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FINANCIAL SECTOR SECURITY ENVIRONMENT: DIAGNOSTIC–ADAPTIVE REGULATION AND LEGAL FRAMEWORK

ABSTRACT

Amid prolonged global instability caused by the COVID-19 pandemic, economic recession, and the consequences of Russian military aggression, ensuring the financial security of the state has become particularly important as a key factor in safeguarding national security.

The purpose of the study is to develop a scientific and methodological approach to regulating the security environment in the financial sector based on diagnostic–adaptive modeling and legal support.

The study applies an updated methodology for calculating the Financial Security Index Core (FSI Core) of Ukraine for the period 2020–2025, with a focus on the key subsystems of budgetary and debt security. A forecast of FSI dynamics for 2026–2028 was conducted, revealing partial stabilization alongside persistent structural vulnerabilities. Correlation analysis made it possible to identify the dominant factors influencing financial stability, while the IDEF0 model represented the mechanism of financial sector management through inputs (analytical, diagnostic, and predictive data), mechanisms (economic and regulatory instruments), controls (regulatory and strategic documents, as well as performance indicators), and outputs (management decisions aimed at ensuring financial security and shaping the security environment).

The obtained results confirmed that external crisis shocks, primarily the war and economic crisis, have significantly transformed the priorities of financial sector management. The developed model enables a transition from reactive anti-crisis response to proactive and predictive governance, strengthening the analytical capacity of public institutions in ensuring financial and national security. The proposed approach forms a methodological and practical foundation for building the state's security environment.

Keywords: financial security, FSI core, forecasting, financial sector management, state security environment, IDEF0 modeling, legal support

JEL Classification: G01, G38, H56, C53, K22

INTRODUCTION

In the contemporary world, the architecture of national and global security is increasingly defined by the stability and adaptability of financial systems. The last decade has demonstrated that financial sustainability is not merely an economic category but a fundamental determinant of a state's overall security environment. Global shocks – including the economic crisis, the COVID-19 pandemic, and new geopolitical conflicts – have exposed systemic vulnerabilities and reshaped approaches to financial governance.

For Ukraine, these challenges are particularly acute. Against the background of global turbulence, the country has faced Russian military aggression, which has transformed from a hybrid confrontation into a full-scale war. Under these conditions, the financial sector acts not only as a fiscal mechanism but as a structural element of the state's security environment, determining resilience, resource allocation, and the capacity for recovery. Ensuring the sustainability of financial institutions and maintaining fiscal stability have thus become essential components of national defense and socio-economic adaptation.

Consequently, the task of financial sector management extends beyond traditional macroeconomic regulation. It involves the design of an integrated security environment that combines financial, institutional, informational, and managerial subsystems. Within this framework, anti-crisis management and diagnostic modeling of financial security become key instruments for anticipating risks and ensuring systemic equilibrium. The transition from static evaluation to predictive modeling of financial security indicators provides a methodological foundation for forming an adaptive and proactive state security system.

LITERATURE REVIEW

Scholarly research on financial security and public sector resilience has evolved significantly in recent years, reflecting growing interest in the interconnection between finance and national security.

A wide range of studies have assessed the consequences of global crises — including the COVID-19 pandemic — for the financial systems of developing and transition economies (Chen & He, 2022; Dankiewicz et al., 2022; Gadanecz & Jayaram, 2009; Kuznyetsova et al., 2021; Marer, 2010; Mihus et al., 2020; Oprisan et al., 2023; Prykaziuk et al., 2023). Researchers have analyzed causal relationships within the "economy–finance–security" triad, emphasizing that the financial sector plays a dual role: as a stabilizer of economic processes and as a critical component of the national security infrastructure (Chen & He, 2022; Syrovackyi et al., 2021; Oprisan et al., 2023; Tataryn & Chornyj, 2022).

Ukrainian and international scholars have investigated how fiscal and debt policies influence the sustainability of national finances and the resilience of state institutions (Levey, 2021; Martyniuk et al., 2020; Sharov, 2022; Xing et al., 2023). Considerable attention has also been given to the functioning of the banking system under crisis conditions and to the tools of monetary and fiscal policy implemented during martial law (Ministry of Finance of Ukraine, 2022; National Bank of Ukraine, 2022a, 2022b; Rakis, 2022).

The National Bank of Ukraine's regulatory measures to preserve liquidity and mitigate financial threats have been analyzed as part of the country's financial defense mechanisms (Vasyltsiv et al., 2019). Moreover, studies have addressed the risks of digitalization and cyber threats in the financial sector, identifying "digital security" as a new dimension of financial sustainability (Sylkin et al., 2019; Shkolnyk et al., 2022).

At the same time, researchers have begun to conceptualize the financial sector as an element of the state's broader security environment, rather than an isolated economic subsystem. This systemic approach combines fiscal policy, debt management, monetary stability, and institutional capacity into a unified security framework (Breiki & Nobanee, 2019; Dankiewicz et al., 2022; Kryshtanovych et al., 2021). Within this paradigm, the Financial Security Index (FSI) serves as a diagnostic tool for assessing the stability and efficiency of the financial system, while new modeling techniques (including correlation analysis and IDEF0 frameworks) enable dynamic evaluation and scenario forecasting (Podra et al., 2022; Dmuchowski et al., 2023; Sylkin et al., 2019).

Studies of anti-crisis management emphasize the need for flexible mechanisms that can anticipate and mitigate shocks rather than merely respond to them (Krasnova et al., 2023; Manzhos, 2014; Mihus et al., 2020). However, most of these works remain descriptive and do not offer integrated predictive models linking diagnostic indicators (such as the FSI) with strategic management systems that shape the security environment.

Research Gap. The existing literature provides substantial insights into financial stability, fiscal resilience, and anti-crisis measures. Nevertheless, a conceptual and methodological gap remains between the diagnostic evaluation of financial security (through static indices such as FSI) and the predictive management of the financial sector as part of the national security environment.

Current research rarely integrates financial security indicators with systemic models (such as IDEF0) that could simulate feedback, control, and adaptation mechanisms within state management processes. Therefore, this study aims to bridge this gap by developing a predictive model of financial sector management based on the core Financial Security Index (FSI core) and its integration into the IDEF0 framework. This approach enables the formation of a state security environment that is diagnostic, adaptive, and future-oriented, aligning financial decision-making with national security priorities under conditions of war and post-war recovery.

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AIMS AND OBJECTIVES

The purpose of this study is to model the process of shaping the state's security environment through financial sector management, thereby facilitating a transition from diagnostic assessment of financial security to its predictive and adaptive regulation.

