УДК 658.15:519.86

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MODELS OF ESTIMATION IN THE MECHANISM OF EARLY INFORMING AND PREVENTION OF FINANCIAL CRISES IN CORPORATE SYSTEMS

Abstract. The paper is devoted to the problem of improving the efficiency of financial management of corporate systems based on the implementing of the mechanisms of early informing and prevention of financial crises. The proposed model basis of the mechanism includes the following modules: a module for analyzing the financial condition of the corporation, a module for analyzing the financial condition of subsidiaries, a module for evaluation the impact of the financial crisis on the financial condition of the corporation as a whole, and the crisis management module. Particular attention is paid to the modules for estimation the financial condition of the corporation and of its subsidiaries. The possibilities of using the neuro-fuzzy approach to estimate the threat of financial crisis forming at subsidiaries and the corporation as a whole are explored. The obtained results showed the high predictive accuracy of the developed neuro-fuzzy models and the expediency of their application in the financial activity of the corporations.

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МОДЕЛІ ОЦІНКИ В МЕХАНІЗМІ РАННЬОГО ІНФОРМУВАННЯ І ПОПЕРЕДЖЕННЯ ФІНАНСОВИХ КРИЗ В КОРПОРАТИВНИХ СИСТЕМАХ

Анотація. В роботі розглядається проблема підвищення ефективності управління фінансовою діяльністю корпоративних систем на підставі впровадження механізмів раннього інформування та попередження фінансових криз. Запропонована структура модельного базису механізму. Особлива увага приділена модулям оцінки фінансового стану корпорації та дочірніх підприємств. Досліджені можливості застосування нейро-нечіткого підходу для оцінки загрози формування фінансової кризи на дочірніх підприємствах і корпорації в цілому. Отримані результати показали високу прогностичну точність розроблених нейро-нечітких моделей і доцільність їх застосування у фінансовій діяльності досліджуваної корпорації.

Ключові слова: корпоративна система, фінансова криза, попередження, оцінка, нейро-нечіткі моделі.

Формул: 0; рис.: 1; табл.: 2; бібл.: 18

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МОДЕЛИ ОЦЕНКИ В МЕХАНИЗМЕ РАННЕГО ИНФОРМИРОВАНИЯ И ПРЕДУПРЕЖДЕНИЯ ФИНАНСОВЫХ КРИЗИСОВ В КОРПОРАТИВНЫХ СИСТЕМАХ

Аннотация. В статье рассматривается проблема повышения эффективности управления финансовой деятельностью корпоративных систем на основе внедрения механизмов раннего информирования и предупреждения финансовых кризисов. Предложена структура модельного базиса механизма. Особое внимание уделено модулям оценки финансового состояния корпорации и дочерних предприятий. Исследованы возможности применения нейро-нечеткого подхода для оценки угрозы формирования финансового кризиса на дочерних предприятиях и корпорации в целом. Полученные результаты показали высокую прогностическую точность разработанных нейро-нечетких моделей и целесообразность их применения в финансовой деятельности исследуемой корпорации.

Ключевые слова: корпоративная система, финансовый кризис, предупреждение, оценка, нейро-нечеткие модели.

Формул: 0; рис.: 1; табл.: 2; библ.: 18

Introduction. The functioning and development of corporate systems (CS) at the present stage of the development of the world economy is carried out under the influence of a large number of negative factors (threats) that are not controlled by the CS. The effect of these threats leads to significant losses and, as a result, to the forming of crisis financial situations.

The current trends actualize the problem of finding the effective tools for preventing

financial crises in corporate systems, in particular, through the implementation of the mechanisms for early warning and crisis prevention, which are based on the principles of proactive management.

Literature review and the problem statement. Problems of development of model basis of the mechanisms of early warning and prevention of crises are widely sanctified in scientific publications. In particular, in the works of Klebanova T. S., Nikolaev I. V., Khayluk S. V. (2010), Guryanova L. S., Trunova T. S. (2010, 2017), Trided A. N. (2007), Yelysyeyev O. K., Reshetnyak, T. V. (2007) the structure of the model basis for assessing and forecasting the financial condition of the enterprise is considered. However, the issues of developing an applied set of models, a comparative analysis of the effectiveness of various methods of modelling of the financial crises are not fully reflected.

