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## **BANKRUPTCY FORECASTING OF UKRAINIAN ENTERPRISES**

### **ПРОГНОЗУВАННЯ БАНКРУТСТВА ПІДПРИЄМСТВ УКРАЇНИ**

*The comparative analysis of methods and models of bankruptcy forecasting of Ukrainian enterprises was conducted in the article. The presented study provides an opportunity to determine that each particular method or model of bankruptcy prediction has both general and special disadvantages, which depend on the specifics and conditions of management in different countries of the world. Therefore, the question of analyzing of the existing methods and models of bankruptcy forecasting is very important, because it most fully and reliably provides an opportunity to assess the financial and economic state of the enterprise in our country. It is determined that some foreign methods or models of bankruptcy prediction do not meet the requirements of Ukrainian realities, as they do not reflect with a significant number of factors of the financial state of the enterprise, as well as in Ukraine a large number of enterprises have not represented in the stock market. That is why, it complicates or excludes variants of calculation on many models, which are designed for this purpose. The study made it possible to determine that among three main approaches for assessing the probability of bankruptcy (discriminant models, comparative methods and models based on the use of artificial neural networks) the last approach has demonstrated the most prominent advantages. The certain research gave an opportunity to discover that the use of comparative methods for analyzing the functioning of Ukrainian enterprises is not too popular, because domestic companies either do not have the funds for such detailed studies or they do not want to show their real financial situation. Using properly, comparative methods are the effective diagnostic tools that can complement other research methods and correct the diagnostic findings obtained with their help. It is necessary to continue improving the mechanisms for assessing the financial situation that take into account the specific features of Ukrainian enterprises and adapting financial models based on domestic accounting and reporting standards.*

**Keywords:** bankruptcy, enterprise, forecasting, bankruptcy diagnostics, discriminant model, artificial neural network.

*У статті проведено компаративний аналіз методів та моделей прогнозування банкрутства підприємств України. Представлене дослідження надає можливість визначити, що у кожного конкретного методу або моделі прогнозування банкрутства є як загальні недоліки, так і особливі, які залежать від специфіки та умов господарювання у різних країнах світу. Через це, дуже важливим постає питання аналізу наявних методів та моделей прогнозування банкрутства, які найбільш повно та достовірно надають можливість оцінити фінансово- економічний стан підприємства саме у нашій державі. Визначено, що деякі зарубіжні методи або моделі прогнозування банкрутства не відповідають вимогам українських реалій, оскільки не відображають значну кількість*

*коефіцієнтів фінансового стану підприємства, а також, в Україні велика кількість підприємств не представлена на фондовому ринку, що ускладнює або виключає варіанти розрахунку по багатьох моделях, які розраховані саме для цього. Проведене дослідження надало можливість визначити, що серед трьох основних підходів до оцінювання ймовірності банкрутств (дискримінантні моделі, порівняльні методи та моделі, що базуються на застосуванні штучних нейронмереж) найбільші переваги продемонстрував останній підхід. Проведене дослідження надало змогу визначити, що використання порівняльних методів для аналізу функціонування українських підприємств не є надто популярним, оскільки вітчизняні компанії або не мають вільних коштів для подібних детальних досліджень, або не бажають відкривати своє реальне фінансове становище. При коректному використанні порівняльні методи є дієвим інструментом діагностики, що може доповнити інші методики дослідження та скорегувати отримані за їх допомогою діагностичні висновки. Необхідно продовжити вдосконалення механізмів оцінки фінансового стану, які враховували б характерні особливості українських підприємств, та адаптацію фінансових моделей, що базуються на вітчизняних стандартах обліку та звітності, а також, поступово, довести стандарти звітності українських підприємств до рівня кращих зарубіжних аналогів.*

**Ключові слова:** банкрутство, підприємство, прогнозування, діагностика банкрутства, дискримінантна модель, штучна нейронна мережа.