To achieve this aim, the study sets out the following objectives:

1. To analyze the existing methodological approaches to assessing and managing the financial security system, identifying their limitations under the conditions of martial law and post-war recovery.
2. To calculate and adapt the integrated Financial Security Index (FSI) of Ukraine for the period 2020–2025, and to develop its core version (FSI core) that reflects the key indicators of budgetary and debt security.
3. To forecast the dynamics of the FSI for the period 2026–2028, determining stabilization trends and potential directions of transformation of the financial sector under conditions of uncertainty.
4. To integrate the diagnostic and predictive components into a financial sector management model developed using the IDEF0 methodology, with the identification of inputs, mechanisms, controls, and outputs within the system of state security governance.
5. To formulate legal recommendations that ensure the institutional and regulatory support of the modeled processes and strengthen the legislative framework for financial security management within the state's security environment.

The implementation of these objectives will make it possible to develop a comprehensive model for managing the state's financial sector, which ensures not only the assessment of the current level of financial security but also the prediction of its future changes. Such an approach forms an analytical basis for decision-making within the broader process of building the state's security environment.

METHODS

The methodological design of this study is grounded in the assumption that large-scale external shocks — particularly war and macroeconomic destabilisation — fundamentally reconfigure the internal dynamics of financial security and reshape the priorities of anti-crisis financial sector management. In response to this context, the research methodology was constructed as a sequential, multi-stage analytical framework integrating calibration, diagnostic assessment, correlation-based factor analysis, forecasting, and functional modelling. Such a structure ensures that each empirical component directly informs the next analytical layer, creating a coherent and continuous methodological trajectory.

At the initial calibration stage, the full Financial Security Index (FSI) was calculated for 2018–2022 using all six sub-indices defined by the official methodology of the Ministry of Economy of Ukraine. This period was selected due to the completeness, reliability, and comparability of macro-financial data, which makes it possible to construct a representative baseline reflecting both pre-war stability and the early impact of the full-scale invasion. The calibrated time series served a dual methodological purpose: (1) to validate the internal structure of the index under conditions of escalating economic stress, and (2) to identify the behavioural patterns of its sub-indices prior to subsequent analytical decomposition. This stage forms the empirical foundation for the diagnostic and correlation-based procedures that follow.

Subsequently, the official FSI computation methodology was applied in full. This methodology incorporates indicator normalisation based on optimal, threshold, and limit values, followed by the weighted aggregation of six sub-indices representing different dimensions of financial security. The structure of the index, as well as the weighting scheme and calculation procedure, is presented in Table 1.

The integral FSI is calculated according to the weighted-sum formula:

$$FS_I = \sum_6^i SI_i \times V_i \quad (1)$$

where: SI_i – normalized sub-index values, and V_i – their weights.

Table 1. Methodological framework of the Financial Security Index (FSI) of Ukraine.

Sub-index	Indicators (examples)	Threshold / Limit value	Weight (V_i)
Budgetary security	Ratio of state budget deficit/surplus to GDP; Level of GDP redistribution through the consolidated budget	Not less than –2%; ≤30%	0.202
Debt security	Total public debt to GDP; External debt to GDP; EMBI+ Ukraine index; Reserve adequacy	≤55%; ≤25%; ≤500; ≥41	0.175
Money market security	Share of cash (M0/M3); Interest rate differential; Long-term lending share	≤25%; ≤5%; ≥30%	0.175
Currency security	Exchange rate variation; Gross reserves (months of imports); Dollarization level	≤6%; ≥3; ≤25%	0.169
Non-banking market security	Insurance premiums to GDP; Market capitalization; PFTS index stability	8–12%; 60–90%; ≤1 critical deviation	0.107
Banking security	Overdue loan share; Return on assets; Share of foreign capital in banks	≤30%; ≥6%; ≤30%	0.172

To identify the internal structure of the Financial Security Index and determine which of its six sub-indices exert the strongest influence on the integral FSI, a first-level correlation analysis was conducted using the Pearson correlation coefficient. The strength and direction of linear dependence between the integral index (Y) and each sub-index (X_1–X_6) were evaluated according to the following formula:

$$r_{xy} = \frac{\sum(x_i-\bar{x})\times(y_i-\bar{y})}{\sqrt{\sum(x_i-\bar{x})^2}\times\sqrt{\sum(y_i-\bar{y})^2}} \quad (2)$$

where: $\bar{x}$, $\bar{y}$ – sample means x^m, y^m; s_x and s_y are sample standard deviations.

To assess the impact of the specified factors (x_1, x_2...x_6) on the dependent variable (y), the scale presented in Table 2 was used.

Table 2. Scale of factor influence (x_1, x_2...x_6) on the dependent variable (y).

№	Range of indicators	Influence
1	< 0.1	negligible impact
2	0.1 – 0.3	weak impact
3	0.3 – 0.5	moderate impact
4	0.5 – 0.7	strong impact
5	0.7 – 0.99	very strong impact

This analysis made it possible to quantify the degree of influence of each structural component of the index and to identify the dominant functional determinants of financial security.

In addition to Pearson's coefficient, the internal consistency and concordance of the ranked influence of the six sub-indices were assessed using Kendall's rank correlation coefficient (τ). This method captures ordinal and non-linear dependencies and ensures robustness of the factor ordering under conditions of data irregularity.

The formula for calculating Kendall's rank correlation coefficient (τ) is as follows:

$$\tau = \frac{2}{n\,(n-1)} \times \sum_{i<j} sgn(x_i - x_j)\ sgn(y_i - y_j) \quad (3)$$

The combined application of Pearson and Kendall coefficients confirmed that budgetary security and debt security demonstrate the strongest and most stable relationships with the integral FSI, whereas other sub-indices displayed significantly weaker or inconsistent effects. These results provided the empirical basis for developing the adapted core Financial Security Index (FSI core), which is used in subsequent stages of the analysis.

To reflect the empirical findings of the first-level correlation analysis and to address the significant data limitations caused by wartime disruptions, the study introduces an adapted version of the index — the core Financial Security Index (FSI core). This modified index integrates only the two sub-indices that demonstrated the strongest and most stable associations with the integral FSI, namely Budgetary Security (r = 0.85) and Debt Security (r = 0.87).

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The FSI core functions as a methodologically simplified yet analytically robust indicator that preserves the essential structural logic of the full index while remaining feasible under conditions where comprehensive data for all six sub-indices are not consistently available. This adaptation ensures continuity of financial security monitoring, supports crisis-time diagnostics, and provides a valid basis for subsequent forecasting and functional modelling.

To assess the prospective trajectory of Ukraine's financial security and evaluate the persistence of wartime vulnerabilities, a forecasting model was developed using the linear trend method (least squares). The model was applied to the FSI core time series for 2020–2025, enabling the construction of projections for 2026–2028.

