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Credibility of Discriminatory Models on the Example of Enterprises from the Lubelskie and Podkarpackie Voivodeships

Keywords: discriminant analysis; early-warning models; financial situation of enterprises; forecast accuracy; company bankruptcy

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Abstract

Theoretical background: The results of the conducted research allowed the classification of early-warning models according to the accuracy of the forecasts received for the last year of the study.
Purpose of the article: The aim of the article was verification and prognostic assessment of discriminative models popular among researchers, answer to the question whether the model properly reflects the financial situation of the company.
Research methods: The basis of all the methods used in this article was the analysis of existing data and methods of discriminant analysis.
Main findings: The selected models properly reflected the financial situation of the 84 enterprises surveyed.

Introduction

In domestic and foreign literature on the subject there are many methods (divided into types) that are used to assess the financial condition of enterprises (financial situation of enterprises) – the terms interchangeably used by the authors. Of the many financial methods, discriminatory models are the most popular tools in the field of early-warning methods. Bankruptcy prediction models (also called "models", "early bankruptcy warning systems") are tools used to assess the economic and financial situation of enterprises, enabling not only forecasting the threat of bankruptcy, but also assessing changes in the condition of the analyzed units and the degree of stability or variability of this condition (Dec, 2009, p. 79).

The purpose of this article concerns verification and prognostic assessment of 10 discriminative models selected for the study. The research sample comprised enterprises from the commercial, production and service industries, originating in the Lubelskie and Podkarpackie voivodeships. Eighty-four enterprises were divided into two groups: 42 bankrupt enterprises and 42 healthy enterprises. For the calculations, the analysis of financial data from the period 2010–2018 was used. Finally, the results obtained and the reliability of the methods used for the study are presented.

Literature review

In the extensive literature on the subject, many researchers attempt to verify early-warning models. Among the available research results, discriminative models are the most popular. The first Polish discriminatory model whose task was the bankruptcy forecast was Mączyńska's model, in which the author used a multiplication model of simplified discriminant analysis to predict the bankruptcy of Polish companies (Mączyńska, 1994). Table 1 presents a summary list of studies conducted in which the authors use the largest number of models and the number of enterprises.

Table 1. Characteristics of selected studies according to the largest number of discriminatory models used and the number of enterprises surveyed

Author of the study	Number of models used	Number of enterprises surveyed	Number of enterprises surveyed bankrupt or threatened with bankruptcy
Antonowicz	41	208	90
Balina	27	60	30
Gołębiowski, Żywno	25	10	10
Rusek	23	6	6
Balina, Pochopień	22	40	
Czarny	21	26	
Mirowska, Lasek	21	30	15
Czapiewski	20	94	48
Grzegorzewska, Runowski	10	51	
Lichota	10	5	

Source: (Kitowski, 2017, p. 181).

From the data presented in Table 1, it follows that the most numerous population of discriminatory models used for the study (41 in number) and the number of enterprises (89 companies in bankruptcy and 119 companies not at risk of losing their financial condition) was examined by Antonowicz (2010, p. 19). In turn, Czapiewski studied 94 companies, 48 of which were threatened with bankruptcy, and 46 enterprises were in good financial condition (Czapiewski, 2009, p. 123). Balina used 27 discriminatory models for the number of 60 enterprises, including 30 threatened with bankruptcy (Balina, 2012, pp. 233–234). Similarly, Pitera verified a sample of 50 enterprises, 25 of which, in the years 2007–2015, were declared bankrupt (Pitera, 2018, p. 58). Other studies that have been carried out are worth mentioning, among others, study conducted by Kuciński on a sample of companies listed on NewConnect (Kuciński, 2011, pp. 146–163), Zarzecki (2003, p. 179), Gołębiowski and Pląsek (2018, pp. 9–24), Kisielińska and Waszkowski (2010, pp. 17–31), or Hamrol with Chodakowski (2008, p. 29).