**Introduction.** The study of bankruptcy prevention and the minimization of its negative effects is not new for economic science, but practical experience suggests that these issues remain key to the economy of any country. This is especially true for the Ukrainian economy, because today it is not going through the best times. For many years, in our country there are such negative phenomena as the crisis of non-payment, lack of investment and financial resources, the state budget deficit, legislative contradictions, political turmoil and many other phenomena that increase crisis processes. Therefore, it is clear that all of the above occurrences reflect in the activities of domestic enterprises and determine their particular propensity to crisis and pre-bankruptcy. In addition, the growing level of bankruptcy of Ukrainian enterprises provides an opportunity to state that there are problems in forecasting and determining the probability of bankruptcy. Prevention of bankruptcy becomes a vital and urgent task for solving. Recently, several scientists have proposed a large number of techniques and models that help to assess the financial situation of organizations and enterprises in advance. The presented study provides an opportunity to determine that each specific method of forecasting bankruptcy has general limitations, which depends on the specifics and conditions of management in different countries of the world. Therefore, the question of analysis of the existing methods of bankruptcy forecasting, which most fully and reliably gives an opportunity to estimate the financial and economic state of the enterprise, is very important. Moreover, the availability of reliable methods for assessing the financial situation of Ukrainian enterprises is also important from the point of view of Ukraine's investment attractiveness, as a large number of unpredictable bankruptcies increase the financial risks for foreign investors. The

problems of forecasting bankruptcy of enterprises are devoted to the work of many scholars. Among them is worth mentioning the works of such scholars as O. Tereshchenko, A. Matviychuk, J. Argenti, V. Kovalev, L. Debunov, D. Kaidanovich and others. However, despite the considerable scientific progress of this issue, the problem of forecasting bankruptcy will require further research.

**Setting objectives.** The aim of the research is to carry out a comparative analysis of domestic and foreign methods of forecasting bankruptcy, to identify their advantages and disadvantages, to assess the possibilities of adapting foreign methods to domestic practices.

**Methodology.** Theoretical and methodological basis of work is the scientific works of domestic and foreign scientists about the development of models of bankruptcy forecasting at the enterprise. For achieving this goal, it was used general scientific and special research methods, such as: system approach, methods of analysis and synthesis, methods of modeling and generalization.

**Research results.** The issue of bankruptcy of enterprises in Ukraine is very relevant due to the crisis situation in the country's economy. To assess the scale of the crisis, let's look at the dynamics of bankruptcy trials by commercial courts in 2011-2016 (Table).

As follows from the figures shown above, the largest number of enterprises was declared bankrupt and liquidated in 2011 - 4086 and 285 (during the crisis period); the largest number of violations of bankruptcy cases was in 2015 for 831 enterprises. Thus, the growth of a large number of bankrupt enterprises indicates the crisis conditions of the Ukrainian economy, which are associated with political, social and economic instability [2].

Table - Bankruptcy statistics of Ukrainian enterprises for the period of 2011-2016 years

Years	Status of the enterprise			
	Recognized as a bankrupt	The enterprise was liquidated	Bankruptcy proceedings were instituted	Bankruptcy proceedings and open sanation were instituted
2011	4086	285	255	21
2012	3289	247	192	16
2013	2964	212	239	25
2014	2238	12	387	7
2015	2985	171	831	2
2016	2671	151	475	2

As shown in Table 1, the higher negative dynamics of enterprises in the crisis testifies to the necessity to use appropriate methodical tools for preventing and

leveling the effects of crisis-forming factors, which lead to bankruptcy of the enterprise in future. There is a number of models and methods of forecasting bankruptcy, which provides an opportunity to assess and diagnose the degree of solvency of an enterprise (institution). Methods of bankruptcy diagnostics provide an opportunity to identify the indicators of payment flows (current and prospective), as well as to assess the production, investment and financial activities of the enterprise. The assessment of the probability of bankruptcy is an integral part of the credit analysis of borrowers.

A multivariate statistical analysis includes a number of methods for studying the interaction of interconnected heterogeneous features in order to decompose the whole set of analyzed multidimensional properties and reduce their number. It is worth noting that the transition itself from a greater number of features to the less has the purpose of reducing their dimensionality and increasing informativity. This can be achieved through the identification of duplicate data, aggregation (association) over several similar features. Aggregation allows you to transform the actual model into a model with a smaller number of factorial properties [1].

