ПІДПРИЄМНИЦТВО, МЕНЕДЖМЕНТ, МАРКЕТИНГ

ENTREPRENEURSHIP, MANAGEMENT, MARKETING

UDC 657.338:334.68
DOI: 10.31651/2076-5843-2020-2-16-24

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ANALYSIS OF DISCRIMINANT MODELS IN FORECASTING BANKRUPTCY OF ENTERPRISES

The problem of bankruptcy forecasting has a special place among the theoretical and practical problems of enterprise management. Ukraine is a transition country, characterized by instability of many factors of the external environment of entrepreneurship. Therefore, effective management of enterprises requires not only financial analysis of the current situation, but also diagnostics for possible bankruptcy in the future.

The use of bankruptcy forecasting techniques is appropriate and useful for both enterprises themselves - for preventive crisis management based on the early detection of signs of deterioration of their situation, and their business partners, as well as credit organizations that will assess the risk of lending to firms of borrowers, controllers and fiscal authorities.

Keywords: *bankruptcy, discriminant models, crisis situation, financial insolvency of enterprises, bankruptcy probability, diagnostics, enterprise, monitoring.*

Introduction. Problem assess the financial condition of enterprises, and in particular, their prediction was possible bankruptcy and still be relevant, since this interest and the internal and external counterparties company.

Each member of the economic community must be assured of the reliability and financial capacity of its partners, otherwise everyone has the opportunity to use the bankruptcy mechanism as a means of repaying debt to insolvent partners. In this regard, managers of enterprises, managers of different levels of management should be able to timely determine the unsatisfactory financial standing of the counterparty companies on the basis of the results of the financial analysis and, if necessary, to use their right to apply bankruptcy procedures to the debtor.

The identification of the factors leading to bankruptcy and the timely prediction of bankruptcy can allow management to take financial difficulties, identify the causes and take the necessary steps to improve the financial condition of the enterprise in a timely manner .

There is a large number of both foreign and domestic techniques for assessing and forecasting financial status. However, research shows that, unfortunately, they often produce conflicting results. As

for foreign methods, firstly, they are based on foreign statistics of 60-80 years of the last century, and secondly, they do not take into account the specifics of Ukrainian enterprises. The methodologies offered by Ukrainian researchers are different. The main reason for counteracting the results is that they are mainly based on statistics collected from retailers, which indirectly take into account the specifics inherent in the industries. However, studies show that this specificity exists. Thus, the development of a model for assessing and forecasting the financial condition of Ukrainian enterprises is quite relevant.

Literature review. Interest in using financial ratios to predict a company's crisis has increased significantly since the works of W. Beaver (1966) and E. Altman (1968). In 1980-1990, models based on the assessment of the probability of bankruptcy of the enterprise (logit models) began to be applied. J. Olson (1980) first used the logistician method to predict bankruptcy. Fulmer (1984) proposed another model for predicting bankruptcy of companies based on an analysis of 60 enterprises, to which 40 financial ratios were applied. The bankruptcy forecasting model of R. Tuffler (1977) included more than 80 financial indicators, which were then calculated for 46 bankruptcies and 46 financially prosperous (healthy) enterprises. The bankruptcy model of G. Springate bankruptcy (1978) used a discriminant analysis and ultimately selected the four most significant indicators from the 19 outputs. M. Zmijewski (1984) proposed a model in which regression was applied. Information from 840 companies (40 bankrupts and 800 healthy companies) from 1972 to 1978 was used as baseline data [1, 2, 3, 8, 9, 11, 15].

In determining the threat of crisis in the enterprise, cited in the studies of foreign scientists, in particular, J. Richard, Z. Helfert, R. Holt, D. Shelder, etc., and Ukrainian scientists, in particular, I. Blank, A. Gradov, R. Rodionova, O. Tereshchenko, A. Matviychuk and others, the most common are two methods: the first is based on a system of models for determining the likelihood of bankruptcy, and the second - on traditional financial analysis. The peculiarity of the first method is that its use makes it possible to determine the degree of manifestation of the crisis in the enterprise, comparing the values of integral indicators with certain limit values (models Altman, Fulmer, Lis, Springate, Chesser, etc.). The peculiarity of the second method is to compare the system of financial indicators with the regulatory ones [12, 13, 14].

