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MODELLING THE ESTIMATION OF THE THREAT OF FINANCIAL CRISES IN CORPORATE SYSTEMS

Анотація. Робота присвячена проблемі запобігання фінансовим кризам на корпоративних підприємствах. Запропоновано методичний підхід до розробки комплексу моделей оцінки загрози фінансових криз у корпоративних системах. Побудовано модельний базис оцінки та попередження фінансових криз у корпоративних підприємствах.

Аннотация. Работа посвящена проблеме предупреждения финансовых кризисов на корпоративных предприятиях. Предложен методический подход к разработке комплекса моделей оценки угрозы финансовых кризисов в

корпоративных системах. Построен модельный базис оценки и предупреждения финансовых кризисов в корпоративных предприятиях

Abstract. The paper is devoted to the problem of preventing financial crises in corporate enterprises. The methodical approach to development the set of models of estimation of the threat of financial crises in corporate systems is proposed. The model basis of estimation and prevention of financial crises in corporate enterprises is built.

Ключові слова: банкрутство, корпорація, криза, модель, оцінка, прогнозування, фінансовий стан.

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Keywords: bankruptcy, corporation, crisis, model, estimation, financial condition, forecasting.

The phenomenon of financial insolvency is presented in economy of any system of market relations. At the present stage of development of Ukraine regarding to the consequences of global financial and local national crises the determining of failure of any economic subject is of considerable interest. To be able to identify and to note in time unfavorable trends of financial activity of the enterprise, to assess their scope properly for prevention a financial collapse of the organizations is vital to any competent manager nowadays [1].

Ukraine has quite a large number of enterprises which pass bankruptcy procedure annually, the result of which may be their liquidation. In addition, many business enterprises are on the brink of solvency and are running at a loss, which can lead to bankruptcy in the future. There are bankrupted companies in every region of Ukraine, both small and large enterprises become bankrupt. But the domestic economy is almost entirely composed of corporate type of companies, moreover, there is a defined trend towards acquisitions of small businesses by large ones that are the part of corporations. Exactly the holdings, financial and industrial groups and

other corporations are now the backbone of Ukraine, which is why the problem of bankruptcies of corporate type firms of modern Ukrainian economy is one of the most important [2].

And the first step in its solution is the estimation of the propensity of individual enterprise from corporate segment to bankruptcy, is to determine how its threat of bankruptcy affects the financial stability of the whole organization, and based on the analysis of the results of this estimation – to develop the crisis management of subsidiary enterprise and of the corporation.

That is why implementation of modern technologies of economic and mathematical modelling into domestic corporate systems for threat estimation of crisis forming in time and for its prevention is of particular importance. The development of such models of estimation of the threat of bankruptcy and researches about general problems of crisis management were started only in the second half of the 20th century. The works of domestic and foreign scientists are devoted to these issues such as works of E. Altman, V. Beaver, V. Vitlynskyi, V. Zabrodskyi, Y. Zaichenko, G. Kadykov, A. Matviychuk, A. Morozevich, A. Nedosekin, D. Olhson, R. Sayfulin, G. Springate, M. Suvorov, R. Taffler, A. Tereshchenko, O. Cherniak, D. Chesser, etc. In particular, such aspects of bankruptcy problem were investigated, as the choice of the most significant factors affecting the probability of bankruptcy, an analysis of the most appropriate methods of estimation of the threat crises forming in enterprises, different approaches to anti-crisis policy of enterprises, implementation of econometric modelling into the process of financial analysis, dynamic assessment of financial stability of different entities depending on various external and internal factors and so on [3-8].

But these works paid less attention to assessing the impact of financial crisis at subsidiaries on bankruptcy of the corporations at the whole. In addition, the most current models of estimation of bankruptcy threat are the models of "pattern recognition", i.e. they definitely characterize enterprise's financial condition to an exact class of crisis. But companies are often in transition from one phase of crisis to another, and it is impossible to accurately describe his financial condition. Also it

should be noted that despite the effectiveness of the approaches proposed by the authors, the issues of forecasting the financial crisis in corporate structures are poorly addressed. Such structures are characterized by large amounts of accounts payable and receivable, related, in particular, to intra-system lending. They carry out financing for the implementation of works, both on system-wide and local projects of individual companies, etc. The use of traditional approaches for forecasting the financial crises of corporate structures reveals their poor prognostic accuracy.

