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University of Rzeszów. Faculty of Economics

RAFAŁ PITERA

ORCID ID: https://orcid.org/0000-0001-9598-1240
rpitera@ur.edu.pl

Evaluation of the Reliability of Selected Discriminatory Methods in Assessing the Financial Condition of an Enterprise

Ocena wiarygodności wybranych metod dyskryminacyjnych w ocenie kondycji finansowej przedsiębiorstwa

Keywords: financial condition; discriminatory model; early-warning models; enterprise bankruptcy

Słowa kluczowe: kondycja finansowa; model dyskryminacyjny; modele wczesnego ostrzegania; upadłość przedsiębiorstw

JEL code: G17; G32; G33

Introduction

The subject literature shows a whole range of methods for evaluating the financial standing of enterprises. However, while choosing a given tool, one cannot be sure of the credibility and reliability of the received results. This is due to the fact that the majority of those methods, despite very good methodological assumptions, are viewed as universal tools. Nevertheless, this is not always the case, and the most likely effect is a false result. An incorrect diagnosis may have different consequences, ranging from a wrong evaluation of an enterprise to extreme cases of insolvency or even bankruptcy. The aim of the article is to subject some common discriminatory methods to prognostic algorithm verification. Those methods are the most frequently used tools for assessing financial standing [Korol, 2010b, p. 158; Kowalak, 2017].

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For the purpose of this article, the 10 most popular discriminatory models were used. They were verified on a sample of 25 enterprises that declared bankruptcy during 2007–2015, and also on their counterparts classified as enterprises with good financial standing. The results achieved and the credibility of particular methods are presented in the last part of the article.

1. The state of research on early-warning models

The subject literature presents numerous attempts to verify early-warning models. Among them, discriminative models are the most dominant. Undoubtedly, the research by Antonowicz is worth mentioning, as he studied 52 discriminative models. His research group covered enterprises declared bankrupt and those in good financial condition. The research group of the study included 89 companies from the Pomeranian Voivodeship that filed for bankruptcy with the District Court and 19 enterprises ranked in *Gazele Biznesu 2004* [Antonowicz, 2010, p. 19]. Balina examined the credibility of early-warning models on the basis of 60 financial reports, with half of the enterprises being bankrupt and the other half being sound counterparts. All the entities were public limited liability companies from the construction sector [Balina, 2012, pp. 233–234]. Also worth noting are the results of the research by Hamrol and Chodakowski. They evaluated early-warning models using the financial data of 36 companies listed on the Warsaw Stock Exchange that filed motions for bankruptcy during the years 2002–2004 or for arrangements with creditors [Hamrol, Chodakowski, 2008, p. 29]. Lichota evaluated discriminative models on a sample of eight enterprises based in the Podkarpackie Voivodeship that filed for bankruptcy during the years 2003–2014 [Lichota, 2017, pp. 212–213]. Kuciński evaluated the financial standing of NewConnect with the use of discriminative models [Kuciński, 2011, pp. 146–163]. Zarzecki evaluated the basis of 21 companies, with nine of them characterised by poor financial conditions and 12 of them being sound counterparts [Zarzecki, 2003, p. 179]. Wojnar attempted to determine the suitability of discriminative models by subjecting them to verification on a sample of 50 listed companies. She distinguished three groups: 20 companies with no threats, 10 companies listed on the stock exchange but with difficult financial conditions and threatened with bankruptcy, and companies once listed but with a financial standing that disqualified them from being present on the trading floor [Wojnar, 2014, pp. 219–231]. Czapiewski used the data from 94 listed companies, 48 of which were threatened with bankruptcy during the period 2000–2004, and 46 with a good level of financial standing [Czapiewski, 2009, p. 123]. Gołębiowski and Żywno evaluated early-warning models on the basis of 10 companies, from the Warsaw Stock Exchange, that went into bankruptcy [Gołębiowski, Żywno, 2008, p. 36]. Similarly, Grzegorzewska and Runowski evaluated the credibility of discriminative models; they used a set of 51 breeding farms of the Agricultural Property Agency. On the basis of three financial indicators for

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each investigated year, they selected 12 enterprises threatened with bankruptcy and 12 enterprises characterised by good financial standing [Grzegorzewska, Runowski, 2008, p. 84].

The above-mentioned most significant and most popular research on verification of the credibility of early-warning models allows the formulation of a few conclusions. In a number of cases, the research was carried out on small samples – hardly ever covering 50 or more entities. Another conclusion is that the conducted research covered the area of one or two voivodeships. All too often, the financial data used in the research came from only one specific sector.