The purpose of the article is to compare the characteristics of methods and models of crisis diagnosis of the enterprise.

Result and discussion. The first attempts to analyze the activities of bankrupt firms were made in the 30^{s}, in the most complete form, the method and technique of bankruptcy prediction is presented in the works of Edward Altman and William Beaver. Studies of foreign scientists in the field of bankruptcy prevention of enterprises suggest that from the set of coefficients used can be selected only a few useful that accurately predict bankruptcy. However, analyzing even a small number of indicators requires a highly qualified analyst because often the results are inconsistent. [2, 4]

Currently, a large number of different financial models have been developed, which combine several different ratios at one time, resulting in the possibility of generalized assessment of financial condition and determination of the probability of bankruptcy. Problems of application of methods of diagnostics of bankruptcy of the enterprise in the early stages are now characterized as the most pressing questions of economic theory in modern economic practice.

When using foreign models in the analysis, it should be taken into account that the models were developed in countries with different economic conditions and the choice of one (several) of them requires caution. And the accuracy of the results of the analysis, in the first place, may depend on the classification feature of the model (geography of origin, the possibility of remote application, the horizon of forecasting, the scale of activity of the enterprise, branch affiliation, method of data processing, degree of formalization) [7].

It should be noted that foreign models are not fully suitable for assessing the bankruptcy risk of Ukrainian enterprises due to the following circumstances: first, the models were developed a long time ago, the macro- and microeconomic situation in both the USA and other countries changed; Secondly, there can be no universal models that would be ideal for all sectors of the economy, even in a single country. It follows that models calculated from the statistics of those years cannot objectively predict

the current state of organizations.

Therefore, the approach to the development of such models deserves attention, but they should be developed for each industry, and at the same time periodically updated according to new statistics, taking into account new trends and patterns in the economy.

One of the most famous bankruptcy forecasting models is rightly considered the Z-score of E. Altman. The most well-known of these are two-factor, five-factor (for organizations whose shares are quoted on the market) and modified five-factor (for organizations that do not place shares in the stock market) models.

The most widespread was the five-factor model of E. Altman. Using multiple discriminant analysis, the scientist developed a linear equation in which the five most important financial indicators were carefully weighted and their sum was some value of the so-called Z-score, which was the basis for the division of enterprises into two groups: bankrupt and financial prosperous businesses. This approach allowed the scientist to reduce the value of several financial indicators to one, which allowed to give a clear assessment of the financial condition of the enterprise [1].

The accuracy of the forecast in this model for the period of one year is 95%, for two years - 83%, which is its merit. The disadvantage of this model is that it can in essence be considered only in relation to large companies that have placed their shares in the stock market [2].

Despite the relative ease of use of this model for the assessment of bankruptcy risk, it should be noted that the use of the Altman model in the described form does not allow to obtain objective results in today's Ukrainian environment. This model was built according to data from 1946-1965, which takes into account the features of the external and internal environment and the valuation of assets of American industrial enterprises. However, this indicator has become practically standard in assessing the probability of bankruptcy of an enterprise.

The complexity of applying the Altman model for Ukrainian enterprises is due to the fact that in calculating the indicators of the level of profitability, profitability and turnover of assets (X_2, X_3, X_5) in the conditions of inflation can not use the book value of these assets, because in this In this case, all considered indicators will be artificially inflated. Therefore, the calculations should use the recoverable (market) value of these assets [13].

Bankruptcy prediction model of R. Tuffler was developed in 1977. The author has developed a linear regression model with four financial ratios to assess the financial health of UK firms based on a study of 46 failed companies and 46 financially sound companies between 1969 and 1975. The model was developed based on data from industrial and construction companies. In further studies, R. Tuffler applied his model to different types of enterprises [11].

The following enterprise bankruptcy forecasting model was created by Canadian scientist G. Springate. Half of the coefficients match the financial ratios used by E. Altman. He used the financial statements of 40 Canadian companies (20 bankrupts / 20 non-bankrupts) to create a bankruptcy model. The author used discriminant analysis and eventually selected the 4 most significant indicators from the 19 baseline.

