

Evaluation of the effectiveness of early warning models on the example of enterprises operating in SEZ

Justyna Chmiel

University of Rzeszów, Poland
E-mail: j.chmiel@ur.edu.pl
ORCID: 0000-0002-3890-2785

Karolina Koziol

University of Rzeszów, Poland
E-mail: kakoziol@ur.edu.pl
ORCID: 0000-0002-2195-6373

Rafał Pitera

University of Rzeszów, Poland
E-mail: rpitera@ur.edu.pl
ORCID: 0000-0001-9598-1240

Abstract: The article aims to verify the effectiveness of selected 10 models of discriminant analysis on the example of 30 enterprises operating in special economic zones: Mielec and Tarnobrzeg. The methodology applied for the research was an analysis of existing data and the use of discriminant analysis methods such as systematic review of literature, analysis of public data of the Ministry of Economy and financial data of enterprises (primarily financial statements). Analysis of companies belonging to the Mielec zone, SEZ Euro-Park Mielec and Tarnobrzeg Euro-Park Wisłosan was conducted on a sample of 30 enterprises, including 15 bankrupt and 15 termed “healthy”. The time horizon of the research was 2009–2017, verification was based on 10 early warning models. The conducted analyzes showed that some models correctly reflect the financial situation of the surveyed enterprises (e.g. Artur Hołda’s model—73.3% accurate forecasts), they also revealed the need to use multiple discriminant analysis models to thoroughly analyze the company’s financial situation—using only one lead model maybe to draw incorrect conclusions. The use of discriminatory models to assess the financial situation of enterprises is in many cases based on early warning methods. These methods are characterized by both advantages and certain limitations; one of the disadvantages is the rapid decline in the effectiveness of models due to constant changes in the economic conditions of market players. That is why models created several years ago may be less effective than newer methods. As for the advantages, it should be emphasized above all the simplicity of the use of such tools and unambiguous results—which in comparison to, for example, traditional indicator analysis, allow to avoid errors in the interpretation of results.

Keywords: discriminant analysis, company’s financial situation, early warning models, bankruptcy, enterprises in Poland

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Correspondence to:
Rafał Pitera
Uniwersytet Rzeszowski
ul. Ćwiklińskiej 2
35-601 Rzeszów, Poland
Tel.: +48 17 872 16 45

1. Introduction

One of the key efforts that contribute to the overall socio-economic development of the region and the country is to stimulate activities aimed at activating society, including unleashing their entrepreneurial potential. By creating appropriate conditions for the functioning of enterprises on the market, entrepreneurs have many tasks to accomplish. One of them concerns the minimization of labour costs in order to create a sustained (promising) company, generating long-term revenues. The authors focus their attention on enterprises that have decided to conduct business in Special Economic Zones. The reason for researching zone enterprises are the authors' scientific interests, as well as methods (forms) of zone companies' activities that efficiently attract foreign capital in the form of foreign direct investment (FDI). More often than off-zone companies they implement new technical and technological solutions, thus increasing the competitiveness of manufactured products and services rendered. The paper focuses on the Mielec zone, created in 1995, located in Mielec (SEZ Euro-Park Mielec), and the Tarnobrzeg Euro-Park Wisłosan, established in 1997, managed by ARP S.A. Branch in Tarnobrzeg, with its range covering as many as three voivodeships: Subcarpathian, Masovian, Lublin.

Research on business bankruptcy and early warning models have gained importance after a change from centrally planned economy to free market economy. There was a sharp increase in the number of enterprises that could not cope with the rules of the free market. The phenomenon of bankruptcy is intensifying or it is more noticeable by market participants during periods of recession, which is shaken by the financial policy, which may lead to the company's insolvency.

Taking into account the above transformations and phenomena, the article attempts to assess the effectiveness of selected models for forecasting bankruptcy of enterprises, SSE companies Europark Mielec and Tarnobrzeg Euro-Park Wisłosan, using ten discriminative models as the most popular tools.

