DISCRIMINATIVE MODELS OF BANKRUPTCY PROBABILITY CALCULATION AND THEIR APPLICATION AT DOMESTIC ENTERPRISES

Proskurina N.M., Pushkar I.V., Sukonnova A.A.
Zaporizhzhia national university
Ukraine, 69000, Zaporizhzhia, Zhukovskij str., 66
profauditzp@ukr.net, iv_pushkar@ukr.net, sukohnnova@gmail.com

The article considers the legal framework for regulating the bankruptcy procedure and its diagnosis, reveals the essence of the bankruptcy of the enterprise and identifies its causes. It was found that the analysis and diagnosis of the probability of bankruptcy is based on discriminant models that are used in domestic enterprises. A comparative analysis of bankruptcy risk assessment models developed by both foreign and domestic scholars has been conducted. The advantages and disadvantages are systematized, the expediency of application of the existing models of diagnostics of probability of bankruptcy at the domestic enterprises is substantiated. It is determined that among the models that have been studied, there is no perfect model, the application of which provides an opportunity to determine with high accuracy the probability of bankruptcy in a particular enterprise. It is established that Ukrainian enterprises should use models for diagnosing the probability of bankruptcy exclusively of domestic scientists and the post-Soviet space. The practical value of the study lies in the fact that the level of probability of bankruptcy of the enterprise SE "Mine named after M.S. Surgay" for the period 2018–2020 by using the considered models of diagnostics of bankruptcy. Measures to overcome the crisis in the company are proposed. In order to improve the financial condition of the enterprise, topical measures are substantiated, in particular: increase of the target volume of income from the main activity and the corresponding level of prime cost; achieving the optimal ratio of equity and debt capital; mobilization of internal reserves.

ДИСКРИМІНАНТНІ МОДЕЛІ РОЗРАХУНКУ ЙМОВІРНОСТІ БАНКРУТСТВА ТА ЇХ ЗАСТОСУВАННЯ НА ВІТЧИЗНЯНИХ ПІДПРИЄМСТВАХ

Проскуріна Н.М., Пушкарь І.В., Суконнова А.А.
Запорізький національний університет
Україна, 69000, м. Запоріжжя, вул. Жуковського, 66

У статті розглянуто нормативно-правову базу регулювання процедури банкрутства та його діагностики, розкрито сутність банкрутства підприємства та визначено його причини. З'ясовано, що в основу аналізу та діагностики ймовірності банкрутства покладено дискримінанті моделі, які застосовуються і на вітчизняних підприємствах. Проведено порівняльний аналіз моделей оцінки ризику банкрутства, розроблених як зарубіжними так і вітчизняними науковцями. Систематизовано переваги та недоліки, обґрунтовано доцільність застосування наявних моделей діагностики ймовірності банкрутства на вітчизняних підприємствах. Визначено, що серед моделей, які було досліджено, не існує досконалої моделі, застосування якої надає можливість з високою точністю визначити ймовірність настання банкрутства на конкретному підприємстві. Встановлено, що українським підприємствам доцільно застосовувати моделі діагностики ймовірності банкрутства виключно вітчизняних вчених та пострадянського простору. Практичне цінність дослідження полягає в тому, що розраховано та визначено рівень ймовірності банкрутства підприємства ДП «Шахта ім. М.С. Сургая» за період 2018–2020 р.р. шляхом використання розглянутих моделей діагностики банкрутства. Запропоновано заходи щодо подолання підприємством кризового стану. З метою поліпшення фінансового стану підприємства, обґрунтовано актуальні заходи, зокрема: збільшення цільового обсягу доходу від основної діяльності та відповідного рівня собівартості; досягнення оптимального співвідношення власного та позикового капіталу; мобілізація внутрішніх резервів.

Formulation of the problem

The external negative economic, political and epidemiological background causes a high level of crisis manifestations and a higher risk of bankruptcy of the entire economic system of Ukraine, as well as individual economic entities. Analysis of the state and trends of industry shows that the share of unprofitable enterprises in most industries remains quite high. Thus, the diagnosis of the probability of bankruptcy of domestic enterprises, today, is quite relevant.

There are a sufficient number of different foreign and domestic methods for diagnosing the risk of bankruptcy. However, the choice of the optimal technique remains problematic. Accordingly, it is important to compare the results of different models for diagnosing the probability of bankruptcy.