The bankruptcy forecasting model for R. Lis was created for UK businesses in 1972. It was one of the first European models created after the model of the American E. Altman (1968). The Fox model is more adaptive to UK businesses, as the financial ratios in the model are taken from Altman's.

There are quite a number of models developed in Ukraine and abroad that are aimed at bankruptcy diagnostics. Having studied many foreign and domestic models, the most famous and used by domestic economists of the model were selected for comparative analysis. For further convenience in the study, we combine the above techniques into a summary table with brief explanations in the order of calculations (Table 1).

Based on the above review and analysis of bankruptcy probability detection models, we can conclude that techniques that have their origin abroad are in most cases unacceptable for use in the Russian environment because they do not take into account the Ukrainian economy. In turn, domestic models are also not ideal, because often as a result of their calculations, the obtained forecasts do not correspond to the real financial condition of the enterprise.

Table 1

Bankruptcy forecasting and determination models

Author of the model	Model and coefficients	Bankruptcy probability, Z-score
E. Altman	$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$ where , X_1 - working capital / total assets X_2 - retained earnings / total assets X_3 - earnings before interest and tax / total assets X_4 - market value of equity / total liabilities X_5 - sales / total assets	Z < 1.81 - very high [1.81 - 2.67] – average [2.67 - 2.99] - small Z > 2.99 - very low
R. Lis	$Z = 0.063X_1 + 0.092X_2 + 0.057X_3 + 0.0014X_4$ where, X_1 - Working capital / Total assets ; X_2 - Earning before interest and tax / Total assets ; X_3 - Retained earning (adjusted for scrip issues) / Total assets ; X_4 - Net worth / Total debt ;	Z < 0.037
R. Tuffler	$Z = 0.53X_1 + 0.13X_2 + 0.18X_3 + 0.16X_4$ where, X_1 - Profit before tax / Current liabilities ; X_2 - Current assets / Total liabilities ; X_3 - Current liabilities / Total assets ; X_4 - No-credit interval ;	Z < 0.2
G. Springate	$Z = 1.03X_1 + 3.07X_2 + 0.66X_3 + 0.4X_4$ where, X_1 - Working capital / Total assets; X_2 - Earnings before interest and taxes / Total assets; X_3 - Earnings before taxes / Current liabilities; X_4 - Sales / Total assets ;	Z < 0.862 - high Z > 2.45 - minimum
O. Tereshchenko	$Z = 1.5X_1 + 0.08X_2 + 10X_3 + 5X_4 + 0.3X_5 + 0.1X_6$ where , X_4 - Cash-Flow / Liabilities ; X_2 - Total assets / Liabilities ; X_3 - Profit / Total assets; X_4 - Profit / Proceeds from realization X_5 - Production inventories / Proceeds from realization X_6 - Fixed Assets Turnover	Z > 2 - not threatened bankruptcy; 1 < Z < 2 - financial equilibrium is broken, bankruptcy is not threatened by the transition to crisis management; 0 < Z < 1 - a threat to bankruptcy if not curative held on march; Z < 0 - the enterprise is bankrupt.
A. Matviychuk	$Z = 0.033X_1 + 0.268X_2 + 0.045X_3 - 0.018X_4 - 0.004X_5 - 0.015X_6 + 0.702X_7$ where , X_1 - Current Assets / Non-current Assets ; X_2 - Net Income / Current liabilities ; X_3 - Net Income / Equity; X_4 - Total Assets / Net Proceeds from realization X_5 - (Current Assets - Current liabilities) / Current Assets X_6 - (Long-term liabilities + Current liabilities / Total Assets X_7 - Equity / (Ensuring the following Costs and Payments + Long-term liabilities + Current liabilities)	Z > 1,104 - low probability of bankruptcy, stable financial position Z < 1,104 - high probability of bankruptcy

Source: compiled by the authors [1, 2, 10, 11, 12, 14]

Each of the models presented above has its advantages and disadvantages. The identified advantages and disadvantages of the previously presented models are reflected in Table 2.

It is worth noting that not all existing methods of forecasting a possible bankruptcy of the enterprise are prepared correctly, not all can be applied in our conditions, not all produce adequate results. The same enterprise can be recognized as a hopeless bankrupt at the same time, a steadily developing economic entity and an enterprise that is in a pre-crisis state - all determine the chosen

method of forecasting possible bankruptcy [12].