The main intention of the authors is to examine enterprises located in Special Economic Zones. This choice was not accidental, because it is associated with the scientific interests of the authors, as well as with research relevance that occurs in both Polish and foreign literature. Increasingly, varied studies on the financial condition of enterprises could be found, as well as the use of early warning models for predicting bankruptcy. However, the specific properties of the surveyed enterprises are not always taken into account and many generalizations are applied. The authors asked themselves whether the models available in Polish literature (details later in the article) can be successfully used to study enterprises located in economic zones, or on the contrary—prove to be ineffective. The following article may be the beginning of research aimed at developing a discriminatory model dedicated to enterprises located in the SEZ.

The need for a good forecasting tool for the bankruptcy of Eastern European companies thus arises; several authors used neural networks to meet this need, including Darvasi (2010) and Dorneanu et al. (2011).

2. Literature review

Many types of prediction models have been formulated in the theory and practice of predicting bankruptcy in economic terms (legal bankruptcy). An exhaustive classification (McKee, 2000), characterizing the following types of procedures and models, has been presented by McKee. It presents itself as shown below:

- one-dimensional indicator models;
- multidimensional discriminant analysis;
- linear probability models;
- logit and probit models;
- decision trees;
- gambling models;
- expert systems;
- mathematical programming;
- neural networks;
- application of the theory of fuzzy sets and rough sets.

The first Polish discrimination model for forecasting bankruptcy was Elżbieta Mączyńska's model, where a multiplication model of simplified discrimination analysis was used to predict the bankruptcy of Polish companies (Mączyńska, 1994). The creation of the model was associated with the adaptation of the Edward I. Altman (1968) western model (or Z-score model) to the conditions of the Polish economy. It was Altman (1968), as a precursor of forecasting threats in the functioning of enterprises, that contributed to the dynamic development of early warning models.

In the literature on the subject, an often occurring case is the assignment, in an unauthorized manner, contrary to the methodology—of the value of universality (where economic conditions or industry specificity of enterprises included in the research sample of the model are ignored). Therefore, it is purposeful to periodically conduct diagnostic credibility of financial condition assessment models (Kitowski, 2013, p. 156).

Measures taken as part of the research route of bankruptcy prediction statistical models designate the taking up of the following analytical activities (Kaczmarek [ed.], 2012):

- identification of dependency of layout: company standing—threat of bankruptcy;
- susceptibility testing: level of threat of bankruptcy—abrupt changes in the determinants of company standing;
- testing of efficiency (identification and dynamic prediction methods);
- prospective analysis and assessment of the state of threat of bankruptcy.

It should be added that the methods of discriminant analysis are devoid of the main disadvantage of indicator analysis, namely the difficulty in explicitly assessing the financial situation of the company at a given moment.

According to Tomasz Korol, the most effective method in forecasting bankruptcy of companies among all statistical methods is multidimensional discrimination analysis (Korol, 2010, p. 158). At the same time, current literature studies show that there is not actually one correct model for assessing the threat of bankruptcy of an enterprise (Mączyńska and Zawadzki 2006, p. 228).

In the opinion of Feliks Wysocki and Agnieszka Kozera, the role of discriminatory 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 and Kozera, 2012, p. 169).

Popular models developed by Polish researchers in this area include: the model by Gajdka and Stos, the model by Mączyńska and the Poznań model, where the advantage of the models is a high percentage of accuracy of forecasts based on them (Bombiak, 2010, p. 145).

Summarizing, it is important that discriminant analysis (also known as Discriminant Function Analysis, DFA) is a powerful descriptive and classificatory technique developed by R. A. Fisher in 1936 (Fisher, 1936, pp. 178–188) to: (a) describe characteristics that are specific to distinct groups (called descriptive discriminant analysis); and (b) classify cases (that are individuals, subjects, participants) into pre-existing groups based on similarities between that case and the other cases belonging to the groups.

3. Research methodology

The starting point, or base for all other methods used in this article, was the analysis of existing data and discriminant analysis methods. In order to assess the predictive credibility of enterprises, a total of 30 financial data was collected. The collected data came from 15 bankrupt entities. The sample of failed enterprises includes enterprises operating in the industry and services sector. The opposite number of healthy enterprises in both sectors was collected as an opposite sample. All enterprises that were selected for the study according to current criteria functioned (went bankrupt) or still operate in special economic zones in the Subcarpathian Voivodeship. The number of enterprises that were selected for the study was dictated by the availability of financial data of bankrupt enterprises. In the case of such entities, it is much more difficult to reach financial statements that contain sufficiently complete information that can be used in the study. An additional difficulty was the fact that in the selection of individual enterprises, entities operating in special economic zones were sought.

