VERIFICATION OF EARLY WARNING MODELS ON ENTERPRISES FROM THE SEZS EUROPARK MIELEC

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Abstract: In this article the authors focus on the verification of models for forecasting bankruptcy of enterprises. 30 enterprises located in the Mielec zone were surveyed. Early warning models were used in the study, including 6 discrimination models and 4 logit models. The purpose of the article is to verify the effectiveness of selected models for forecasting the bankruptcy of enterprises that operate in the Mielec special economic zone. The financial data came from the period 1999-2017. It should be noted that "healthy" enterprises, i.e. those in good financial condition, operate in the zone to date. The conducted research shows that the selected models correctly reflected the financial situation of the surveyed enterprises (Institute of Economic Sciences of the Polish Academy of Sciences model of F. Mączyńska and M. Zawadzki 80% accurate forecasts, and the model of J. Gajdka and D. Stos 73.3%). The authors point out the need to use many analysis models to reliably assess the financial situation of enterprises. If only one model is used, the results may lead to erroneous conclusions.

Keywords: financial situation of an enterprise, early warning models, company bankruptcy forecast, special economic zone.

Introduction

Mielec SEZ belongs to the group of leading industrial zones in Poland. It is located in a town of 61 thousand, located in the south-eastern part of Poland, in Podkarpackie Province. The zone creates favourable conditions for new investments, both domestic and foreign. In addition to aviation, the dynamically developing sectors in the zone include automotive, metalworking and plastics processing. The largest foreign investors are companies from the USA, Germany, Austria and Italy.

The areas covered by the status of special economic zones, at the end of December 2004, covered an area of approx. 6526.3 hectares (i.e. 0.02% of the country), they occupied the

territory of 79 cities and 55 rural municipalities. According to the legal status, as at December 31, 2017, the total area of areas covered by Special Economic Zones could not exceed 25,000. ha (i.e. 250 km2), and the period of their existence was determined by the end of 2026 (PARP, 2018).

It is worth mentioning that the Polish Investment Zone replacing the previous SEZ is an instrument that is designed to support the sustainable development of the Polish economy. In accordance with the Act of May 10, 2018 on supporting new investments, the existing permits to conduct business activities in Special Economic Zones (SEZ) remain in force until the end of 2026 (Waćkowska-Kabaczyńska, 2019). The newly created tool stimulates areas that have been defined in the Strategy for Responsible Development (among others: stimulation of entrepreneurship, innovation of companies, or foreign expansion of Polish enterprises).

The reason for researching the enterprises of the Mielec zone, created as one of the first in 1995, are the authors' scientific interests in the activities of zone companies that efficiently attract foreign capital, and more often implement new technical and technological solutions, thus affecting the competitiveness of the manufactured products and services rendered.

The process of continuous adaptation to changing environmental conditions (including legal, fiscal or administrative regulations) and increasingly demanding customers are the requirements that 21st century enterprises must meet.

At a time when a different political system prevailed in Poland (centrally planned economy) the phenomenon of bankruptcy did not occur.

The turn of the1990s in Poland brought about important political changes in the country. The fact is that the transition from a centrally planned economy to a market economy gave Poland a chance to modernize the country. One of the tasks was to reduce the distance in relation to the highest and most developed EU countries.

In 1997, the social market economy was recognized as the constitutional basis of the Polish economic system, and the inspiration was the experience of Germany, which, drawing on the doctrine of ordoliberalism, built a social market economy and achieved spectacular success after World War II (Przybyciński, 2009, p.192).

Immediately after 1990 there was widespread enthusiasm for starting new private companies; this enthusiasm is measured at an economical level through entrepreneurial indicators – in the short term, the number of private companies increased, but, as enthusiasm was not always a good substitute for managerial skills and experience, many newly-founded companies faced bankruptcy (Pirtea, 2003).

The phenomenon intensified with the appearance of periods of recession in the country, when the financial policy was upset, which could have resulted in the company's insolvency. Taking into account the above changes and phenomena, the article attempts to assess the effectiveness of selected models for forecasting the bankruptcy of enterprises, companies from Special Economic Zones of Europark Mielec, using 6 discriminative models (as the most popular tools) and 4 logit models.

Literature review

Many different models have been formulated in the theory and practice of predicting business bankruptcy (in economic terms of bankruptcy). McKee (T.E. McKee, 2000) presented an exhaustive classification listing the following types of procedures and models:

- one-dimensional indicator models,
- multidimensional discriminatory 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 discriminatory model whose task was bankruptcy forecast was E. Mączyńska's model. The author used a multiplication model of simplified discriminant analysis to predict the bankruptcy of Polish companies (Mączyńska, 1994). The creation of the model was associated with the adaptation of E. Altman's western model (or Z-score model) to Polish conditions. Thanks to E. Altman, a precursor in forecasting threats to the functioning of enterprises, we can talk about the dynamic development of early warning models.

