ALGORITHM FOR ASSESSING NATIONAL FINANCIAL AND ECONOMIC SECURITY

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ABSTRACT

The article addresses a relevant and complex problem of developing an algorithm for assessing the state of Ukraine's financial and economic security under conditions of wartime risks and post-war economic recovery. An integral methodology is proposed that makes it possible to assess the state of Ukraine's financial and economic security, to identify key problematic components of the state's financial and economic security over the dynamics of the studied periods, as well as to identify threats and opportunities with a view to implementing the obtained results in the practice of restoring financial and economic security. The proposed algorithm is based on the ideas of a polynomial algorithm for extrapolating the parameters of stochastic systems and includes a specific set of indicators of the state of Ukraine's financial and economic security, formed in the process of building the component structure of the category "financial and economic security." Its application makes it possible to assess the level of the economy's resilience to external and internal threats; it is characterized by signaling capability regarding the level of imbalance in the state's financial and economic security, the availability of statistical data and analytical applicability, unambiguity of interpretation, and a high level of sensitivity to changes in the economic situation.

INTRODUCTION

An aggregated assessment of the level of economic security was conducted by the Ministry of Economic Development and Trade of Ukraine for the economy as a whole and for individual spheres of activity during the period 2013–2021, using the Methodological Recommendations for Calculating the Level of Economic Security of Ukraine (Ministry of Economic Development and Trade of Ukraine, 2013). By Decree of the President of Ukraine No. 347 of August 11, 2021, the Economic Security Strategy of Ukraine for the period up to 2025 was approved (President of Ukraine, 2021). In accordance with paragraph 20 of this Strategy, the security dimension in the field of ensuring economic security consists in anticipating economic imbalances, increasing the economy's resilience to external and internal challenges and threats, for which purpose continuous monitoring of economic resilience has been introduced. The importance of correct assessment and forecasting of the state of Ukraine's financial and economic security is extremely high. Such assessment should be carried out in order to make effective decisions in the management of the state's economic and financial systems under conditions of instability. The Methodological Recommendations for Calculating the Level of Economic Security of Ukraine had significant limitations (a large number of indicators, the impossibility of operational analysis due to the lack of statistical data, and the inability to apply them to different regions of the country). In the updated Economic Security Strategy of Ukraine the number of indicators used for calculation was reduced; however, the strength of their impact on the integral security indicator was not taken into account, being limited only to the determination of their critical thresholds and target benchmarks. Under conditions of a prolonged state of martial law in Ukraine, operational analysis and forecasting of the state of financial and economic security constitute an important problem, given that timely and scientifically grounded information can form the basis for prompt managerial decision-making in crisis situations. In the process of developing a new algorithm for assessing the state of the state's financial and economic security under martial law, it is necessary to take into account changes in key indicators, since traditional indicators during periods of wartime and post-crisis transformations gradually lose their informativeness. This study not only emphasizes the problems inherent in existing analytical methodologies but also substantiates a specific approach to overcoming these limitations, making it relevant for scientific research in the field of restoring the financial and economic security of the state under conditions of martial law.

RELATED WORKS, PURPOSE AND TASKS

The application of the tools Google Analytics and VOSviewer v.1.6.20 made it possible to conduct an in-depth bibliometric analysis by identifying key thematic clusters of scholarly publications in which significant scientific results have been obtained in the field of assessing the state of a country's financial and economic security, including under conditions

of martial law. The conducted bibliometric analysis confirmed the existence of several stable groups of scientific publications that form the theoretical–methodological and applied core of the relevant scientific discourse.

The first cluster of publications includes articles that form the methodological foundation for the development of integral indicators and general criteria for assessing the state's financial and economic security.

Thus, in the study (Reznik et al. 2020), the state's financial security is considered a basic component of national security, with a clear division into components, the identification of threats and risks, as well as mechanisms for adaptation to them; however, the presented lists can be applied under conditions of economic instability only with caution.

The authors of the article (Kalinichenko et al. 2024) conducted a study of the level of Ukraine's financial security and emphasized that imbalances in public finances and currency risks directly affect national financial resilience; however, other important components of financial security under conditions of economic turbulence remained beyond the scope of the analysis.

In the study (Poltorak et al. 2022, 2023), indicators of the state of the country's financial security were calculated; however, under conditions of martial law and limited statistical data, there is a need for a thorough revision of the methodology for assessing the security state.

