

Simulation of the Performance of the Financial Market of Ukraine in the Conditions of Overcoming Threats to Economic Security

INNA IRTYSHCHEVA¹, MARIANNA STEHNEI², IRYNA KRAMARENKO¹,
OLEKSANDRA LIASHENKO³, HALYNA MYKHALCHYNETS²,
NATALIIA MYKHALCHYNETS², VIKTOR NEIMET²

¹Department of Management, Admiral Makarov National University of Shipbuilding,
Heroes of Ukraine Prospect, 9 Mykolaiv, 54000,
UKRAINE

²Department of Economics and Finance,
Mukachevo State University,
str. Uzhgorodskaya, 26, Mukachevo, 89600,
UKRAINE

³Ukrainian Catholic University,
Str. Ill. 17 Svientsitskoho, LVIV, 79011,
UKRAINE

Abstract: - The purpose of the article is the process of modeling the effectiveness of the financial market of Ukraine in the conditions of overcoming threats to economic security. Forecasting possible behavioral reactions to the integrated performance of the financial market of Ukraine is necessary for connection with the academic environment, the variability of risks formed by the content of influencing factors, by setting the volumes of critical operations to respond to the effect of influencing factors. This is because the volumes of critical financial market operations, according to its combinatorial structure, are also aimed at obtaining a result. Therefore, we suggest predicting possible behavioral reactions to the integrated performance of the financial market of Ukraine. The forecast is focused on obtaining reaction values regarding critical financial market operations for the next resolution/achievement of good target values. The received forecast of changes creates an opportunity with sufficient accuracy to reveal the conditions for the formation of results, notably that characteristic of critical operations of the financial market, using studies of its internal reactivity, which is guided by the action of influencing factors. According to the results of the performance evaluation, it is evident that the expected integral performance of the financial market of Ukraine will demonstrate a much lower expected increase in benefits due to the likely narrowing of the market capacity and reduction of investment options. The results of such analysis and forecasting will make it possible to reasonably approach the development of sets of priority actions within the framework of strategic maps, the fixation of outlined priorities, and predictive analysis of changes in their effectiveness over time (which provides visualization of the movement towards absorption or complete absorption of destabilizing processes in the financial market).

Key-Words: - financial market, modeling, lending, deposits, economic security, threats.

Received: June 11, 2023. Revised: October 9, 2023. Accepted: November 13, 2023. Available online: December 13, 2023.

1 Introduction

All critical operations of the financial market change the operating environment as they aim to obtain a result (which is to ensure fluctuations in the value of assets around the average value and increase the volume of critical operations). Therefore, the reactivity of the operating environment is essential, subject to the same factors as the performance in terms of the value of assets

(which, in a certain way, adjusts the demand and supply for the primary assets of the financial market). Such duality forms the possibility of determining performance indicators due to the nature of observed changes in critical operations of the financial market based on changes in its integral effectiveness and identification of the conditions for the formation of effects that are characteristic of critical operations of the financial market, using

studies of its internal reactivity (according to the content of the reaction matrix). The forecasting results determine the forecast values, which are the most accurate because they are formed from all the versatility of the reactions of the integral effectiveness. Such forecasting is essential in the conditions of increasing stochasticity of the financial market (after all, there can be no certainty that the values will be formed according to the existing trend and not according to reaction).

Analyze financial market data to produce an ex-ante assessment of the economic consequences of war with Iraq, [1].

Troeger examine the influence that the political developments within three war regions had on global financial markets from 1990 to 2000, [2]. They embed a rational expectation framework within commercial liberalism, a theoretical strand that tries to assess the interrelationship between war and economic exchanges. Time-series analyses account for the effects that the conflict between Israel and the Palestinians, the first confrontation of a U.S.-led alliance against Iraq, and the wars fought in Ex-Yugoslavia exerted. Using daily stock market data, the authors show that the conflicts affected the interactions at the core financial markets in the Western world negatively if they had any systematic influence at all.

The authors consider a sample of 101 internal and inter-state conflicts during the period 1974-2004 and find that a sizeable fraction of them has had a significant impact on stock market indices, exchange rates, and oil and commodity prices. This fraction is inconsistent with pure chance, i.e., with the selected probability of type-I errors in our tests of statistical significance. The results suggest that, on average, national stock markets are more likely to display positive than negative reactions to conflict onset, [3].

The full-scale invasion of the Russian Federation on the territory of Ukraine led to significant fluctuations in the currency market. The war affected all spheres of life of Ukrainians, [4].

That is why the article aims to model the financial market of Ukraine in the conditions of overcoming threats to economic security.

2 Methodology

Therefore, we suggest predicting possible behavioral reactions to the integrated performance of the financial market of Ukraine. The forecast is focused on obtaining reaction values regarding critical financial market operations for the next

resolution/achievement of good target values. The process involves:

- Determination of the effect of behavioral reactions on the integral performance of the financial market through simplex equations of multiple regression on the monetary expression of the value of assets (dependent variable) from influencing factors (predictor);
- Determination of the components of the reaction matrix, which reflects general or detailed (if possible) values by volumes of key transactions related to the primary assets of the financial market;
- Formation by components of the reaction matrix of reaction modulations.

It is essential to build equations as close as possible to 1 in terms of structural coefficient determination. The result of forecasting should be a performance management system that produces command information to regulate its changes, taking into account all possible behavioral reactions that may appear after critical financial market operations. Ascertained from the dependent equations of multiple regression, formed according to the structural components of the financial market. Within the scope of the study, the forecasting of possible behavioral reactions to the performance of the financial market was implemented in the following sequence (Table 1):

So:

- 1) the stage of formalization of factors influencing the performance of the financial market by sector through multiple regression equations;
- 2) the stage of identification of the essential behavioral reactions of critical operations of the financial market to changes in X;
- 3) the stage of forecasting the development of the operational environment of the financial market of Ukraine based on possible behavioral reactions of critical operations. The general summation of stages considers the financial market as an integral calculation. Forecasting possible behavioral reactions to the performance of the financial market of Ukraine should contain precisely the number of multiple regression equations and reaction matrices that will integrally reflect most of the processes of changing the value characteristics of the main assets of the financial market and critical operations with them, in particular by the value of the coefficients of determination or R^2 . Within the scope of this study, an integrated model for visualizing the financial market's performance is presented for further forecasting by fluctuations in the value of assets and volumes of critical

transactions for each multiple regression equation (Table 1).

Visualization was based on finding equations with the highest R^2 . In our case, the value of the coef ranges from 0.567 to 0.79, providing an average forecast accuracy at the level of $R^2=0.665$.

The description of the logic of the formation of the model for visualizing the effectiveness of the financial market according to the content of stochastic models is given in Table 2.

Table 1. Prediction of possible behavioral reactions to the integrated performance of the financial market

Stage	Components of stages	Implementation model
Formalization of influencing factors on integral performance through the equation of multiple regression on its basic assets	formalization of factors affecting the effectiveness of the foreign exchange market	Formation of performance equations by basic assets: foreign currency ¹
	«...» credit and deposit markets	Formulation of performance equations by basic assets: deposits ² ; loans ³
	«...» securities market	Formation of performance equations for basic assets: shares ⁴ ; domestic state loan bonds, business structures ⁴ ; investment certificates of mutual investment funds ⁴
	«...» The market of financial instruments and futures contracts	Formation of performance equations for basic assets: option contracts; futures contracts; forward contracts ⁵
	«...» real estate market	Formation of performance equations by basic assets: property rights to residential and non-residential real estate ⁶
Identification of behavioral reactions of key operations to changes in financial market performance	determination of the components of the reaction matrix	A description of the behavioral reactions of the financial market and the construction of a reaction matrix along with a multiple regression equation based on the monetary value of the underlying assets
	formation of reaction modulations	Determining the behavioral reactions of key operations to the action of key influencing factors (which led to the change in the value of the asset) through the formation of performance equations ⁷ through a covalent polar/nonpolar bond
Forecasting the development of the financial market	prediction of directions and trends of productivity development	The forecast of changes in the internal environment for key operations with basic assets is adjusted for behavioral reactions

Notes: 1 – equation of effectiveness of the change in the exchange rate of the national currency to the foreign currency (Y); 2 – efficiency equations due to the change in the average deposit rate; 3 – efficiency equations due to the change in the average loan rate without taking into account the overdraft; 4 – performance equations due to changes in the average annual rate of return on these securities; 5 – efficiency equations due to the change in profitability based on the difference in the value of the underlying asset; 6 – efficiency equations due to changes in profitability or price indices for real estate transactions; 7 – performance equations in terms of Y or the value of the key operation for each with a factor affecting performance.