Researches presented in the work of Klebanova T. S., Kizim N. A. et al. (2010) consider the possibility of applying methods of complete and incomplete reduction of symptoms, methods of expert analysis, hierarchical and iterative cluster analysis methods for solving the problems of formation of system diagnostic indicators and of classification of financial enterprise situations. In the works of Berneti, S. (2011), Javier De Andres, Pedro Lorca, Francisco Javier de Cos Juez, Fernando Sánchez-Lasheras (2011), Ning Chen, Bernardete Ribeiro, Armando Vieira, An Chen (2013), a method of fuzzy c-means and self-organizing maps of Kohonen are used to classify financial situations and to choose differentiated strategies for financial stabilization. Researches presented in the works of Ko, Yu-Chien (2017), Davidenko N. M. (2012), Matviychuk A. V. (2010), Li S. (2014), Brezigar-Masten A., Masten I. (2012), Klebanova T. S., Chahovets L. O., Panasenko O. V. (2011), Zarei M., Rabiee M., Zanganeh T. (2011), Bahia I. (2013) consider the application of methods of discriminant analysis, logit, probit analysis, neural network modelling, fuzzy logic theory for identifying and forecasting the class of financial situations of the enterprise. 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.

Research results. The conceptual scheme of the proposed mechanism of early warning and crises prevention in corporate systems includes these main modules:

Module 1. Analysis of the financial condition of the corporation. The main tasks of this module are the forming of an information space for the characteristics of the financial condition of the enterprise; substantiation of classes of financial conditions of the corporation; estimation of the threat of a crisis; identification of the class of financial crisis. These problems are solved using expert, cluster analysis, multiple choice models and neuro-fuzzy networks. The model basis of this module forms **model M1** – model of estimation the threat of forming of financial crisis in a corporation.

Module 2. Analysis of the financial condition of subsidiaries. In this module, an estimation of the threat of the crisis and identification of the crisis class at the subsidiaries, assessment of deviations of financial indicators from the normative values are carried out. The solution of the tasks of this module is based on the neuro-fuzzy approach. The model basis of the module includes **model M2** – model of estimation the threat of forming of financial crisis at the subsidiaries of the corporate structure.

Module 3. Evaluation of the impact of the financial crisis at the subsidiaries on the threat of bankruptcy of the corporation. This module analyzes the nature of the relationships between subsidiaries and parent enterprises, the financial flows between all corporate structural units; linguistic terms and rules of recognition are formed; the calculation of the impact evaluation of crises at the subsidiaries on the threat of bankruptcy of the corporation is carried out. To implement the tasks of this module the theory of fuzzy logic is used. The model basis of the module forms the **model M3** – model of evaluation of the impact of crisis events at the subsidiaries on the financial condition of the corporation.

Module 4. Forecasting the financial condition of subsidiaries and of corporation as a whole. In this module, financial indicators are diagnosed, the levels are synthesized, and the threat of the

crisis at the subsidiaries and the corporation as a whole is estimated. The solution of the tasks of this module is carried out using the "Caterpillar" method. The model basis of the module is formed by **models M4** – models of forecasting the financial indicators.

Module 5. Anti-crisis management. In this module, the development of the anti-crisis management scheme is carried out, optimal anti-crisis measures are determined, and the quality of measures is assessed. These tasks are solved with the help of decision-making methods, additive convolution, simulation modeling and system dynamics. The model basis of the module is formed by **models M5** – models of selection of optimal anti-crisis measures.

Thus, 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.

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.

In accordance with the proposed conceptual scheme, 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). The initial list of indicators was formed on the basis of methodological recommendations for identifying the signs of bankruptcy of enterprises, developed by the Ministry of Economy of Ukraine. To reduce the information space posteriori list of indicators was obtained by expert evaluation which presents the most important indicator in each of 5 groups. The values of the consistency coefficients of experts' opinions are given in Table 1.

