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

The paper discusses the problem of preventing financial crises in corporate systems, whose activities are becoming increasingly complex in the context of globalization. Particular attention is paid to assessing the impact of financial crises on the subsidiaries to bankruptcy of corporations as a whole. To estimate the threat of crises in the corporate system, neural networks, a mathematical apparatus of fuzzy logic, the "Caterpillar" method are used. Approbation of the set of models showed that the financial condition of the corporation under investigation is characterized by a low level of threat of the crisis, while for a number of subsidiaries there is a high probability of bankruptcy, which leads to the need of implementation of anti-crisis measures in the corporate structure. The adequate tool for selecting the anti-crisis measures and for the forming of scenarios is a simulation based on system dynamics concepts.

***Keywords:*** corporate system, financial crisis, prevention, forecasting, neuro-fuzzy models, "caterpillar" method

fig.: 4, tables: 2

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# МОДЕЛІ ПРОГНОЗУВАННЯ В МЕХАНІЗМІ РАННЬОГО ІНФОРМУВАННЯ І ПОПЕРЕДЖЕННЯ ФІНАНСОВИХ КРИЗ В КОРПОРАТИВНИХ СИСТЕМАХ

В роботі розглядається проблема запобігання фінансовим кризам в корпоративних системах, діяльність яких стає дедалі складнішою у контексті глобалізації. Особливу увагу приділено оцінці впливу фінансових криз дочірніх компаній на банкрутство корпорацій в цілому. Для оцінки загрози кризи корпоративної системи використовуються нейронні мережі, математичний апарат нечіткої логіки, метод "Caterpillar".

***Ключові слова:*** корпоративна система, фінансова криза, попередження, прогнозування, нейрон-нечіткі моделі, метод «Гусениця»

рис.: 4, табл.: 2

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# МОДЕЛИ ПРОГНОЗИРОВАНИЯ В МЕХАНИЗМЕ РАННЕГО ИНФОРМИРОВАНИЯ И ПРЕДУПРЕЖДЕНИЯ ФИНАНСОВЫХ КРИЗИСОВ В КОРПОРАТИВНЫХ СИСТЕМАХ

В статье рассматривается проблема предупреждения финансовых кризисов в корпоративных системах, деятельность которых становится все более сложной в контексте глобализации. Особое внимание уделяется оценке влияния финансовых кризисов дочерних компаний на банкротство корпораций в целом. Для оценки угрозы кризисов в корпоративной системе используются нейронные сети, математический аппарат нечеткой логики, метод «Caterpillar».

***Ключевые слова:*** корпоративная система, финансовый кризис, предупреждение,

прогнозирование, нейро-нечеткие модели, метод «Гусеница»
рис.: 4, табл.: 2

**Introduction.** By the results of the first quarter of 2017, 26.6% of enterprises are unprofitable. The most severe financial crisis situation is in the corporate sector of Ukrainian economy. In particular, the share of unprofitable enterprises in this sector is 34%; the amount of losses is 97 795 million UAH (i.e. more than 60% of pre-tax profits received by corporations). Along with this, the intensification of the financial crisis in corporate structures leads to significant negative social and economic consequences. Thus, Ukrainian corporations accounts 67% share of the entire employment and more than 80% of the volume of products sold (goods, services).

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. The implementation of such mechanisms into the financial activities of corporations allows timely diagnosis of negative events and processes, developing appropriate effective management decisions, determining the optimal amount of reserves and preventing asynchrony in financial flows of corporate structures.

**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 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.

Crisis development tendencies led to a wide dissemination of researches related to the justification of the financial strategy and the optimization of the financial performance of the enterprise in the conditions of threats. Zelenkov Yuri, Fedorova Elena, Cherkizov Dmitry (2017), Niccolò Gordini (2014) proposed to use genetic algorithms to optimize the parameters of the financial strategy in order to prevent the transition of enterprises to a class of financial crisis (bankruptcy). Combined optimization and simulation models of financial activity are considered in the works of Klebanova T.S., Guryanova L.S., Kononov O.J. (2006), Barannikov V.V. (2008). The suggested in the above-mentioned works set of models allows analyzing the financial flows considering managerial influences; determining the optimal production plan; determining the system of strategic standards of financial activities that ensure the sustainable operation and development of the enterprise considering

the effect of threats.