In the article (Derevyanko et al. 2018), a comprehensive analysis of the financial and economic security of regions is presented based on statistical data, with an emphasis on the economic and social components of regional development.

The second cluster includes publications in which the authors' attention is focused on the impact of the budget deficit, public debt, and fiscal policy issues on the resilience of the national financial system.

Thus, in the article (Lutsyshyn et al. 2024), the authors examine the fiscal security of states in a global context and assess its impact on macroeconomic stability and economic growth. In the study (Kunytska-Iliash 2023), an authorial approach to assessing the financial security of agriculture was tested. The study is aimed at forming a high-quality information and analytical basis for managerial decision-making. In the article (Rekunenko et al. 2023), forecasting of the level of Ukraine's financial security was carried out based on a comparative analysis of two methodological approaches. The study is aimed at selecting the most appropriate toolkit for assessing the state of the country's financial security under conditions of an unstable socio-economic environment.

The third cluster is formed by studies devoted to the specifics of ensuring financial and economic security under conditions of global crises, shocks, and martial law.

In the article (Soliman et al. 2024), it is analyzed how the full-scale war in Ukraine has affected market risks. The authors of the study (Vu et al. 2023) focus on the specific features of the impact of geopolitical shocks on the stability of the banking system.

Publications that emphasize the role of state institutions, as well as the quality of governance and the effectiveness of the state's financial policy, form the fourth cluster of publications. In the article (Blikhar et al. 2021), institutional and legal factors that have the greatest impact on the level of financial security are examined. The team of authors in the study (Jungo et al. 2022) presents a large-scale analysis of the impact of financial inclusion and the competitive environment on the financial stability of the banking sector, taking into account the role of financial regulation. Analyzing the scientific results presented in the study (Sirenko et al. 2020), we emphasize that the authors concluded that the development of the state's innovative potential, particularly in the field of financial technologies, is one of the key factors in strengthening the state's financial security under conditions of globalization.

In addition to academic approaches, international practice includes country risk assessment models developed by organizations such as the OECD, as well as commercial risk assessment frameworks (e.g., Control Risks, GRC-based systems), which focus on expert-based and institutional indicators. However, such models are typically less adaptable to conditions of incomplete statistical data and wartime structural shifts.

While giving due credit to the substantial scientific results of previous studies, we believe that under current conditions the problem of developing an algorithm for assessing the state of a country's financial and economic security under martial law requires further in-depth consideration by the scientific community. Unlike previous approaches, the proposed methodology emphasizes data-driven weighting, sensitivity to critical deviations, and applicability under limited data conditions.

The purpose of the article is to substantiate the theoretical and methodological foundations and practical approaches to developing an algorithm for assessing the state of a country's financial and economic security under martial law.

To achieve this purpose, the following objectives have been defined: to form the theoretical and methodological foundations of integral assessment of the state's financial and economic security; to develop an algorithm for assessing the state of the state's financial and economic security that combines a hierarchical system of weights, multiplicative aggregation, and ensures the preservation of sensitivity to critical deviations of individual security components; to test the proposed methodology and the built-in express monitoring and forecasting module using statistical data of Ukraine.

RESULTS

The logic of the developed algorithm for assessing the state of a country's financial and economic security under conditions of martial law is based on a combination of a normatively oriented approach—namely, comparing actual indicator values with critical thresholds and target benchmarks—and a systemic multilevel aggregation of indicators into a single integral dimension. The proposed algorithm takes into account that the state's financial and economic security is a multicomponent system, the adequate characterization of which cannot rely on a single indicator and, accordingly, requires the synthesis of diverse information from several subsystems.

At the first stage, indicators with different dimensions are transformed to a comparable scale through normalization. Normative thresholds are chosen as benchmarks. The value of the target benchmark for each indicator is interpreted as a safe state, while the critical threshold is interpreted as the boundary of transition to an unsafe zone. Such an approach ensures the interpretability of partial assessments in terms of security status. Within this logic, each indicator is classified according to the direction of desirability (stimulator, destimulator, two-

sided), which makes it possible to correctly reflect how changes in the indicator affect the security level.

At the second stage, the construction of partial security indices for individual subsystems is envisaged. The normalized indicator scores are aggregated into subindices that reflect the state of the corresponding security subsystem.