The forecasting procedure relied on the standard linear trend equation:

$$P = a + bx \tag{4}$$

where the coefficients are determined as:

$$a = \bar{y} - \overline{bx} \tag{5}$$

$$b = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})^2} \tag{6}$$

This approach made it possible to trace expected recovery dynamics and to identify potential deviations from the long-term trajectory of financial stability under the influence of external shocks.

The resulting projections also allow calculating the FSI gap, which reflects the difference between the pre-war trend and the wartime-adjusted trajectory of financial security, thereby quantifying the magnitude of war-induced distortions in the financial system.

To transform the analytical results into a management-oriented framework, the study integrates the calibrated FSI, the adapted FSI core, and their respective determinants into an IDEF0 functional model of financial sector governance. The purpose of this stage is to formalise the structure, logic, and sequence of anti-crisis financial management processes under wartime conditions.

The IDEF0 framework enables the representation of financial security assessment as a system of interrelated functions, where inputs, mechanisms, controls, and outputs are formally linked to quantitative indicators derived from the previous stages of the analysis. Specifically, the forecasted values of the FSI core serve as the primary input for diagnostic functions, while the identified key drivers of budgetary and debt security operate as internal mechanisms guiding managerial responses.

Strategic and regulatory documents — including the Budget Declaration, the Financial Stability Strategy, NBU operational guidelines, and other normative acts — serve as control elements that define permissible thresholds, regulatory constraints, and policy priorities. The functional output of this system is a signal of change in financial security (improvement, deterioration, or instability), which enables proactive decision-making and the adjustment of anti-crisis instruments.

The correspondence between the key IDEF0 elements and the analytical components of the proposed financial security management framework is presented in Table 3.

Table 3. Functional structure of IDEF0.

IDEF0 Element	Content	Purpose
Input	Current and forecasted values of the FSI core (2020–2028)	Provide quantitative inputs for diagnostics, early warning, and monitoring
Mechanism	Key determinants of budgetary and debt security; statistical and forecasting tools	Support analytical processing and generation of management signals
Output	Budget Declaration, Financial Stability Strategy, NBU guidelines, regulatory thresholds	Ensure compliance with the legal framework and policy constraints
Control	Signal of change in financial security (improvement/deterioration)	Inform strategic and operational anti-crisis decisions

In addition to functional modelling, the study employs comparative legal analysis, normative diagnostics, and regulatory gap assessment to determine whether the institutional environment sufficiently supports the functioning of the proposed financial governance model. These methods make it possible to align quantitative and predictive results with the existing

legal framework of Ukraine and to formulate recommendations aimed at strengthening regulatory coherence, ensuring compliance with European financial stability standards, and improving the institutional resilience of financial sector management under conditions of uncertainty and war-related disruptions.

RESULTS

The first empirical stage of the study consisted of calibrating the full Financial Security Index (FSI) for the period 2018–2022 using all six sub-indices defined by the official methodology of the Ministry of Economy of Ukraine. This calibration was necessary to reconstruct the baseline dynamics of Ukraine's financial security prior to the emergence of large-scale wartime data disruptions and to identify the structural behaviour of the index under pre-war and early-war conditions (Figure 1).

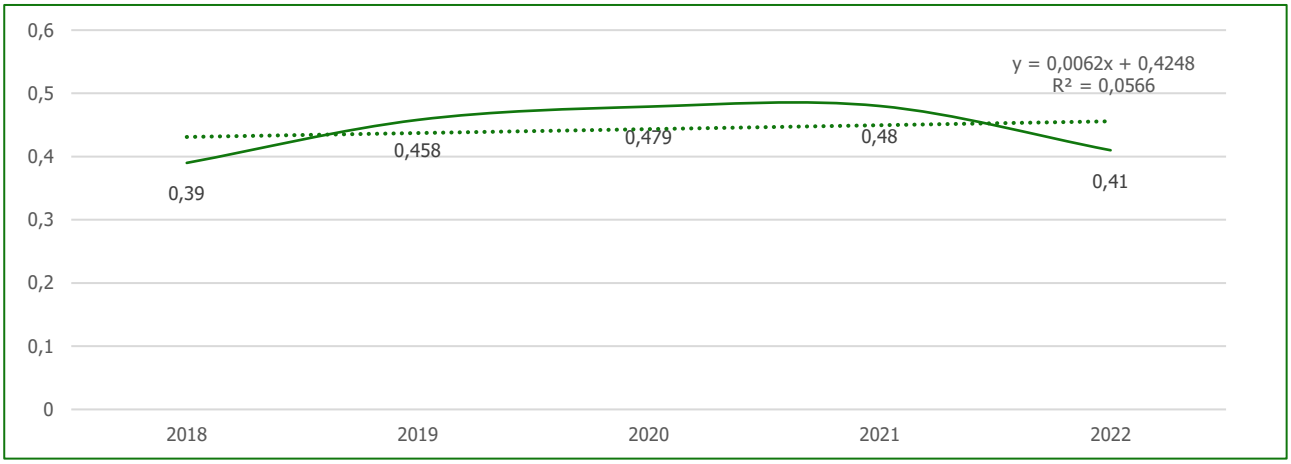

Figure 1. Trend of the Financial Security Index (FSI) in 2018–2022.

The results demonstrate that the integral FSI fluctuated within a relatively narrow range, increasing from 0.39 in 2018 to 0.48 in 2021, followed by a sharp decline to 0.41 in 2022. This trajectory reflects a moderate pre-war improvement in fiscal and debt indicators, coupled with growing instability in monetary and currency markets, and a subsequent deterioration following the onset of the full-scale invasion.

These calibration findings confirm that the financial system entered the full-scale war with structural vulnerabilities and limited resilience reserves. The reconstructed time series of the FSI, together with the underlying component values presented in Table 4, forms the empirical foundation for the subsequent correlation analysis and the derivation of the core Financial Security Index (FSI core), which is applied in periods where full sub-index data are unavailable.

Table 4. Values of financial security sub-indices and the integral FSI (2018–2022).

	2018	2019	2020	2021	2022
Budgetary security	0.55	0.513	0.65	0.719	0.669
Money market security	0.591	0.41	0.58	0.539	0.466
Debt security	0.42	0.331	0.425	0.587	0.598
Currency security	0.317	0.209	0.233	0.331	0.415
Non-banking security	0.46	0.341	0.32	0.304	0.342
Banking security	0.463	0.504	0.455	0.423	0.52
Integral FSI	0.39	0.458	0.479	0.48	0.41

The tabulated values complement the graphical dynamics by revealing the structural sources of volatility within the FSI. The most pronounced fluctuations are observed in currency security, which reflects heightened sensitivity of the exchange rate and reserve position to external shocks. Debt security and budgetary security show clear upward movement prior to the invasion, followed by deceleration in 2022. In contrast, non-banking and banking security remain structurally weak and exhibit only moderate improvement, which is quickly offset by wartime pressures. This heterogeneous behaviour

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explains the relatively low internal coherence of the six-component index and provides the empirical motivation for conducting the first-level correlation analysis.