Summarizing the above analysis, it is necessary to note the unconditional promise of applying the approaches proposed by the authors in choosing the most significant factors that affect the probability of bankruptcy of enterprises; of the methods for assessing the threat of crisis forming at enterprises; in development of anti-crisis policy of enterprises; in implementation of econometric modelling in the process of financial analysis, etc. But in the works mentioned above, 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, the development of a model basis of the mechanisms of early warning and crisis prevention in corporate systems is an urgent way to improve the efficiency of financial activities of corporations.

**Research results**.The conceptual scheme of the proposed mechanism of early warning and crises prevention in corporate systems is shown on Fig. 1 and includes these main modules: ***Module 1.*** Analysis of the financial condition of the corporation; ***Module 2.*** Analysis of the financial condition of subsidiaries; ***Module 3.*** Evaluation of the impact of the financial crisis at the subsidiaries on the threat of bankruptcy of the corporation; ***Module 4.*** Forecasting the financial condition of subsidiaries and of corporation as a whole; ***Module 5.*** Anti-crisis management. 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 research the main emphasis is made on the features of the development of forecasting models that support the principles of proactive management (models M3-M4).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 conceptual scheme (Fig. 1), the third module 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: X1 – the share of subsidiary's revenue in the corporation; X2 – the nature of production links; X3 – the presence of subsidiary's granddaughter companies; X4 – the share of subsidiary's authorized capital in the corporation; X5 – the share of external accounts payable. Herewith, the factor "X2" 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 "X3" can take two values: "0" – if the enterprise does not have subsidiaries; "1" – if it has.