And still unresolved problem is the possibility of using such models for corporate enterprises of all sizes and of various industries; as well, currently not enough attention is paid to the development and making of anti-crisis management decisions and to the assessment of their effectiveness in these enterprises [3, 6-7, 9].

So, as above analysis shows, an insufficient attention is paid to the problem of the complex improvement of the financial management system of corporations. In most cases, the central issue is the development and implementation of tools for local diagnosis of crisis phenomena in individual enterprises. The issues of evaluating the impact of local financial crises on the financial state of the corporate structure as a whole, of predicting the financial crises of the corporate structure with the aim of preventing or localizing the consequences are poorly considered. Due to this, in corporate systems for estimating the crises threat there should be implemented a new, improved approach which, considering the elimination of detected shortcomings in the above analysis, must be based on a synthesis of economic and mathematical models of estimation the crises threat in corporate management systems and on proactive technology [9]. Implementing this approach will allow to diagnose the possibility of financial crisis in the particular company (subsidiary) and in the corporation at whole, to determine crisis' depth, and to develop and to make appropriate crisis management decisions.

The proposed methodological approach is shown on Fig. 1.

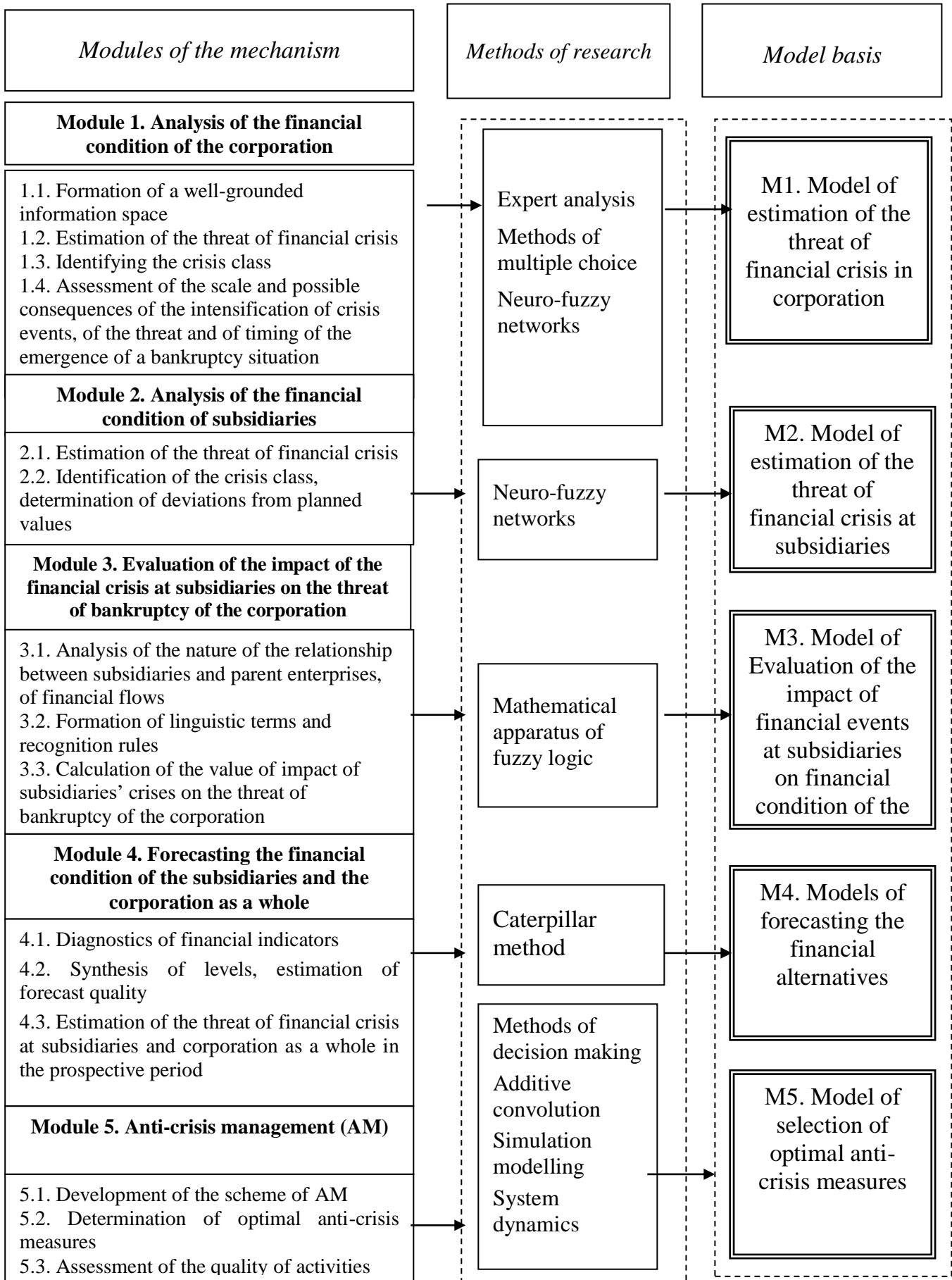


Fig. 1. Methodological approach to development a model basis of estimation of the threats of financial crises in corporate systems

In the proposed approach there are such used methods as econometric methods, complex of methods of decision theory and modern economic and mathematical methods, such as neural fuzzy modelling and forecasting method "caterpillar". Its use will allow implementing the technology of proactive crisis management in the activities of corporations, analyzing the financial condition of both the subsidiary and the entire corporation adequately, assessing the impact of financial crisis on the subsidiaries to the threat of bankruptcy of the whole organization and implementing the necessary range of measures for its prevention.