This structural differentiation, combined with the uneven wartime data availability, creates the need for a diagnostic decomposition of the full index. Therefore, the next stage of the analysis applies a first-level correlation procedure to identify which sub-indices exert the strongest systematic influence on the overall FSI.

To identify which structural components of the Financial Security Index exert the strongest influence on its overall dynamics, a first-level correlation analysis was conducted. The Pearson correlation coefficient was applied to assess the strength of the linear relationship between the integral FSI (dependent variable, Y) and each of the six sub-indices (independent variables, X_1–X_6). The results indicate a clear differentiation in the degree of influence across components.

Budgetary security (r = 0.85) and debt security (r = 0.87) demonstrate the strongest and most stable correlations with the integral FSI. These two dimensions form the fiscal–debt backbone of financial stability and display consistent behavioral patterns throughout 2018–2022, including during the early stages of wartime disruption. In contrast, money market security, currency security, non-banking financial market security, and banking security exhibit weaker, volatile, or statistically unstable relationships with the integral index.

To ensure robustness of these findings, Kendall's rank correlation coefficient (τ) was additionally applied to verify the concordance of factor rankings and the internal consistency of the identified influence structure. The Kendall results confirmed the stability of the ranking order, with budgetary and debt security forming the dominant cluster of determinants under both linear and ordinal correlation measures.

These results provide the empirical justification for methodological simplification in wartime conditions. Given that comprehensive datasets for all six sub-indices are not consistently available after 2022, the analysis supports constructing an adapted two-component version of the index — the core Financial Security Index (FSI core) — which retains the most informative and behaviorally stable elements of the full FSI.

On the basis of the correlation results, the study develops a simplified two-component version of the index — the core Financial Security Index (FSI core). This indicator retains only those dimensions that demonstrated the strongest structural influence on the full FSI, namely budgetary and debt security. Their official weights were normalised (w_1 = 0.535 and w_2 = 0.465), preserving the internal logic of the Ministry of Economy methodology while ensuring analytical feasibility under wartime statistical constraints.

Using these weights, the FSI core was recalculated for 2018–2022 and extended for 2023–2025. The dynamics of the index are presented in Figure 2.

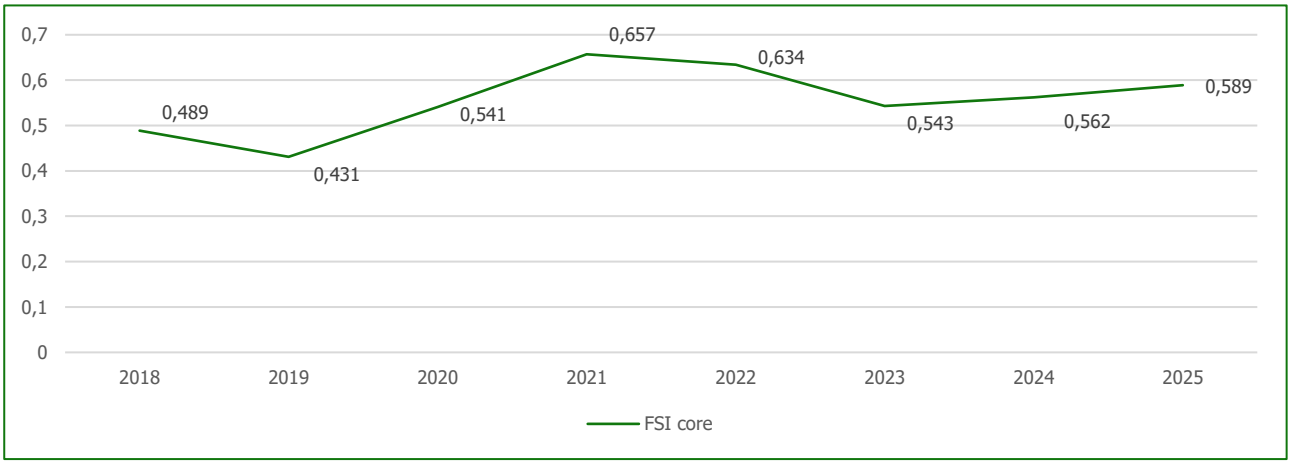

Figure 2. Values of the core Financial Security Index (FSI core), 2018–2025.

The dynamics of the FSI core reflect a consistent fiscal–debt trajectory. It should be emphasised that the relatively higher values of the FSI core compared to the integral FSI do not indicate an improvement in overall financial security. This effect is methodological in nature and reflects the exclusion of highly volatile subsystems — particularly currency, banking, and non-banking market security — which experienced the most severe disruptions under wartime conditions. By design, the FSI core captures the fiscal-debt backbone of financial stability and therefore demonstrates smoother dynamics and lower

sensitivity to short-term shocks. This distinction reinforces the diagnostic role of the FSI core as a crisis-resilient monitoring instrument rather than a substitute for the full Financial Security Index.

The index rises steadily during the pre-war period, reaching its peak in 2021 (0.657), followed by a decline in 2022 associated with the onset of the full-scale invasion. The values for 2023–2025 indicate partial stabilisation but remain below the pre-war peak, revealing structural rigidity and limited recovery capacity of Ukraine's fiscal and debt system.

This indicator thus provides a stable and analytically robust basis for forecasting the medium-term financial security trajectory.

Given the structural incompleteness and volatility of several sub-indices after 2022, forecasting was conducted using the FSI core, which ensures temporal consistency and statistical reliability of the projected trend. To evaluate the prospective evolution of Ukraine's financial security, a linear trend forecasting model was constructed using the FSI core values for 2018–2025. The model is based on the least-squares method and described by the standard equation:

$$P = a + bx,$$

where b is the estimated slope coefficient; a is the intercept term.

This approach enables the identification of longer-term tendencies in the behaviour of the core financial security indicator and provides a statistical basis for evaluating recovery prospects under post-war economic conditions.

The forecasting results indicate a moderate upward trajectory beginning in 2026, reflecting gradual improvement in fiscal and debt parameters. However, the projected values remain below the pre-war maximum, suggesting that Ukraine's financial security recovery will be prolonged and will require sustained policy interventions, including fiscal consolidation, debt restructuring, and institutional strengthening.

The resulting trend also makes it possible to calculate the FSI gap — the difference between the pre-war trend and the wartime-adjusted trajectory — which quantifies the magnitude of war-induced distortions in the financial system.