Table 2. Description of the logic of forming a model for visualizing the performance of the financial market of Ukraine for 2010-2021 based on the content of stochastic models**

C*	Accuracy for R^2	Multiple regression equations for measuring performance through
1	$R^2=0.635$	dollar exchange rate change to UAH (Y) and reactivity of key operations
2	$R^2=0.704$	change in the average interest rate on deposits in national and foreign currencies and «...»
	$R^2=0.692$	
3	$R^2=0.706$	change in the average loan rate (national and foreign currency) and «...»
	$R^2=0.4$	
4	$R^2=0.679$	change in the average rate of annual return on shares and «...»
	$R^2=0.567$	change in the average rate of annual yield of OVDP and «...»
	$R^2=0.791$	a change in the average annual rate of return of OPS and «...»
	$R^2=0.751$	change in the average rate of annual yield of the CPSI and «...»
5	$R^2=0.589$	change in the rate of the average annual yield of derivatives and «...»
6	$R^2=0.588$	change in the average rate of return on real estate transactions (primary/secondary markets) and «...»
	$R^2=0.626$	
7	$R^2=0.665$	Integral index

Notes: * Components of the financial market: (1) foreign exchange market; (2) deposit market; (3) credit market; (4) securities market; (5) market of financial instruments and term contracts; (6) real estate market. ** Performance is visualized in accordance with fluctuations in the value of assets and forecasted in accordance with the volumes of key operations.

The obtained data, formed according to stochastic models, reveal the inefficiency of the financial market, therefore, they depict mostly excessive fluctuations in the value of most basic assets and predict a decrease in the volume of most key operations with assets. The obtained results are formed because fluctuations in the value of the underlying assets create a modeling signal and create opportunities for studying the reactivity of the market's operating environment (on its key transactions with the underlying assets). The results are displayed in the form of a detailed system of modeling signals, in which the entire set of conditions for the reaction of the operating environment to influencing factors due to the covalent non-polar/polar connection of key operations with fluctuations in the value of market assets over time (reaction modulations) is defined. Let's consider the result of visualizing and forecasting the performance of the financial market based on the content of stochastic models in more detail.

3 The Results

The stochastic model of the performance of the foreign exchange market of Ukraine for 2010-2021 made it possible to visualize changes in the value of the currency and predict the behavioral reactions of the operating environment through modeling signals, which is described by the equation:

$$Y = -19.7139 - 0.01369X_1 + 0.2049X_2 + 0.000908X_3 + 0.000148X_4, \quad (1)$$

where:

Y is the exchange rate of the US dollar to UAH.
(for \$100);

X_1 – price index of oil and gas extraction producers, %;

X_2 – inflation index, %;

X_3 – remittances to Ukraine from abroad, UAH million;

X_4 – total assets of banks in foreign currency, UAH million.

Regarding the interpretation of possible changes in the currency's value according to the stochastic model in Art. Scale, confirms the reaction, however, due to the significant influence of the factor total assets of banks in foreign currency, UAH million (X_4). In addition, data on the evaluation of the quality of the equation reveal its significance $R^2=0.6316$. Therefore, the visualization of the logic of the change in the value of the currency on the foreign exchange market of Ukraine is given in Table 3. The following operands are used as a basis for visualization: increase ($\uparrow$), leads to ($\rightarrow$), and decrease ($\downarrow$).

About modeling signals from changes in the value of the currency on the foreign exchange market of Ukraine, the effect of factors X_3 and X_4 is quite specific because it causes a specific reaction - money transfers to Ukraine from abroad and related operations of banks on the foreign exchange market lead to an increase in the money supply, which falls mainly on the cash sector. This constantly multiplies the cash supply in circulation. The logic of changes, according to X_1 and X_2 , is multidirectional. In particular, an increase in producer prices is accompanied by an increase in other raw material markets. If foreign exchange earnings increase, foreign currency receipts from other sources increase. If oil and gas prices grow faster than the inflow of currency, this will only cause the devaluation of the hryvnia and increase the inflation index.

Table 3. Visualization of the logic of changes in the value of currency on the currency market of Ukraine, 2010-2021

Factor	Modeling signal from changes*	The specificity of reactivity
X_1	Proportion of change: $\uparrow$ price index of producers of oil and gas extraction by 1% $\rightarrow$ strengthening of the hryvnia against the dollar. USA (Y) by 0.014 UAH on average	an increase in x_1 is accompanied by an increase in prices on other commodity markets, an increase in foreign exchange earnings, and foreign currency inflows from other sources. If oil and gas prices increase by more than the incoming currency, x_1 increases
X_2	Proportion of change: $\uparrow$ inflation index by 1% $\rightarrow$ devaluation of the hryvnia against the dollar. USA (Y) by 0.2049 hryvnias on average	
X_3	Proportion of change: $\uparrow$ remittances to Ukraine from abroad by 1 million hryvnia $\rightarrow$ devaluation of the hryvnia against the dollar. USA (Y) by UAH 0.0009	remittances from abroad lead to an increase in the money supply and the volume of bank operations, which are in the cash sector. X_3 and X_4 multiply the cash supply in circulation
X_4	Proportion of change: $\uparrow$ volumes of bank transactions on the foreign exchange market of Ukraine by 1 million hryvnias. leads to the devaluation of the hryvnia against the dollar. USA (Y) by UAH 0.000148	

Notes: *Modeling signal from changes in foreign exchange market performance: $X1/Y$; $X2/Y$; $X3/Y$; $(MC4) - X4/Y$.

The given logic of changing the currency's value on the foreign exchange market of Ukraine leads to the formation of a rather complex system of modulations for critical operations with foreign currency, which should be clearly defined. The above modeling signal from changes in the currency's value on the foreign exchange market of Ukraine leads to the fact that it is difficult for the NBU to remove excess national currency from circulation and influence the process of forming the money supply within the framework of currency interventions. The outlined problems can be solved by studying the effects of the modeling signal on the operating environment of the foreign exchange market through its essential operation (Y). The content of the forming reaction modulations (hereafter PM) is given in Table 4. The modeling signal from changes in the effectiveness of the foreign exchange market can affect operations with VM and investment coins, [5]. At the same time, due to the lack of statistical data on these operations, it is impossible to make reaction modulations for them. However, by the reaction modulations presented above for operations with foreign currency, a forecast of the development of the operating environment of the foreign exchange

market for 2022-2024 was compiled, which takes into account the value of the average coefficient. Increase/decrease and adjust for environmental reactivity. With the stabilization of the situation, the value of the volumes of outlined transactions will be restored during 2023 and will reach growth by the end of 2024. A specific trend will be characteristic of anonymous cash transactions of clients of non-banking institutions with IP and exchange between private individuals. The volume for 2021-2024 will decrease from UAH 82,946 to UAH 59,613.2 million. As for the volume of transactions with cash foreign currency of banks for 2021-2024, a steady increase in value is expected from UAH 21,512.5 million. Up to UAH 39,643.7 million. At the same time, the given forecast values are approximate since the modulation signals (Table 3) and modulations (Table 4). However, they formalize the changes in the values of each given foreign exchange market transaction and do not reflect all changes.

The majority of young people left Ukraine for the countries of the European Union to improve their financial situation. Currently, the monetary resources of employees are financial reserves for the financial market of Ukraine, [6].

Table 4. Analysis of the content of reaction modulations (RM), which formalize changes in the values of each key operation of the foreign exchange market (Y) according to the MS, 2022-2024

MS	Action	RM	MS	RM
Bank operations with non-cash IP on the terms "tod", "volume", "spot"				
1	purchase	↑X1 on 1 %→↑Y on 46.2 UAH million	3	↑X on 1 UAH million →↑Y on 6.6 UAH million
	selling	↑ X on 1 % →↑Y on 36.46 UAH million		↑ X on 1 UAH million →↑Y on 6.8 UAH million
2	purchase	↑ X on 1 %. →↓Y on 497 UAH million	4	↑ X on 1 UAH million →↑Y on 0,4 UAH million
	selling	↑ X on 1 %. →↓Y on 565 UAH million		↑ X on 1 UAH million →↑Y on 0,4 UAH million
NBU interventions				
1	purchase	↑X on 1 % →↓Y on 32 UAH million	3	↑ X on 1 UAH million →↑ Y on 0,29 UAH million
	selling	↑ X on 1 % →↑Y on 3.9 UAH million		↑ X on 1 UAH million →↑Y on 0.29 UAH million
2	purchase	↑X on 1 %→↓Y on 91 UAH million	4	↑X on 1 UAH million →↓Y on 0,02 UAH million
	selling	↑ X on 1 %→↑Y on 4.6 UAH million		↑X on 1 UAH million →↑Y on 0,01 UAH million
Volume of transactions with cash foreign currency of banks				
1	purchase	↑X on 1 %→↓Y on 54.5 UAH million	3	↑X on 1 UAH million →↑ Y on 3 UAH million
	selling	↑X on 1 %→↓Y on 62 UAH million		↑X on 1 UAH million →↑Y on 3.14 UAH million
2	purchase	↑X on 1 % →↓Y on 344 UAH million	4	↑X on 1 UAH million →↑ Y on 0,04 UAH million
	selling	↑ X on 1 % →↓Y on 360.431 UAH		↑ X on 1 UAH million →↑ Y on 0,03 UAH million
The volume of transactions of bank customers with non-cash foreign currency				
1	purchase	↑ X on 1 %→↑Y on 13 UAH million	3	↑ X on 1 UAH million →↑Y on 6 UAH million
	selling	↑ X on 1 %→↓Y on 295 UAH million		↑ X on 1 UAH million →↑Y on 6 UAH million
2	purchase	↑ X on 1 %→↓Y on 542 UAH million	4	↑ X on 1 UAH million →↑Y on 0,2 UAH million
	selling	↑ X on 1 %→↓Y on 643 UAH million		↑ X on 1 UAH million →↑Y on 0,2 UAH million
Anonymous cash currency transactions (clients of non-banking institutions, private individuals)				
1	purchase	↑ X on 1 %→↓Y on 65 UAH million	3	↑ X on 1 UAH million →↓Y on 2.9 UAH million
	selling	↑ X on 1 %→↓Y on 87.7 UAH million		↑ X on 1 UAH million →↓Y on 2 UAH million
2	purchase	↑ X on 1 %→↑Y on 135 UAH million	4	↑ X on 1 UAH million →↓Y on 0.2 UAH million
	selling	↑ X on 1 %→↑Y on 21.9 UAH million		↑ X on 1 UAH million →↓Y on 0.2 UAH million