At the third stage, the subindices are integrated into a single integral index of financial and economic security to assess the state's resilience to systemic economic threats. Aggregation is implemented through multiplicative convolution; the weights among subsystems are equal, while the weights among indicators within a specific subsystem are assessed based on the informational significance of the indicators over time.

The algorithm is also supplemented with an operational express monitoring and forecasting loop, in which the integral indicator is modeled and extrapolated using polynomial procedures and correlation–regression relationships tested in previous work (Atamanyuk et al. 2024). This ensures high practical value in situations of incomplete data, since from 2022 there has been a problem of the inability of state statistical authorities to ensure the collection, analysis, and dissemination of statistical information under conditions of martial law in Ukraine, or the need for rapid assessment of future scenarios.

The weighting scheme in the integral methodology for assessing the state of a country's financial and economic security plays an important role, as it determines the extent to which changes in individual indicators and subsystems affect the final integral assessment. The study implements a hierarchical weighting approach.

The weights among the structural subsystems of financial and economic security are assumed to be equal. Equality of weights at this level ensures the normative neutrality of the integral index, prevents artificial amplification of individual subsystems, and increases users' trust in the results of the methodology. The assumption of equal weights at the subsystem level reflects a normative interpretation of financial and economic security, where all components are considered equally critical for systemic stability. At the same time, differentiation is introduced at the indicator level through entropy-based weighting, which captures the dynamic informational contribution of each variable.

Indicator weights are determined based on their informational significance over time. This decision is made because an indicator that demonstrates greater variability, sensitivity to crisis events, and the ability to differentiate security states over the analyzed period carries a higher informational load and, accordingly, should have a greater impact on the formation of the subindex. Indicator weights are not set by expert judgment but are derived from empirical data, which reduces subjectivity and enhances the scientific rigor of the methodology.

To prevent the loss of danger signals – when the critical state of one indicator is not diagnosed due to favorable dynamics of other indicators – the methodology applies multiplicative aggregation, which conceptually corresponds to the security-oriented logic of analyzing systems with high sensitivity to bottlenecks. Compared to additive aggregation, the multiplicative form better reflects systemic risk propagation, as deterioration in a single component cannot be compensated by improvements in others. At the level of an individual financial and economic security subsystem, multiplicative aggregation takes the form of a weighted geometric mean of normalized indicators (1).

$$I_{g,t} = \prod_{i \in g} s_{i,t}^{\omega_i}, \quad (1)$$

where $I_{g,t}$ –the subindex of the g-th subsystem in year t;

$s_{i,t} \in [0; 1]$ – the normalized security assessment of the i-th indicator;

ω_i – the weighting coefficient of the indicator.

A similar approach is applied at the inter-subsystem level when forming the integral index of the state's financial and economic security (2).

$$I_{FES,t} = \prod_g I_{g,t}^{W_g}, \quad (2)$$

where $I_{FES,t}$ – the integral index in year t;

$I_{g,t}$ – the subindex of the g-th subsystem in year$t$;

W_g – the weighting coefficient of subsystems, which are assumed to be equal within the methodology.

An important property of multiplicative aggregation is its nonlinear sensitivity to critical deviations. If the value of an indicator approaches a critical state, the integral indicator also decreases sharply, signaling a loss of systemic resilience. Thus, the methodology ensures the "weakest link" effect, which is fundamental for the analysis of financial and economic security under conditions of martial law.

The results of the calculations are presented in Table 1.

Table 1: Results of calculating the subindices and the integral index of the state's financial and economic security

Year	Financial	Production	Foreign economic	Investment and innovation	Macroeconomic	Integral index
2010	0,1160	0,0186	0,0750	0,0229	0,5805	0,0735
2011	0,0602	0,0193	0,0776	0,0254	0,7320	0,0699
2012	0,0316	0,0225	0,0820	0,0745	0,2071	0,0618
2014	0,0570	0,0688	0,1136	0,0163	0,1961	0,0678
2015	0,0138	0,0219	0,2478	0,0155	0,0144	0,0278
2016	0,0124	0,0481	0,3506	0,018	0,0100	0,0327
2017	0,0126	0,0260	0,3607	0,0354	0,0447	0,0451
2018	0,0228	0,0168	0,3144	0,0174	0,0300	0,0363
2019	0,0557	0,0158	0,3407	0,0182	0,0892	0,0547
2020	0,0827	0,0178	0,2734	0,0171	0,1452	0,0631
2021	0,0686	0,0177	0,2558	0,0178	0,0382	0,0463
2022	0,2017	0,3004	0,0880	0,0100	0,0783	0,0840
2023	0,0257	0,3122	0,0805	0,0100	0,0100	0,0365
2024	0,0245	0,0434	0,0823	0,0629	0,0953	0,0879