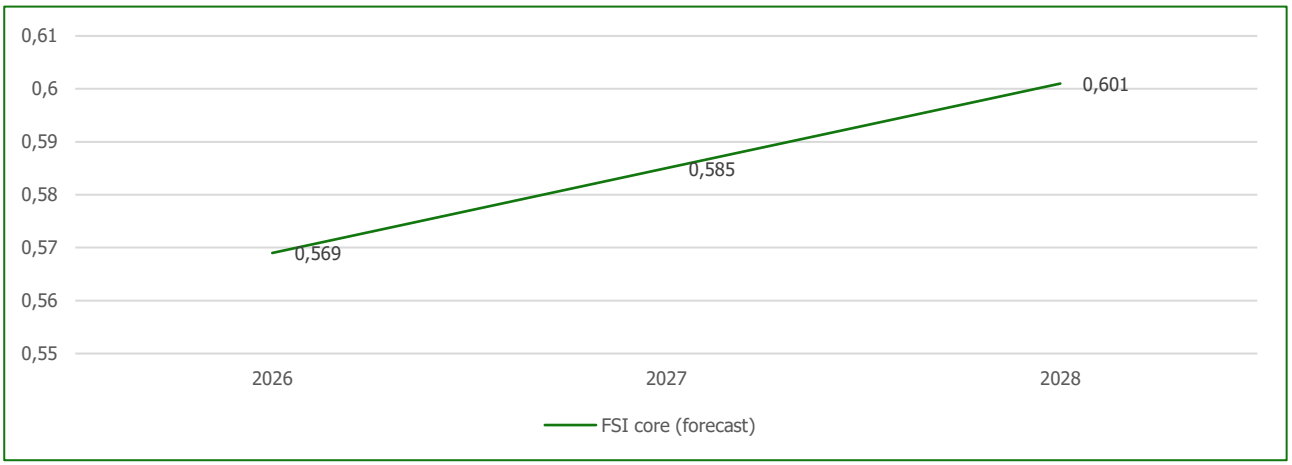

Figure 3. Values of the core Financial Security Index (FSI core), 2018–2025.

The graph illustrates the calibrated values of the FSI core for 2018–2025 and the linear-trend forecast for 2026–2028. The projection suggests a moderate upward trajectory beginning in 2026, indicating gradual recovery of fiscal and debt-related components of financial security. Nevertheless, the forecasted values remain below the pre-war peak (2021), reflecting the long-term structural impact of wartime disruptions and the protracted nature of financial system recovery.

While the first-level correlation analysis identified budgetary and debt security as the dominant structural determinants of the integral FSI, it does not explain which specific fiscal and debt-related mechanisms drive their behavior. To address this limitation, a second-level correlation analysis was conducted in order to decompose each of these sub-indices into their underlying indicators and to identify the most influential internal drivers shaping fiscal–debt stability under wartime conditions.

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To identify the internal drivers of the most influential component of the Financial Security Index — Budgetary Security — a second-level correlation analysis was conducted using the component indicators X1.1–X1.4 (Table 5). The analysis evaluates how fiscal balance, public-sector financing, redistribution ratios, and debt-service pressures contribute to the behaviour of the sub-index.

Table 5. The factors influence on the Budgetary Security. Note: X1.1 – ratio of deficit/surplus of the state budget to GDP, %; X1.2 – deficit/surplus of budgetary and extra-budgetary funds of the general public administration sector, % of GDP; X1.3 – the level of redistribution of GDP through the consolidated budget (without taking into account the income of the Pension Fund), %; X1.4 – the ratio of total payments for servicing and repayment of the state debt to state budget revenues, %. Y1 – Budgetary Security.

	Y_1	$X_{1.1}$	$X_{1.2}$	$X_{1.3}$	$X_{1.4}$
Y_1	–	0.560588	0.391568	0.61059	-0.53717
$X_{1.1}$	–	–	0.572521	0.961392	-0.21694
$X_{1.2}$	–	–	–	0.699327	0.361552
$X_{1.3}$	–	–	–	–	-0.03599
$X_{1.4}$	–	–	–	–	–

To ensure robustness and consistency in the ranking of determinants, Kendall's rank correlation coefficient (τ) was computed:

The result is:

- $\tau Y1 = 0.417$

Interpretation:

- τ = 0.417 indicates moderate concordance among the rankings of fiscal determinants;
- no single indicator exhibits dominant explanatory power; instead, Y_1 reflects a multifactor fiscal equilibrium.

This confirms that Budgetary Security is shaped by a broad set of fiscal conditions, rather than by a single driver.

Debt Security — the second key sub-index underlying the FSI core — was decomposed using a similar correlation procedure to evaluate the contribution of five debt-related indicators (X3.1–X3.5 – Table 6).

Table 6. The factors' influence on Debt Security. Note: X3.1 – the ratio of the total volume of public debt to GDP, %; X3.2 – the ratio of the total external debt to GDP, %; X3.3 – weighted average yield of Domestic Government Loan Bonds on the primary market, %; X3.4 – EMBI index + Ukraine; X3.5 – ratio of official international reserves to gross foreign debt; Y3 – Debt Security.

	Y_3	$X_{3.1}$	$X_{3.2}$	$X_{3.3}$	$X_{3.4}$	$X_{3.5}$
Y_3	–	**0.96832**	**0.94722**	-0.6694	-0.3717	-0.4307
$X_{3.1}$	–	–	0.9322	-0.8218	-0.1942	-0.2914
$X_{3.2}$	–	–	–	-0.6156	-0.1137	-0.1443
$X_{3.3}$	–	–	–	–	-0.1194	0.09955
$X_{3.4}$	–	–	–	–	–	0.94528
$X_{3.5}$	–	–	–	–	–	–

Kendall τ for Debt Security:

$\tau Y3 = 0.822$

Interpretation:

- τ = 0.822 indicates very high concordance, confirming a stable and statistically robust ranking of determinants.

Two indicators clearly dominate the subsystem:

- X3.1 – total public debt to GDP;
- X3.2 – external debt to GDP.

This result indicates that debt security in wartime conditions is driven by a balanced interaction of fiscal variables rather than by a single dominant factor, which increases its sensitivity to policy coordination failures.

These two variables are responsible for the majority of the variance in Y_3 and align with macro-financial patterns typical for wartime economies:

rapid debt accumulation + increased external financing dependence.

The two-level correlation analysis provides a statistically grounded understanding of the structural determinants of Ukraine's financial security. Budgetary security and debt security were identified as the dominant drivers of the full FSI, while their internal indicators revealed stable behavioural patterns consistent with wartime fiscal pressure and debt accumulation dynamics. These empirical results form the analytical basis for translating the diagnostic findings into a functional management framework. Accordingly, the next step of the study involves formalising the financial security assessment and response mechanisms within an IDEF0 model, which captures the logic, structure, and operational pathways of anti-crisis financial sector governance.

The obtained results demonstrate that Ukraine's financial security under wartime conditions is characterised by a limited number of structurally dominant determinants, primarily related to fiscal balance and public debt dynamics. This concentration of influence allows the transition from descriptive diagnostics toward a management-oriented representation of financial security.