Notes: * the average ability to change is determined

In addition to fundamental factors, the modeling signal from changes in the performance of the foreign exchange market by 36.84% depends on other factors. The result of the general formalization of the integral effect of the foreign exchange market of Ukraine does not take into account the factors integrated by the effect of currency liberalization, and the fact that maintaining a fixed exchange rate in Ukraine (as it was until 2015) leads to the consumption of international reserves. Factors that cannot yet be taken into account in the modulations: cancellation of restrictions on the purchase of currency by individuals; cancellation of restrictions on offsetting of foreign exchange liabilities; abolition of restrictions on the purchase of foreign currency with credit funds; cancellation of the mandatory sale of foreign exchange; canceling the reservation of national currency for the purchase of foreign currency; cancellation of repatriation of dividends and repatriation of funds from the sale of bonds and unlisted securities, etc. In addition, the BRES action plan (This creates conditions for investments by legal entities and individuals abroad) has been implemented within the framework of currency liberalization. The 2019 law "On Amendments to Certain Legislative Acts of Ukraine Regarding the Improvement of Functions of State Regulation of Financial Services Markets" entered into force. This creates conditions for the online purchase of currency from financial institutions and for the access of non-banking institutions to the currency interbank. In the conditions of the Russian-Ukrainian war, there may be risks of a sudden reversal of liquid capital. In addition, official statistics on the volume of transactions on the foreign exchange market do not reflect the validity due to the presence of a liquid and accessible black market, [7].

The stochastic model of the performance of the deposit market of Ukraine for 2010-2021 made it possible to visualize the changes in the average deposit rate (Table 5) and predict the behavioral reactions of the operating environment through modeling signals, which is described by the equations:

$$1) \quad \text{for deposits raised in UAH. (Table 5):}$$

$$Y_1 = 0.876 + 0.2253X_1 + 0.000836X_2 + 4.9144X_3, \quad (2)$$

where:

Y_1 is the average interest rate on deposits raised in UAH.%;

X_1 – NBU discount rate, %;

X_2 – the number of balances on deposit accounts in national currency, million hryvnias;

X_3 – average terms of attracting deposits in the national currency, year/month/day (d);

2) for deposits raised in foreign currency (Table 5):

$$Y_2 = 0.5754 + 0.09163X_1 + 0.00131X_2 + 2.1313X_3, \quad (3)$$

where:

Y_2 is the average rate on deposits raised in foreign currency, %;

X_1 – NBU discount rate, %;

X_2 – the number of balances on deposit accounts in foreign currency, UAH million;

X_3 – average terms of attracting deposits in foreign currency, r.

Regarding the interpretation of possible behavioral reactions of the result according to the models in Art. Scale, confirmed reactivity, however, under the significant influence of factor X_3 .

In addition, data on the evaluation of the quality of the equation reveal its significance according to R^2 . So, visualization of the logic of changes in the value of deposits on the deposit market of Ukraine for the period 2010-2021 (Table 5) is formalized with an accuracy of up to 70%.

The modeling signal given above synthesizes multidirectional changes in the value of deposits because there is an "unclean" market in Ukraine. Naturally, during crises that provoke rising prices and deepening monopolization of the economy due to some factors (including changes in the NBU's discount rate), the reaction may weaken or be absent. This is characteristic of the modern deposit market, as the index of industrial production in Ukraine decreased by -4.7% in 2018, by -8.3% in 2019, and by -2.2% in 2021; increasing the discount rate only strengthens it.

Therefore, it is essential to predict all possible changes in critical operations to prevent disruptions in deposit placement and return processes. The analysis of the effects of the modeling signal (Table 5) in the operational environment of the deposit market according to the content of its characteristic reaction modulations is given in Table 6. The following operands are used as a basis for analyzing the content of reaction modulations: increase ($\uparrow$); leads to ($\rightarrow$); and decrease ($\downarrow$).

Table 5. Visualization of the logic of changes in the value of deposits on the deposit market, 2010-2021.

Factor	Modeling signal from changes*	The specificity of reactivity
For deposits in national currency		
X ₁	↑ the NBU discount rate (X ₁) by 1% leads to ↑ the rate on deposits raised in UAH (Y) by 0.2253%	when the subjects of the economy spend more, producers raise prices, however, when the discount rate increases in a market economy, it is difficult to take loans, it is difficult to borrow, and money in the economy becomes less. However, reactivity weakens or is absent during crises, industrial production falls and the economy is monopolized (monopolists set extremely high prices). Violations of deposit placement and return processes are possible
X ₂	↑ the amount of deposits raised in the national currency (X ₂) for 1 million hryvnias, leads to ↑ Y by 0.0008 %	
X ₃	↑ average terms of attracting deposits in the national currency for 1 month, leads to ↑ Y by 4.914 %	
For deposits in foreign currency		
X ₁	↑ of the NBU discount rate (X ₁) by 1% leads to a ↑ rate on deposits raised in foreign currency (Y) by 0.092%	during crises (which provoke an increase in prices) and monopolization of the economy, according to some factors, the reaction is weakened or absent. The process of placement and return of deposits raised in foreign currency may be disrupted during a sharp rise in the dollar rate (owners seek to benefit from the devaluation of the hryvnia, and banks do not need corresponding additional resources at a high price)
X ₂	↑ the amount of deposits raised in foreign currency for 1 UAH million, leads to ↑ Y by 0.09163 %	
X ₃	↑ average terms of attracting deposits in foreign currency for 1 month, leads to ↑ Y by 2.1313%	

Notes: * Modeling signal from changes in the performance of the deposit market: X₁/Y; X₂/Y; X₃/Y.

Table 6. Analysis of the content of reaction modulations (RM), which formalize changes in the values of each key operation of the deposit market (Y) according to the MS, 2022-2024

MS	Action	RM
Total deposits of residents (except deposit corporations)		
1	on request	NC: ↑X on 1 % → ↓Y on 0,0178 UAH million; FC: ↑X on 1 % → ↓Y on 0,0237 UAH million
	up to 1 year	NC: ↑X on 1 % → ↓Y on 0,0582 UAH million; FC: ↑X on 1 % → ↑Y on 0,0265 UAH million
	1 to 2 years	NC: ↑X on 1 % → ↓Y on 0,23 UAH million; FC: ↑X on 1 % → ↑Y on 0,0842 UAH million
	from 2 years	NC: ↑X on 1 % → ↑Y on 0,288 UAH million; FC: ↑X on 1 % → ↓Y on 0,0805 UAH million
2	on request	NC: ↑X on 1 UAH million → ↑Y on 0,9 UAH million; FC: ↑X1 on 1 UAH million → ↓Y on 0,5 UAH million
	up to 1 year	NC: ↑X on 1 UAH million → ↑Y on 3 UAH million; FC: ↑X1 on 1 UAH million → ↓Y on 0,02 UAH million
	1 to 2 years	NC: ↑X on 1 UAH million → ↑Y on 8.7 UAH million; FC: ↑X1 on 1 UAH million → ↑Y on 0,06 UAH million
	from 2 years	NC: ↑X on 1 UAH million → ↓Y on 8 UAH million; no FC: ↑X1 on 1 UAH million → ↓Y on 0,05 UAH million
3	on request	NC: ↑X on 1 d. → ↓Y on 0.002 UAH million; FC: ↑X1 on 1 d. → ↓Y on 0.0036 UAH million
	up to 1 year	NC: ↑X on 1 d. → ↓Y on 0.002 UAH million; FC: ↑X1 on 1 d. → ↓Y on 0.007 UAH million
	1 to 2 years	NC: ↑X on 1 d. → ↑Y on 0.0238 UAH million; FC: ↑X1 on 1 d. → ↓Y on 0.003 UAH million
	from 2 years	NC: ↑X on 1 d. → ↑Y on 0.038 UAH million; FC: ↑X1 on 1 d. → ↓Y on 0.019 UAH million
The volume of deposits of other deposit corporations		
1	on request	NC: ↑X on 1 % → ↓Y on 0,92 UAH million; FC: ↑X1 on 1 % → ↑Y on 0,262 UAH million
	up to 1 year	NC: ↑X on 1 % → ↑Y on 0,017 UAH million; no FC: ↑X1 on 1 % → ↓Y on 3.04 UAH million
	1 to 2 years	NC: ↑X on 1 % → ↓Y on 0,027 UAH million; FC: ↑X1 on 1 % → ↓Y on 6.88 UAH million
	from 2 years	NC: ↑X on 1 % → ↑Y on 0,031 UAH million; FC: ↑X1 on 1 % → ↓Y on 6.882 UAH million
2	on request	NC: ↑X on 1 UAH million → ↓Y on 0,9 UAH million; FC: ↑X1 on 1 UAH million → ↑Y on 0,3 UAH million
3	on request	NC: ↑X on 1 d. → ↓Y on 0.202 UAH million; FC: ↑X1 on 1 d. → ↑Y on 0.00919 UAH million
	up to 1 year	NC: ↑X on 1 d. → ↑Y on 0.427 UAH million; FC: ↑X1 on 1 d. → ↓Y on 0.234 UAH million
	1 to 2 years	NC: ↑X on 1 d. → ↑Y on 4.079 UAH million; FC: ↑X1 on 1 d. → ↓Y on 0.497 UAH million
	from 2 years	NC: ↑X on 1 d. → ↑Y on 5.301 UAH million; FC: ↑X1 on 1 d. → ↑Y on 10.509 UAH million
The amount of deposits raised from non-residents		
1	on request	NC: ↑X on 1 % → ↑Y on 0,228 UAH million; FC: ↑X1 on 1 % → ↑Y on 0.075 UAH million
	up to 1 year	NC: ↑X on 1 % → ↓Y on 3.437 UAH million; FC: ↑X1 on 1 % → ↑Y on 1.547 UAH million
	1 to 2 years	NC: ↑X on 1 % → ↑Y on 1.252 UAH million; FC: ↑X1 on 1 % → ↑Y on 1.159 UAH million
	from 2 years	NC: ↑X1 on 1 % → ↑Y on 26.589 UAH million; FC: ↑X1 on 1 % → ↑Y on 0.869 UAH million
2	on request	NC: ↑X1 on 1 UAH million → ↑Y on 48 UAH million; FC: ↑X1 on 1 UAH million → ↑Y on 2 UAH million
	up to 1 year	NC: ↑X1 on 1 UAH million → ↓Y on 227 UAH million; FC: ↑X1 on 1 UAH million → ↑Y on 17 UAH million
	1 to 2 years	NC: ↑X1 on 1 UAH million → ↑Y on 0.01 UAH million; FC: ↑X1 on 1 UAH million → ↑Y on 20 UAH million
	from 2 years	NC: ↑X on 1 UAH million → ↓Y on 418 UAH million; FC: ↑X1 on 1 UAH million → ↑Y on 11 UAH million
3	on request	NC: ↑X on 1 d. → ↑Y on 0.02 UAH million; FC: ↑X1 on 1 d. → ↑Y on 0.0174 UAH million
	up to 1 year	NC: ↑X1 on 1 d. → ↓Y on 0.385 od.; FC: ↑X on 1 d. → ↑Y on 0.297 UAH million
	1 to 2 years	NC: ↑X1 on 1 d. → ↓Y on 0.385 UAH million; FC: ↑X1 on 1 d. → ↑Y on 0.189 UAH million
	from 2 years	NC: ↑X1 on 1 d. → ↑Y on 2.555 UAH million; FC: ↑X1 on 1 d. → ↑Y on 0.157 UAH million