A developed application of Fisher's linear discriminant function is the bankruptcy prediction model for Polish companies presented in the work of Gajdka and Stos (1996), where the sample of industrial enterprises surveyed was equal to 40 entities, half of which were bankrupt, and the other half – "healthy", listed on Warsaw Stock Exchange.

Discriminant analysis methods are free from one major drawback to indicator analysis, namely the difficulty of clearly and accurately assessing a company's financial position. According to T. Korol, the most effective method in forecasting the bankruptcy of companies among all statistical methods is multidimensional discrimination analysis (Korol, 2010, p. 158). At the same time, current research allows the conclusion that there is not actually one correct model for assessing the threat of bankruptcy of an enterprise (Mączyńska, Zawadzki 2006, p. 228). The table below is presented, detailing the research of selected authors with the largest number of discriminatory models used, as well as the number of enterprises surveyed.

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
P. Antonowicz	41	208	90
R. Balina	27	60	30
G. Gołębiowski, K. Żywno	25	10	10
O. Rusek	23	6	6
R. Balina, J. Pochopień	22	40	
A. Czarny	21	26	
D. Mirowska, M. Lasek	21	30	15
L. Czapiewski	20	94	48
E. Grzegorzewska, H. Runowski	10	51	
W. Lichota	10	5	

Source: Kitowski, 2017, p. 181.

The above data show that the most numerous population of discriminatory models used in the study (41) and the number of enterprises (89 companies declared bankrupt and 119 companies not at risk of losing their financial condition) was examined by P. Antonowicz (Antonowicz, 2010, p. 19); then L. Czapiewski, who examined 94 companies, 48 of which were threatened with bankruptcy, and 46 enterprises were in good financial condition (Czapiewski, 2009, p. 123), and R. Balina, who used 27 discriminatory models to study 60 enterprises, including 30 at risk of bankruptcy (Balina, 2012, p. 233-234).

The results of the study showed the effectiveness of individual models. Not all of the verified models achieved the effectiveness of results above half. Therefore, not all of the models used can be considered fully effective, because the results below 50% of the effectiveness of diagnoses show a high probability of getting an incorrect diagnosis. From the study, only the three best models in this respect can be considered reliable, and their effectiveness above the 65% threshold may give hope for getting the correct diagnosis. In the case of other tools (even those that exceeded the performance threshold above 50%), such chances significantly decrease.

The conducted research results and their confrontation with the declared prognostic values of the authors themselves and with other research results may indicate that early warning models have a certain useful life. They have remained highly effective since their inception for a certain unspecified period of time. None of the studies carried out brings the exact period, whether it is 4, 5 or 8 years from the time of its creation.

The obtained results and their comparison to other applications of this type show that despite the huge range of different tools used to assess financial condition and forecast it in the future, only some of them can actually be used. In the case of the conducted research, only three of all the models used were effective at a level that provided adequate results.

Research sample and research methodology

The basis for all the methods used in the article was the analysis of existing data. The analysis includes: a systematic review of the literature, analysis of public data, including data of the Ministry of Economy, and financial data on enterprises (primarily income statement, balance sheet).

Based on the collected financial data, 30 enterprises located in the Europark Mielec SEZ – i.e. 15 bankrupt and 15 termed "healthy"; 10 early warning models were verified (6 discriminative models and 4 logit models).

The selection of enterprises, apart from operations in the same zone, also concerned a similar business profile, the number of employees, and the size of assets. All enterprises operated (operate) in the broadly understood industrial sector. The financial data came from the period 1999 - 2017. It is also worth adding that healthy enterprises still operate in the zone. The model of R. Jagiełło was selected for discriminatory models. The author, while creating the model, took into account the specifics of the industry in which a given company operated.

The following models were evaluated:

Discriminatory models:

- model of M. Pogodzińska and S. Sojak

Z_{PS} = 0.644741W1 + 0.912304W2

W1 = (Current assets - Inventories) / (Short-term liabilities)

W2 = (Gross result) / (Sales revenues)

ZPS > 0 good financial condition

ZPS < 0 bankruptcy threat (Pogodzińska, Sojak, 1995);

- model of S. Sojak and J. Stawicki

ZSS bad = -11.6499 - 0.1144W1 + 0.5178W2 - 20.4475W3 - 0.0661W4

ZSS average = -2.3333 - 0.0586W1 - 3.3608W2 + 10.7088W3 + 0.1455W4 - 0.066W5 + 4.5837W6 + 2.4329W7

ZSS good = -5.992 - 0.0153W1 + 2.0482W2 + 9.637W3 + 0.1714W4 - 0.0091W5 - 15.78W6 - 0.0018W7