Analysis of recent research and publications

The work of both foreign and domestic scientists is devoted to the analysis of the probability of bankruptcy and areas of financial recovery of an enterprise in financial crisis. Methods and criteria for assessing the probability of bankruptcy have been developed by leading scientists such as E. Altman [1], G. Springgate [2], O. Tereshchenko [3] and others. A. Matviychuk [4], O. Yankovsky [5] devoted their works to the improvement of the proposed models of bankruptcy risk assessment and their adaptation to the Ukrainian economy. I. Zhuchkova and V. Fedoryuk dealt with the issue of adaptation of the method of expert assessments for the diagnosis of bankruptcy of domestic banking institutions [6]. The introduction of a stochastic simulation model was proposed by L. Lygonenko [7]. Neural network systems for bankruptcy assessment were used by B. Odintsov and A. Romanov [8]. Despite the importance of scientific research, there are still a number of debatable issues that are relevant and need further research.

Formulation of the goals of the article

The purpose of the study is to analyze foreign and domestic models for predicting the risk of bankruptcy on the example of indicators of a particular enterprise, systematization of their advantages and disadvantages to justify the feasibility of using these models to assess the probability of bankruptcy in domestic practice.

Presentation of the main research material

The development and formation of the Ukrainian regulatory framework for the regulation of bankruptcy proceedings consists of four stages, which are listed in Table 1. The first stage is the adoption of the Law of Ukraine, which regulates bankruptcy, and the next two – new versions (the last version of the Law expired 10/21/2019 p.). The fourth stage of development of the regulatory framework in Ukraine includes the reform of the regulatory framework in this area and the adoption of the Bankruptcy Code of Ukraine dated 18.10.2018 № 2597-VIII [9].

In order to assess the financial condition of domestic enterprises and diagnose the risk of bankruptcy apply «Guidelines for identifying signs of insolvency and signs of actions to conceal bankruptcy, fictitious bankruptcy or bankruptcy», which was first developed in 2001 (updated version in 2006., current edition – from 26.10.2010) [11].

According to the Bankruptcy Procedure Code of Ukraine, bankruptcy is the inability of a debtor recognized by a commercial court to restore its solvency through reorganization and restructuring and to repay creditors' monetary claims established in accordance with this Code other than through liquidation proceedings [9]. Its appearance – the inevitability of the head, which is due to:

− reduction of production and sales (actual indicators compared to the plan);

− negative dynamics of financial results, the state of losses;

− increase in production costs;

− insufficient resources of the enterprise, such as little cash flow or no cash flow at all, inefficient asset management;

− not optimal structures of assets and liabilities;

− unstable financial condition.

To predict bankruptcy, companies use many different models that have been studied for a long time. All of these models have strengths and weaknesses, and the choice between them is difficult, as most models are characterized by their reference to a specific industry or a specific country. Thus, when diagnosing the probability of bankruptcy,

Table 1 – Comparative analysis of legislation in the field of bankruptcy regulation in Ukraine during 1992–2000

Stage	Name of the Law of Ukraine	General conclusion on type of model	Types procedures
1	Law of Ukraine "On Bankruptcy" from 14.05.1992 № 2343-XII	pro-creditor	sanitation; liquidation
2	Law of Ukraine "On Restoration solvency of the debtor or recognition of his bankruptcy" from 30.06.1999 № 784-XIV	moderately pro-creditor	property disposal; the settlement agreement; sanitation; liquidation
3	Law of Ukraine "On Restoration solvency of the debtor or declaring him bankrupt" from 22.12.2011 № 4212-VI	moderately pro-creditor	property disposal; the settlement agreement; sanitation; liquidation
4	Code of Ukraine on Procedures bankruptcy from 10/18/2018 № 2597-VIII	pro-creditor	1. Regarding the debtor of a legal entity: disposal of property; sanitation; liquidation. 2. Regarding the debtor – an individual: debt restructuring; debt repayment

Source: grouped by [10]

in foreign and domestic practice, the most common are models that are based on discriminant analysis (Table 2). Among the most common models of foreign scientists are the models of probability of bankruptcy of Altman, Conan and Gelder, Springweight and the model of W. Beaver, and among the models of domestic scientists – models of O. Tereshchenko, A. Matviychuk, R-model of bankruptcy risk assessment.