Notes: NC – national currency; FC – foreign currency

According to the visualization of the logic of changes in the value of deposits (Table 5) and the analysis of the content of the reaction modulations that formalize the changes in the values of each key operation (Table 6), the forecast of the development of the operating environment of the deposit market for 2022-2024 is compiled based on the value of the average coefficient. Increase/decrease can be adjusted, considering the reactivity of the environment (Table 1). As a result, it is possible to compare the forecast of deposit market transactions taking into account the reactivity of the operating environment and existing trends. It should be noted that the forecast is approximate since modulation signals (Table 5) and modulations (Table 6) formalize changes in the values of each key operation of the deposit market without reflecting all changes. In particular, in addition to fundamental factors, the modeling signal from changes in the performance of the foreign exchange market depends on other factors by $\approx 30\%$.

The result of the general formalization of the integral effectiveness of the deposit market of Ukraine can be additionally absorbed due to the action of other factors that will expand with currency liberalization. The stochastic model of the performance of the credit market of Ukraine for 2010-2021 made it possible to visualize the changes in the average loan rate without taking into account the overdraft for 2010-2021 and to predict the behavioral reactions of the operating environment through modeling signals, which is described by equations:

1) for loans in hryvnia (HV):

$$Y_1 = 11.3905 + 0.335X_1 + 0.00172X_2 + 0.7484X_3 - 0.01912X_4, \quad (4)$$

where: Y_1 is the average loan rate (excluding overdraft) in hryvnias, %;
 X_1 – NBU discount rate, %;
 X_2 – balances on credit accounts in national currency (except NBU), UAH million;
 X_3 – average terms of lending, year/month/day (d);
 X_4 – the number of loans in the national currency with security, million hryvnias.

2) for loans in IP:

$$Y_2 = 14.0869 - 0.02257X_1 - 0.00135X_2 - 1.057X_3 - 0.00759X_4, \quad (5)$$

where:
 Y_2 is the average loan rate (excluding overdraft) in IB%;
 X_1 – NBU discount rate, %;
 X_2 – the number of loans granted in IP, million dollars in equivalent;
 X_3 – average terms of lending, year/month/day (d);
 X_4 – the number of loans in IP with security, million dollars in the equivalent. Interpretations of possible behavioral reactions of the result according to the models in Art. Scale-confirmed reactivity, however, under the significant influence of factor X_4 . In addition, equation quality assessment data reveal its significance by R^2 .

Therefore, the visualization of the logic of changes in the value of loans on the credit market of Ukraine for the time interval 2010-2021 (Table 7) is formalized with an accuracy of up to 64%. The following operands were used as a basis for content analysis: increase ($\uparrow$), leads to ($\rightarrow$), and decrease ($\downarrow$).

Table 7. Visualization of the logic of changes in the cost of loans on the credit market of Ukraine, 2010 - 2021.

Factor		Simulating signal from changes*	The specificity of reactivity The internal environment depends on the security of lending, such as collateral, guarantee, etc. As for the reactivity in terms of the discount rate and the size of loans granted, it is quite low (because Ukraine does not have a clear market)
Calculations for loans in national currency			
X ₁	↑ of the NBU discount rate by 1% → ↑ loan rates (excluding overdraft) in UAH. by 0.338%		
X ₂	↑ the number of loans granted in national currency, except for the NBU, for USD 1 million USA → ↑ In by 0.0021 %		
X ₃	↑ average credit terms for 1 day → ↑ loan rates (excluding overdraft) in UAH by 0.739 %		
X ₄	↑ amount of loans in the national currency with a security of USD 1 million USA → ↓Y by 0.0204 %		
Calculations for loans in foreign currency			
X ₁	↑ NBU discount rate by 1% → ↓ loan rates (excluding overdraft) in foreign currency (Y) by 0.02257%		
X ₂	↑ the number of loans granted in foreign currency for 1 million dollars, in the equivalent of → ↓ Y by 0.00135 %		
X ₃	↑ average credit terms by 1 day → ↓ Y by 1.057%		
X ₄	↑ amount of loans in foreign currency with USD 1 million collateral, in the equivalent of → ↓ Y by 0.0143 %		

Notes: *Modeling signal from changes in foreign exchange market performance: X_1/Y ; X_2/Y ; X_3/Y ; X_4/Y .

Changes in the loan rate (excluding overdrafts) are most dependent on the provision of loans, such as a pledge, guarantee, etc., in relation to the reactivity of the discount rate, which is quite low. Such specificity requires an in-depth study of reaction modulations that formalize changes in the values of each key operation of the credit market (U) according to the MS (Table 8).

These modulations will make it possible to take a balanced approach to determine the direction of

further development of the credit market and prevent possible destabilizing processes associated with the disruption of deposit placement and return processes. According to the visualization of the logic of changes in the value of loans (Table 7) and the content of reaction modulations that formalize changes in the values of each essential operation (Table 8), the forecast for the development of the internal environment of the credit market covers 2022-2024.

Table 8. Analysis of the content of reaction modulations formalizing changes in the values of each key operation of the credit market (Y) according to the MS, 2022-2024