Modules 1-4 of the scheme (Fig. 1) are the blocks of implementing of proactive anti-crisis management in a corporation which is aimed at preventing the emergence of a crisis state, both in individual elements and the corporate system as a whole. Module 5 is used in conditions of current negative estimation of the state of the corporation, and it is a "reaction" to the already existing crisis processes and events in the corporation. After its implementation, in the process of monitoring the financial condition, proactive control modules are used, allowing early diagnostics and preventing a crisis state. Further in the work the main emphasis is made on the features of the application of the model basis of modules of the mechanisms that support the principles of proactive control (models M1-M4). The detailed description of the proposed approach is presented in studies [10-11].

The developed model basis was tested in the activity of one of the agricultural corporations of Kharkiv region. The model of estimation of the threat of a crisis at the parent enterprise of the corporation (model M1) was built on the basis of 36 non-state parent enterprises of the corporate structures of the agricultural sector of Ukraine, of which 12 are bankrupt, and 24 belong to sustainably functioning corporations. The model of estimation of the threat of forming of financial crises at subsidiaries (model M2) was built on the basis of 40 non-governmental subsidiaries of Ukrainian agricultural corporations, of which 24 belong to normally functioning enterprises and 16 belong to the class of bankrupts. These models were tested in the activities of the parent enterprise of the agricultural corporation and of its 5 subsidiaries. Models M3-

M4 are developed on the basis of data from the parent enterprise and subsidiaries of investigated corporate structure over the past fifteen years.

In accordance with the proposed approach (Fig. 1), at the first stage of the research, such task was carried out as the formation and justification of the information space for research. The a priori list of factors that affect the threat of crises included 36 financial indicators divided into 5 groups (group 1 – indicators of property status, group 2 – liquidity indicators, group 3 – indicators of financial stability, group 4 – indicators of business activity, group 5 – profitability indicators). Forming and justification of posteriori list of indicators was carried out in previous studies [12]. It includes 5 indicators (1 from each group): X1 – the coefficient of usefulness of fixed assets; X2 – quick liquidity ratio; X3 – coefficient of financial autonomy; X4 – turnover ratio of assets; X5 – profitability of activity.