To determine the feasibility and accuracy of the models from table 1 at domestic enterprises, we will diagnose the probability of bankruptcy of the mining enterprise SE «Mine named after M.S. Surgay». Let's start the diagnosis with the model of Ukrainian scientist O. Tereshchenko.

O. Tereshchenko's bankruptcy assessment model is a model developed using the methodology of discriminant

analysis; characterized by reference to the financial performance of Ukrainian enterprises and their financial condition. This model has two options (10 factors – there is a differentiation by industry, and 6 – universal) [3]. Calculations for this model are presented in Table 3.

The calculations based on the model of the Ukrainian scientist O. Tereshchenko allow us to state that in 2018 there are signs of the threat of bankruptcy at the enterprise, as $0 < Z < 1$. The management carried out remediation measures. This is evidenced by the value of the Z-indicator in 2019, which no longer indicates a threat, but only a violation of the financial balance and the need to move to crisis management. In 2020, the financial condition of SE «Mine named after M.S. Surgay» has deteriorated significantly, ie anti-crisis measures have been ineffective,

Table 2 – Models for diagnosing the probability of bankruptcy

№	The author of the model, year, country of origin	Marking	Calculation	Probability of bankruptcy, value Z
			Model and coefficients	
1	E. Altman, 1968, USA	Z	$= 1,2 \times A + 1,4 \times B + 3,3 \times C + 0,6 \times D + 0,999 \times E$	$Z < 1.81$ is very high; $[1.81–2.67]$ – average; $[2.67–2.99]$ – small; $Z > 2.99$ – very low;
		A	working capital / total asset value	
		B	total value of assets	
		C	operating profit / total value of assets	
		D	market value of shares / debt	
		E	net income (revenue) from sales / total value of assets	
2	R. Lisa, 1972, Great Britain	Z	$= 0,063 \times A_1 + 0,092 \times B_2 + 0,057 \times C_3 + 0,001 \times D_4,$	Critical value $Z \leq 0.037$
		A	working capital / total value of assets	
		B	operating profit / total value of assets	
		C	retained earnings / total assets	
		D	equity / loan capital	
3	R. Taffler and G. Tishaw, 1977, Great Britain	Z	$= 0,53 \times X_1 + 0,13 \times X_2 + 0,18 \times X_3 + 0,16 \times X_4$	Critical value $Z \leq 0.2$; $Z > 0,3$ – the probability of bankruptcy is very low
		X_1	operating profit / short-term liabilities	
		X_2	current assets / total value of assets	
		X_3	short-term liabilities / total assets	
		X_4	net income (revenue) from sales / total value of assets	
4	G. Springgate, 1978, USA	Z	$= 1,03 \times A + 3,07 \times B + 0,66 \times C + 0,4 \times D$	$Z < 0.862$ – high; $Z > 2.45$ is minimal
		A	working capital / total asset value	
		B	profit before taxes and interest / total value of assets	
		C	taxable income / short-term liabilities;	
		D	sales volume / total asset value	
5	O.O. Tereshchenko, 2003, Ukraine	Z	$= 1,5 \times X_1 + 0,08 \times X_2 + 10 \times X_3 + 5 \times X_4 + 0,3 \times X_5 + 0,1 \times X_6$	$Z > 2$ – does not threaten; $1 < Z < 2$ – financial the balance is disturbed; $0 < Z < 1$ – threat, if not remedial measures were taken; $Z < 0$ – the company is semi-bankrupt
		X_1	cash-flow / liability	
		X_2	balance sheet / liability currency	
		X_3	profit / currency balance	
		X_4	profit / revenue from sales	
		X_5	inventories / sales revenue	
		X_6	fixed capital turnover (sales revenue / balance sheet currency)	
6	A. Matviychuk, 2005, Ukraine	Z	$= 0,033 \times X_1 + 0,268 \times X_2 + 0,045 \times X_3 - 0,018 \times X_4 - 0,004 \times X_5 - 0,015 \times X_6 + 0,702 \times X_7,$	$Z > 1,104$ – low probability of bankruptcy, stable financial position; $Z < 1,104$ – the threat of financial crisis
		X_1	current assets / non-current assets	
		X_2	net sales revenue / current liabilities	
		X_3	net sales income / equity	
		X_4	balance / net sales income	
		X_5	(current assets – current liabilities) / current assets	
		X_6	(long – term liabilities + current liabilities) / Balance	
		X_7	equity / (provision of subsequent expenses and payments + long-term liabilities + current liabilities)	