Research methods

The basis of all the methods used in this article was the analysis of existing data and methods of discriminant analysis. The study uses 10 discriminatory models that are very popular among researchers. The following models were used in the article:

- Hadasik model (1998),
- Wierzba model (2000),
- Hołda model (2001),
- Gajdka and Stos modified model (2003),
- Hamrol (Poznań) model (2004),
- the first model of Appenzeller and Szarzec (2004),

– the first model of Prusak (2005),
– "G" model of the Institute of Economics of the Polish Academy of Sciences also referred to the model of Mączyńska and Zawadzki (2006),
– Maślanka model (2008),
– Korol model (2010).

Table 2 provides the description of individual models.

Table 2. Characteristics of discriminatory models

Number	Author/model name	Model description
1	Hadasik model	I_1 = (Current assets) / (Current liabilities) I_2 = (Current assets-Inventories) / (Current liabilities) I_3 = (Total liabilities) / (Total assets) I_4 = (Current assets – Short-term liabilities) / (Total liabilities) I_5 = (Receivables) / (Sales revenues) I_6 = (Inventories) / (Sales revenues) $Z_{DH} = 2.3626 + 0.3654I_1 – 0.7655I_2 – 2.4043I_3 + 1.5908I_4 + 0.0023I_5 – 0.0128I_6$ $Z_{DH} > 0$ good financial condition $Z_{DH} < 0$ bankruptcy
2	Wierzba model	I_1 = (Operating profit – Depreciation) / (Total assets) I_2 = (Operating profit – Depreciation) / (Sales revenues) I_3 = (Current assets) / (Total liabilities) I_4 = (Working capital) / (Assets) $Z_{DW} = 3.26I_1 + 2.16I_2 + 0.3I_3 + 0.69I_4$ $Z_{DW} > 0$ good financial condition $Z_{DW} < 0$ bankruptcy
3	Hołda model	I_1 = (Current assets) / (Short-term liabilities) I_2 = (Liabilities and provisions for liabilities) / Assets x 100 I_3 = (Net profit) / (Average annual assets) x 100 I_4 = (Average annual short-term liabilities x 360) / (Costs of products, goods and materials sold) I_5 = (Total sales revenue) / (Annual average assets) $Z_{AH} = 0.605 + 0.681I_1 + -0.0196I_2 + 0.00969I_3 + 0.0006725I_4 + 0.157I_5$ $Z_{AH} > 0$ is not bankrupt $Z_{AH} < 0$ enterprise threatened with bankruptcy $-0.3 <= Z_{AH} <= 0.1$ area of uncertainty
4	Gajdka and Stos – modified model	I_1 = (Average annual short-term liabilities x 360) / (Production cost) I_2 = (Net profit) / (Annual assets) I_3 = (Gross profit) / (Total sales revenue) I_4 = (Assets) / (Liabilities) $Z_{JG2} = -0.0005I_1 + 2.0552I_2 + 1.7260I_3 + 0.1155I_4 – 0.3342$ $Z_{JG2} > 0$ good financial condition $Z_{JG2} < 0$ bankruptcy $-0.49 <= Z_{JG2} =< 0.49$ "uncertainty area", no financial statement
5	Hamrol model (Poznań model)	I_1 = (Net profit) / (Assets) I_2 = (Current assets – Inventories – Short-term prepayments) / (Short-term liabilities) I_3 = (Fixed capital) / (Assets)