MS	Action	RM (magnification (↑); results in (→) reduction (↓))
Loans granted to residents		
1	up to 1 year	NC: ↑X on 1%→↓Y on 10992 UAH million; FC: ↑X on 1%→ ↑Y on 6456.13 UAH million
	from 1 to 5 years	NC: ↑X on 1%. →↓Y on 2294.59 UAH million; FC: ↑X1 on 1% →↑Y on 2701 UAH million
	> 5 years	NC: ↑X on 1%→↑Y on 599.5 UAH million; FC: ↑X1 on 1% → ↑Y on 3033 UAH million
2	up to 1 year	NC: ↑X on 1 UAH million→↑Y on 0.3 UAH million; FC: ↑X on 1 UAH million→↑Y on 0.5 UAH million
	from 1 to 5 years	NC: ↑X on 1 UAH million→↑Y on 0.3 UAH million; FC: ↑X1 on 1 UAH million→ ↑Y on 0.2 UAH million
	> 5 years	NC: ↑X on 1 UAH million→↑Y on 0.005 UAH million; FC: ↑X1 on 1 UAH million→↑Y on 0.1 UAH million
3	up to 1 year	NC: ↑X on 1 д. →↓Y on 22 UAH million; FC: ↑X1 on 1д. → ↓Y on 65.686 UAH million
	from 1 to 5 years	NC: ↑X1 on 1 д. →↓Y on 11 UAH million; FC: ↑X1 on 1 д. →↓Y on 25.042 UAH million
	> 5 years	NC: ↑X on 1 д. →↓Y on 9.9 UAH million; FC: ↑X1 on 1 д. → ↓Y on 26.754 UAH million
4	up to 1 year	NC: ↑X on 1 UAH million→ ↓Y on 0.3 UAH million; FC: ↑X on 1 UAH million→↓Y on 0.02 UAH million
	from 1 to 5 years	NC: ↑X on 1 UAH million →↑Y on 0.363 UAH million; FC: ↑X on 1 UAH million →↓Y on 0.22 UAH million
	> 5 years	NC: ↑X on 1 UAH million→↓Y on 0.02 UAH million; FC: ↑X on 1 UAH million→↓Y on 0.25 UAH million
Loans granted to non-residents		
1	up to 1 year	NC: ↑X on 1% → ↑Y on 0.09 UAH million; FC: ↑X1 on 1%→↓Y on 0.98 UAH million
	from 1 to 5 years	NC: 3↑X on 1%→↑Y on 0.07 UAH million; FC: ↑X on 1 % → ↑Y on 0.113 UAH million
	> 5 years	NC: ↑X on 1% →↑Y on 0.011 UAH million; FC: ↑X on 1% → ↑Y on 0.9 UAH million
2	up to 1 year	NC:↑X on 1 UAH million→↓Y on 0.001 UAH million; FC: ↑X on 1 UAH million→↑Y on 0.07 UAH million
	from 1 to 5 years	NC: ↑X on 1 UAH million →↑Y on 0.0002 UAH million; FC: ↑X on 1 UAH million →↑Y on 0.0003 UAH million
	> 5 years	NC: ↑X on 1 UAH million →↑Y on 0.001 UAH million; FC: ↑X on 1 UAH million→↓Y on 0.06 UAH million
3	up to 1 year	NC: ↑X on 1 д. →↑Y on 0.44 UAH million; FC: ↑X1 on 1 д. → ↑Y on 8.211 UAH million
	from 1 to 5 years	NC: ↑X on 1 д. →↑Y on 0.212 UAH million; FC: ↑X on 1 д. → ↑Y on 3.163 UAH million
	> 5 years	NC: ↑X on 1 д. →↑Y on 0.017 UAH million; FC: ↑X on 1 д. → ↓Y on 2.9 UAH million
4	up to 1 year	NC: ↑ X1 on 1 UAH million →↑Y on 0.000815 UAH million
	from 1 to 5 years	NC: ↑X1 on 1 UAH million → ↓Y on 0.00185 UAH million
	> 5 years	NC: ↑X on 1 UAH million→↓Y on 0.00232 UAH million

Notes: NC – national currency; FC – foreign currency

The forecast, according to the average coef. increase/decrease can be adjusted, taking into account the reactivity of the medium. According to the forecasting result, by the end of 2024, the expected volume of granted loans, taking into account the reactivity of the environment, may reach 1,057,156 million hryvnias, just when, according to the previously existing trends, it could reach 1,349,725 million hryvnias.

Therefore, the expected values regarding the volumes of credit market operations, taking into account the reactivity of its environment, are significantly lower than the values predicted according to the existing development trends. Among other factors that affect performance are the crossing of crediting grace periods, normative terms of credit use, violation of the payment schedule for it, being in the field "Rate + monthly and other commission", etc. For loans in foreign currency, among other factors affecting performance, the risk of a decrease in the income of a particular borrower is significant, [5].

Due to the lack of corrective actions and taking into account the likely reorientation of the deposit market to transactions with deposits on the terms of their issuance, at the first demand of the depositor, it is possible to form a deficit of bank assets and the occurrence of destabilization processes.

The stochastic model of the performance of the securities market of Ukraine for 2010-2021 made it possible to visualize the changes in the average rate of the average annual return on shares, bonds of the domestic state loan, bonds of enterprises, banks, insurance companies, joint investment securities and to predict the behavioral reactions of the operating environment through modeling signals described by equations:

$$1) \quad \text{by shares: } Y = 4.5899 - 0.00536X_1 - 0.1154X_2 + 0.3733X_3, \quad (6)$$

where Y_1 is the average annual rate of return on shares, %;

X_1 – the total volume of registered share issues, UAH million;

X_2 – the total volume of share trading on the platforms of the organized market, million hryvnias;

X_3 – profit of issuing enterprises, UAH million.

2) by domestic state loan bonds (from now on referred to as OVDP). This equation is basic since OVDP is the largest in the securities market of Ukraine.:

$$Y = 11.7568 - 0.01499X_1 - 0.000348X_2 + 0.01679X_3 + 0.02709X_4, \quad (7)$$

where Y_2 is the rate of the average annual yield of OVDP, %;

X_1 – placement of OVDP of Ukraine on the primary market, million hryvnias;

X_2 – funds raised for the OVDP to the budget, million hryvnias;

X_3 – the volume of OVDP bonds in circulation, at nominal and amortized cost, UAH million;

X_4 – crediting of the consolidated budget, million hryvnias.

3) for bonds of business structures (from now on - OPS) (or enterprises, banks, insurance companies):

$$Y = 16.8013 - 0.01399X_1 + 0.03178X_2 - 0.01602X_3 - 0.3946X_4 \quad (8)$$

where: Y_3 – average annual return on OPS (%);

X_1 – the volume of registered issues of such bonds, UAH million;

X_2 – the volume of exchange contracts on the organizers of trade on the OPS, million hryvnias;

X_3 – placement of OVDP of Ukraine, on the primary market, UAH million;

X_4 – profit of companies issuing securities registered by the National Commission for Securities and the Stock Market, million hryvnias.

4) by joint investment securities (from now on referred to as CPSI):

$$Y = 19.5811 + 0.06431X_1 - 0.3255X_2 - 0.1262X_3 + 0.00567X_4, \quad (9)$$

where Y_4 is the average annual yield of investment certificates of mutual investment funds, %;

X_1 – the issue of investment certificates of mutual investment funds, UAH million;

X_2 – the volume of trades in investment certificates of mutual investment funds, UAH million;

X_3 – the value of net assets of the investment fund in UAH million;

X_4 – the amount of foreign direct investment, UAH million. Interpretations of possible behavioral reactions of the result according to the equations outlined above in Art. scale, confirms reactivity, however, due to the significant influence of factors X_3 and X_1 for OVDP. Data on the quality of the equation reveal its significance according to R^2 .

Therefore, the visualization of the logic of the change in the average annual rate of return on shares, OVDP, OPS, and CPSI on the securities

market of Ukraine for the time interval 2010-2021 (Table 9) is formalized with an accuracy of 69.7%.

Visualization of the logic of changes in the rate of average annual return on shares, OVDP, OPS, and CPSI illustrates that the operating environment of the securities market is primarily dependent on factors that ensure specific volumes of securities absorption based on the level of profitability. At the same time, some factors adjust the need to absorb the relevant securities. In the synthesis, modulated signals affect each essential operation uniquely, which is analyzed through the immediate reaction modulations for each of them (Table 10). The following operands were used as the basis for analyzing the content of reaction modulations: increase ($\uparrow$), leads to ($\rightarrow$), and decrease ($\downarrow$).

According to the logic of the change in the rate of average annual return on shares, OVDP, OPS, CPSI (Table 7), and the content of reaction modulations formalizing changes in the values of

each critical transaction (Table 8), the forecast for the development of the operating environment of the securities market covers 2022-2024.

Forecasts based on the average coefficient increase/decrease and adjusted for reactivity by environment operations differ. In particular, for critical operations with shares until the end of 2024, the value may amount to UAH 522,092.8 million. (in particular, UAH 166,100 million for speculative operations), while according to the previously existing trends, UAH 750,959 million, in particular, UAH 226,145.7 million, by speculative operations. At the same time, regarding the volume of transactions with shares on the securities market of Ukraine for 2022-2024, specific growth is expected, which, however, may be absorbed or absorbed by the action of the other 30% of factors and their corresponding behavioral reactions, which cannot be taken into account in the forecast.