The algorithm of multivariate statistical analysis makes it possible to identify patterns that really exist, but can not be explicitly expressed. With this you can meet when solving practical economic problems. For example, in the study of indicators of production efficiency of homogeneous (under the economic conditions and specifics of the industry) enterprises, it may be noted that in the transition between objects most of the selected features contain a different numerical value - that is, there is an uncontrolled (random) spread. However, such a "random" variation of characteristics, as a rule, obeys some tendencies, such as certain average sizes of characteristics, the circle of which is a spread, as well as the degree and interdependence of this variation [3].

Discriminant analysis is a method of multidimensional statistical analysis relating to the theory of pattern recognition. To date, discriminatory methods have a wide application for constructing economic and mathematical models of forecasting bankruptcy. The most well-known models for assessing the probability of bankruptcy on the basis of multivariate discriminant analysis are the models of Altman, Conan, and Golder, Lis, Taffler, Sprygeyte, and Beaver [1, 4].

When applying these models to Ukrainian companies or organizations, you need to take into account a number of specific circumstances. For example, old, worn-out fixed assets, as well as the new ones, have the same meaning, which contributes to an unjustified increase in the share of equity capital at the expense of the revaluation fund. As a result, the relation between own and borrowed capital does not correspond to reality. For this reason, the models and methods using this indicator do not reflect the current state of the enterprise [5]. In addition, some models do not display a significant proportion of the financial ratios of the company. In Ukraine there is a large number of enterprises are not represented in

the stock market, which complicates or excludes the calculation options for many models that are specifically designed for this.

The conditions for the activities of Ukrainian enterprises are most consistent with the universal discriminatory function of the Ukrainian researcher - O. Tereshchenko [6]:

$$Z = 1,5K_1 + 0,08K_2 + 10K_3 + 5K_4 + 0,3K_5 + 0,1K_6 \quad (1)$$

where  $K_1$  - ratio of funds to attracted capital;  $K_2$  - the ratio of the currency of the balance sheet to the attracted capital;  $K_3$  - ratio of balance profit to balance currency;  $K_4$  - the ratio of balance profit to sales proceeds from sales;  $K_5$  - the ratio of inventories to sales proceeds from sales;  $K_6$  - turnover of fixed capital.

If  $Z > 2$ , the enterprise does not threaten bankruptcy; if  $1 < Z < 2$ , the financial stability of the enterprise is violated; however, if timely introduction of anti-crisis measures, bankruptcy will not be threatened; if  $0 < Z < 1$ , there is a threat of bankruptcy in the absence of sanitation measures; if  $Z < 0$ , the enterprise is almost bankrupt. The optimal discriminatory function should take into account all components of the financial state: liquidity, profitability, turnover, structure of property, capital, etc. [6].

The advantages of the model are the simplicity of calculations. Taking into account the industrial specifics of enterprises, due to the use of various modifications of the base model to enterprises of different types of activity solves the problem of determining the critical values of indicators, which is an indicator of the probability of bankruptcy of an enterprise in a particular industry. However, it is not without disadvantages, because the forecast data are very subjective, so there may be problems with the accuracy of the assessment. In addition, the model aimed the universality more than practical efficiency [6].

Today, one of the most popular models for assessing the probability of bankruptcy for Ukrainian enterprises is the model of economist A. Matviichuk [7]. This model includes a number of factors that cover the main financial and economic indicators of domestic enterprises have high accuracy to predict bankruptcy and lack the linear relationship between factor variables. This ensures the stability and reliability of this discriminating model. Matviychuk proposed the following model of assessment:

$$Z = 0,033x_1 + 0,268x_2 + 0,045x_3 - 0,018x_4 - 0,004x_5 - 0,015x_6 + 0,702x_7 \quad (2)$$

where  $x_1$  - Mobility of assets;  $x_2$  - turnover of payable accounts;  $x_3$  - turnover of own capital;  $x_4$  - profitability of assets;  $x_5$  - provision of own working capital;  $x_6$  - concentration of attracted capital;  $x_7$  - covering of debts by own capital.