Number	Author/model name	Model description
5	Hamrol model (Poznań model)	I_4 = (Profit on sales) / (Net revenues from sales and equalized to them) $Z_{MH} = 3.562I_1 + 1.588I_2 + 4.228I_3 + 6.719I_4 – 2.368$ $Z_{MH} > 0$ good financial condition $Z_{MH} < 0$ bankruptcy
6	The first model of Appenzeller and Szarzec	I_1 = (Current assets) / (Short-term liabilities) I_2 = (EBIT) / (Total sales revenue) I_3 = (Annual average inventories x number of days) / (Total sales revenue) I_4 = Receivables turnover + Inventory turnover I_5 = (Liabilities and provisions for liabilities) / (EBITDA) x (12) / (Accounting period) $Z_{DA} = 0.819I_1 + 2.567I_2 – 0.005I_3 + 0.0006I_4 – 0.0095I_5 – 0.556$ $Z_{DA} > 0$ good financial condition $Z_{DA} < 0$ bankruptcy
7	The first model of Prusak	I_1 = (Net profit + Depreciation) / Liabilities I_2 = (Operating costs) / (Short-term liabilities) I_3 = (Profit on sales) / (Assets) $Z_{BP} = 1.438I_1 + 0.188I_2 + 5.023I_3 – 1.871$ Z_{BP} >= -0.295 good financial condition Z_{BP}< -0.295 bankruptcy -0.7 =< Z_{BP} =< 0.2 “uncertainty area”, no definition of the financial situation
8	“G” model of the Institute of Economics of the Polish Academy of Sciences also referred to in literature as the model of Mączyńska and Zawadzki	I_1 = EBIT / (Assets) I_2 = (Equity) / (Assets) I_3 = (Net profit + Depreciation) / (Liabilities) I_4 = (Current assets) / (Short-term liabilities) $Z_{EM2} = 9.498I_1 + 3.566I_2 + 2.903I_3 + 0.452I_4 – 1.498$ $Z_{EM2} > 0$ good financial condition $Z_{EM2} < 0$ bankruptcy
9	Maślanka model	I_1 = (Working capital) / Assets I_2 = (Cash from operating activities [segment A with cash flow]) / (Assets) I_3 = (Operating profit + Depreciation) / (Liabilities) $Z_{TM} = -0.41052 + 1.59208I_1 + 4.35604I_2 + 5.92212I_3$ $Z_{TM} > 0$ good financial condition $Z_{TM} < 0$ bankruptcy
10	Korol model	I_1 = (Profit on sales) / (Assets) I_2 = (Working capital) / (Assets) I_3 = (Net profit + Depreciation) / (Liabilities) I_4 = (Operating expenses (excluding other operating expenses)) / (Short-term liabilities) $Z_{ban} = -1.97 + 2.35I_1 – 2.90I_2 – 2.68I_3 + 0.79I_4$ $Z_{non} = -3.49 + 9.93I_1 – 0.05I_2 – 0.62I_3 + 1.19I_4$ $Z_{non} – Z_{ban} < 0$ bankruptcy $Z_{non} – Z_{ban} >= 0$ no threat of bankruptcy

Source: (Hadasik, 1998; Wierzba, 2000; Hołda, 2001; Stos & Gajdka, 2003; Hamrol, Czajka, & Piechocki, 2004; Appenzeller & Szarzec, 2004; Prusak, 2005; Mączyńska & Zawadzki, 2006; Maślanka, 2008; Korol, 2010).

The analysis of early warning models was carried out based on the collected financial data of enterprises that declared bankruptcy in the years 2010–2018. The enterprises were located in two provinces – Podkarpackie and Lubelskie.

The research sample consisted of enterprises from the commercial, production and service industries. The enterprises were divided into two groups: bankrupt (in poor condition) and healthy (in good condition). Healthy enterprises were selected in a purposeful way, they had a similar business profile in relation to bankrupt enterprises and a similar property and capital structure. Finally, data on 42 entities with poor financial condition – bankrupt from both voivodeships – and the same number of their healthy counterparts was collected.

Table 3. Classification of enterprises used for the survey

Trade	Number of enterprises			
	From the Podkarpackie Voivodeship		From the Lubelskie Voivodeship	
	Bankrupt enterprises	Healthy enterprises	Bankrupt enterprises	Healthy enterprises
Manufacturing	7	7	7	7
Services	7	7	7	7
Commerce	7	7	7	7
Sum	21	21	21	21

Source: Authors' own study based on collected financial data.

Results

The prognostic effectiveness of 10 discriminative models was assessed based on the collected financial data over a five-year period. The last year of the survey was the year of bankruptcy by the bankrupt group. The calculations were made adequately for five periods of enterprises included in the healthy group. Finally, attention was focused on the last year of the study. Table 4 contains detailed results obtained for the analysed sample for the last year of the survey.