Based on the collected financial data, early warning models were calculated for a period of 5 years. Based on a sample of 30 enterprises that declared bankruptcy in 2009–2017 and their healthy counterparts, the data included in the financial statements was reviewed and analyzed. The detailed sector membership is presented in Table 1.

Table 1. Classification of bankrupt enterprises covered by the survey according to the Polish Classification of Activities

Description	Polish Classification of Activities	Number of entities used in the study	
		Failed enterprises	Healthy enterprises
Metal production	24	1	1
Manufacture of fabricated metal products, except machinery and equipment	25	2	2
Manufacture of other transport equipment	30	1	1
Other production	32	2	2
Repair, maintenance and installation of machinery and equipment	33	1	1
Activities related to the collection, processing and disposal of waste; raw material recovery	38	1	1
Wholesale trade, except of motor vehicles	46	1	1
Construction works for buildings	41	3	3
Specialized construction works	43	1	1
Warehousing and support services for transportation	52	2	2
TOTAL		15	15

Source: Authors' own elaboration.

Ten discriminatory models called early warning models were used in the study. These models are the most commonly used methods among statistical tools when forecasting bankruptcy of enterprises (Aziz and Dar, 2006, pp. 18–33). The selection of models was dictated by several factors. The most popular and most frequently used methods were selected.

Foreign models were ignored in the selection. According to the position of most people dealing with the subject, models constructed in other countries were based on other conditions. Therefore, their use in the conditions of the Polish economy should take place only after prior adaptation. Such views include accepting the following authors: Rogowski (1999), Zaleska (2002), Nowak (2005), Mączyńska and Zawadzki (2006), Korol (2010), Kitowski (2011). Therefore, no foreign models, often as popular as domestic models (e.g. E. Altman's models), were not used in the study. In addition, due to the fact that companies from various industries were selected for the sample of enterprises, universal models were used for the study, i.e. dedicated to use in many industries. Hence, models that apply only to a particular industry (e.g. Robert Jagiełło discriminative models [Jagiełło, 2013], or Sławomir Juszczyk's and Rafał Balina's models [Juszczyk and Balina, 2014] or provinces—Małgorzata Kasjaniuk models [Kasjaniuk, 2006], were not used in the study). Table 2 shows the individual models in detail.