Table 9. Visualization of the logic of changes in the average annual rate of return on shares, OVDP, OPS, and CPSI on the securities market of Ukraine, 2010-2021

OFPI on the securities market of Ukraine, 2010-2021		
Factor	Modeling signal (MS) from changes*	The specificity of reactivity
by shares		
X ₁	↑ of the volume of registered share issues for 1 UAH million → ↓ average annual return on shares (Y) by 0.00481% (possible reverse influence)	The reactivity of factors X1 and X2 is caused by the desire of investors to sell their securities. The market is not always able to absorb its volume, which is offered for sale at the declared profitability. The reactivity of X3 is formed according to the state of production
X ₂	↑ of the total volume of share trading (X2) for UAH 1 million → ↓ Y by 0.149 %	
X ₃	↑ profit of enterprises that are issuers of shares for 1 UAH million → ↑ Y by 0.367%	
on domestic state loan bonds (OVDP)		
X ₁	↑ volumes of placement of OVDP in UAH million → ↓ average rate of return by 0.015%	The reactivity of the factors is due to the fact that due to the desire of the state to implement OVDP, the securities market of Ukraine is not always able to fully absorb the number of securities offered for sale at the declared yield. The X4/Y ratio is a factor that increases the need to issue the corresponding securities
X ₂	↑ of funds raised under OVDP to the budget by UAH 1 million → ↓ Y by 0.000348%	
X ₃	↑ the volume of OVDP in circulation, at nominal and amortization cost by 1 UAH million → ↑ Y by 0.0168%	
X ₄	↑ crediting of the consolidated budget by 1 UAH million → ↑ Y by 0.027%	
by bonds of business structures (OPS)		
X ₁	↑ volumes of registered issues of OPS by UAH million ↓ Y or average profitability for OPS (Y) by 0.014%	Responsiveness is formed from the ratio of factors that provide certain amounts of absorption, based on the level of profitability. The X4/Y ratio is a factor that reduces the need to issue the corresponding securities. however, the effect of X4 can be reversed
X ₂	↑ volumes of exchange contracts on OPS trade organizers by 1 UAH million → ↑ Y by 0.0318%	
X ₃	↑ the volume of OVDP placement on the primary market by UAH 1 million → ↓ Y by 0.01602%	
X ₄	↑ profit of companies issuing securities by UAH 1 million → ↓ Y by 0.395%	
by investment certificates of mutual investment funds (IS)		
X ₁	↑ IS output by 1 UAH million → ↑ their average rate of return (Y) by 0.06431%	Responsiveness is formed from the ratio of factors that provide certain amounts of absorption, based on the level of profitability. The X4/Y ratio is a factor that increases the need to issue the corresponding securities
X ₂	↑ the volume of IS trades by 1 UAH million → ↑ Y by 0.3255%	
X ₃	↑ value of net assets of the investment fund by UAH 1 million → ↓ Y by 0.1262%	
X ₄	↑ the volume of direct foreign investment by UAH 1 million → ↑ Y by 0.00567%	

Notes: * Modeling signal from changes in foreign exchange market performance: X₁/Y; X₂/Y; X₃/Y; X₄/Y.

Table 10. Analysis of the content of reaction modulations formalizing changes in the values of each key operation of the securities market (Y) according to the MS, 2022-2024

MS	Action	RM	MS	RM
by shares				
1	together	↑X on 1 UAH million→↓ Y on 0.1 UAH million	3	↑X on 1 UAH million → ↑Y on 0.4UAH million
	including up to 1 year	↑X on 1 UAH million→↓Y on 0.02 UAH million		↑X on 1 UAH million→ ↑ Y on 0.2 UAH million
2	together	↑X on 1 UAH million →↓Y on 3 UAH million		-
	including up to 1 year	↑X on 1 UAH million→↓Y on 0.8 UAH million		-
on domestic state loan bonds (OVDP)				
1	together	↑X on 1 UAH million →↓Y on 0.05 UAH million	3	↑X on 1 UAH million → ↑Y on 0.5 UAH million
	including up to 1 year	↑X on 1 UAH million →↑Y on 0.1 UAH million		↑X on 1 UAH million →↓Y on 0.53 UAH million
	together	↑X on 1 UAH million→↑Y on 0.2 UAH million		↑X on 1 UAH million → ↓Y on 0.78 UAH million
	including up to 1 year	↑X on 1 UAH million →↑Y on 0.6 UAH million		↑X on 1 UAH million →↓Y on 2.7 UAH million
2	together	↑X on 1 UAH million →↑ Y on 0.1 UAH million	4	↑X on 1 UAH million → ↓Y on 8.2 UAH million
	including up to 1 year	↑X on 1 UAH million →↑Y on 0.12 UAH million		↑X on 1 UAH million →↑Y on 9.1 UAH million
	together	↑X on 1 UAH million → ↑Y on 0.2 UAH million		↑X1 on 1 UAH million → ↑Y on 6 UAH million
	including up to 1 year	↑X1 on 1 UAH million →↑Y on 0.7 UAH million		↑X1 on 1 UAH million →↑Y on 33 UAH million
by bonds of business structures (OPS)				
1	together	↑X on 1 UAH million →↓Y on 0.3 UAH million	3	↑X on 1 UAH million →↓Y on 0.02 UAH million
	including up to 1 year	↑X on 1 UAH million → ↑Y on 1.8 UAH million		↑X on 1 UAH million →↑Y on 0.064 UAH million
	together	↑X on 1 UAH million → ↑Y on 0.6 UAH million		↑X on 1 UAH million →↑Y on 0.07 UAH million
	including up to 1 year	↑X on 1 UAH million н → ↑Y on 5 UAH million		↑X on 1 UAH million→↑ Y on 0.237 UAH million
2	together	↑X on 1 UAH million →↑Y on 0.0001 UAH million	4	↑X on 1 UAH million → ↑Y on 0.3 UAH million
	including up to 1 year	↑X on 1 UAH million →↓Y on 3.36 UAH million		↑X on 1 UAH million →↑Y on 9 UAH million
	together	↑X on 1 UAH million →↓Y on 4,06 UAH million		↑X on 1 UAH million → ↑Y on 9UAH million
	including up to 1 year	↑X on 1 UAH million → ↓Y on 11 UAH million		↑X on 1 UAH million н → ↑Y on 28 UAH million
by investment certificates of mutual investment funds (IS)				
1	together	↑X on 1 UAH million → ↓Y on 0.9 UAH million	2	↑X on 1 UAH million →↓Y on 1.54 UAH million
	including up to 1 year	↑X on 1 UAH million → ↓ Y on 3. UAH million		↑X on 1 UAH million →↓ Y on 7.9 UAH million
	together	↑X on 1 UAH million → ↓Y on 4. UAH million		↑X on 1UAH million → ↑ Y on 5.2 UAH million
	including up to 1 year	↑X on 1 UAH million →↓Y on 10 UAH million		↑X on 1 UAH million→ ↑ Y on 17.4 UAH million

By the end of 2024, according to critical transactions with securities, except for shares, the value may amount to UAH 2,344,721 million, while, according to the previously existing trends, it could amount to UAH 2,384,490 million. The volume of such transactions exceeds the volume of transactions with shares since a significant share here falls on bonds, which are considered a safer

investment instrument (bond owners have priority in demanding a share of the company's assets in the event of its liquidation or restructuring, under the OVDP the state guarantees 100% of payment). The difference in forecasts is insignificant and can be absorbed by the action of 31% of other factors and their corresponding behavioral reactions, which are

not defined and, therefore, not considered in the forecast.

According to the formed forecast of the reactivity of the operational environment of the Ukrainian securities market for its critical operations with securities, in addition to shares, changes should be expected that do not contradict the trends observed during 2015-2021. This also applies to the time structure of operations, since from 2021 by 2024, expect a further increase in the share of investments in securities with a term of more than two years, from UAH 405,406 to UAH 1,656,145 million, while their share in the total amount of transactions with securities, excluding shares, will increase from 64.23 to 70, 6%.

The stochastic model of the performance of the market of financial instruments and futures contracts (derivatives) in Ukraine for 2010-2021 made it possible to visualize changes in the average yield of futures, options (corresponding to the average difference in the value of the underlying asset) and predict the behavioral reactions of the operating environment through modeling signals, which is described by the equations:

$$Y = 13.8419 - 0.00611X_1 + 0.1742X_2 + 0.07988X_3, \quad (10)$$

where: Y is the average annual yield rate of options and futures on UB and UMVB (corresponding to the difference in the value of the underlying asset), %;

X_1 – the volume of exchange contracts on trade organizers for financial instruments and term contracts, UAH million;

X_2 – transaction currency risk of users, UAH million;

X_3 – currency and price risk of loan capital, UAH million.

There is currently no data to formalize market performance in terms of the average yield of forwards. Visualization of the logic of changes in the value of assets is incomplete and according to the equations in Art. Scale confirms reactivity, however, under the significant influence of factor X_2 . Data on the evaluation of the quality of the equation reveal its significance. So, the visualization of the logic of the change in the average rate of return of options and futures on the market of financial instruments and futures contracts for 2010-2021 (Table 11) is formalized with an accuracy of up to 56%.

The logic of changing the average yield rate of options and futures depends on factors that ensure specific volumes of their absorption and adjust operations with such assets based on their yield and risk levels. Naturally, according to the results of the analysis of the modeling signals, the factors we selected uniquely affect each essential market operation, which is illustrated by the specificity of reaction modulations (Table 12).

Table 11. Visualization of the logic of changes in the average rate of return of options and futures on the financial instruments and term contracts market, 2010-2021.

Factor	Modeling signal from changes in the performance of the foreign exchange market (increase (↑), decrease (↓))*	The specificity of reactivity
X_1	↑ volumes of exchange contracts on trade organizers for all types of financial instruments by UAH 1 million leads to ↓Y by 0.00611%	reactivity is due to the presence of a factor that ensures certain amounts of absorption, based on the level of profitability and levels of risks
X_2	↑ transaction currency risk of asset users (X_3) by 1 UAH million leads to ↑Y by 0.174%	reactivity is due to the formation of a gap in time between the date of conclusion of the contract and the date of payment for short-term contracts (2% of currency losses = 20% of unreceived marginal income)
X_3	↑ currency and price risk of loan capital, which arises in the period before the return of borrowed funds for 1 UAH million ↑Y by 0.0799 %	reactivity is due to the formation of conditions that 5% of currency/value losses = 40% of unobtained marginal income

Notes: * Modeling signal from changes in foreign exchange market performance: $\overline{X1/Y}$; $\overline{X2/Y}$; $\overline{X3/Y}$; $\overline{X4/Y}$.