Accordingly, the next analytical step focuses on formalising the identified causal relationships, information flows, and decision-making mechanisms within a functional governance framework. This makes it possible to translate quantitative indicators and forecast signals into structured anti-crisis management actions, ensuring coherence between diagnostics, prediction, and regulatory response. To transform the analytical results into an operational management tool, the study applies the IDEF0 functional modelling methodology. This approach makes it possible to represent the financial sector's anti-crisis management process as a structured system of inputs, controls, mechanisms, and outputs, thereby linking diagnostic indicators with managerial decisions (Figure 4).

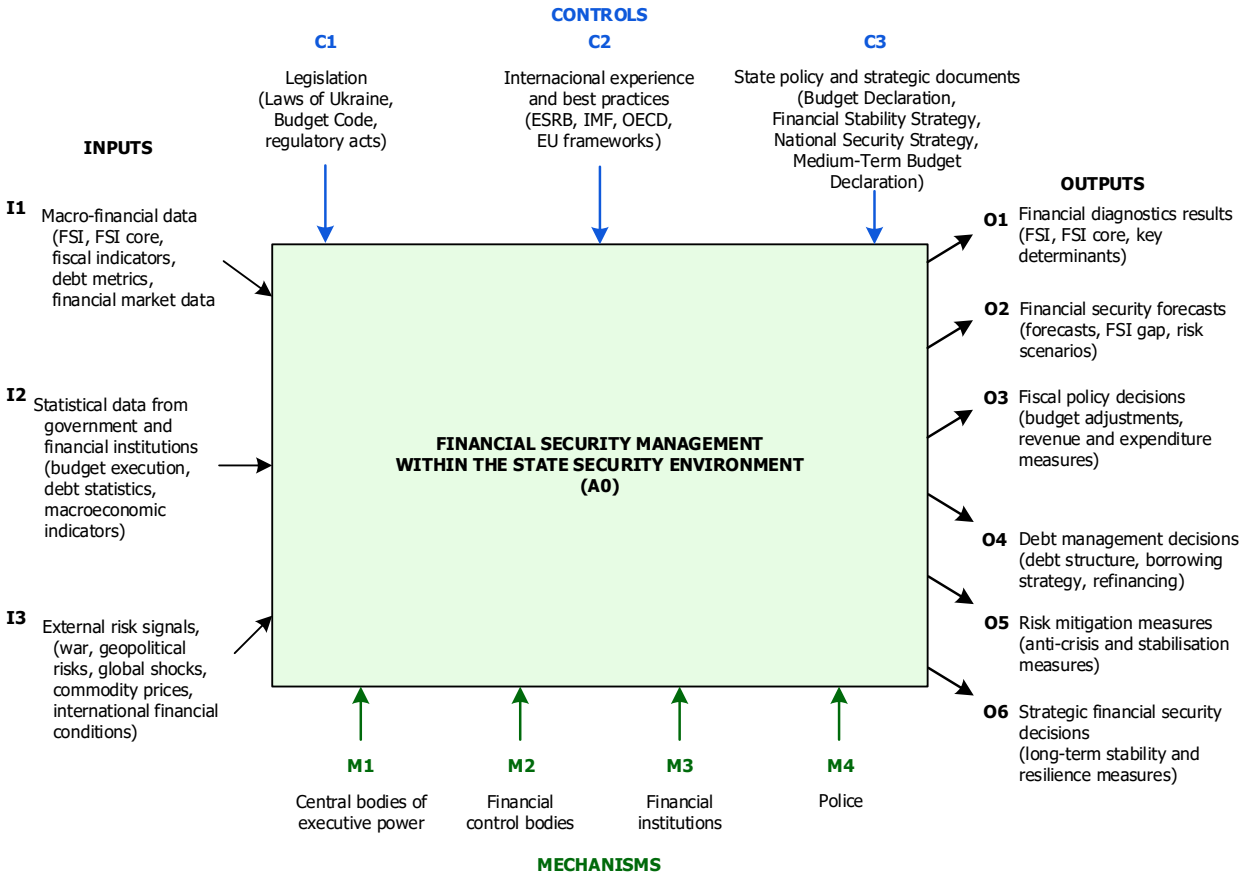

Figure 4. The first-level IDEF0 model of security management in the financial sector. *(Source: developed by authors using the IDEF0 functional modelling methodology)*

The first-level model conceptualises financial sector management as an integral component of the national security architecture. Importantly, the selection of inputs and internal mechanisms in the model is empirically grounded in the results

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of the correlation analysis and the constructed FSI core, ensuring that the IDEF0 representation reflects the actual structure of financial security determinants rather than a purely normative design. It reflects the general structure of the system, where the Input includes macro-financial indicators (FSI, FSI core, fiscal parameters, debt metrics); Controls consist of strategic documents such as the Budget Declaration and the Financial Stability Strategy; Mechanisms comprise institutional actors (Ministry of Finance, NBU, State Treasury, Debt Agency) and analytical tools; and Outputs represent strategic and operational decisions aimed at preserving financial stability.

This top-level representation defines the boundaries and operating logic of the system, establishing how diagnostic information influences the decision-making framework under crisis conditions (Figure 5).