Table 2. Characteristics of selected early warning models

No.	Model	Formula for a given model
1.	Model by Mączyńska	$ZEM = 1.5W_1 + 0.08W_2 + 10.0W_3 + 5.0W_4 + 0.3W_5 + 0.1W_6$ $W_1 = (\text{Gross profit} + \text{Depreciation}) / \text{Liabilities}$ $W_2 = \text{Assets} / \text{Liabilities}$ $W_3 = \text{Gross profit} / \text{Assets}$ $W_4 = \text{Gross profit} / \text{Sales}$ $W_5 = \text{Stocks} / \text{Sales}$ $W_6 = \text{Sales} / \text{Assets}$ $ZEM < 0$ —company in danger of bankruptcy $0 < ZEM < 1$ —poor financial condition but no threat of bankruptcy $1 = < ZEM < 2$ —good financial condition $2 = < ZEM$ —very good financial condition
2.	Model by Gajdka and Stos	$ZGS = 0.7732 - 0.0856W_1 + 0.00077W_2 + 0.9221W_3 + 0.6536W_4 - 0.5947W_5$ $W_1 = \text{Sales} / \text{Annual assets}$ $W_2 = (\text{Short-term average annual liabilities} \times 360) / \text{Production cost}$ $W_3 = \text{Net profit} / \text{Assets}$ $W_4 = \text{Gross profit} / \text{Sales}$ $W_5 = \text{Liabilities} / \text{Assets}$ $ZGS < 0.45$ —enterprise threatened with bankruptcy $ZGS > 0.45$ —enterprise in good financial condition
3.	Model by Hadasik	$ZDH = 2.3626 + 0.3654W_1 - 0.7655W_2 - 2.4043W_3 + 1.5908W_4 + 0.0023W_5 - 0.0128W_6$ $W_1 = \text{Current assets} / \text{Current liabilities}$ $W_2 = (\text{Current assets} - \text{Inventories}) / \text{Current liabilities}$ $W_3 = \text{Total liabilities} / \text{Total assets}$ $W_4 = (\text{Current assets} - \text{Current liabilities}) / \text{Total liabilities}$ $W_5 = \text{Receivables} / \text{Sales revenues}$ $W_6 = \text{Inventories} / \text{Sales revenues}$ $ZDH > 0$ —good financial condition $ZDH < 0$ —bankruptcy
4.	Model by Wierzba	$ZDW = 3.26W_1 + 2.16W_2 + 0.3W_3 + 0.69W_4$ $W_1 = (\text{Operating profit} - \text{Depreciation}) / \text{Total assets}$ $W_2 = (\text{Operating profit} - \text{Depreciation}) / \text{Sales}$ $W_3 = \text{Current assets} / \text{Total liabilities}$ $W_4 = \text{Working capital} / \text{Assets}$ $ZDW > 0$ —good financial condition $ZDW < 0$ —bankruptcy
5.	Model by Hołda	$ZAH = 0.605 + 0.681W_1 - 0.0196W_2 + 0.00969W_3 + 0.000672W_4 + 0.157W_5$ $W_1 = \text{Current Assets} / \text{Short-term liabilities}$ $W_2 = \text{Liabilities} / \text{Assets} \times 100$ $W_3 = \text{Net profit} / \text{Annual assets} \times 100$ $W_4 = (\text{Average current short-term liabilities} \times 360) / \text{Costs of sold products, goods and materials}$ $W_5 = \text{Sales} / \text{Annual assets}$ $ZAH > 0$ —good financial condition $ZAH < 0$ —bankruptcy $-0.3 \leq ZAH \leq 0.1$ —“area of uncertainty”, no determination of the financial situation

6.	Poznań model	$Z = -2.368 + 3.562 W_1 + 1.588 W_2 + 4.288 W_3 + 6.719 W_4$ $W_1 = \text{Net profit} / \text{Assets}$ $W_2 = (\text{Current assets} - \text{Inventories}) / \text{Short-term liabilities}$ $W_3 = \text{Fixed capital} / \text{Assets}$ $W_4 = \text{Profit on sales} / \text{Revenue from sales and equalized to them}$ $Z > 0$ —good financial condition
7.	Model by Appenzeller and Szarzec	$ZDA = 0.819 W_1 + 2.567 W_2 - 0.005 W_3 + 0.0006 W_4 - 0.0095 W_5 - 0.556$ $W_1 = \text{Net profit} / \text{Assets}$ $W_2 = (\text{Current Assets} - \text{Inventories} - \text{Short-term prepayments}) / \text{Short-term liabilities}$ $W_3 = \text{Fixed capital} / \text{Assets}$ $W_4 = \text{Profit on sales} / \text{Revenue from sales and equalized to them}$ $W_5 = \text{Liabilities} / \text{EBITDA}$ $ZDA > 0$ —good financial condition $ZDA < 0$ —bankruptcy
8.	Model by Prusak	$ZBP = 1.438 W_1 + 0.188 W_2 + 5.023 W_3 - 1.871$ $W_1 = (\text{Net profit} + \text{Depreciation}) / \text{Liabilities}$ $W_2 = \text{Operating costs} / \text{Short-term liabilities}$ $W_3 = \text{Profit on sales} / \text{Assets}$ $ZBP \geq -0.295$ —good financial condition $ZBP < -0.295$ —bankruptcy $-0.7 \leq ZBP \leq 0.2$ —“uncertainty area”, no definition of the financial situation
9.	Model of the Institute of Economic Sciences of the Polish Academy of Sciences “G” by Mączyńska and Zawadzki	$ZEM_2 = 9.498 W_1 + 3.566 W_2 + 2.903 W_3 + 0.452 W_4 - 1.498$ $W_1 = \text{EBIT} / \text{Assets}$ $W_2 = \text{Equity} / \text{Assets}$ $W_3 = (\text{Net profit} + \text{Depreciation}) / \text{Liabilities}$ $W_4 = \text{Current Assets} / \text{Short-term liabilities}$ $ZEM_2 > 0$ —good financial condition $ZEM_2 < 0$ —bankruptcy
10.	Model by Maślanka	$ZTM = -0.41052 + 1.59208 W_1 + 4.35604 W_2 + 5.92212 W_3$ $W_1 = \text{Working capital} / \text{Assets}$ $W_2 = \text{Cash from operations [segment A with cash flow]} / \text{Assets}$ $W_3 = (\text{Profit from operations} + \text{Depreciation}) / \text{Liabilities}$ $ZTM > 0$ —good financial condition $ZTM < 0$ —bankruptcy