Source: systematized by [12, p. 335]

Table 3 – Assessment of bankruptcy according to the model of O. Tereshchenko SE Mine naned after M.S. Surgay

Indicator	Formula	2018	2019	2020
X_1	$\dfrac{\text{f. 2 r. 2350 or 2355 + amort. f. 2 r. 2515}}{\text{f. 1 r. 1595 + f. 1 r. 1695}}$	0,028	0,156	−0,035
X_2	$\dfrac{\text{f. 1 r. 1300}}{\text{f. 1 r. 1595 + f. 1 r. 1695}}$	0,659	0,763	0,638
X_3	$\dfrac{\text{f. 2 r. 2350 or 2355}}{\text{f. 1 r. 1300}}$	−0,002	0,078	−0,211
X_4	$\dfrac{\text{f. 2 r. 2350 or 2355}}{\text{f. 2 r. 2000}}$	−0,004	0,075	−0,460
X_5	$\dfrac{\text{f. 1 from 1101 to 1104}}{\text{f. 2 r. 2000}}$	0,171	0,129	0,405
X_6	$\dfrac{\text{f. 2 r. 2000}}{\text{f. 1 r. 1300}}$	0,569	1,049	0,458
Z	$= 1{,}5 \times X_1 + 0{,}08 \times X_2 + 10 \times X_3 + 5 \times X_4 + 0{,}3 \times X_5 + 0{,}1 \times X_6$	0,156	1,596	−4,247

as a result of which the financial situation is already diagnosed as semi-bankrupt.

Thus, Tereshchenko's model in the diagnosis of bankruptcy is quite convenient, and this is undoubtedly its advantage. Its advantages also include its adaptability to domestic enterprises, the model takes into account the industry characteristics of enterprises and modern international practice. Equally important, in our opinion, is the ability of this model to solve the problems of critical values of indicators, as the enterprises of different industries use modifications of the basic model.

But this model also has certain disadvantages:
− only satisfactory and unsatisfactory financial condition is diagnosed, ie the method does not contain a deeper assessment of financial condition;
− the method is characterized by inaccurate fixation of normative values of financial indicators due to insufficient substantiation of critical points (intervals) for certain financial indicators;
− long interval of uncertainty.

Let's continue the diagnosis of the financial condition of the enterprise using the model of foreign scientist E. Altman. Altman developed three models of bankruptcy prediction in different periods:
− Z-Score model (1968)
− Zeta model (1983)
− Modified model Z3 (1993)
We will use the Z-Score model in the study.

This model was developed by Edward Altman using multiple discriminant analysis to relatively predict the threat of bankruptcy in the next five years. The model allows on the basis of financial and accounting statements to establish indicators that indicate whether the company is approaching bankruptcy. The scientist pointed out that the model is a reliable tool for predicting the bankruptcy of various industries, it is universal. As for the weighting factors (1.21; 1.41; 3.3; 0.6; 0.999), they take into account the relative importance of each variable based on what is used by enterprises [12].

Calculations for this model are presented in Table 4.

Defined in table. 4 indicators allow us to state that at the enterprise SE «Mine named after M.S. Surgay» in 2018 and 2020 there is an average probability of bankruptcy, and in 2019 – diagnosed very low, although for three years the company is in a difficult financial situation. Thus, we can conclude that the results of calculations indicate the inconsistency of the Altman model with the economic conditions of the domestic market, as well as the feasibility of its use in diagnosing the probability of bankruptcy of domestic enterprises. This is the main disadvantage of this model. Another disadvantage is that the Altman model is based on data from the 1950s, in the model is outdated, because during this time there have been significant changes in the level of economic development.