Depending on the value of  $Z$ , the following probability of bankruptcy is forecasted: if in the assessment of the financial position of the enterprise we obtain

$Z > 1,104$ , this indicates a satisfactory financial condition and a low probability of bankruptcy. As the value of  $Z$  increases, the firm's stability grows. If the value  $Z \leq 1,104$ , then there is a threat of financial crisis. In accordance with the decrease  $Z$  the threat of bankruptcy of the analyzed enterprise grows. [7]

The advantages of this approach have much higher accuracy of the bankruptcy diagnosis of the enterprise, compared with other models. Among the disadvantages it is possible to mark the allocation of only two classes of company position, since using a discriminant model is not enough to assess the real financial situation.

In order to increase the accuracy of the prediction of the probability of bankruptcy, you can convert the  $Z$ -factor to the PAS-factor (Performance Analysis Score) also to track the company over time. Analyzing the change in the PAS-coefficient from a critical value, track down the downtrend and the revival of businesses at the very beginning. The PAS-ratio is the relative level of financial activity of the company, derived from its  $Z$ -factor for the year and expressed as a percentage of 1 to 100. That is, if the  $Z$ -factor can indicate that the company is at risk, then PAS- the coefficient reflects the historical trend and current activity in the future. [8]

The advantage of the above method is the ability to combine key features of profitability and loss-making balance in one relation. That is, an enterprise with stable profits, but the "weak" balance can be compared with the enterprise less profitable, but with an equilibrate balance. Consequently, using the PAS-coefficient, a quick assessment of financial risks at the enterprise is carried out. That is, such an approach is systemic and aimed at studying the essence of an object as a whole.

The additional characteristic of the PAS-factor model is the use of the so-called "risk rating" to identify hidden risks [8]. This rating is statistically calculated only with a negative  $Z$ -factor based on the  $Z$ -factor trend, the value of the negative  $Z$ -factor and the number of years in which the company was in a risky financial position. The risk rating uses a five-point scale, in which 1 indicates "a risk but an insignificant probability of an immediate crisis," while 5 means "the absolute impossibility of preserving the former state." [8]

The use of an integrated approach to assess and forecast the financial position of the enterprise significantly improves the accuracy and objectivity of the analysis, and the use of such models can quickly identify loss-making companies. It can predict the effects in time and through rapid action to change the situation for the better. In addition to discriminatory analysis, the company also uses comparative and qualitative methods for assessing the threat of bankruptcy, since targeting one selected criteria, even very attractive from a theoretical point of view, does not always justify itself from the practical side.

Considered methods and criteria for assessing the probability of bankruptcy provide an opportunity to analyze such processes that are not described by methods

that use only one estimate. However, each solution that is predicted in this way depends on the chosen criteria, that is, it is subjective, and the calculated values are more of a recommendatory nature.

In addition to the above models and methods, there is also an approach based on the use of artificial neural networks that were created to reproduce and simulate the structure of the brain and the ability of biological nervous systems to learn and correct errors. Each neuron of such a network deals only with signals that it receives from time to time, and signals that it periodically sends to others. In this way, we generate and output, we can get the corresponding result ("bankrupt" / "not bankrupt"):