S o u r c e: Authors' own elaboration based on: Mączyńska, 1994, pp. 42–45; Gajdka and Stos, 1996, pp. 56–65; Hadasik, 1998, pp. 22–37; Wierzbza, 2000, pp. 79–104; Hołda, 2001, pp. 306–310; Hamrol, 2004, pp. 34–38; Appenzeller and Szarzec, 2004, pp. 120–128; Prusak, 2005, p. 151; Mączyńska and Zawadzki, 2006, pp. 225–228; Maślanka, 2008, pp. 206–208, pp. 230–241.

4. Research findings/ results

Based on a sample of 30 companies, 10 models using the linear discriminant function were verified. The calculations were made for 5 research periods, of which the article presents the results only for the last study period. It was the year in which the “bankrupt” enterprises announced liquidation. Tables 3 and 4 present the results of the assessment of the financial condition of enterprises made using selected discriminant analysis models. The “B” designation in the table refers to bankrupt enterprises, while the “H” designation refers to healthy enterprises.

Table 3. Presentation of the results of the survey for the last period analyzed
(year of declaration of bankruptcy)

Model Enterprise	Model by Mączyńska	Model by Gajdka and Stos	Model by Hadasik	Model by Wierzba	Model by Hołda	Poznań model	Model by Appenzeller and Szarzec	Model “G” IE PAS	Model by Prusak	Model by Maślanka
B1	4.71	-1.1	-0.821	-1.457	-4.180	0.950	0.858	-1.868	0.819	-3.311
B2	-1.100	0.816	2.103	0.602	1.607	0.625	-0.914	0.874	0.514	3.707
B3	2.516	-1.082	0.519	1.157	-2.889	-1.059	0.785	0.879	-1.868	-0.583
B4	0.966	0.702	0.714	0.489	1.308	0.826	1.978	0.527	0.874	1.065
B5	-3.265	-2.807	-1.872	-3.327	-3.895	-2.337	-0.884	-0.878	-1.879	-0.747
B6	-0.924	0.735	-0.705	2.017	0.613	-0.684	-3.912	-1.245	-0.827	-2.956
B7	1.168	3.959	-1.442	0.718	-0.948	-2.818	-2.361	0.914	0.973	-2.415
B8	-2.078	-1.641	0.942	-2.468	-3.577	0.928	-1.140	-0.643	-1.955	-0.479
B9	0.729	0.908	0.712	1.457	3.449	0.885	0.288	-3.544	0.938	1.008
B10	-0.513	1.094	1.231	1.730	-0.549	-0.119	-2.994	-0.592	1.736	-2.602
B 11	-0.326	-2.402	0.655	-0.524	1.375	1.983	2.027	0.679	0.956	-1.249
B12	-0.326	-0.833	-1.502	-0.939	-1.401	-0.699	-0.669	-1.631	1.528	-2.536
B13	0.961	0.717	-0.799	-1.278	-1.521	0.379	-1.192	1.144	-1.629	0.725
B14	-1.298	-1.871	0.516	-2.186	-2.727	-1.284	0.278	-0.572	-1.833	-1.092
B15	-2.167	-0.819	-1.298	0.728	-0.598	-2.163	-0.922	-1.328	-2.199	-0.591
H1	1.715	0.982	2.311	-0.717	3.112	1.332	0.713	0.933	1.711	1.291
H2	-0.322	1.114	-0.799	-2.133	1.771	1.225	1.299	0.567	0.912	0.781
H3	1.819	-0.899	-1.299	-0.483	0.776	4.311	0.911	1.234	3.719	1.992
H4	1.922	2.112	3.144	1.257	1.387	-0.992	-1.223	3.991	3.712	3.198
H5	2.392	0.994	0.566	2.388	2.311	1.771	-0.931	-0.783	-2.392	-0.921
H6	7.192	3.282	0.927	2.109	3.134	3.189	3.216	3.193	-1.781	1.732
H7	-0.931	1.299	-1.922	3.671	-0.478	-0.766	-0.299	1.872	-1.253	-0.924
H8	3.293	-0.879	2.133	-0.911	-0.989	-1.348	0.597	1.739	-3.839	0.782
H9	5.133	3.221	0.988	1.673	1.421	3.288	-0.577	-1.829	0.938	0.663
H10	-2.193	-0.989	-0.919	0.344	0.577	1.284	1.221	-0.799	0.821	-0.582
H11	-0.993	1.226	0.566	-0.388	1.654	2.576	-0.719	1.788	-0.928	-1.241
H12	3.453	-1.244	-1.238	1.922	-0.799	3.199	2.399	2.492	2.183	3.219