The advantages of the model are its ease of use. Since this is a quantitative model, it is very easy to draw conclusions from forecasting results. The model uses five financial ratios, which are calculated based on seven financial data that are readily available in the balance

Table 4 – Bankruptcy assessment according to the model of E. Altman SE "Mine named after M.S. Surgay" for 2018–2020

Indicator	Formula	2018	2019	2020
A	$\dfrac{\text{f. 2 r. 1195}}{\text{f. 1 r. 1300}}$	0,254	0,340	0,268
B	$\dfrac{\text{f. 2 r. 2350 or 2055}}{\text{f. 1 r. 1300}}$	−0,002	0,078	0,211
C	$\dfrac{\text{f. 2 r. 2000}}{\text{f. 1 r. 1300}}$	0,569	1,049	0,458
D	$\dfrac{\text{f. 2 r. 2350 or 2355}}{\text{f. 2 r. 2000}}$	−0,004	0,075	0,460
E	$\dfrac{\text{f. 1 r. 1495}}{\text{f. 1 r. 1300}}$	−0,517	−0,310	−0,568
Z	$= 1{,}2 \times A + 1{,}4 \times B + 3{,}3 \times C + 0{,}6 \times D + 0{,}999 \times E$	2,258	4,344	2,622

sheet and other reports. Investors usually use it to assess the solvency of the enterprise, in order to determine the feasibility of investing in this enterprise.

The next model we will study is the model of the foreign scientist G. Springgate. Based on the procedures developed by Altman for US enterprises, Springgate, at Simon Fraser University, used step-by-step multiple discriminant analysis to select four ratios of the 19 popular financial instruments that best distinguish between a «healthy» business and one that has really failed. Thus, the model was developed for US and Canadian companies and reached 92.5 % accuracy in forecasting using indicators from 40 companies tested by Springgate [13].

Calculations for this model are presented in Table 5.

The results of calculations show that applying the Springgate model in predicting the probability of bankruptcy of SE «Mine named after M.S. Surgay», you can get more accurate results than the Altman model. Based on the obtained results, we can conclude that in 2018 and 2020 at the SE «Mine named after M.S. Surgay» is a sign of potential bankruptcy, and in 2019 – the company operates quite efficiently, so it is not threatened with bankruptcy. Such results differ from the results of the previous model.

The advantage of the Springgate model is the high accuracy of predicting the probability of bankruptcy of the company. The disadvantages include the focus of the scientist only on the economies of Canada and the United States. The coefficients were presented by the scientist in dollars. When converting, the exchange rate will leave a deviation [13].

The last model we will study is the model of R. Taffler and G. Tishaw. Taffler proposed a model based on a large data set. The model is designed to analyze the performance of industrial companies. Using computer technology, 80 financial ratios were calculated using the figures of all listed industrial companies that went bankrupt between 1968 and 1976. There were also 46 randomly selected industrial enterprises for the production of solvents. This information was processed using a number of statistical methods, and the model was constructed using a multidimensional discriminant method. To create the model, profitability, liquidity, capital adequacy and other parameters were evaluated. The model can be used only by joint-stock companies whose shares have been listed on stock exchanges [14].

Calculations for this model are presented in Table 6.

The results obtained indicate the impractical use of this technique in the diagnosis of bankruptcy of domestic enterprises, as the results of the diagnosis during 2018–2020 SE «Mine named after M.S. Surgay» works quite efficiently and is not threatened with bankruptcy.

Due to the fact that the model was developed on the basis of a large array of data, the obtained forecast results must be with a high percentage of accuracy. The disadvantages of the model will be the limitation of the scope and impossibility of application in the diagnosis of bankruptcy of Ukrainian enterprises [14].

The generalization of the obtained results of the diagnosis of the probability of bankruptcy according to the studied models is clearly shown in Figure 1.

According to the results of the analysis, the company in order to improve the financial condition of the company needs to implement a set of measures:
- increase in income from operating activities;
- reduction of production costs;
- achieving the optimal level of equity and debt capital;

Table 5 – Assessment of bankruptcy according to the model of Springgate SE "Mine named after M.S. Surgay" for 2018–2020

Indicator	Formula	2018	2019	2020
A	$\dfrac{\text{f. 1 r. 1195}}{\text{f. 1 r. 1300}}$	0,254	0,340	0,268
B	$\dfrac{\text{f. 2 r. 2290}}{\text{f. 1 r. 1300}}$	0,000	0,078	0,000
C	$\dfrac{\text{f. 2 r. 2290}}{\text{f. 1 r. 1695}}$	0,000	0,061	0,000
D	$\dfrac{\text{f. 1 r. 2000}}{\text{f. 1 r. 1300}}$	0,569	1,049	0,458
Z	$= 1{,}03 \times A + 3{,}07 \times B + 0{,}66 \times C + 0{,}4 \times D$	0,489	1,050	0,459