As the resultant variable Y of the neural-fuzzy model M1, the estimation of the threat of the formation of a financial crisis in the corporation is used. To scale the values of the Y estimator, a cluster analysis was performed. The effectiveness of partitioning of the scale of Y values into 3, 4, 5 and 6 clusters was compared by the method of k-means. Number of classified objects in each cluster for all variants and appropriate values of total variance within groups are presented in Table 1.

Table 1

Partitioning of Y values into clusters

Characteristic	Partitioning into			
	3 clusters	4 clusters	5 clusters	6 clusters
The number of objects in clusters	cluster 1 – 5 objects cluster 2 – 13 objects cluster 3 – 59 objects	cluster 1 – 5 objects cluster 2 – 12 objects cluster 3 – 10 objects cluster 4 – 50 objects	cluster 1 – 4 objects cluster 2 – 4 objects cluster 3 – 10 objects cluster 4 – 32 objects cluster 5 – 27 objects	cluster 1 – 10 objects cluster 2 – 4 objects cluster 3 – 1 objects cluster 4 – 3 objects cluster 5 – 32 objects cluster 6 – 27 objects
The value of total variance within group	47,39	43,36	41,23	43,20

Thus, by the criterion of minimization of total variance within group the best conducted partitioning is done into 5 clusters. Thus, formed scale of interpretation of Y values is presented in Table 2.

Table 2

Interpretation of Y values

Y value	Threat of crises forming
$Y \leq 0$	Very low
$Y \in (0;0.25]$	Low
$Y \in (0.25;0.75]$	Medium
$Y \in (0.75;1)$	High
$Y \geq 1$	Very high

The construction of the neural-fuzzy model of estimation of the threat of financial crises at the parent enterprise of the corporation was carried out in Matlab package [11]. Input parameters (input) of the model are five selected indicators X1-X5, the resultant variable (output) is an estimation of the threat of crisis forming (Y). The structure of the fuzzy inference system (FIS) was generated in the packet of the selected type (Sugeno). Based on the results of the research, the number of linguistic terms (for all 5 inputs) and the type of membership functions have been chosen by the selection method to achieve the best results of constructing the model (obtaining the least error). Thus, for each of the input variables X1-X5, 3 linguistic terms were assigned; the triangle type was chosen as the type of membership functions. The rules of fuzzy inference were formed automatically; each fuzzy rule is checked on the logical and theoretical economic content, on the lack of contradictions. So, all the formed rules turned out to be adequate, and there is no need for their editing. Thus, the structure of the generated Sugeno fuzzy inference system has the following form: it contains 5 input variables (input1 = X1-input5 = X5), 15 terms (3 terms per input variable), 243 fuzzy rules, 1 output variable Y, 243 terms of output variable. To train the neural network, a hybrid method was chosen that is a combination of the least squares method and the method of decreasing the inverse gradient, and 40 training

cycles were established. Testing of the constructed neural-fuzzy system showed that the average error is 0.10985%. Thus, it is advisable to use the constructed model in further research.

In particular, based on the model, it was determined that the value of the resulting variable Y at the end of the period under study for the analyzed agricultural corporation is -0.541, i.e. the probability of bankruptcy of this enterprise is very low.

In the second module (Fig. 1), a model of estimation the threat of crisis forming at corporate subsidiaries was constructed (model M2). As in the implementation of module 1, a tool of neuro-fuzzy networks was used, and a corresponding model was constructed in a similar way. Note that to construct a neural-fuzzy model, the trapezoidal functions of the input factors and the linear type of the membership function of the initial (resulting) variable were used, since this combination made it possible to obtain the smallest prediction error equal to 0.0012%.

The dynamics of changes in the estimations of the threat of financial crises forming at the subsidiaries of the corporation is presented on Fig. 2.