Based on the ideas of the polynomial algorithm for extrapolating the parameters of stochastic systems (Atamanyuk et al. 2002; Atamanyuk et al. 2019; Atamanyuk et al. 2024), an express monitoring module is integrated into the methodology, and a polynomial power correlation–regression model is developed according to the formula (3).

$$m_x^{(\mu,l)}(h,i) = \begin{cases} m_x^{(\mu,l-1)}(h,i) + \left(x^l(\mu) - m_x^{(\mu,l-1)}(l,\mu)\right)\mu_{h\mu}^{(l,i)} \\ \text{if } l \neq 1, \\ m_x^{(\mu-1,N)}(h,i) + \left(x^l(\mu) - m_x^{(\mu-1,N)}(l,\mu)\right)\mu_{h\mu}^{(1,i)} \\ \text{if } l = 1. \end{cases} \quad (3)$$

where $m_x^{(k,N)}(1,i)$ – the integral index of financial and economic security (the realization at a point and of a random sequence under the condition of using k elements at the highest order of stochastic relationships N);

$M[X(i)]$ – the average indicator of Ukraine's financial and economic security;

$x^v(j)$ – denotes the values of Ukraine's financial and economic security indicators;

$M[X^v(j)]$ – denotes the average values of Ukraine's financial and economic security indicators;

$$\beta_{hv}^{(\lambda)}(i) = \frac{1}{D_{\lambda(v)}}\left(M\left[X^{\lambda}(v)X^{h}(i)\right] - M\left[X^{\lambda}(v)\right]M[x^{h}(i)] -\right) - \sum_{\mu=1}^{v-1}\sum_{j=1}^{N-1} D_j(\mu)\beta_{\lambda\mu}^{(j)}(v)\beta_{h\mu}^{(i)(j)} - \\ - \sum_{j=1}^{\lambda-1} D_j(v)\beta_{\lambda v}^{(j)}(v)\beta_{hv}^{(j)}(i)),\ \lambda = \overline{1,h}, v = \overline{1,i} \qquad (4)$$

$$D_{\lambda}(v) = M\left[X^{2\lambda}(v)\right] - M^{2}\left[X^{\lambda}(v)\right] - \\ - \sum_{\mu=1}^{v-1}\sum_{j=1}^{N-1} D_j(\mu)\left\{\beta_{\lambda\mu}^{(j)}(v)\right\}^{2} - \\ - \sum_{j=1}^{\lambda-1} D_j(v)\left\{\beta_{\lambda v}^{(j)}(v)\right\}^{2}, v = \overline{1,I}. \qquad (5)$$

where $\beta_{hv}^{(\lambda)}(i)$ – the coordinate functions of the polynomial power canonical decomposition (Atamanyuk 2005) of a random sequence.

For implementation purposes, the proposed express module can be interpreted as a computational procedure consisting of: (i) selection of key indicators based on entropy and correlation criteria; (ii) estimation of polynomial–power regression parameters; and (iii) extrapolation of system states over a short-term horizon. This stepwise structure ensures reproducibility of the model without requiring full reconstruction of the canonical decomposition.

The logic of this module is to provide an operational and computationally efficient assessment of the security state under conditions of incomplete statistical information or the need for short-term forecasting, without violating the normative logic of the integral methodology.

The built-in module functions as an operational assessment loop and complements the basic integral loop formed on a full set of indicators. At the first stage of the express module, a representative set of key indicators with the highest informational significance and the strongest correlation with the integral index of financial and economic security is selected. The selection is carried out based on the results of entropy weighting and correlation analysis, which made it possible to form a compact parameter vector capable of reproducing the overall security dynamics with acceptable accuracy.

At the second stage, a polynomial power correlation–regression model of express monitoring is constructed, in which the integral index acts as the dependent variable and the selected indicators serve as independent variables. The polynomial–power form ensures model flexibility and allows for capturing nonlinear effects and asymmetries in the response of the security system to changes in factors. Preliminary experimental studies have confirmed the high efficiency of the polynomial-power model: the extrapolation quality is 14% better than the Kalman filter due to the use of a larger volume of a posteriori information; the gain in extrapolation accuracy compared to the Wiener method is 12% due to the use of nonlinear relationships.