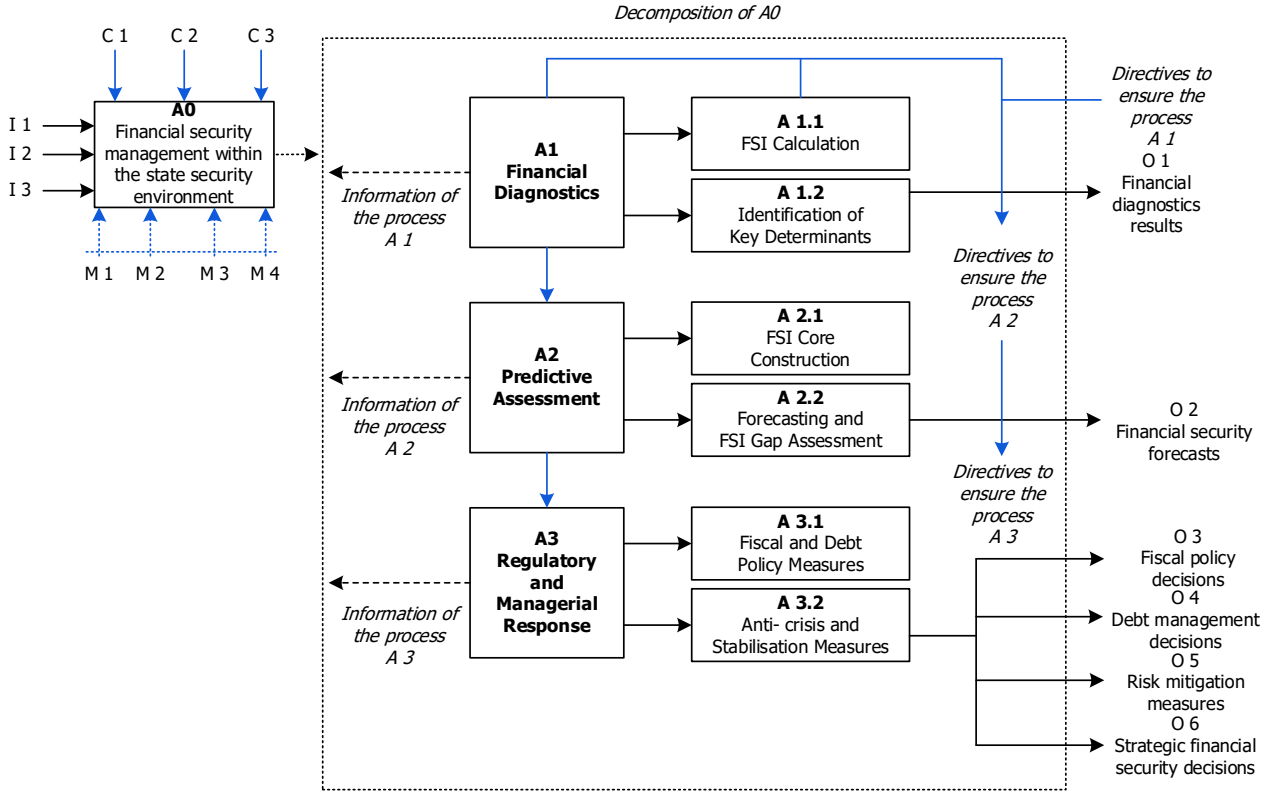

Figure 5. Second-level IDEF0 diagram: internal logic of financial security management. *(Source: developed by authors using the IDEF0 functional modelling methodology)*

Building on the first-level model, the second-level diagram discloses the internal functional structure of financial security governance. It identifies three interconnected functional blocks:

Financial diagnostics (A1) — processing FSI and FSI core, monitoring fiscal indicators, identifying deviations from threshold values.

Predictive assessment (A2) — incorporating the forecasting model, projecting future risks, and calculating the FSI gap to quantify war-induced distortions.

Regulatory and managerial response (A3) — activation of fiscal, debt, and monetary policy instruments, implementation of stabilisation measures, and coordination among government bodies.

Information flows connect these functions, illustrating the transformation of quantitative assessment into predictive insights and, ultimately, into crisis-response actions. The model demonstrates that effective financial security management relies on a continuous feedback loop in which updated diagnostic data recalibrate predictive outputs and support timely adjustments to policy measures.

A key feature of the second-level model is the presence of an explicit feedback loop, whereby the outcomes of regulatory and managerial responses (A3) are continuously re-integrated into the diagnostic block (A1) through updated FSI and FSI core values. This feedback mechanism ensures adaptive recalibration of forecasts and policy instruments under rapidly changing wartime and post-war conditions.

The IDEF0 model shows that the financial security system functions as a dynamic governance mechanism rather than a static monitoring tool. By integrating the calibrated FSI, the FSI core, and their determinants, it formalises the processes through which the state anticipates, evaluates, and mitigates financial risks. This functional mapping provides institutional clarity, strengthens transparency, and establishes a structured foundation for implementing preventive and adaptive financial security policies.

Overall, the results of the study demonstrate that Ukraine's financial security under wartime conditions is determined by a limited set of structurally dominant factors concentrated within the fiscal–debt subsystem. The calibration of the full Financial Security Index, the identification of its key determinants through multi-level correlation analysis, and the construction of the adapted FSI core provide a coherent empirical framework for diagnosing financial vulnerability and resilience. The integration of these analytical results into the IDEF0 functional model transforms static index-based assessment into a dynamic, feedback-driven management mechanism. This confirms that effective financial security governance in conditions of prolonged external shock requires not only monitoring of indicators, but also predictive modelling and institutionalised decision-making logic, thereby creating a foundation for evidence-based anti-crisis policy design.

A fragmented and sectoral approach characterises the current legal and institutional framework governing financial security in Ukraine. While financial stability and fiscal sustainability are addressed in several legislative acts — including the Law of Ukraine ON National Security of Ukraine (Verkhovna Rada of Ukraine, 2018), the Budget Code of Ukraine (Verkhovna Rada of Ukraine, 2010), and the Law of Ukraine ON the National Bank of Ukraine (Verkhovna Rada of Ukraine, 1999), these documents do not establish an integrated analytical mechanism for diagnosing systemic financial risks.

In particular, existing strategic and regulatory instruments lack a unified quantitative indicator that can serve as an early warning signal of financial security deterioration. Financial risks are assessed indirectly through separate fiscal, monetary, and debt-related parameters, without a formalised procedure for aggregating these signals into a comprehensive diagnostic framework. As a result, decision-making in the sphere of financial security remains predominantly reactive and fragmented, especially under conditions of large-scale external shocks such as war.

Against this background, the development of an integrated analytical and regulatory framework requires complementary legal adjustments aimed at institutionalising the results of financial security assessment and embedding them into the system of state financial governance. The proposed Financial Security Index (FSI) and its adapted core version (FSI core), together with the IDEF0-based functional model, create the analytical preconditions for such institutionalisation and provide a basis for formulating targeted legal recommendations.

Firstly, it is advisable to establish the Financial Security Index (FSI) in the Law of Ukraine "On the Fundamentals of Financial Policy", defining it as an official analytical indicator that reflects the resilience of the state's financial system. It is also proposed to ensure annual monitoring and publication of FSI results by the Ministry of Finance of Ukraine in cooperation with the National Bank of Ukraine (NBU) to enable timely detection of financial risks and systemic imbalances.

Secondly, it is recommended to develop a subordinate legislative act that determines the procedure for activating anti-crisis financial measures in the event that the FSI falls below a critical threshold. This act should establish a clear vertical of decision-making authority and interagency coordination mechanisms for implementing urgent measures aimed at financial stabilization.

Thirdly, it is proposed to integrate the FSI model into the Unified State System of Economic Forecasting, coordinated by the Ministry of Economy of Ukraine. It is necessary to legally define the obligation of central executive authorities to provide primary statistical data required for the calculation of FSI components, even under conditions of limited data availability during wartime or post-war recovery.

Finally, national legislation should be harmonized with European financial stability frameworks, in particular with the methodologies of the European Systemic Risk Board (ESRB) and the EU Fiscal Compact. This will ensure methodological consistency, enhance transparency, and facilitate the future integration of Ukraine's financial monitoring system into the EU macroeconomic coordination architecture.