H13	2.333	1.024	-1.991	0.799	1.323	-0.772	1.588	2.189	-1.817	2.396
H14	1.348	-2.114	3.122	2.101	3.918	-0.332	-0.280	-0.922	-0.982	3.457
H15	3.477	0.799	3.577	-0.677	1.711	4.312	2.711	3.782	1.293	-1.294

S o u r c e: Authors' own elaboration based on the financial statements of the entities surveyed from the EMIS website.

In the examined period, the A. Hołda model had the highest prognostic reliability in 73.3% correctly diagnosed financial condition of enterprises (22 correct and 8 incorrect assessments, respectively). The second model with the highest prognostic reliability was the one by Maślanka with 70% forecast effectiveness (21 correct and 9 incorrect results). The third position was taken by two models by Mączyńska with 66.7% efficiency (20 correct and 10 incorrect assessments). Table 4 presents the classification of all models based on the relevance of the results for the last year of the study.

Table 4. Early warning model results classified by the accuracy of the results obtained for the last year of the study

Model	Forecast accuracy (in %)	Number of correct grades	Number of incorrect ratings	
			First degree error	Second degree error
Model by Hołda	73.3	22	3	5
Model by Maślanka	70.0	21	5	4
Model of IE PAS by Mączyńska and Zawadzki	66.7	20	4	6
Model by Mączyńska	66.7	20	4	6
Poznań model (Hamrol)	60.0	18	5	7
Model by Appenzeller and Szarzec	60.0	18	6	6
Model by Gajdka and Stos	60.0	18	5	7
Model by Hadasik	53.3	16	6	8
Model by Wierzba	53.3	16	6	8
Model by Prusak	50.0	15	7	8

S o u r c e: Authors' own elaboration based on the survey results.

The obtained results show the classification of the models used by the authors in the study. Noteworthy is the fact that each of the 10 models has obtained prognostic reliability of 50% and more. However, it should also be added that in the same period none of the models was more than 80% effective. In most models, the second degree error was more common than the

1st degree. Only in one model it was opposite. In one model, the number of incorrect diagnoses of the first and the second kind was the same.

5. Discussion

The use of discriminatory models to assess the financial situation of an enterprise in the context of early warning methods, in addition to many advantages, also has a number of limitations. One of the disadvantages is the occurrence of outdated phenomena, which results from constant changes in the economic conditions of entities operating on the market. Hence, models developed several years ago may fail, thus hindering a reliable forecast of the financial situation of the twenty-first-century enterprises.

An important issue from the point of view of the methods used for testing is the complex construction of models, which is due to the differing diagnostic parameters taken into account in the models and omission of qualitative factors. This results in discrepancies in the financial assessment of economic entities (economic result).

The fact that discriminatory models are highly useful cannot be discussed. The models mostly include data from enterprise balance sheets and profit and loss accounts. The reason for the incorrect financial standing of enterprises may be the so-called clever accounting procedures (including creative accounting), or even the sale of company assets resulting in only a short-term increase in cash.

The study conducted by the authors is one of the few among many such scientific publications. For example, many science employees use early warning models to examine the financial condition of enterprises or verify the effectiveness of forecasts, but in this area of scientific research there is still a scientific gap. Enterprises outside the SEZ are mainly surveyed.