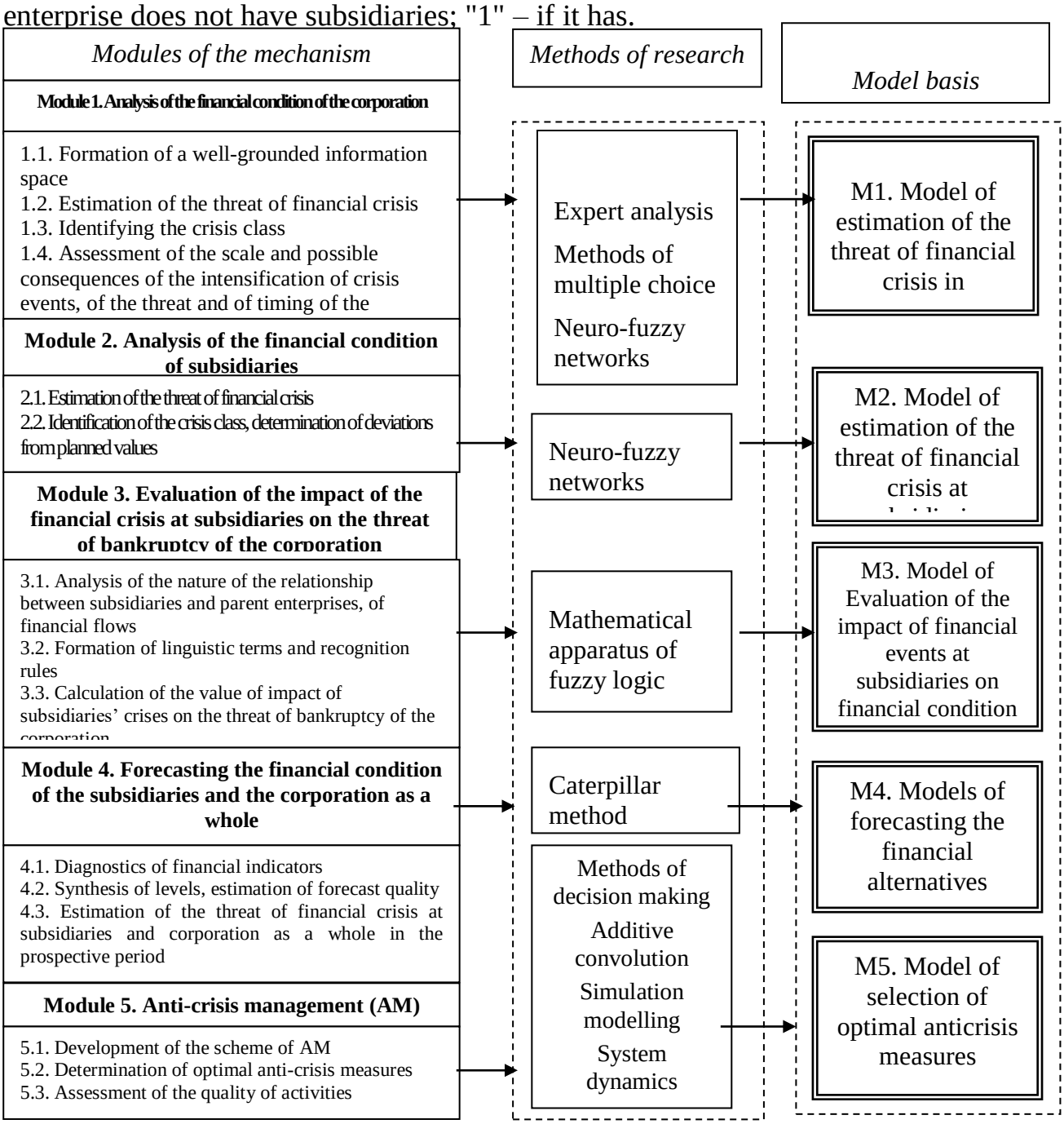



Figure 1. Conceptual scheme of the mechanism of early warning and crisis prevention in corporate systems

The set of membership functions (of a trapezoidal type) of complex indicator V is given as follows:

$$\mu v1=(0; 0; 0.15; 0.25);$$
$$\mu v2=(0.15; 0.25; 0.35; 0.45);$$
$$\mu v3=(0.35; 0.45; 0.55; 0.65);$$
$$\mu v4=(0.55; 0.65; 0.75; 0.85);$$
$$\mu v5=(0.75; 0.85; 1; 1),$$

where μv1-5 are the membership functions of the indicator V, which correspond to all variants of the corporation's dependence on subsidiary: from almost its absence (μv1) to the maximum (μv5).

For the chosen indicators of the financial condition of the enterprise Xi, the linguistic variables Li "Level of indicator Xi" were set (5 subsets of levels from "very low" to "very high"). The levels of the values of the selected indicators and the corresponding membership functions are shown in Table 1.

Table 1

Rules for recognizing the degree of influence of the threat of the emergence of crisis events at the subsidiaries on the bankruptcy of a corporation

| Value Range | Degree of influence | The membership function |
|---|---|---|
| 0<=V<=0.075 | Very low (V1) | 1 |
| 0.075<V<0.125 | Very low (V1) | μ1=10*(0.25-V) |
| | Low (V2) | μ2=1- μ1 |
| 0.125<=V<=0.17 | Low (V2) | 1 |
| 0.17<V<0.2 | Low (V2) | μ2=10*(0.45-V) |
| | Medium (V3) | μ3=1- μ2 |
| 0.2<=V<=0.35 | Medium (V3) | 1 |
| 0.35<V<0.4 | Medium (V3) | μ3=10*(0.65-V) |
| | High (V4) | μ4=1- μ3 |
| 0.4<=V<=0.6 | High (V4) | 1 |
| 0.6<V<0.65 | High (V4) | μ4=10*(0.85-V) |
| | Very high (V5) | μ5=1- μ4 |
| 0.65<=V<=1 | Very high (V5) | 1 |

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. 2.

Table 2

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 2, all five investigated subsidiaries of the have a significant impact on the financial condition of the corporate structure as a whole. 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.