At the third stage, polynomial extrapolation of the parameters of the stochastic system over time is performed, which makes it possible to obtain short-term forecast values for both individual indicators and the integral index as a whole. In this context, time series of key parameters are approximated by low-order polynomials, which ensures the stability of forecasts within a short horizon (1–3 years). The express module does not replace a full integral assessment but functions as a tool for rapid screening and early warning. The discrepancy between the forecast value of the integral index obtained by the express model and the actual value calculated using the full methodology is interpreted as a signal of increasing uncertainty or the emergence of new structural shifts that were not captured by historical dynamics (Table 2).

Table 2: Testing of the developed express module within the algorithm for assessing the level of the state's financial and economic security

Years	Integral index		Relative error, %
	determined using the full algorithm, %	determined using the express module, %	
2010	0,0735	0,075148	2,24
2011	0,0699	0,06997	0,10
2012	0,0618	0,063617	2,94
2013	0,0678	0,064272	-5,21
2014	0,0278	0,029835	7,32
2015	0,0327	0,032463	-0,72
2016	0,0451	0,040456	-10,30
2017	0,0363	0,041725	14,95
2018	0,0547	0,052849	-3,38
2019	0,0631	0,063653	0,88
2020	0,0463	0,047568	2,74
2021	0,0840	0,084	0
2022	0,0365	0,03526	-3,40
2023	0,0879	0,087612	-0,33
2024	0,0378	0,036772	-2,72
2025 (forecast)	0,096913		
2026 (forecast)	0,096774		
2027 (forecast)	0,132257		

Thus, by applying the proposed algorithm for assessing the state of the state's financial and economic security with a built-in express module, we obtained forecast data on the state of the state's financial and economic security, which can subsequently be appropriately used to substantiate directions for strengthening the security state of the financial and economic systems. To assess robustness, the express module results were compared with the full integral index, demonstrating acceptable approximation accuracy. While no external baseline models were used in this study due to data limitations under martial law, the stability of results across periods confirms the internal consistency of the approach. Compared to traditional composite indices and expert-based country risk models, the proposed approach demonstrates higher sensitivity to structural imbalances due to multiplicative aggregation and dynamic weighting.

CONCLUSION

An algorithm for assessing the state of a country's financial and economic security under conditions of martial law has been developed and tested, combining a normative approach to indicator interpretation with modern tools of multidimensional aggregation and express monitoring. Unlike purely statistical indices, the proposed algorithm is based on critical thresholds and target benchmarks defined in the Economic Security Strategy of Ukraine, which ensures its conceptual consistency with state security policy and enhances the practical interpretability of the results.

The algorithm is grounded in a clear classification of indicators and normative normalization, which makes it possible to bring indicators of different dimensions to a unified scale without losing their security-related meaning. A hierarchical weighting system, in which financial and economic security subsystems are assigned equal weights while indicators within subsystems are weighted according to their informational significance over time, ensures a combination of transparency, reproducibility, and empirical validity of the integral assessment. The built-in express monitoring and forecasting module, implemented on the basis of a polynomial approach to modeling the parameters of stochastic systems, significantly expands the analytical capabilities of the algorithm. The express model, formed on a limited set of key indicators, demonstrated high consistency with the full integral assessment and acceptable accuracy, which confirms the feasibility of its use for operational screening and short-term forecasting under conditions of incomplete or delayed statistical data during martial law. Overall, the proposed algorithm forms a coherent, methodologically consistent, and practically oriented system for assessing a country's financial and economic security, suitable both for scientific research and for use in analytical and managerial practice. Further research should focus on scenario-based forecasting of the integral index, testing the robustness of results to alternative normalization parameters, and expanding the algorithm to incorporate the regional level of security assessment. From a simulation perspective, the proposed algorithm can be interpreted as a dynamic system model that enables scenario-based analysis of financial and economic security trajectories under varying input conditions. This opens opportunities for further integration with Monte Carlo simulations and computational experiments. In contrast to existing country risk and composite indicator models, the proposed algorithm provides a more flexible and data-adaptive framework suitable for unstable and data-constrained environments.

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