2. Research sample

The research used 10 discriminatory models. The methods used for assessing financial standing include statistical models (64% used most often), soft computing techniques (25% of the research) and theoretical methods (11% in the remaining cases). Models based on the linear discriminant function are most frequent in this group [Aziz, Dar, 2006]. Therefore, the main focus of the research is these diagnostic tools. For the purpose of the research, the selected models were those for which the authors, while working on the issue, used data from enterprises running their business activities under the conditions of the Polish economy. Such an approach corresponds with the majority of approaches presented in the literature [i.a. Mączyńska, Zawadzki, 2006, pp. 209–210; Kitowski, 2011; Zaleska, 2002, p. 127; Rogowski, 1999, p. 71; Nowak, 2005, p. 252]. To verify the efficiency of the discriminatory models, the data from 50 enterprises were used. The research considered 25 entities that filed for liquidation bankruptcy during 2007–2015 and 25 entities with good financial conditions. Among the bankrupt enterprises, there were entities from eight voivodeships that were running business activity in the industrial, construction and services sectors. The group of "healthy" enterprises comprised entities with a similar business profile, number of employees and volume of assets to those that went bankrupt over the same period.

The discriminatory models of the following researchers were used in the study:

- Pogodzińska and Sojak [1995, pp. 53–61];
- Gajdka and Stos model 4 [1996, p. 62];
- Hadasik model 1 [1998, p. 153];
- Hadasik model 7 [1998, p. 160];
- Wierzba [2000, p. 94];
- Sojak and Stawicki [2001, pp. 45–52];
- Appenzeller and Szarzec model 1 [2004, pp. 124–126];
- Prusak model 1 [2005, p. 174];
- Mączyńska and Zawadzki INE PAN model "F" [2006, pp. 205–235];
- Korol [2010a, p. 149].

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The results of each model were presented. The financial standing may be assessed correctly or incorrectly both for the bankrupt enterprises and enterprises with good financial conditions. An incorrect diagnosis may be a Type-I error – wrong assignment of an entity with good financial standing to the group of bankruptcies – or a Type-II error – assigning a bankrupt enterprise to the "healthy" group. Those kinds of errors in classification are referred to as *ex ante*. Prediction errors may also occur, known as *ex post*. Errors of this type incorrectly assign an examined enterprise to a fixed time horizon [Pociecha, 2007].

3. Empirical studies

On the basis of the financial data of 50 enterprises, 10 discriminatory models were calculated for five reporting periods. The last reporting period was the year in which the bankrupt enterprises declared bankruptcy and the corresponding year for the enterprises with good financial standing. The article presents the results for the last research period (Table 1). For improved clarity of the results, the enterprises were marked as follows: "healthy" as Z1, Z2, Z3, etc., and "bankrupt" as B1, B2, B3, etc. The diagnoses of particular models were marked as: Pogodzińska and Sojak – M1, Gajdka and Stos – M2, etc. The results marked in bold show a correct diagnosis, i.e. a forecast of a fall for a bankrupt enterprise and a positive evaluation of financial standing for a "healthy" enterprise. Where the value of a given function is uncertain, the diagnosis is assumed to be incorrect. For the model of Korol, the functions Z_{non} and Z_{ban} were calculated. If the difference between Z_{non} and Z_{ban} was lower than zero, the diagnosis indicated a threat of bankruptcy. A positive result indicated good financial conditions of enterprises.

Table 1. Research results for the last analysed period (the year of bankruptcy)

Model / Entity	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Diagnosis	$Z < 0$ bankruptcy	$Z < 0.45$ bankruptcy	$Z < -0.3842325$ bankruptcy	$Z < 0$ bankruptcy	$Z < 0$ bankruptcy	$Z < 0$ bankruptcy	$Z < 0$ bankruptcy	$Z <= -0.13$ bankruptcy	$Z < 0$ bankruptcy	$Z_{non} - Z_{ban} < 0$ bankruptcy
B 1	0.50	**-1.11**	**-1.1**	**-0.99**	1.77	**-3.1**	**-0.94**	0.58	**-1.87**	**-1.29**
B 2	0.71	**0.29**	**-0.94**	**-1.33**	1.29	0.54	**-0.86**	0.14	**-2.11**	**-0.33**
B 3	0.82	**-1.22**	**-3.48**	**-2.33**	0.28	**-4.48**	**-2.1**	0.19	**-2.13**	2.13
B 4	0.11	**-2.48**	**-1.44**	**-1.27**	0.47	**-3.44**	**-1.45**	**-1.57**	**-0.99**	**-2.34**
B 5	0.13	**-4.29**	0.98	0.99	**-0.47**	0.58	**-1.87**	**-2.84**	**-0.49**	**-0.38**
B 6	**-0.7**	**-0.57**	0.45	0.14	**-0.48**	0.15	**-0.98**	**-2.18**	**-0.49**	**-2.33**
B 7	**-0.89**	1.24	2.44	2.59	0.47	**-2.44**	**-1.29**	**-3.29**	**-0.74**	1.29
B 8	**-1.24**	**-0.99**	**-4.44**	**-2.89**	**-2.49**	**-0.44**	**-1.49**	**-2.18**	**-2.45**	**-0.93**