Only Wojciech Lichota in the article *Verification of the effectiveness of prediction of selected models of discriminant analysis on the example of enterprises operating in special economic zones in Poland and others* (Lichota, 2018) undertook a similar task by testing zone enterprises. Other authors, e.g. Paweł Antonowicz (2010), Emilia Grzegorzewska and Henryk Runowski (2008) or Dariusz Zarzecki (2003)—rated early warning models but not on enterprises located in the SEZ.

6. Conclusion

Based on the conducted research, it can be concluded that the discriminatory models used in the study reflect the financial situation of enterprises well (73% level). It is important to note that some models indicated a good financial situation of the company, while others indicated a weak financial situation. For example, in most models, the 2nd degree error was more common. The reverse situation took place only in one model (model by Maślanka). There was also a case in one of the models, where the number of incorrect diagnoses of the 1st and 2nd kind was the same (model by Appenzeller and Szarzec).

Conducting an effective analysis of the financial situation (i.e. one that will give meaningful results) based on discriminatory models requires the use of at least several models, hence the authors of the article used calculations of 10 models. The highest predictive reliability

was the model by Hołda, which in 73.3% correctly diagnosed the state of financial condition of enterprises (correct 22/ incorrect 8).

The conducted research showed that universal discriminatory models can also be applied to enterprises operating in Special Economic Zones. The results do not differ significantly from surveys that were conducted on a sample of enterprises operating outside the zone. It could therefore be concluded that the fact of operating in enterprises in the Special Economic Zone does not affect the lower efficiency of the models used. It is worth adding, however, that this article should be treated as an introduction to further research and analysis. The authors' intention is to create a model that would reflect the specificity of enterprises operating in the SEZ. The above study is an attempt to draw attention to the still existing research gap in this area. According to the authors, it is worth focusing on adapting the existing early warning models to changing economic conditions, so that their effectiveness and prediction of bankruptcy is as high as possible.

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Ocena skuteczności modeli wczesnego ostrzegania na przykładzie przedsiębiorstw działających w specjalnych strefach ekonomicznych

Abstrakt: Celem artykułu jest weryfikacja skuteczności wybranych dziesięciu modeli analizy dyskryminacyjnej na przykładzie 30 przedsiębiorstw działających w specjalnych strefach ekonomicznych w Mielcu i w Tarnobrzegu. W badaniu zastosowano metody analizy danych i analizy dyskryminacyjnej. Wykorzystano dane publicznie dostępne, pochodzące głównie ze sprawozdań finansowych przedsiębiorstw. Badanie przeprowadzono na próbie 30 przedsiębiorstw (w tym 15 upadłych i 15 określanych jako „zdrowe”), działających w strefach Euro-Park Mielec i Euro-Park Wisłosan Tarnobrzeg. Zakres czasowy badań to lata 2009–2017. Przeprowadzone analizy wykazały, że niektóre modele w prawidłowy sposób odzwierciedlają sytuację finansową badanych przedsiębiorstw (np. model Artura Hołdy – 73,3% trafnych prognoz), ujawniły także potrzebę zastosowania wielu modeli analizy dyskrymina-

cyjnej do dokładnej analizy sytuacji finansowej przedsiębiorstwa – użycie jednego tylko modelu prowadzić może do wyciągania nieprawidłowych wniosków. Wykorzystanie modeli dyskryminacyjnych do oceny sytuacji finansowej przedsiębiorstw w wielu przypadkach opiera się na metodach wczesnego ostrzegania. Wspomniane metody charakteryzują się zarówno zaletami, jak i pewnymi ograniczeniami; jedną z wad jest szybki spadek skuteczności modeli ze względu na ciągłe zmiany warunków ekonomicznych podmiotów działających na rynku. Dlatego modele powstałe przed kilkunastoma laty mogą być mniej skuteczne niż odpowiednio nowsze metody. Co do zalety, to podkreślić należy przede wszystkim prostotę zastosowania takich narzędzi oraz jednoznaczne wyniki – które w porównaniu na przykład do tradycyjnej analizy wskaźnikowej pozwalają na uniknięcie błędów w interpretacji wyników.

Słowa kluczowe: analiza dyskryminacyjna, sytuacja finansowa przedsiębiorstwa, modele wczesnego ostrzegania, bankructwo, przedsiębiorstwa w Polsce