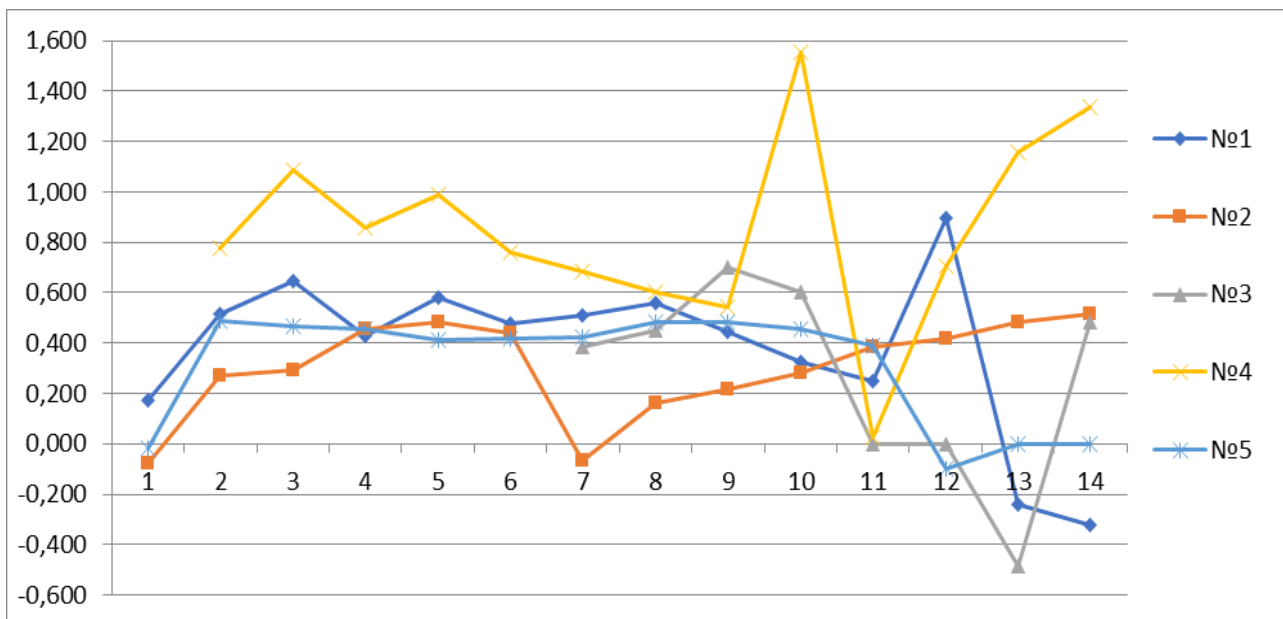


Fig. 2. Dynamics of the change in the value of the threat of financial crises forming at the subsidiaries of the corporation

As can be seen from Fig. 2, the most problematic are enterprises No. 2 and No. 4, which during the past four years had an increase in the threat of bankruptcy. The enterprise No. 3 is also at risk, which has a sharp increase in the complex indicator of the threat of bankruptcy by the end of the period. Thus, for three out of five subsidiaries, the probability of bankruptcy is estimated as average and very high, which leads to the need to investigate the impact of the situation on the financial condition of the corporation as a whole and the development of adequate preventive measures.

The third module (Fig. 1) assesses the impact of the threats of crisis forming at subsidiaries on the probability of bankruptcy of the corporation as a whole. As it was said above, the mathematical apparatus of fuzzy logic is used to construct the M3 model. Denote by V a complex indicator of the degree of influence of subsidiary's financial condition on the overall corporation's condition. The higher value of the V – the higher the degree of influence. This complex indicator takes values in the range from 0 to 1. The system of indicators for evaluation the impact of crisis threat at subsidiaries on the financial condition of the corporation as a whole was selected on the basis of an analysis of corporate performance and statistics of bankruptcy procedures. This system of indicators includes: X_1 – the share of subsidiary's revenue in the corporation; X_2 – the nature of production links; X_3 – the presence of subsidiary's granddaughter companies; X_4 – the share of subsidiary's authorized capital in the corporation; X_5 – the share of external accounts payable. Herewith, the factor " X_2 " can take one of three values: "0" – with the object type of the production structure (if an enterprise produces and sells finished products independently, and does not transfer its products to the following enterprises in the chain of production of the corporation's finished products) "1" – with the technological type (if the enterprise produces the products which are necessary for the ordinary production of another enterprise in the corporation), "2" – with a mixed type. Factor " X_3 " can take two values: "0" – if the enterprise does not have subsidiaries; "1" – if it has.