W1 = (Net profit) / Current assets average) * 100

W2 = (Current Assets - Inventories - Short-term prepayments) / (Short-term liabilities)

W3 = (Average annual working capital) / Average annual assets)

W4 = (Net profit) / (Equity average) * 100

W5 = (Net profit) / Non-current assets average) * 100

W6 = (Net result + Interest on foreign capital - income tax) / (Average assets)

W7 = (Current assets) / (Short-term liabilities)

ZSS > 0 good financial condition

ZSS < 0 bankruptcy threat (Sojak, Stawicki, 2001);

- model of J. Gajdka and D. Stos

ZJG2 = -0.0005W1 + 2.0552W2 + 1.7260W3 + 0.1155W4 - 0.3342

W1 = (Short-term average annual liabilities - 360) / (Production costs)

W2 = (Net profit) / (Annual assets)

W3 = (Gross profit) / (Sales)

W4 = Assets / Liabilities

ZJG2 > 0 good financial condition,

ZJG2 < 0 bankruptcy

-0.49 <= ZBP =< 0.49 – uncertainty area, no definition of the financial situation (Stos, Gajdka, 2003).

- B. Prusak's model

ZBP = -1.5685 + 6.5245W1 + 0.148W2 + 0.4061W3 + 2.1754W4

W1 = (EBIT) / (Assets)

W2 = (Operating costs) / (Short-term liabilities)

W3 = (Current assets) / (Short-term liabilities)

W4 = (EBIT) / (Total revenues)

ZBP >= -0.13 good financial condition,

ZBP < -0.13 bankruptcy

-0.13 =< ZBP = < 0.65 "area of uncertainty", no determination of the financial situation (Prusak, 2005);

- Model "F" of the Institute of Economic Sciences of the Polish Academy of Sciences E. Mączyńska and M. Zawadzki

Z_{EM2} = -2.478 + 9.478W1 + 3.613W2 + 3.246W3 +0.455W4 + 0.802W5

W1 = EBIT / (Assets)

W2 = (Equity) / (Assets)

W3 = (Net profit + Depreciation) / (Liabilities)

W4 = (Current Assets) / (Short-term liabilities)

W5 = (Total revenues) / (Assets)

ZEM2 > 0 good financial condition,

ZEM2 < 0 bankruptcy (Mączyńska, 2006);

- R. Jagiełło model for the 'Industry' sector

W = -1.8603 + 12.296W1 + 0.1675W2 + 1.399W3

W1 = Profit (loss) on gross sales / Operating expenses

W2 = Total revenues / Assets

W3 = Equity / Assets

With < 0 there is a high probability that this company will be classified as at risk over the next year

Z > 0 company not in danger of bankruptcy (Jagiełło, 2013).

Logit models:

- T. Korol model

ZTK = 2.0 - 10.19W1 - 4.58W2 - 0.57W3

W1 = Profit on sales / Assets

W2 = (Net profit + Depreciation) / Liabilities

W3 = Operating costs / Short-term liabilities

ZTK <= 0.5 good financial condition,

ZTK > 0.5 bankruptcy.

This is a conventional limit value, because the author himself did not specify such a level. The value of 0.5 was due to the fact that the learning sample roughly contained a 50%/50% bankrupt/non-bankrupt ratio. Hence the limit value adopted in this way (Korol, 2010).

- model of D. Wędzki

ZDW = -4.0 - 6.0W1 + 9.387W2 - 2.088W3 + 1.317W4 + 0.04W5 - 4.217W6

W1 = (Current assets + Prepayments) / (Short-term liabilities and Special funds + Prepayments and deferred income)

W2 = (Provisions + Long-term liabilities + Short-term liabilities and Special funds + Accruals and deferred income) / Assets

W3 = Interest payable / (Profit (loss) on business activities + Interest payable)

W4 = [Net profit (loss) / Equity] / [(Net profit (loss) + Interest payable * (1- Obligatory encumbrances on the financial result / Gross profit (loss))) / Assets]

W5 = Short-term receivables * Number of days in the period / Net revenues from sales

W6 = Profit (loss) on sales / Net revenues from sales

ZDW =< 0.5 good financial condition,

ZDW > 0.5 bankruptcy (Wędzki, 2005).

- M. Gruszczyński model,

on the form of the function: ZMG = 4.3515 + 22.8748W1 - 5.5926W2 - 26.1083W3,

W1 = Gross profit/Total revenues

W2 = Liabilities/Assets

W3 = Inventory/Total revenues

where: ZMG > 0, the audited entity is in good financial standing (Gruszczyński, 2003)

- P. Stępnia and T. Strąk model,

on the form of the function: ZSS = −19 - 11W1 + 6W2 + 40W3 + 19W4,

W1 = Foreign capital/Total capital

W2 = (Current assets - Inventories)/Short-term liabilities

W3 = Net profit/Total capital

W4 = Sales revenues/Operating expenses

where: ZSS > 0, the examined entity is in good financial standing (Stępień, 2004).