Table 2

Advantages and disadvantages of bankruptcy forecasting models

Model	Advantages	Disadvantages
Five-factor E. Altman	- ease of calculation; - the presence of the study sequence	- model applicable only for joint stock companies
R. Lis	- very high accuracy of calculations for enterprises	- the model is not adapted to Ukrainian enterprises, it is designed for England - the model was created taking into account western development
R. Tuffler	- ease of calculation	- the results of the model may not adequately reflect the situation in current Ukrainian conditions
G. Springate	- accuracy exceeding 90%	- the model was created for USA and Canadian businesses - odds are in dollars - a model created to evaluate the creditworthiness of enterprises.
O. Tereshchenko	- created on the basis of the financial statements of Ukraine, takes into account the structure and sectoral affiliation of enterprises - the model identifies a crisis in enterprises of different spheres of the national economy	- the model shows the current crisis or financial stability - is not able to analyze the pre-crisis phenomena at the enterprise
A. Matviychuk	- significantly higher accuracy in bankruptcy diagnosis than in other models	- there are only two classes of enterprise status, and when constructing a discriminatory model this is not enough to assess the financial status of enterprises

Source: compiled by the authors [1, 2, 10, 11, 12, 14]

The construction of multifactor models for the Ukrainian economy still remains problematic, first of all, because of the instability and imperfection of the regulatory framework of bankruptcy of Ukrainian enterprises; second, due to the lack of consideration of many factors affecting the financial sustainability of enterprises; third, because of biased data on bankruptcy statistics. In addition, these models are based on a discriminatory method based on country-specific enterprise statistics, while the use of the models is restricted to that country.

Most models are based on the fact that there is a certain factor. So some models are focused on the factor of financial stability, which is related to the financial structure of the enterprise, liquidity, dependence of the enterprise on creditors.

Some models evaluate a bankruptcy propensity on the basis of business activity and profitability. In such models, these indicators dominate both in quantitative composition and in the importance of influencing the final result of the model. Such models include the Altman model, the Springate model and the Lis model. In these models, targeting bankruptcy for business activity and profitability is not always justified. Although the loss-making of an enterprise's financial and economic activity indicates a risk of bankruptcy, however, it does not mean that any loss-making enterprise must go bankrupt. The loss can be temporary, and thanks to effective management actions, the company can quickly recover profitability [6, 13, 14].

Focusing on bankruptcy forecasting for financial sustainability indicators does not always give a correct estimate, since an enterprise may have a significant share of borrowed funds, however, it also makes efficient use of financial resources and provides high profitability that will allow it to settle with creditors. [9]

Models Altman, Tuffler, Lis are widely used in international practice, this is due to the following advantages:

1. Analytical information for the calculation of indicators is available because it is reflected in the financial statements.

2. There is a possibility of bankruptcy forecasting, determination of the risk zone in which the enterprise is located.

3. These models have a small number of indicators that provide high accuracy of results, with little cost.

It is advisable to point out the following aspects of research for the future and outline the following areas, namely: assessment of the likelihood of bankruptcy of an enterprise in terms of both sectoral features and unified models; development of a system of indicators and criteria that are unified and can be used to assess bankruptcy prospects as needed.

Let's demonstrate the application of the principal component analysis on practical statistics. For example, let's take several enterprises in the same industry (Table 3).