DISCUSSION

The results obtained in this study confirm that the financial sector is a key determinant of the state's overall security environment. The calculated and forecasted values of the FSI core indicate that Ukraine's financial security deterioration in 2022–2023 was not an isolated phenomenon, but rather the result of accumulated structural vulnerabilities — particularly in public debt and fiscal balance management. The moderate improvement observed in 2024–2025 reflects the resilience

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of financial institutions and the gradual adaptation of fiscal policy to wartime conditions. These findings substantiate the hypothesis that the management of the financial sector plays a crucial role in shaping the state's security environment, where financial indicators serve as early warning signals of systemic risks.

The IDEF0-based model proposed in this study further enhances the analytical interpretation of financial sector management. Unlike traditional financial monitoring systems that merely react to instability, the IDEF0 model visualizes the interaction between inputs (diagnostic and predictive data), mechanisms (forecasting tools, statistical systems), controls (strategic documents and regulations), and outputs (management decisions). This modeling framework allows decision-makers to trace how shifts in key indicators — such as debt-to-GDP ratio or fiscal deficit — translate into actionable management responses, thereby embedding the financial sector into the broader process of adaptive security governance.

These results also align with international findings emphasizing the interdependence between financial governance and resilience. Similar conclusions are reported in international studies, which emphasize that fiscal sustainability and debt dynamics represent core pillars of financial stability under conditions of systemic stress (Baldacci et al., 2012; Gadanecz & Jayaram, 2009). Research on crisis governance further demonstrates that simplified and analytically focused indicators often outperform complex composite systems during periods of heightened uncertainty (Brunnermeier & Oehmke, 2013). In particular, the study corroborates the view that proactive risk identification and predictive modeling significantly improve the effectiveness of national crisis management frameworks. However, unlike models developed for stable economies, Ukraine's context demonstrates that resilience in a wartime setting requires not only financial stabilization but also institutional adaptability and transparent coordination mechanisms.

Despite the robustness of the analytical framework, several limitations must be acknowledged. First, the restricted access to complete macro-financial data during the war constrained the scope of the FSI calculation. Second, the forecasting model is based on linear extrapolation, which may not fully capture nonlinear dynamics caused by unpredictable geopolitical or macroeconomic shocks. Third, while the IDEF0 model provides a structured view of decision-making processes, its validation in practice will require additional empirical testing and integration with governmental data systems.

In summary, this discussion demonstrates that the developed approach — combining diagnostic assessment (FSI core), predictive modeling, and IDEF0-based management design — provides a novel framework for linking financial stability with national security governance. The research highlights the dual nature of financial sector management: as both a diagnostic mechanism for identifying systemic risks and a strategic instrument for shaping the state's security environment.

CONCLUSIONS

The conducted research confirmed that the financial sector plays a decisive role in shaping the state's security environment. The analysis of existing methodological approaches to assessing and managing financial security demonstrated that traditional diagnostic frameworks require the integration of predictive and management-oriented instruments, particularly under conditions of martial law and post-war recovery.

The introduction of the FSI core enabled the identification of key parameters — budgetary and debt security — that determine the dynamics of financial stability. The adaptation of the Financial Security Index made it possible to preserve the analytical value of financial security assessment under conditions of limited wartime data availability.

The forecasting of FSI trends for 2026–2028 revealed gradual stabilization accompanied by persistent structural vulnerabilities that require adaptive management solutions. Although the projected trajectory indicates recovery tendencies, the long-term consequences of wartime disruptions continue to influence the fiscal and debt sustainability of the financial system.

The integration of diagnostic and predictive components into the IDEF0-based financial sector management model provides a structured mechanism for linking financial stability with national security governance. The model supports a transition from reactive crisis response to proactive and predictive regulation, ensuring greater resilience of the state's financial system under conditions of uncertainty.

In addition, the study formulated legal recommendations aimed at institutionalising financial security assessment, strengthening regulatory support for anti-crisis financial management, and integrating analytical results into the state decision-making system.

The working hypothesis — that external shocks such as war and economic instability have changed the structural priorities of financial sector management — was indirectly validated through statistical evaluation of the FSI core, its predictive

dynamics, and the correlation analysis of financial subsystems. These results provide quantitative evidence that external pressures reshape the configuration of financial security priorities.

The obtained findings thus form a conceptual and analytical foundation for further development of national financial security policy and can serve as a methodological basis for building integrated models of the state's security environment. Future research should focus on expanding the model to include social and institutional indicators, as well as testing its applicability within real-time policy analysis platforms.

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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БЕЗПЕКОВЕ СЕРЕДОВИЩЕ У ФІНАНСОВІЙ ГАЛУЗІ: ДІАГНОСТИЧНО-АДАПТИВНЕ МОДЕЛЮВАННЯ ТА ПРАВОВЕ ЗАБЕЗПЕЧЕННЯ

В умовах тривалої глобальної нестабільності, спричиненої пандемією COVID-19, економічною рецесією та наслідками російської воєнної агресії, забезпечення фінансової безпеки держави набуває особливого значення як ключовий чинник забезпечення національної безпеки.

Метою дослідження є розробка науково-методичного підходу до регулювання безпекового середовища у фінансовій галузі на засадах діагностично-адаптивного моделювання та правового забезпечення.

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У дослідженні застосовано оновлену методику розрахунку індексу фінансової безпеки (ІФББ) України за період 2020–2025 рр. із акцентом на ключових підсистемах — бюджетній і борговій безпеці. Здійснено прогноз динаміки ІФБ на 2026–2028 рр., який виявив часткову стабілізацію поруч зі збереженням структурних слабких місць. Кореляційний аналіз дозволив визначити домінуючі фактори, що впливають на фінансову стабільність, а модель IDEF0 відобразила механізм управління фінансовим сектором через вхідні параметри (аналітичні, діагностичні та прогнозні дані), механізми (економічні й регуляторні інструменти), контроль (нормативно-стратегічні документи й показники ефективності) та вихід (управлінські рішення, спрямовані на забезпечення фінансової безпеки та формування безпекового середовища).

Отримані результати підтвердили, що зовнішні кризові шоки — насамперед війна та економічна криза — суттєво трансформували пріоритети управління фінансовим сектором. Розроблена модель забезпечує перехід від реактивного антикризового реагування до проактивного та прогностичного управління, посилюючи аналітичний потенціал державних інституцій у забезпеченні фінансової та національної безпеки. Запропонований підхід формує методологічну й практичну основу для побудови безпекового середовища держави.

Ключові слова: фінансова безпека, базовий індекс фінансової безпеки, прогнозування, управління фінансовим сектором, безпекове середовище, моделювання IDEF0, правове забезпечення

JEL Класифікація: G01, G38, H56, C53, K22

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