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Model / Entity	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Diagnosis	$Z < 0$ bankruptcy	$Z < 0.45$ bankruptcy	$Z < -0.3842325$ bankruptcy	$Z < 0$ bankruptcy	$Z < 0$ bankruptcy	$Z < 0$ bankruptcy	$Z < 0$ bankruptcy	$Z <= -0.13$ bankruptcy	$Z < 0$ bankruptcy	$Z_{non} - Z_{ban} < 0$ bankruptcy
B 9	**-0.99**	0.74	**-2.38**	**-3.47**	**-4.49**	**-3.38**	**-0.93**	**-3.28**	**-0.48**	**-0.46**
B 10	**-2.53**	**-1.28**	**-4.84**	**-5.17**	**-2.49**	**-5.84**	**-0.39**	**-4.38**	**-0.38**	**-0.56**
B 11	**0.89**	0.97	1.04	2.09	0.49	0.84	0.28	**-3.29**	**-0.91**	**-3.48**
B 12	**-1.7**	2.14	4.21	3.75	0.57	1.51	2.16	**-2.38**	1.24	**-0.48**
B 13	0.98	1.92	0.92	**-0.85**	**-1.34**	3.72	**-0.58**	**-3.95**	2.11	0.85
B 14	2.4	2.57	**-0.75**	**-3.27**	**-2.35**	**-2.55**	**-2.31**	**-3.58**	**-0.93**	**-0.87**
B 15	2.5	4.21	**-0.47**	**-0.58**	0.49	**-1.49**	**-0.48**	0.48	**-0.85**	**-0.49**
B 16	2.11	1.35	**-1.46**	**-0.57**	0.87	**-0.46**	0.37	0.57	2.15	**-0.49**
B 17	3.15	2.41	2.14	2.54	2.11	**-0.14**	0.21	0.28	2.91	**-0.37**
B 18	**-0.89**	**-0.83**	2.57	1.59	**-3.44**	**-0.57**	1.56	0.28	0.39	2.01
B 19	1.2	**-0.92**	**-3.48**	**-1.45**	1.24	**-0.58**	**-0.68**	**-2.19**	**-2.39**	**-2.10**
B 20	0.2	0.55	**-0.89**	**-3.19**	**-3.59**	**-2.79**	**-3.11**	**-2.78**	**-1.23**	**-2.17**
B 21	**-0.12**	1.29	**-0.56**	**-1.57**	0.48	**-2.76**	**-2.17**	0.47	**-2.54**	**-2.03**
B 22	4.50	**-0.90**	1.94	**-0.48**	0.76	1.78	0.24	0.59	0.37	**-1.39**
B 23	3.30	1.29	2.48	1.49	**-0.88**	0.78	0.62	**-2.19**	1.68	**-1.34**
B 24	**-0.76**	**-1.22**	**-2.10**	1.14	**-0.94**	3.16	1.55	**-3.17**	2.95	**-1.59**
B 25	0.55	**-2.76**	**-0.94**	**-0.96**	2.19	**-2.54**	**-2.38**	**-0.84**	**-0.75**	**-0.94**
Z 1	**0.34**	-0.92	**0.67**	**0.84**	**1.13**	**3.67**	**2.31**	-0.37	**0.99**	**2.45**
Z 2	**0.43**	-0.27	**0.98**	**2.11**	**1.99**	-0.38	**0.93**	-0.73	**0.43**	**1.20**
