Application of discriminant models in predicting a company's risk of bankruptcy

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Abstract:

Aim: The aim of the paper is to review Polish discriminant models and their application to predict bankruptcy on the examples of selected joint stock companies in the years 2013-2015.

Design / Research methods: The paper was written on the basis of literature search within the scope discussed. Further, the authors carried out their own examination of certain joint stock companies listed on the Warsaw Stock Exchange (WSE). The discriminant analysis was conducted on the basis of financial statements of the selected companies using Mączynska's model, the model developed by Gajdka and Stos, Hadasik's model and the Poznański model.

Conclusions / findings: The analysis shows that not all discriminant models reflect changes in the financial condition of a company. Nevertheless, they are a good tool to evaluate the risk of failure, provided that more than one model are used.

Originality / value of the article: Discriminant models are universal, which means that they can be applied to any company, regardless of the industry they operate in. The results of the analysis can be used as a basis for further studies on the accurate adjustment of discriminant models to companies, depending on the type of business.

Keywords: bankruptcy, company's bankruptcy, discriminant models.
JEL: G30.

1. Introduction

The ever changing global economy of today has the effect that companies operate in an environment that is much unpredictable and full of risk. In market economy, there are no guarantees that a company will be successful and will stay in business. Companies which are capable of adapting to unstable conditions are likely to survive. Those which, for whatever reasons, do not evince such abilities run the risk of either being taken over by another entity or going bankrupt. The phenomenon of the company's failure is a sort of a natural regulator in the economic system, leading to replacing some resources with the more useful ones in that companies which are not efficient and cannot withstand competition simply disappear (Hadasik 1998). One could argue that bankruptcy is some sort of an economic selection which is conducive to cleansing economy from entities which are incapable of adapting to the demands of the market. However, in practical terms, one cannot determine with such clarity the significance of the bankruptcy process. Nowadays in a globalizing world there are numerous links between both domestic and foreign business entities. Thus, failure of one company may have far reaching consequences which are felt across regions, impacting an entire economy. That is why anticipating risks involved in the functioning of a company and predicting its failure continuous to be a very much alive issue.

One of the possibilities of early warning against the company's failure are quantitative models for predicting bankruptcy, that is, discriminant models. The aim of this paper is to review Polish discriminant models for predicting a company's failure and their application based on the examples of selected companies.

In the first part of the paper, the terms liquidation and bankruptcy are explained with the indication of differences between the two. Next, the discriminant models developed by Polish economists are demonstrated. Further, an analysis of bankruptcy risk employing the selected discriminant models is conducted on the example of three joint stock companies listed on the stock exchange. The findings obtained based on the analysis conclude the paper.

The study was carried out on the basis of individual financial statements for the years 2013-2015.

2. Company's failure vs. company's bankruptcy

Taking into consideration the economic and legal sphere, the term failure should be distinguished from bankruptcy. The company's failure is an economic term, while bankruptcy a legal one.

In economic terms, a failed company is a company which is unable to pay its debts and the value of its assets is not sufficient to cover all its obligations. In legal terms, bankruptcy of a company comes after the company has been declared bankrupt by court. Its purpose is to satisfy, in equal measure, all creditors' claims against the debtor who cannot compensate every one of them separately. This should prevent the conduct of enforcement proceedings against the debtor by only some of the creditors: when other creditors do not yet have an enforcement title, e.g. when their debts are not payable yet, and in a situation when there is a priority system regarding the enforcement proceeding. This means that the fact of going bankrupt is determined by the court based on a petition filed either by a debtor, creditor or a group of creditors. In the first case we talk about a voluntary bankruptcy, and in the latter – an involuntary bankruptcy. The main reason behind filing petition for bankruptcy under Polish law (Ustawa z dn. 28.02.2003 r.)) is the cessation of paying one's liabilities for a considerable period of time. A short-term cessation of payment due to temporary difficulties therefore does not constitute grounds for declaring bankruptcy. The law provides that bankruptcy is declared for a debtor who has become insolvent (Mączyńska, Zawadzki 2006). Thus, the economic bankruptcy could be defined as a state in which a company has no possibilities to continue its operations independently in such a way as to have its competitive capacity restored, as well as its profitability, liquidity and solvency (here understood as holding company's assets whose market value is sufficient to cover all debts), without any external aid. Moreover, legal bankruptcy, also referred to as judicial bankruptcy, could be defined as a set of rules and procedures governed by the Bankruptcy and Restructuring Act comprising, for example:

- bankruptcy declaration of an economic entity
- Conduct and completion of bankruptcy proceeding

Conducting and completing a bankruptcy proceeding encompasses, among other things: valuation and selling of the debtor's assets to satisfy creditors' claims, which allows the desired objectives to be attained, such as: fairness in the distribution of a debtor's assets, satisfying creditors' claims from the assets to the highest degree possible, liquidation of economic units whose competitive ability cannot be restored and other. In the further part of the paper, bankruptcy and failure are used interchangeably in economic terms.