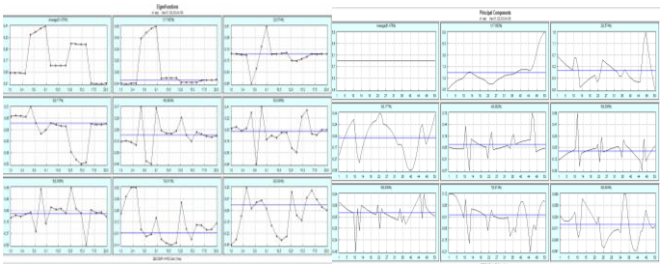
Thus, the constructed model allows to adequately evaluate the impact of the crisis threat at subsidiaries on the corporation condition. Based on the results of modelling, all enterprises have a significant impact on the financial condition of the corporation. Taking into account the fact that the threat 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. 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.

Forecasting using the caterpillar method was carried out in Caterpillarssa 3.4 software package. Note that realization of the method was carried out simultaneously for all series (X1-X5), as they have the same dimension. This program allows conducting multi-dimensional research.

Based on the results of the analysis of the chart of the initial series of financial indicators of enterprise No. 1 and of the series of average covariances, it was concluded that the series have an annual periodicity, that is, the length of the track must be a multiple of 12. For this case, it is advisable to select a track length of 4. A centering procedure was also carried out.

For the analysis of the principal components (PC), in the caterpillar method analysis of the characteristics of eigenvalues and eigenfunctions of the covariance matrix is used. One-dimensional graphs of the eigenfunctions and of PC are shown on Fig. 2.

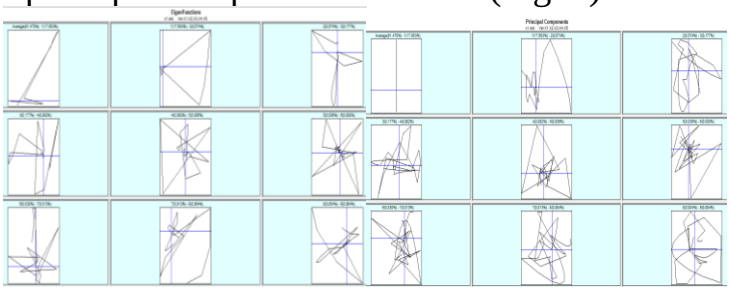


a) of eigenfunctions b) of principal components

Figure 2. One-dimensional graphs of eigenfunctions and PC

Based on the results of visual analysis of one-dimensional graphs (Fig. 3), it is impossible to infer whether a certain PC is a component of the trend. That is, all pairs of PC can be regarded both as a trend and as a low-frequency component. The most obvious is the presence of a semiannual (PC 3-6) periodicity.

To facilitate the partitioning of PC into pairs, two-dimensional graphs of eigenvectors and of principal components are used (Fig. 3).



a) of eigenfunctions b) of principal components

Figure 3. Two-dimensional graphs of eigenfunctions and PC

Similarly, models of time series of financial indicators X1-X5 for enterprises N2-N5 were constructed. The mean absolute percentage error of approximation for the time series of enterprise N1 indicators X1-X5 equals appropriately 7.78%; 2.15%; 2.59%; 1.80%; 5.70%, which allows us to speak about high accuracy of the forecast. The obtained results made 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 5.

Table 5

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 5, 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.

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

the possibilities of using the methods of fuzzy logic theory to evaluate the impact of the financial crisis at the subsidiaries on the financial condition of the corporation as a whole are explored. The system of variables is grounded, the rules of fuzzy inference are developed. Approbation of the model on the data of the corporation under investigation shows the effectiveness of the proposed approach, which allows to obtain a quantitative and qualitative evaluation of the impact of the threat of the forming of local crises on the stability of the corporate structure as a whole;

models for forecasting financial indicators of enterprises of the corporate system based on the "Caterpillar" method have been developed. This method allows making better reconstruction of the time series, providing higher forecast accuracy in a complex data structure;

developed on the basis of fuzzy logic methods, neural networks, the "Caterpillar" method set of models for estimation the financial condition of corporate systems allows to use the fuzzy rules to estimate the threat of financial crisis forming at the parent and subsidiary enterprises of the corporation, not only in the current but also in the prospective period. The obtained results indicate the increased threat of bankruptcy at a number of subsidiaries in the prospective period and the strong impact of local crises on the financial condition of the corporation as a whole. This leads to the need to optimize the parameters of the financial activity of subsidiaries in order to ensure the sustainable functioning of the corporate structure.

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