Z 3	**0.21**	**1.22**	**2.45**	**4.22**	**1.38**	**1.49**	**1.99**	-0.39	**0.37**	-0.43
Z 4	-0.99	-0.38	**4.29**	**1.49**	**1.86**	**3.29**	**2.35**	-1.47	**2.19**	-0.57
Z 5	-1.20	-0.74	-2.1	-0.89	-0.93	**1.15**	**0.35**	-1.75	**2.85**	-0.47
Z 6	-1.76	**0.87**	-1.55	-1.22	-0.64	-0.17	**0.95**	-1.27	**3.29**	-0.57
Z 7	-0.90	**1.29**	**0.99**	**0.15**	-0.36	**3.09**	**3.44**	-0.48	-0.94	-1.39
Z 8	-3.45	-1.98	**-0.29**	**1.49**	**2.39**	-0.89	-1.84	**2.11**	-0.48	**2.13**
Z 9	-2.11	-2.48	-0.47	**2.11**	**3.28**	**0.77**	**0.59**	**2.92**	-0.92	**4.31**
Z 10	-0.91	**0.75**	**-0.24**	-0.84	-0.56	-0.58	**0.87**	**1.94**	-1.38	**2.49**
Z 11	**0.55**	**2.22**	**1.22**	**0.46**	**1.23**	**1.92**	**1.58**	**1.57**	**0.19**	**3.78**
Z 12	**0.65**	**0.88**	**1.09**	**2.58**	**1.28**	**0.98**	**3.19**	**1.36**	**1.39**	**1.57**
Z 13	-2.14	**0.57**	-1.48	-0.45	-0.48	-0.76	**1.44**	**1.30**	**2.48**	**2.57**
Z 14	-3.32	**3.11**	**0.13**	**0.98**	**2.16**	-0.63	-0.48	-0.39	**3.48**	**2.39**
Z 15	-2.45	-2.29	-1.49	-0.47	-0.97	**0.37**	-0.85	**0.94**	-0.93	**2.48**
Z 16	-0.47	**0.98**	**0.95**	**2.14**	**2.35**	**0.95**	**0.87**	**0.89**	**3.28**	**0.94**
Z 17	-0.19	0.34	**2.45**	**0.45**	**2.37**	-0.56	-0.87	**2.11**	**0.57**	**0.85**
Z 18	-0.93	-1.29	**1.11**	**2.74**	**0.75**	-0.71	**1.24**	**2.49**	**0.96**	-1.29
Z 19	**0.58**	**3.22**	**2.45**	-0.94	-2.78	**2.62**	**1.22**	**3.58**	-0.38	**2.19**
Z 20	**0.92**	**4.55**	**1.09**	-0.76	**0.76**	-0.67	**0.57**	-0.98	**3.12**	**3.27**
Z 21	**0.72**	**2.35**	**0.56**	-1.23	**2.39**	**0.56**	**1.21**	**3.29**	**1.49**	**3.36**
Z 22	**0.75**	**0.96**	**2.11**	-1.29	-0.76	-1.17	-2.31	-1.48	**2.22**	-0.49
Z 23	-1.26	**5.78**	**2.85**	**3.5**	**2.45**	**2.57**	-2.59	**2.48**	**1.29**	-0.56
Z 24	-2.84	**1.76**	-0.98	**0.46**	**0.96**	**0.83**	-0.48	**1.39**	**3.49**	**2.47**
Z 25	-0.48	**1.88**	-1.89	**0.57**	**1.28**	**1.74**	**0.94**	**1.93**	**0.43**	**3.27**