Table 3

Z-score indicators of enterprises of the Kirovohrad region*

Enterprises	Altman	Springate	Lis	Tuffler	Tereshchenko
Year 2017					
LLC Dobrovelichkivka Cannery	4,692	2,542	0,082	0,306	2,194
PrJSC Dolinsky Bakery	3,618	5,624	0,075	0,551	1,915
PJSC Kirovogradolia	7,020	4,146	0,103	0,327	2,029
PJSC Novoarhangelsk cheese factory	5,588	8,490	0,482	1,056	3,413
PrJSC Alexandria Bakery	4,941	8,559	0,189	0,560	2,416
PJSC Svetlovodsk butter - cheese plant	5,655	7,936	0,127	0,611	2,019
Year 2018					
LLC Dobrovelichkivka Cannery	6,605	2,712	0,099	0,358	2,240
PrJSC Dolinsky Bakery	5,411	4,275	0,101	0,393	1,693
PJSC Kirovogradolia	9,713	2,584	0,403	0,154	0,451
PJSC Novoarhangelsk cheese factory	6,160	6,595	0,426	1,254	4,470
PrJSC Alexandria Bakery	5,908	4,902	0,128	0,468	2,348
PJSC Svetlovodsk butter - cheese plant	6,960	9,200	0,201	0,549	2,310
Year 2019					
LLC Dobrovelichkivka Cannery	6,970	1,464	0,077	0,329	2,187
PrJSC Dolinsky Bakery	2,162	6,830	0,190	0,491	2,943
PJSC Kirovogradolia	7,487	1,215	0,024	0,127	0,891
PJSC Novoarhangelsk cheese factory	4,297	9,124	0,491	1,035	4,325
PrJSC Alexandria Bakery	5,082	4,953	0,123	0,475	2,851
PJSC Svetlovodsk butter - cheese plant	7,361	9,937	0,200	0,493	1,889

** Source: calculated by the authors [16]*

- enterprises that are not in danger of bankruptcy;
- financial equilibrium is broken, bankruptcy is not threatened during the transition to crisis management;
- the threat of bankruptcy, if not curative held on march;
- the company is bankrupt.

Analysis of the data showed that most of the enterprises are in the area of normal financial condition, the obtained coefficient calculations are consistent with model forecasts. In addition, models built on some statistical sample will sufficiently accurately describe the status of only the objects that fall into this sample and objects that have characteristics close to those of the organizations that make up the sample. And it should be noted that models built for organizations located in one country can not adequately take into account the specific conditions of economic development of another country.

Thus, to date, there has not been a single universal method for assessing bankruptcy of

organizations that could be used both in international and domestic practice, which is confirmed by numerous attempts by scientists to solve this problem by building new models [14].

To summarize, it should be said that all the above models, like any other, should be used only as an aid to financial analysis of enterprises. This does not mean that the data obtained as a result of their construction cannot be used to develop a firm's strategy. It is necessary to diagnose the enterprise on the basis of any of the above models, but in addition to analyze the enterprise and using other financial indicators to obtain more reliable information about its financial condition.

Conclusions. Therefore, the problem for Ukrainian enterprises is the lack of their own model, which would take into account Ukrainian business conditions. The use of some overseas models is impossible due to the lack of information on certain indicators. Many financial sustainability indicators are unaccounted for when using these models. A fairly accurate result is difficult to obtain for Ukrainian companies, using models that are developed for Western companies. As a result, in the current conditions of development of the domestic economy there is a need for a more systematic approach to the analysis of the financial state of the enterprise through the creation of its own econometric models of crisis diagnosis, which would take into account the results of production, commercial and financial activities of enterprises.

In the conditions of increasing bankruptcy of enterprises in Ukraine, it is necessary to choose a model for diagnostics of financial condition and probability of bankruptcy, which would take into account all the peculiarities of the Ukrainian economic space and the branch in which the enterprise operates. One of the most rational for use in Ukraine is Tereshchenko and Matviychuk models that are easy to use.

Any model will give reliable results only under the specific conditions of operation of the objects being investigated, which is not typical for domestic enterprises and can not affect both the coefficients of the model and its critical values, which are used to evaluate the financial condition of the enterprise and predicting its bankruptcy. Yes, it is necessary to develop a model in which the assessment of the financial status of Ukrainian enterprises would be based on domestic accounting and reporting standards, which would use the statistical, information base of domestic enterprises, taking into account the specificity of the industry.

Using of only discriminatory models of bankruptcy probability assessment does not reflect the real situation. For this reason, it is necessary to take into account the specifics of the activity of enterprises, the situation on the market, the main indicators of financial activity and their ranking, the work of risk management of the organization and comprehensively assess the probability of bankruptcy.