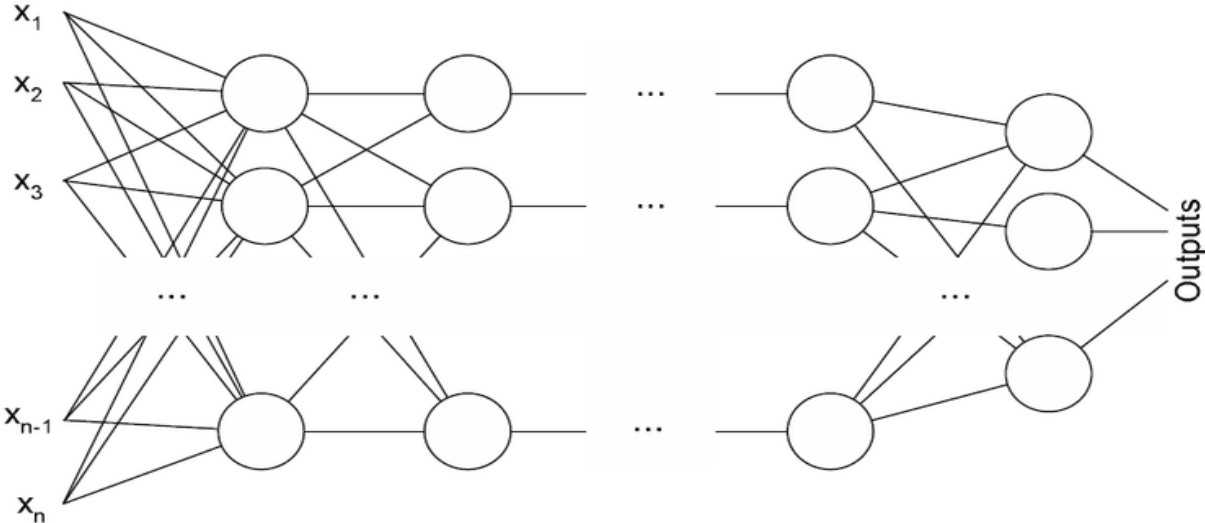


Figure 1 - Architecture of artificial neural network

For teaching neural networks it were used the algorithms of two types: controlled (training with a teacher) and uncontrolled (without a teacher). The most common algorithm, which was used, it was "training with the teacher". The advantage of artificial neural networks is the ability to learn without assumptions about the functional dependence of variables. The peculiarity of the neural network is that it looks like a "black box", so explicitly to get knowledge seems to be problematic. Another disadvantage is the complexity of the process of creating and optimizing the topology of the neural network.

In the work of L. Debunova "Using artificial neural networks in modeling financial sustainability of the enterprise" input data in the training and testing of the network were selected by financial indicators of 49 enterprises. The data were collected from 25 enterprises for some time before bankruptcy and from 24 stable enterprises. It is important to note that it was not expedient to use the reporting enterprise at the time of bankruptcy, but a model becomes useful when it recognizes the risk of a company's financial crash[10].

At the entrance it were introduced 21 inputs, which took into account the versatility and uncertainty of financial sustainability, as well as the most fully described the financial position of the enterprise. The research observed 15 samples from the class from stable and 16 from bankrupt enterprises. The 9 of remaining belonged to the test sample. The best results showed that the networks of multilayer perceptron, containing in the hidden layer from 10 to 18 neurons, as well as hyperbolic and logistic activation functions in the neurons of the latent and the original layers. The greatest accuracy was given by the architecture of the multilayer perceptron MLP 21-18-2 - with 18 neurons in the hidden layer, the function of the sum of squares as a function of the error, the hyperbolic activation function on the hidden and the initial layers, which was 100% on the training sample, and 88% . That is, out of 18 enterprises of the test sample only 2 enterprises were classified incorrectly, which can be said about the good result of the given model of the neural network.

D. Kaidanovich suggested another model, which was based on artificial neural networks, in his paper "Estimating the risk of bankruptcy of enterprises with the use of counter-proliferation of neural networks". The mathematical basis of the model is the artificial neural network, built with the combination of a layer of Kohonen's neurons, which can distinguish common features in the objects under study with clustering, and the original Grossberg star, which is characterized by ease in training and interpreting of the clustering [11]:

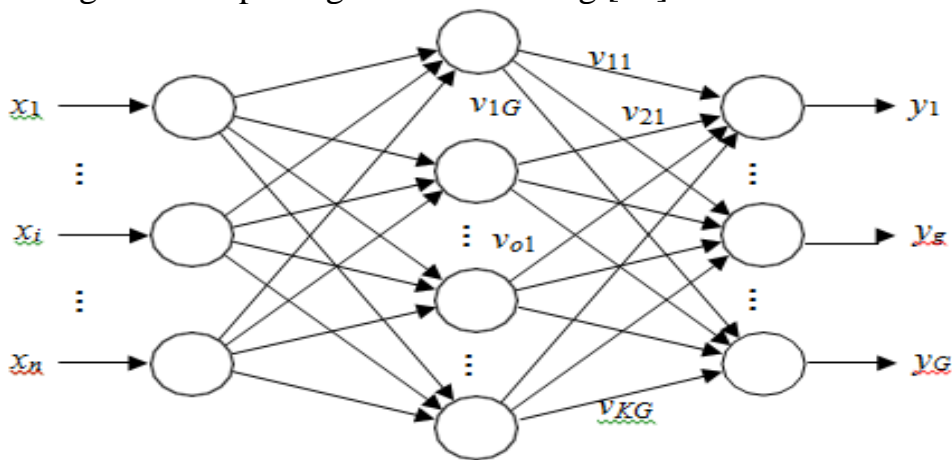


Figure 2 - The architecture of the counter-proliferation network

The first part of the bankruptcy forecasting model was used by variables selected for a discriminant econometric model of A. Matviychuk that checks the financial indicators for multicollinearity: X1 - asset mobility coefficient, X2 - turnover rate of payable accounts, X3 - return on equity, X4 - return on assets, X5 - equity ratio of own working capital, X6 - capital concentration ratio X7 - the ratio of indebtedness to equity [7]. That is, such a network combines "training with a teacher" and "without a teacher".



Each observation in the input sample characterizes the enterprise according to the above selected coefficients. The number of input observation elements is equal to the number of parameters of each neuron of the Kohonen's layer. Through the implementation of the "without a teacher" training, a search is made of hidden dependencies between financial indicators of enterprises.

The next part was realized by a layer of Grossberg, which implements 'training with the teacher' and defines the financial state of the enterprise by combining a cluster with one of the established classes ("bankrupt" or "not bankrupt"). That is, with this layer, the matching of the scales of output connections to certain categories-classes, which form an array of outputs [12].

With the implementation of the neuron network with 80 Kohonen's neurons, the accuracy of the definition of bankrupt enterprises was 91.9%, and stable enterprises - 60.6%. The general level of correctly defined classes is 77.14% [11].

Neural network of counter-proliferation, in the layer of Kohonen which includes 30 neurons, showed the highest efficiency. The accuracy of classification for all enterprises on the basis of this model is 81.63%, of which the level of correctly identified bankrupts is 92%, and stable enterprises - 72.72%. [11]

The advantages of such an approach include the ability to detect latent nonlinear patterns in the input data without the need for tuning the specific values of output variables, the absence of restrictions on the stationary process or the unchangeability of external conditions, rapid self-adaptation to new data without the involvement of experts [12].

**Conclusions** The scientific novelty of the obtained results is a comparative analysis of domestic and foreign methods of forecasting bankruptcy, revealing their advantages and disadvantages, and the possibility of adapting foreign methods for domestic practice. Thus, the study made it possible to determine that among the three main approaches to assessing the likelihood of bankruptcy (discriminant models, comparative methods and methods based on the use of artificial neural networks) the most prominent advantages were demonstrated by the latter approach.

Discriminatory models reflect adequate results only in the real conditions for which they were created. In order to use them in the modern economic system of Ukraine it is necessary to take into account the peculiarities of accounting and financial reporting in the conditions of unstable activity of Ukrainian companies. Each discriminatory model will provide reliable results only under certain conditions of the operation of the objects which are studied.

The use of comparative methods for analyzing the functioning of Ukrainian enterprises is not too popular, because domestic companies either do not have the funds for such detailed studies or they do not want to show their real financial situation. Using properly, comparative methods are the effective diagnostic tools that can complement other research methods and correct the diagnostic findings obtained with their help.

Based on the use of artificial neural networks, the approach characterizes by a high degree of accuracy of bankruptcy probabilities and the ability to detect hidden nonlinear relationships between the main financial indicators. Thus, these models reveal latent forms of enterprise crisis and contribute to increasing the reliability of forecasting, and therefore can be recommended in the compilation of state-of-the-art methods for determining the financial condition of enterprises.

It is necessary to continue improving the mechanisms for assessing the financial situation that take into account the specific features of Ukrainian enterprises and adapting financial models based on domestic accounting and reporting standards. And over time, try to bring the standards of reporting Ukrainian enterprises to the level of the best foreign analogues.

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