agricultural sector in Ukraine is approximately 1.7 times more sensitive than the average for the European Union countries. This difference is explained by the combined effect of such factors as: higher volatility of the foreign exchange market, lower level of diversification of agricultural exports, limited access to long-term lending and the lack of developed insurance mechanisms to cover political and military risks. In contrast, EU countries are characterized by higher stability of the agricultural sector, which is associated with the availability of access to instruments [24] and initiatives [25] aimed at supporting agribusiness entities during periods of macroeconomic and geopolitical instability. The use of such measures contributes to the stabilization of the income of agricultural enterprises, minimizing credit risks and negative impacts of external factors on the financial results of agricultural enterprises.

The results obtained confirm the hypothesis of a lower impact of geopolitical factors on the level of financial stability of the agricultural sector of the European Union countries, compared to Ukrainian agribusiness.

Analysis of the results obtained in comparison with the conclusions of studies [8, 16] gives grounds to assert that the level of financial stability of the agricultural sector is formed under the influence of certain key factors. Namely, macrofinancial stability, access to financial resources, state support and the level of security. In the context of Ukraine, the primary task is the harmonious combination of internal strategies (reducing the debt burden, increasing the efficiency of asset use, forming an optimal capital structure) with external instruments.

Thus, the results of the analysis confirm that macroeconomic factors significantly reduce the level of financial stability of the agricultural sector of Ukraine. At the same time, state support, export diversification and integration with the European Union create the basis for its increase in the medium and long term.

The practical significance of the results obtained lies in the level of use by financial managers of agricultural enterprises as a tool for assessing financial stability and monitoring foreign economic risks. The presented integral indicator will contribute to the justification of management decisions regarding the debt structure of an agricultural enterprise, currency position and improvement of the financial adaptability of agribusiness.

The limitation of research is the use of aggregated panel data, which suggests the possibility of not fully taking into account the financial characteristics of individual enterprises. The practical implementation of research results requires the involvement of complete financial information and taking into account the specifics of a particular enterprise when determining a set of indicators.

Further research should be directed to a micro-level analysis of the financial stability of individual agricultural enterprises. As well as im-proving the integral indicator by including non-financial and institutional factors. A promising task is to model scenarios for ensuring the financial sustainability of agricultural enterprises in the conditions of post-war development.

## 4. Conclusions

1. Four main types of external risks for the agricultural sector are identified: military-political, trade, currency and energy. Their impact is systematized through financial channels, such as profitability, liquidity, access to financing, cost and currency position. Quantitative analysis has shown a statistically significant negative impact of geopolitical risks on the integral indicator of financial stability ($\beta = -0.04$ at $p < 0.1$). During periods of war or sanctions, the financial stability of the agricultural sector is significantly reduced. This is explained by logistical gaps, high credit risks and worsening financing conditions in the face of external shocks.

2. A balanced panel database for six countries for the period 2014–2024 (66 observations) has been compiled based on information from official sources: Eurostat, World Bank, FAOSTAT, OECD. The indicators were normalized and based on them, the integral index of financial stability index (*IIFS*) was calculated in the range from 0 to 1 as a weighted composition of financial and institutional indicators. To determine the *IIFS* determinants, a model with fixed effects for countries and time was used, the effectiveness of which was confirmed by the Hausman test ($\chi^2(5) = 17.42$; $p = 0.007$). During the diagnostics, heteroscedasticity was detected ($LM = 12.38$; $p = 0.029$), which required the use of clustered standard errors. The model assessment showed a statistically significant negative impact of currency volatility ($\beta = -0.02$; $p < 0.1$) and financial leverage ($\beta = -0.06$; $p < 0.1$) on the *IIFS* due to the increase in the cost of capital, the difficulty of forecasting cash flows, and the decrease in financial flexibility in crisis periods.

3. A comparative analysis of the dynamics of the *IIFS* of Ukraine and five EU countries showed a stable structural imbalance. The average *IIFS* of Ukraine is about 0.38, while in EU countries it is about 0.54 (a lag of about 30%). The reasons for this gap are considered through a comparative analysis of the average values of key factors: Ukraine's financial leverage exceeds the EU indicators by 44.4%, the autonomy coefficient is 34% lower, state support is 33.3% lower, currency instability is 57.1% higher, and the share of agricultural exports is 26.9% lower. The importance of these results lies in the possibility of quantitatively confirming the influence of geopolitical, currency and debt factors through the FE model and explaining cross-country differences through the IIFS indicator to ensure comparability of Ukraine with EU countries. On this basis, a mechanism for increasing the financial stability of the agricultural sector of Ukraine at the macro level and creating conditions for strengthening the financial position of agricultural enterprises at the micro level is proposed. Macro-level instruments include expanding credit guarantee systems, regulating currency transactions, and providing state support. At the same time, micro-level mechanisms include improving the structure of debt obligations, expanding export destinations, and implementing advanced financial approaches.

### Conflict of interest

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

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The research was conducted without financial support.

## Data availability

The manuscript has no related data.

## Use of artificial intelligence

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

## Authors' contributions

*Tatyana Kuzenko:* Conceptualization, Methodology, Validation, Writing – review and editing, Project administration; *Nataliia Sablina:* Conceptualization, Methodology, Validation, Writing – review and editing, Project administration; *Maksym Voloschuk:* Conceptualization, Methodology, Formal analysis; *Oleg Glushkov:* Conceptualization, Methodology, Investigation; *Olena Drugova:* Conceptualization, Methodology, Formal analysis, Writing – original draft; *Oleksandr Sherstyuk:* Conceptualization, Methodology, Investigation.

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