Source: Author's own study on the basis of financial reports of researched entities.

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The research carried out shows that Korol's model has the highest credibility of forecasts. This is the most recent model among all the others subjected to verification. In terms of reliability, the second best model is that of Mączyńska and Zawadzki (INE PAN model "F"). The third best model was that of Appenzeller and Szarzec (model 1) from 2004. The least efficient method appears to be the model created by Pogodzińska and Sojak.

Table 2. Classification of discriminatory models according to the accuracy of forecasts for the last research year

Model	Accurate forecast (%)	Correct assessments	Incorrect assessments	
			Incorrect assessments	Model
M10 Korol Model	**74**	37	9	4
M9 Mączyńska and Zawadzki INE PAN model "F"	**72**	36	6	8
M7 Appenzeller and Szarzec model 1	**70**	35	7	8
M3 Hadasik model 1	**66**	33	7	10
M4 Hadasik model 7	**64**	32	9	9
M8 lB Prusak model 1	**62**	31	10	9
M6 Sojak and Stawicki model	**62**	31	10	9
M2 Gajdka and Stos model 4	**60**	30	8	12
M5 Wierzba model	**56**	28	8	14
M1 Pogodzińska and Sojak model	**38**	19	16	15

Source: Author's own study based on the research.

Only one (by Pogodzińska and Sojak) out of the 10 analysed models did not have a prognostic value above 50%. It should be noted, however, that it was constructed in a different economic situation. Besides, it was created more than 20 years ago. Hence, it seems reasonable to consider the "newest" tools, which are more effective in taking into account the current economic situation and a situation for a particular industry or economy in general. This is in line with the approaches presented in the literature by such authors as, among others, Korol [2010a, p. 129], Rogowski [2008, p. 248], Hołda [2001, p. 310], and Kitowski [2012, pp. 262–286].

Conclusions

The research carried out allowed classification of discriminatory models from the group of early-warning models by the efficiency of their results. Nine out of 10 models used to assess financial standing achieved a prognostic value above 50%. The three models with the most accurate prognostics were also the newest models of all those examined. The best accuracy was proved for Korol's model, while the weakest was for the model created by Pogodzińska and Sojak.

With regard to the accuracy of particular models, it should be noted that the models assessed the best enterprises from the construction sector, while the least accurate

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were assessments of bankrupt enterprises from the services sector. Additionally, the level of accuracy of diagnoses for bankrupt enterprises varied more widely among the different models than for the group of "healthy" enterprises. In this "healthy" group, each of the three sectors – i.e. construction, industrial, and services – was diagnosed at a similar level. The least correct was the diagnosis for the services sector; however, it had a lower percentage of incorrect diagnoses than for the bankrupt enterprises. Within the two groups, the better results in prognostics were recorded for enterprises operating for fewer than 10 years. In the case of shorter periods of business activity, the diagnoses were characterised by a higher accuracy than those related to enterprises with a longer presence in the market. Moreover, the majority of those models responded more efficiently to enterprises with negative financial results and a high level of debt. This is connected with applying a high number of indicators for profitability and financial structure. Less frequently used indicators assessing efficiency of performance did not always show a lower level of importance of particular positions and their impact on the diagnosis. Surprisingly enough, the models responded to the least extent to distortions in liquidity. This results from the fact that in some models these kinds of measurements are neglected or they are attributed with lower values of parameters of the discriminatory function than the indicators from other groups.

The discrepancies in the achieved results were influenced by, apart from the time of creation of a given model, the selection of indicators to models, the sector enterprises that were or are operating, or the time of their operations. Therefore, while choosing a model for research, more attention should be paid to its credibility. This may allow, at least to some extent, minimising of incorrect diagnoses, as was attempted by this very research. While evaluating the financial standing of a researched entity, it is advisable to extend valuation with a ratio analysis or logit models. This will reduce the risk of errors resulting from, e.g. sector specificity or the economic situation.

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Ocena wiarygodności wybranych metod dyskryminacyjnych w ocenie kondycji finansowej przedsiębiorstwa

Celem artykułu była kompleksowa ocena możliwości prognostycznych metod dyskryminacyjnych wykorzystywanych w badaniu standingu finansowego przedsiębiorstw. Do osiągnięcia postawionego celu wykorzystano analizę danych empirycznych 50 przedsiębiorstw przy wykorzystaniu 10 modeli dyskryminacyjnych. Próbę przedsiębiorstw tworzyło 25 podmiotów, wobec których ogłoszono upadłość likwidacyjną w latach 2007–2015 oraz ich „zdrowych" odpowiedników. Przeprowadzone badania pozwoliły na otrzymanie wiarygodności poszczególnych modeli oraz dokonanie ich oceny pod kątem użyteczności wykorzystania w badaniu sytuacji finansowej przez osoby środowiska naukowego, a także praktyków na co dzień zajmujących się analizą sytuacji finansowej przedsiębiorstw, potencjalnych i dotychczasowych inwestorów, audytorów, członków rad nadzorczych oraz biegłych rewidentów. Na podstawie wyników badań sklasyfikowano modele dyskryminacyjne za ostatni okres badania według trafności prognoz.

Evaluation of the Reliability of Selected Discriminatory Methods in Assessing the Financial Condition of an Enterprise

The article aimed to comprehensively assess the predictive possibilities of discriminatory methods used in the study of financial standing of enterprises. The empirical data analysis of 50 enterprises using 10 discriminatory models was carried out to achieve the set goal. The sample of enterprises was created by 25 entities against which liquidation bankruptcy was declared during 2007–2015 and their "healthy" counterparts. The research revealed the reliability of individual models and their usefulness in the study of financial situations by the scientific community, as well as practitioners who analyse the financial standing of enterprises: potential and existing investors, auditors, members of supervisory boards and experts. Based on the research results, discriminant models were classified for the last period of the study according to the accuracy of the forecasts. The publication is part of the cycle dealing with the issues of credibility assessment of early-warning methods.