Table 12. Analysis of the content of reaction modulations, which formalize changes in the values of each essential operation of the market of financial instruments and futures contracts (U) under the 2022-2024 MS.

MS	Action	RM
1	purchase/sale, execution of futures, and option contracts	↑ X for UAH 1 million → ↓Y on average by UAH 0.0148 million
2		↑ X for UAH 1 million → ↑Y on average by UAH 0.173 million
3		↑ X for UAH 1 million → ↑ Y by an average of 0.0549 UAH million

According to the visualization of the logic of the change in the average rate of return of options and futures on the market of financial instruments and futures contracts (Table 11) and the analysis of the content of reaction modulations that formalize changes in the values of each essential operation (Table 12), the forecast for the development of the operating environment covers 2022 - 2024.

The average growth/decrease forecast will be significantly adjusted to consider the reactivity of the operating environment. The difference in forecasts is significant and cannot be absorbed or absorbed by the action of 31% of other factors (statistical data for which are currently unavailable) and their corresponding behavioral reactions, which are not taken into account in the forecast.

There is currently no data for forming a stochastic model of the market performance based on the average yield of forwards, so the forecast can only be formed based on the expected growth/decrease ratio, in which the volume of operations is expected to grow from UAH 40 to 60.8 million in 2021-2024, with the orientation of the operating environment on price and transaction risk insurance (40.13%) and a significant share of speculative operations. The forecast is approximate since there is currently no way to measure the factors that form modeling signals for such vital operations. The accuracy of the forecast based on trends regarding the volume of operations with forwards will further decrease in connection with currency liberalization and the following modulation signals: 1) the lifting of the ban for legal entities to carry out operations for the sale of foreign currency on "forward" terms; 2) a series of relaxations for currency operations of the population. So far, currency liberalization does not apply to foreign currency purchase transactions for legal entities. However, the NBU has opened the forwards market for individuals, both for sale and for purchase and SWOP (this created an opportunity to make currency settlements for domestic government bonds denominated in foreign currency).

The stochastic model of the performance of the real estate market in Ukraine for 2013-2021 made it possible to visualize changes in the average annual rate of return on investments in it and to predict the behavioral reactions of the operating environment through modeling signals, which is described by the equations: 1) for the primary real estate market:

$$Y_1 = 15.4101 + 0.09372X_1 - 0.0903X_2 - 0.229X_3, \quad (11)$$

where: Y_1 is the average annual rate of return on investments in real estate with land plots, %;

X_1 – the cost of construction of the new real estate, million hryvnias;

X_2 – final costs of real estate owners for water, electricity, gas, and other types of fuel, million hryvnias; X_3 – the volume of loans issued for the purchase of the real estate, UAH million.

3) for the secondary real estate market:

$$Y_2 = 15.7424 - 0.02513X_1 - 0.04531X_2 + 0.01844X_3, \quad (12)$$

where Y_2 is the average annual rate of return on investments in real estate with land plots, %;

X_1 – the value of real estate objects that are put up for sale and are a secondary type of property, UAH million;

X_2 – the cost of construction of the new real estate, UAH million;

X_3 – the volume of loans issued for the purchase of the real estate, UAH million.

Interpretations of possible behavioral reactions according to equations 11-12 in Art. The scale confirms reactivity; however, due to the significant impact of the volume of loans issued for the purchase of real estate and the volume of construction of new real estate objects (X_3). There is a possibility that these factors will be important in connection with the war in Ukraine and will form such a modeling signal on the critical operations of the real estate market. The data on assessing the quality of the regression equation allows us to conclude that the description of possible behavioral reactions to the real estate market performance is entirely accurate. So, the visualization of the logic of the change in the average annual rate of return on investments in real estate with land plots on the real estate market of Ukraine for the time interval 2010-2021 (Table 13) is formalized with a degree of accuracy of up to 65%.

At the same time, it is essential not only to specify changes in the average annual rate of return on investments in real estate with land plots but also to determine their modulatory effect since it will differ by types of critical transactions with property rights and by types of such rights, in terms of short-term transactions (CO); medium-term operations (MO); long-term operations (LO). Therefore, the reactions that will be characteristic of the operating environment of the real estate market should determine the reaction modulations (Table 14).

Table 13. Visualization of the logic of changes in the average annual rate of return on investments in real estate with land plots on the real estate market of Ukraine in the time interval 2010-2021

Factor	Modeling signal from changes in the performance of the foreign exchange market (increase (↑), leads to (→), decrease (↓))*	The specificity of reactivity
Primary market		
X ₁	↑volumes of construction of new facilities (X ₁) by 1% → average annual rate of return on investments in new real estate (Y) by 0.094%	Market reactivity is caused by the impact of loans issued for the purchase of real estate and the volume of construction of new real estate objects
X ₂	↑of final consumer expenditure of households on water, electricity, gas, and other types of fuel (X ₂) by 1 UAH million → ↓Y by 0.0903%	
X ₃	↑volumes of loans issued for the purchase of real estate (X ₃) by 1% → ↓Y by 0.229%	
Secondary market		
X ₁	↑number of real estate objects put up for sale as a secondary type of property for 1 UAH million, → ↓average annual rate of return on real estate investments on the secondary market (Y) by 0.02513%	The reactivity of the market is due to the influence of loans issued for the purchase of real estate and the volume of construction of new real estate objects
X ₂	from ↑ the cost of construction of new real estate objects by UAH 1 million → ↓Y by 0.04531%	
X ₃	from ↑ volumes of loans granted for the purchase of real estate for 1 UAH million → ↑ Y by 0.01844%	

Notes: * Modeling signal from changes in foreign exchange market performance: X1/Y; X2/Y; X3/Y.

Table 14. Analysis of the content of reaction modulations that formalize changes in the values of each essential operation of the real estate market (U) according to the MC for 2022-2024

MS	Actions	RM	MS	RM
Operations on the primary market				
Property rights to residential real estate			Property rights to non-residential real estate	
1	SO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.1 UAH million	1	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.2 UAH million
	MO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.15 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.3 UAH million
	LO	$\uparrow X$ on 1 UAH million $\rightarrow Y$ on 0.15 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.2 UAH million
2	SO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.11 UAH million	2	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.3 UAH million
	MO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.2 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.5 UAH million
	LO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.2 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.4 UAH million
3	SO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.06 UAH million	3	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.27 UAH million
	MO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.15 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.55 UAH million
	LO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.24 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.45 UAH million
Operations on the secondary market				
Property rights to residential real estate			Property rights to non-residential real estate	
1	SO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.2 UAH million	1	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.032 UAH million
	MO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.11 UAH million		$\uparrow X$ on 1UAH million $\rightarrow \uparrow Y$ on 0.124 UAH million
	LO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.2 UAH million		$\uparrow X$ on 1UAH million $\rightarrow \uparrow Y$ on 0.455 UAH million
2	SO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.2 UAH million	2	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.36 UAH million
	MO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.12 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.082 UAH million
	LO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.12 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y \approx$ on 0.8 UAH million
3	SO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.03 UAH million	3	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 1.1 UAH million
	MO	$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 0.1 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \downarrow Y$ on 0.06 UAH million
	LO	$\uparrow X$ on 1 UAH million $\rightarrow \downarrow Y$ on 0.2 UAH million		$\uparrow X$ on 1 UAH million $\rightarrow \uparrow Y$ on 1.41UAH million

According to the logic of changes in the average annual rate of return on investments in real estate with land plots on the real estate market of Ukraine (Table 13) and the content of reaction modulations that formalize changes in the values of each key operation with rights to real estate objects (Table 14), the development forecast its operating environment covers 2022-2024. Forecast based on the average coef. increase/decrease will be significantly adjusted for the reactivity of each key transaction. The difference in forecasts is significant. In particular, as of 2024, the volume of transactions with property rights to real estate objects on the primary market, taking into account

its reactivity, will amount to UAH 117,837 million, which is 44% lower than the forecast value according to trends, which reaches UAH 210,952 million.

The volume of operations with property rights to real estate objects on the secondary market for the outlined period, taking into account the reactivity of the operating environment, will amount to UAH 252,317 million, which is 25.34% below the forecast value according to trends, which reaches UAH 337,990 million. Conditionality should be canceled of the adjusted forecast, which is caused by the fact that ≈40% of the factors that form the modulatory influence are missing from the

regression equations because the statistical data for them are missing or cannot be taken into account. In the primary real estate market, the expansion of influencing factors will take place in connection with the cancellation of the moratorium on the sale of agricultural land and the consideration of the draft law "On Amendments to Certain Legislative Acts of Ukraine on the Protection of the Rights of Creditors of Construction Objects", which introduces the procedure for registering the ownership of future objects and determines the possibility of selling such housing, if this right is registered. In the secondary real estate market, this is due to a gradual increase in the maximum tax on square meters that exceeds the established norm. Since February 24, 2022, the risk of destruction of real estate objects has become quite significant in the real estate market as a whole. Despite the conditionality of the forecast, the real estate market is expected to focus on long-term transactions with property rights (the share of which in 2024 will reach 42.3% of their total volume), with a high share of speculative transactions. Despite the absence of corrective actions, the artificial increase in prices from speculation with property rights creates the prerequisites for a price bubble and a sharp collapse of real estate prices.