The membership functions (μ_{V1-5}) of the indicator V, which correspond to all variants of the corporation's dependence on subsidiary: from almost its absence (μ_{V1}) to the maximum (μ_{V5}) were set as a trapezoidal type.

For the chosen indicators of the financial condition of the enterprise X_i , the linguistic variables L_i "Level of indicator X_i " were set (5 subsets of levels from "very low" to "very high"). The calculated values of the complex indicator of the degree of influence of threats to the formation of crisis events at the subsidiaries on the financial condition of the corporation as a whole are presented in Table 3.

Table 3

Recognition of the degree of influence of enterprises on the financial condition of the corporation

Enterprise	Value of V	Degree of influence	The membership function
Enterprise №1	0,57	High	1
Enterprise №2	0,43	High	1
Enterprise №3	0,23	Medium	1
Enterprise №4	0,37	Medium	0,13
		High	0,87
Enterprise №5	0,24	Medium	1

As can be seen from Table 3, all five investigated subsidiaries have a significant impact on the financial condition of the corporate structure. Enterprise No. 1 is the core of the entire corporation. This enterprise accounts for 70% of the total corporate revenues. Enterprise No. 2 ranks second in this indicator, but it shows a significant increase in production and sales of products over the past few years. Enterprises No. 3-5 occupy a small share in the corporation's revenues. The main goal of incorporating these enterprises into the corporate structure is to provide the leading enterprises with the necessary raw materials: different grains and sugar. Deepening the crisis at one of these enterprises will necessarily affect the activities of the two main profitable factories of the corporation, and this, in turn, will provoke the deterioration of the financial condition of the whole corporation [13].

Thus, the constructed model allows to adequately evaluate the impact of the crisis threat at subsidiaries on the corporation condition. Based on the results of modelling, all enterprises have a significant impact on the financial condition of the corporation. Taking into account the fact that the threat of bankruptcy of the enterprise No. 4 is very high based on the results of the simulation of the crises threat estimation at subsidiaries, then the efficiency of this particular subsidiary should be given the greatest attention by the corporation management. In order to adequately assess the possible threats to the corporation, it is necessary to predict the future condition of each subsidiary and how the forecasted situation at subsidiaries will affect the financial condition of the corporation as a whole.

In the fourth module (Fig. 1), the construction of models of forecasting the financial indicators (model M4) is carried out. As already mentioned above, the "Caterpillar" method is used as a tool for forecasting. The choice of this method for studying the structure of time series is explained by the fact that it combines the advantages of many other methods, in particular, Fourier analysis and regression analysis [14]. The essence of the method consists in converting one-dimensional series into multidimensional using one-parameter displacement procedure; in study of the obtained multidimensional trajectory on the basis of analysis of the principal components (singular decomposition); in recovery (approximation) of the series for selected main components. The detailed explanation of the fourth module realization was presented in study [15].

On the example of the enterprise No. 1 the mean absolute percentage error of approximation for the time series of indicators X1-X5 equals appropriately 7.78%; 2.15%; 2.59%; 1.80%; 5.70%, which allows us to conclude about high accuracy of the forecast. Point and interval forecast of financial indicators for the period of anticipation, equal to 12 months, is shown on Fig. 3.