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АНАЛІЗ ДИСКРИМІНАНТНИХ МОДЕЛЕЙ В ПРОГНОЗУВАННІ БАНКРУТСТВА ПІДПРИЄМСТВ

Проблема. *Проблема прогнозування банкрутства займає особливе місце серед теоретичних та практичних проблем управління підприємством. Оскільки Україна характеризується нестабільністю багатьох факторів зовнішнього середовища підприємництва, ефективне управління підприємствами вимагає не лише фінансового аналізу поточної ситуації, а й діагностики можливого банкрутства в майбутньому. Таким чином, виявлення небажаних тенденцій розвитку підприємства, прогнозування кризи та банкрутства мають першорядне значення. Використання методів прогнозування банкрутства є доцільним та корисним як для самих підприємств - для превентивного управління кризовими ситуаціями на основі раннього виявлення ознак погіршення їх фінансового стану, так і для їх ділових партнерів, а також кредитних організацій, які оцінюють ризики кредитування фірм-позичальників, контролюючих та фіскальних органів. У світовій і вітчизняній економічній науці та в економічній практиці застосовується багато моделей оцінки ймовірності банкрутства підприємств на основі різних принципів і методів.*

Мета *дослідження – застосування дискримінантних моделей прогнозування ймовірності банкрутства та доцільності їх застосування.*

Результати. *Вибір напрямів і стратегії розвитку, підготовка і прийняття управлінських рішень в рамках антикризового менеджменту, спрямованих на забезпечення платоспроможності підприємства, обґрунтовано зв'язуються з моніторингом та діагностикою переходу в стан неплатоспроможності (банкрутства). Сучасна концепція антикризового управління підприємствами ґрунтується на превентивному підході, який передбачає формування і використання комплексу інструментів, які дозволяють розпізнати дисфункції, що заважають ефективній роботі підприємства. У зв'язку з цим, об'єктом антикризового управління є не стільки заходи фінансового оздоровлення підприємств, скільки різні варіанти попередження виникнення кризової ситуації. Це особливо актуально в умовах економічної нестабільності і практично реалізовується тільки при використанні адекватних методів оцінки ризику банкрутства. У той же час сучасні макроекономічні умови ставлять під сумнів доцільність застосування цілого ряду методів оцінки ймовірності банкрутства, розроблених як українськими, так і зарубіжними вченими. Істотні диспропорції в розвитку галузей економіки також обумовлюють необхідність розвитку методичної бази для діагностики і прогнозування неплатоспроможності підприємств, які враховують їх галузеву специфіку.*

Наукова новизна *полягає у вдосконаленні методичної бази прогнозування банкрутства господарюючих суб'єктів на основі дискримінантних моделей, які враховують специфіку видів економічної діяльності, здійснюваних господарюючими суб'єктами, і вплив факторів зовнішнього середовища; систематизації існуючих українських та зарубіжних моделей оцінки ризику банкрутства підприємств та виявлення сильних та слабких сторін прогнозних моделей.*

Висновки. *В даний час перед багатьма підприємствами постає важлива проблема - неплатоспроможності у зв'язку з мінливими умовами сьогодення. Дана проблема стосується не тільки підприємств зі слабкою фінансовою стійкістю, але й тих, що стабільно функціонують на ринку, яким необхідно підтвердити свою платоспроможність у довгостроковій перспективі. В результаті, постійно існує необхідність проводити діагностику ризиків, які можуть негативно вплинути на діяльність підприємства і привести його до стану банкрутства. Діагностика ризику банкрутства є одним з головних напрямків фінансового аналізу підприємства. Існує безліч критеріїв, за якими можна оцінити фінансовий стан підприємства. Своєчасне виявлення кризових явищ допоможе прийняти правильне управлінське рішення, попередити можливий ризик і дозволить уникнути можливого банкрутства. Розглянуті найбільш поширені моделі оцінки ймовірності настання банкрутства підприємства дають зробити висновок, що для українських підприємств краще використовувати вітчизняні розробки. Однак, при детальному аналізі варто не обмежуватися однією методикою. Крім того, необхідна комплексна оцінка з визначенням цілого кола фінансових показників таких, як коефіцієнти фінансової стійкості, ліквідності, платоспроможності тощо та порівнянням отриманих значень із встановленими нормативами.*

Ключові слова: *банкрутство, дискримінанті моделі, кризовий стан, фінансова неплатоспроможність підприємств, ймовірність банкрутства, діагностика, моніторинг.*

Одержано редакцією: 11.01.2020
Прийнято до публікації: 15.03.2020