Globalization processes affected the change in the structure of the financial market of Ukraine, [8].

Any lessons investors might take from the last war could have limited relevance for the next—or be forgotten after a generation of relative peace has led to complacency, [9]. The war in Ukraine is a human tragedy for the people of Ukraine, but its economic implications are global. This instant report focuses on the direct impact of the war on world trade and investment. It identifies five trade and investment channels through which countries will be affected by the war in Ukraine. These encompass disruptions to: (i) commodity markets (especially food and energy), (ii) logistic networks, (iii) supply chains, (iv) foreign direct investment, and (v) specific sectors. Beyond these direct effects, the war's long-term implications for global trade and investment will largely depend on how governments respond to the changing geopolitical environment, [10].

In the conditions of turbulent challenges and threats to the foreign exchange market, there is a possibility of obtaining a multiplier effect of investment support for all sectors of the economy, [11].

In the conditions of turbulent challenges and threats to the foreign exchange market, there is a

possibility of obtaining a multiplier effect of investment support for all sectors of the economy.

The geopolitical conflict between Russia and Ukraine has noted derailing impacts on financial markets. Since tensions from geopolitical risks (GPR) can amplify the pessimistic views of investors, we envisage this issue from the position of shorted stocks. In a wavelet-based analysis, we examine the impact of the Russian-Ukrainian military conflict on different economic sectors. We found strong and high comovements between shorted stocks and GPR. The lead-lag dynamics evidence that hedging strategies with shorted stocks would be beneficial, particularly in the very short, [12].

Markets did not completely anticipate the war, and asset price reactions strengthened from the first week—when there were hopes for a quick resolution—to the second week when prices generally peaked and began to partially revert to prewar values. Exposure to commodity trade and trade with Russia and Ukraine determined market perceptions of the riskiness of equity and foreign exchange assets. Credit default swap prices on sovereign debt and breakeven inflation rates indicate that markets saw the war as a measurable fiscal risk even for nonbelligerents, [13].

The influence of various factors was studied by scientists when modeling the financial market, in particular war, globalization, and internationalization, [14].

According to the content of stochastic models, Ukraine's financial market is affected by many factors. However, the logic of the reactions of its operating environment to these factors can be analyzed and predicted through the content of the modeling signal and reaction modulations that formalize changes in the values of each key operation. Summing up the results allows us to consider the financial market as the central concept of integral calculus, with each component having its properties. The results of such analysis and forecasting will make it possible to reasonably approach the development of sets of priority actions within the framework of strategic maps, the fixation of outlined priorities, and predictive analysis of changes in their effectiveness over time (which provides visualization of the movement towards absorption or complete absorption of destabilizing processes in the financial market).

4 Conclusions

Forecasting possible behavioral reactions to the integrated performance of the financial market of

Ukraine is necessary for connection with the scholastic environment, the variability of risks formed by the content of influencing factors, by setting the volumes of critical operations to respond to the effect of influencing factors. This is because the volumes of critical financial market operations, according to its combinatorial structure, are also aimed at obtaining a result. Therefore their reactivity is subject to the same factors as the price of the primary assets of the financial market. The accuracy of the results is determined by the values of the integral coefficient of determination, which is at the level of $R^2=0.665$. The received forecast of changes creates an opportunity with sufficient accuracy to reveal the conditions for the formation of results, notably that characteristic of critical operations of the financial market, using studies of its internal reactivity, which is guided by the action of influencing factors. According to the results of the performance evaluation, it is evident that the expected integral performance of the financial market of Ukraine will demonstrate a much lower expected increase in benefits due to the likely narrowing of the market capacity and reduction of investment options. Unpredictable and adverse events accompanying destabilization processes are predicted to develop in the financial market. However, by the end of 2024, it is expected that the financial market's performance will exceed the value of 2021, provided that an adequate market structure will be formed with the help of complex strategic measures. Such measures should be part of strategic maps of financial market performance.

References:

- [1] Andrew Leigh, Justin Wolfers, and Eric Zitzewitz (2003). *National Bureau Of Economic Research (NBER)*, working paper series, "What do financial markets think of war in Iraq?", [Online]. Working Paper 9587. <http://www.nber.org/papers/w9587> (Accessed Date: November 12, 2023).
- [2] Gerald Schneider and Vera E. Troeger (2006). War and the World Economy: Stock Market Reactions to International Conflicts. *The Journal of Conflict Resolution*. Vol. 50, No. 5, pp. 623-645 (23 pages). Sage Publications, Inc.
- [3] Massimo Guidolin, Eliana La Ferrara (2010). The Economic Effects of Violent Conflict: Evidence from Asset Market Reactions, [Online]. https://igier.unibocconi.eu/sites/default/files/media/attach/The_Economic_Effects_of_Violent_Conflict-Evidence_from_Asset_Market_Reactions.pdf (Accessed Date: November 12, 2023).
- [4] Irtyshcheva, I., Pavlenko, O., Kramarenko, I., Liashenko, O., Stehnei, M., Nadtochiy, I., Boiko, Y., Zavorodnij, K., Hryshyna, N., Ishchenko, O. (2022) Environmental Security of Territories: Challenges of Today and Guidelines for Strengthening in War. *Journal of Environmental Management and Tourism*, 13(5), pp.1229-1239
- [5] Kharlamov, P. (2021). How much does it cost to take a loan in Ukraine: Rates, conditions, penalties. (Скільки коштує взяти кредит в Україні: Ставки, умови, штрафи). *Money*, Issue from January 28. [Online]. <https://dengi.ua/magazine/zarplata-skinul-v-lichku/2952424-skolko-stoit-vzyat-kredit-v-ukraine> 245 (Accessed Date: November 12, 2023).
- [6] Nadtochiy, I., Krylenko, V., Tkach, V., Kramarenko, I., Chumakov, K. (2022). Economic Diagnostics of Territorial Development: National Dimension and Experience of EU Countries. *WSEAS Transactions on Environment and Development*, 18, pp.486-495, <https://doi.org/10.37394/232015.2022.18.47>.
- [7] Zholud O. and Repko M. (2016). Black currency market: scope of the problem: Presentation of research results. (Чорний ринок валюти: масштаби проблеми) *Analytical note. Center for Economic Strategy*, [Online]. <https://ces.org.ua/chornyi-rynok-valiuty-masshtaby-problem/> (Accessed Date: November 12, 2023).
- [8] Vyshnevskaya, O., Irtyshcheva, I., Kramarenko, I., Popadynets, N., Ponomarova, M. (2022). The Influence of Globalization Processes on Forecasting the Activities of Market Entities. *Journal of Optimization in Industrial Engineering*, vol.15(1), pp.261-268.
- [9] Ferguson Niall (2008). Earning from History? Financial Markets and the Approach of World Wars. *Brookings Papers on Economic Activity*, Vol. 2008 (Spring, 2008), pp.431-477 (47 pages).
- [10] Ruta, Michele (ed.). (2022). The Impact of the War in Ukraine on Global Trade and Investment. Washington, DC. © World Bank, [Online]. <https://openknowledge.worldbank.org/handle/document/17042/1>

[/10986/37359](#), License: CC BY 3.0 IGO
(Accessed Date: November 12, 2023).

- [11] Irtysheva, I., Nosar, A., Boiko, Y., Stehnei, M., Kramarenko, I., Zavorodnij, K. (2023). The multiplier effect of investment and innovation support for the development of transport and logistics systems: foreign experience and practice for Ukraine. *Journal of Hygienic Engineering and Design*, 41, pp.211-219
- [12] Umar, Zaghum, Bossman, Ahmed, Choi, Sun-Yong, Vinh Vo, Xuan (2022). Are short stocks susceptible to geopolitical shocks? Time-Frequency evidence from the Russian-Ukrainian conflict. *Finance Research Letters*, <https://doi.org/10.1016/j.frl.2022.103388>.
- [13] Christopher J. Neely (2022). Financial Market Reactions to the Russian Invasion of Ukraine. Federal Reserve Bank of St. Louis Review, Fourth Quarter 2022, vol.104(4), pp. 266-96. <https://doi.org/10.20955/r.104.266-96>
- [14] Kramarenko, I., Stehnei, M., Boiko, Y., Nadtochii, I., Pavlenko, O., Vladislav, R., Hryshyna, N., Sirenko, I., Ishchenko, O., Tubaltseva, N. (2022). Socio-economic development in conditions of digital transformations: regional features, strategic analysis, and prospects. *7th International Conference on Mathematics and Computers in Sciences and Industry (MCSI 2022)*, pp.175-182, <https://doi.org/10.1109/MCSI55933.2022.00035>.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

-Halyna Mykhalchynets, Nataliia Mykhalchynets carried out the simulation and the optimization, formal analysis .

-Inna Irtysheva, Marianna Stehnei, Iryna Kramarenko, Viktor Neimet was responsible for the Statistics, conceptualization.

-Oleksandra Liashenko has organized writing - original draft.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare.

Creative Commons Attribution License 4.0 (Attribution 4.0 International, CC BY 4.0)

This article is published under the terms of the Creative Commons Attribution License 4.0

https://creativecommons.org/licenses/by/4.0/deed.en_US