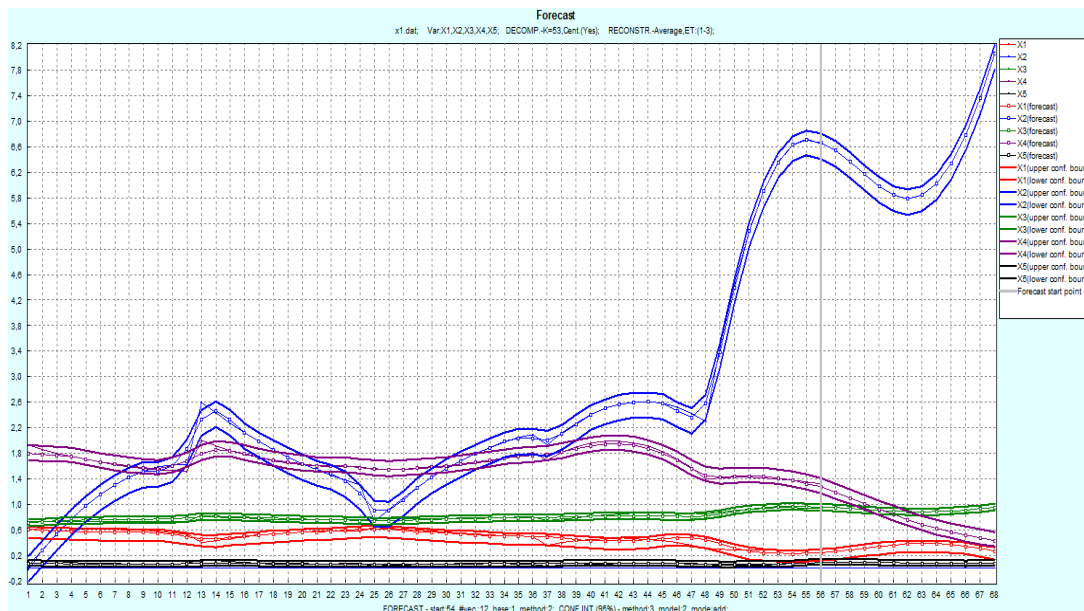


Fig. 3. Graphs of forecast values

Similarly, models of time series of financial indicators X1-X5 for enterprises N2-N5 were constructed. The obtained results make it possible to conclude about the effectiveness of the application of the caterpillar method in forecasting the financial activity of corporations. The obtained forecast values were considered as initial data in estimation of the threat of crises forming in the prospective period based on neural-fuzzy models. The results of modelling for all subsidiaries and corporation as a whole are given in Table 4.

Table 4

Forecasted values of the threat of financial crises forming in the corporate system

Enterprise	Retrospective value	Forecasted value		
		Pessimistic	Realistic	Optimistic
Enterprise №1	-0,320	-0,216	-0,535	-0,623
Enterprise №2	0,513	0,495	0,501	0,374
Enterprise №3	0,481	0,757	0,735	0,565
Enterprise №4	1,337	1,241	1,031	0,839
Enterprise №5	0,000	-0,163	-0,188	-0,189
Corporation as a whole	-0,541	0,396	0,113	-0,182

As can be seen from the table, the financial condition of the corporation as a whole will significantly worsen: the estimation of the threat of forming the financial

crises will increase from -0.541 to 0.396 according to the pessimistic forecast and to -0.182 in the optimistic scenario.

Thus, based on the results of the simulation, it can be concluded that the current financial condition of the corporation is characterized by a very low threat of a crisis, but at the same time, some of the subsidiaries of the corporation have a significant threat of bankruptcy. This can lead to a significant deterioration in the financial condition of the corporation as a whole in the prospective period, which was proved by constructed forecasting models. The current situation requires the development of preventive measures and optimization of the financial performance of subsidiaries, which will ensure the sustainable functioning of the corporate structure as a whole.

Conclusion.

The proposed methodological approach to the formation of model basis of the estimation of the threat of financial crises in corporate systems allows early diagnosis of crisis trends in the development of individual subsidiaries and corporations as a whole, preventing catastrophic financial risks, conducting adequate assessments of the reserves for financial stability of the corporate structure; developing preventive measures aimed at financial stabilization. The developed model basis showed high predictive accuracy and the expediency of their application in the financial activity of the corporations.

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