Table 6 – Bankruptcy assessment according to the model of R. Taffler and G. Tishaw SE "Mine named after M.S. Surgay" for 2018–2020

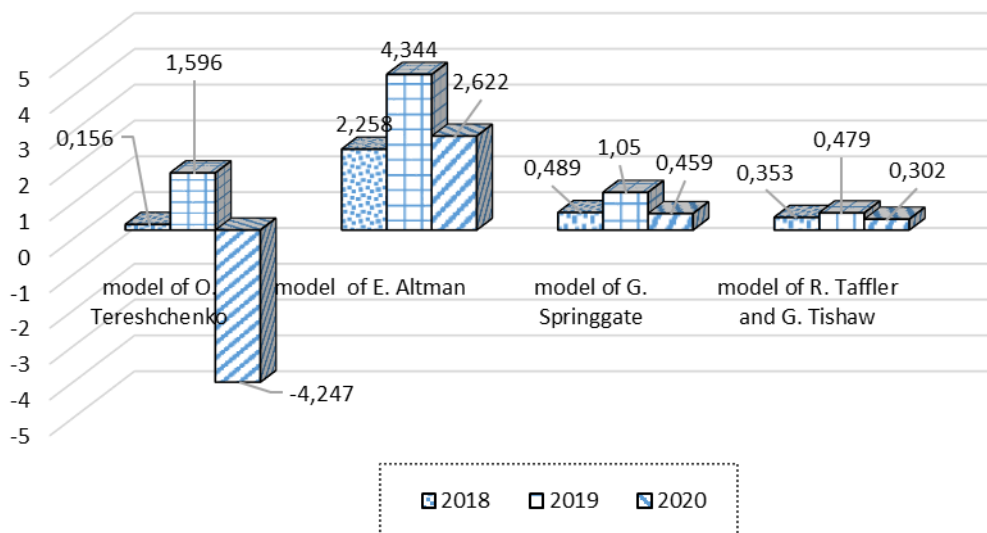| Indicator	Formula	2018	2019	2020
A	$\dfrac{\text{f. 2 r. 2190 or 2195}}{\text{f. 1 r. 1695}}$	−0,025	0,062	−0,137
B	$\dfrac{\text{f. 1 r. 1195}}{\text{f. 1 r. 1595 + f. 1 r.1695}}$	0,167	0,352	0,171
C	$\dfrac{\text{f. 1 r. 1695}}{\text{f. 1 r. 1300}}$	1,409	1,292	1,550
D	$\dfrac{\text{f. 2 r. 2000}}{\text{f. 1 r. 1300}}$	0,569	1,049	0,458
Z	$= 0{,}53 \times A_1 + 0{,}13 \times B_2 + 0{,}18 \times C_3 + 0{,}16 \times D_4$	0,353	0,479	0,302

Fig. 1 – The results of the diagnosis of the probability of bankruptcy of SE «Mine named after M.S. Surgay» for 2018–2020

− increasing the competitiveness of coal as the main type of product;

− reduction of expenses covered by the company's profit;

− conducting a comprehensive analysis of internal factors that led to the crisis;

− implementation of financial planning taking into account external factors that may adversely affect the financial condition of the enterprise;

− conducting constant monitoring to identify risks «on weak signals» and timely implementation of internal reserves.

Conclusions

Today in foreign and domestic practice there are many models for predicting the probability of bankruptcy, each of which has certain advantages and disadvantages. There is no single right approach to assessing the risk of bankruptcy. The studied models of foreign scientists do not reflect the real financial condition of Ukrainian enterprises, because the basis in the process of developing these discriminatory models by foreign scientists was taken key economic indicators of a country that are not adapted to domestic economic realities. Also, the considered models of foreign analytical practice are generalized and do not take into account the sectoral features of the functioning of economic entities. Thus, it is expedient to apply bankruptcy probability assessment models developed by O. Tereshchenko, A. Matviychuk and R-model of bankruptcy risk assessment at Ukrainian enterprises, the peculiarities of practical application of which will be the object of our further research.

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