Results of empirical research

Based on a sample of 30 surveyed enterprises, calculations were made for 5 research periods. Due to the volume, the results are presented only for the last study period. It was the year in which the "bankrupt" enterprises announced their liquidation.

Five consecutive reporting periods of enterprises were examined, of which the most recent (the last period analyzed) was the year of declaration of bankruptcy by the enterprises belonging to its bankrupt group.

The table below presents the classification of all models, assuming the accuracy of the results for the last year of the test.

Table 2.
Classification of early warning models according to the accuracy of the diagnosis – last year of the study

Model	Number of correct grades	Number of incorrect ratings	Number of incorrect ratings		Percentage of accurate forecasts
			First degree error	Second degree error	
Model "F" of the Institute of Economic Sciences of the Polish Academy of Sciences E. Mączyńska and M. Zawadzki	24	6	1	5	**80%**
Model of J. Gajdka and D. Stos	22	8	2	6	**73.3%**
Model of R. Jagiełło	20	10	4	6	**66.7%**
Model of Sojak and Stawicki	18	12	7	5	**60%**
Model Stępnia and Strąka	17	13	5	8	**56.7%**
Model of T. Korol	16	14	6	8	**53.3%**
Model of D. Wędzki	16	14	5	9	**53.3%**
Model of B. Prusak	16	14	7	7	**53.3%**
Model of M. Gruszczyński	13	17	6	11	**43.3%**
Model of Pogodzińska and Sojak	12	18	6	12	**40%**

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

As the data show, for the last year of the study the model of the Institute of Economic Sciences of the Polish Academy of Sciences of E. Mączyńska and M. Zawadzki with 80% forecast accuracy, and the J. Gajdka and D. Stos model with 73.3% accuracy were characterized by the highest prognostic reliability. These models correctly diagnosed the financial condition of enterprises in the proportion of 24 correct to 6 incorrect results in the first model, and in the case of the second model 22 to 8. The obtained results show the classification of early warning models used by the authors according to the accuracy of the diagnosis for the last year of the study.

Noteworthy is the fact that 8 out of 10 models have obtained prognostic reliability of over 53% and more, except for the model of M. Gruszczyński (43.3%) and the model of Pogodzińska and Sojak (40%). It can be seen that in the analyzed period none of the models had a predictive effectiveness above 80%.

In the case of both examined groups of enterprises, i.e. healthy and bankrupt ones, guided by the criterion of their financial condition, researchers can make an appropriate or incorrect diagnosis, which results in the occurrence of a 1st and / or 2nd degree error. Occurring in the case of an incorrect diagnosis – 1st degree error concerns the incorrect allocation of enterprises in good financial condition to a group of bankrupt (bankrupt companies), and the second degree error concerns the incorrect assignment of enterprises referred to as bankrupt to enterprises in good financial condition. The discussed errors considered in the category (ex ante), prediction errors (ex post), indicate an incorrect classification of the surveyed enterprise in the set time horizon (Pociecha, 2007).

In most models, a second degree error was more common than a first degree error. In only one model was the situation opposite (Sojak and Stawicki's model). In one of the models the number of incorrect diagnoses of the first and second kind was the same (B. Prusak's model).

Summary

The actual state of the economic crisis severely affected young Eastern European private companies, including in Poland. The uncertainty of the medium- and short-term situation of a company caused unwanted market blockages (Slavici, Maris, Pirtea, 2015, p. 387). 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), Dorneanu et al. (2011).

The results of the research, which aimed to assess the effectiveness of selected models for forecasting the bankruptcy of enterprises from the Mielec SEZ, confirm the validity of the research. Each of the 10 models used obtained 50% or more prognostic reliability.

None of the models in the same period was more than 80% effective. The selected models properly reflected the financial situation of the surveyed enterprises (the model of the Institute of Economic Sciences of the Polish Academy of Sciences of E. Mączyńska and M. Zawadzki obtained as much as 80% of accurate forecasts, and the model of J. Gajdka and D. Stos 73.3%).

In most models, the second degree error was more common than the 1st degree. The reverse occurred in only one of the models. In only one of the models was the number of incorrect diagnoses of the first and second kind the same.

Studies show that the time of creation of the model is not the main determinant of its effectiveness. Models that were created earlier assess the financial situation as well as models

that were created later. Therefore, it is difficult to determine the useful life of a given model. However, one should not forget about the choice of methods to assess the financial condition of enterprises, which is dictated naturally by industry matching. Its task is to reduce the risk of incorrect model mapping.

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