Table 4. Classification of early warning models according to the accuracy of forecasts for the last year of the study

Model	Model year	Number of correct grades		Number of incorrect ratings				Percentage of accurate forecasts		The percentage of accurate forecasts combined
				First degree error		Second degree error				
		Lubelskie Voivodeship	Podkarpackie Voivodeship	Lubelskie Voivodeship	Podkarpackie Voivodeship	Lubelskie Voivodeship	Podkarpackie Voivodeship	Lubelskie Voivodeship	Podkarpackie Voivodeship	
"G" model of the Institute of Economics of the Polish Academy of Sciences	2006	38	37	1	2	3	3	90.5%	88%	89%
Korol model	2010	36	37	3	1	3	4	86%	88%	87%
Hamrol model (Poznań model)	2004	37	35	1	3	4	4	88%	83%	86%
Hołda model	2001	33	34	4	3	5	5	79%	81%	80%

Model	Model year	Number of correct grades		Number of incorrect ratings: First degree error		Number of incorrect ratings: Second degree error		Percentage of accurate forecasts		The percentage of accurate forecasts combined
		Lubelskie Voivodeship	Podkarpackie Voivodeship	Lubelskie Voivodeship	Podkarpackie Voivodeship	Lubelskie Voivodeship	Podkarpackie Voivodeship	Lubelskie Voivodeship	Podkarpackie Voivodeship	
Appenzeller and Szarzec model	2004	33	32	3	3	6	7	79%	76%	77%
Gajdka and Stos model	2003	30	33	4	3	8	6	71%	76%	75%
Maślanka model	2008	30	31	6	5	6	6	71%	74%	73%
Prusak model	2005	25	26	10	10	7	6	60%	62%	61%
Wierzba model	2000	25	24	6	7	11	11	60%	57%	58%
Hadasik model	1998	24	24	6	7	12	11	57%	57%	57%

Source: Authors' own study based on the survey results obtained.

Of the respondents, three models achieved the highest prognostic values, above 80%. Mączyńska and Zawadzki's "G" model turned out to be the best diagnosing model. The Korol model was second in this respect, and the Poznań model came in third. All 10 models had a prognostic value above 50%. Hadasik and Wierzba methods were characterized by the lowest prognostic values. Both models achieved predictive efficacy slightly above 50% – 57% and 58%, respectively. As for the effectiveness of forecasts by voivodeships, there were no significant differences in the assessment of individual enterprises from the Podkarpackie and Lubelskie voivodeships. The percentage of accuracy of diagnoses in the assessment of enterprises by voivodeship did not mean significant differences.

Conclusions

The role of discriminant analysis and early warning systems based on it is to make a comprehensive assessment of the company's financial condition and to reveal elements indicating the increasing risk of bankruptcy (Wysocki & Kozera, 2012, p. 169). The results of the conducted research, whose purpose was verification and prognostic assessment of discriminative models popular among researchers for predicting bankruptcy of enterprises from the Lubelskie and Podkarpackie voivodeships confirm the validity of the research. Each of the 10 models used for research obtained prognostic reliability of 57% and more.

None of the discriminant analysis models in the same period had credibility above 90% efficiency. In the authors' opinion, the selected models correctly reflected the financial situation of the 84 enterprises surveyed (the highest prognostic value concerned the "G" model of Mączyńska and Zawadzki, the Korol model and the Poznań model).

In the article, the second degree error was more frequent than the first degree error. However, in a few cases the number of incorrect diagnoses of the first and second degree of the tested models was the same (first degree error: Appenzeller and Szarzec models and Prusak model; second degree error: INE PAN model by Mączyńska and Zawadzki, Poznań model by Hamrol, Hołda model, Maślanka model and Wierzba model). As research shows, the time of creation of a given model does not determine its effectiveness. Therefore, it is difficult to determine the useful life of a particular model. It is similar with the number of indicators used in the studied models, it does not determine the effectiveness of the results.

Based on the review of the literature and the results of the authors' research, it can be concluded that the time in which the model was created does not affect (or clearly does not determine) its efficiency of calculations and thus the reliability of the results obtained. Hence, it is really difficult to determine the usefulness time, use of a specific model for research on bankruptcy of enterprises; similarly, the number of indicators used in the studied models does not prejudge the effectiveness of the results.

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