Table 1

Assessment of the consistency of expert opinions

Group of indicators	The value of the concordance coefficient Wi	The value of criterion χ2	The table value of the criterion χ2
Group 1	W1 = 0.828	$\chi^2 = 39.72$	$\chi^2_{табл} = 5,99$
Group 2	W2 = 0.747	$\chi^2 = 53.76$	$\chi^2_{табл} = 7,81$
Group 3	W3 = 0.734	$\chi^2 = 123.39$	$\chi^2_{табл} = 14,07$
Group 4	W4 = 0.660	$\chi^2 = 126.76$	$\chi^2_{табл} = 15,51$
Group 5	W5 = 0.673	$\chi^2 = 48.48$	$\chi^2_{табл} = 7,81$

As can be seen from Table 1, the values of the concordance coefficient vary in the range from 0.6 to 0.8, so, according to the results of estimating the statistical significance of the coefficients using the chi-square test, it can be concluded that the results of the examination can be used further research. Thus, the final system of indicators, which was used to construct the neural-fuzzy **model M1**, included the following indicators: 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. A comparative analysis of the quality of different variants of partitioning the original population into 3, 4, 5, and 6 clusters obtained using the k-means method showed that the best partition is the partitioning into 5 clusters.

The values of the functional of the decomposition quality – the total intragroup dispersion – are given in table 2.

Table 2

Dividing the values of the estimates of Y into clusters

Characteristic	Dividing into			
	3 clusters	4 clusters	5 clusters	6 clusters
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 object cluster 4 – 3 objects cluster 5 – 32 objects cluster 6 – 27 objects
The value of the total intraclass variance	47,39	43,36	41,23	43,20

The resulting partition was used as the basis for interpreting the scale of Y values: $Y \leq 0$ – the threat of a crisis is very low; $Y \in (0;0.25]$ – low level of the threat; $Y \in (0.25;0.75]$ – medium level of the threat; $Y \in (0.75;1)$ – high level of the threat; $Y \geq 1$ – very high level of the threat.

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. 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 for 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. 1.
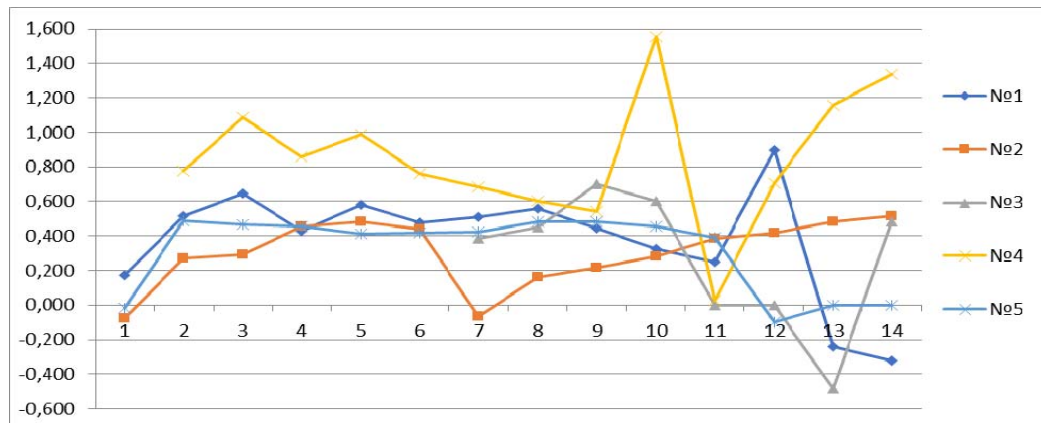

Fig. 1. Dynamics of the change in the value of the threat of financial crises forming at the subsidiaries of the corporation

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.

Summary and Concluding Remarks. The conducted researches allowed to conclude the following:

a conceptual approach to the formation of a model basis of the mechanism of early warning and crisis prevention in corporate systems is proposed, the implementation of which in the financial activities of corporations will allow 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 possibilities of using a neuro-fuzzy approach to estimate the threat of the forming of a financial crisis at subsidiaries and the corporation as a whole are explored. The obtained results showed high predictive accuracy of the developed neuro-fuzzy models and the expediency of their application in the financial activity of the corporation under study.

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Стаття надійшла до редакції 08.09.2017   ©*Клебанова Т. С. , Гвоздицький В. С.,*
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Received 08.09.2017   ©*Klebanova T. S., Gvozdytskyi V. S.,*
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