3. Discriminant models as an early-warning tool

The research in developed market economies suggests that bankruptcy does not occur all of a sudden. There is a variety of warning signals which can be spotted well in advance. This gives a company a chance to take appropriate corrective actions so as to prevent the company from going bankrupt. Therefore, knowing early enough the reasons which may lead to the company's failure is crucial. To this end, it is necessary to use tools which would allow for an early identification of bankruptcy risk. In this respect, some help can be offered by a discriminant analysis, which is becoming an increasingly attractive instrument for bankruptcy risk assessment.

An exceptionally strong demand for predictive models occurred at the time of Great Depression in the twenties and thirties of the twentieth century. However, a breakthrough came in the sixties in the USA when E. Altman built models which could quickly identify risk in the company's operations. E. Altman is considered to be the precursor to making a transition from univariate to multivariate statistical methods of discriminant analysis applied as a tool to predict bankruptcy. His works gave rise to a dynamic development of early-warning discriminant models, becoming an inspiration to others in their various searches for new solutions in this area.

The changes taking place in the Polish economy in the 1990s prompted Polish scholars to take interest in bankruptcy prediction models, while taking notice of the fact that the foreign models were not adapted to the Polish environment. The first

Polish paper on quantitative surveys of companies' failure is by D. Hadasik. The authors of subsequent works focusing on the application of the discriminant analysis in predicting bankruptcy risk, among others, include: A. Hołda, E. Mączyńska i M. Zawadzki, J. Gajdka and D. Stos as well we D. Wierzba (Tłuczak 2013: 426).

In literature, the disriminant models are also referred to as Z-score function because they reduce the evaluation of the company's condition to the analysis of a single indicator. This indicator connects various financial indicators in a weighted way. The value of the Z function is determined based on the data coming from financial statements. This method allows for a clear assessment of the company's financial situation. The discriminant function applied to examine the company's risk of failure is given by (Galbarczyk, Świderska 2011: 265):

$$Z = ax_1 + bx_2 + cx_3 + \cdots + dx_n \qquad (1)$$

where:
$x_1 - x_n$ - indicators characterizing a company which are selected on the basis of an empirical examination of the reported data from a great number of companies with satisfactory liquidity and at risk of failure.
a, b, c, d...- estimated parameters of the model (weight).

The studies show that the discriminant functions are an effective tool in formulating bankruptcy forecasts (Rólczyński 2006). It is estimated that their effectiveness is rather high and ranges between 80 and 90% , depending on the model (Hamrol, Chodakowski 2008). It should be underlined that the models are universal in nature and no findings have been made based on the analyses suggesting that there is any relationship between the prediction results and the line of business or the form of ownership.

3.1 Mączyńska's model

Mączyńska's model was built to reflect the need of customizing Altman's model to Polish conditions. E. Mączyńska and Zawadzki have developed 7 early-warning models. The authors carried out an analysis on a balanced sample of 80 companies listed on the WSE in Warsaw, using the financial statements from the years 1997-

2001, and financial indicators calculated on their basis. The study employed 45 indicators characteristic for profitability, liquidity, debt level, operational efficiency and the companies' growth dynamics. The final version of the model is given by the following formula (Mączyńska, Zawadzki 2006: 7):

$$Z_M = 1{,}5w_1 + 0{,}08w_2 + 10w_3 + 5w_4 + 0{,}3w_5 + 0{,}1w_6 \qquad (2)$$

where:

$$w_1 = \frac{gross\ profit + depreciation}{total\ liabilities}$$

$$w_2 = \frac{balance\ sheet\ total}{total\ liabilities}$$

$$w_3 = \frac{gross\ profit}{balance\ sheet\ total}$$

$$w_4 = \frac{gross\ profit}{sales\ revenues}$$

$$w_5 = \frac{value\ of\ inventory}{sales\ profit}$$

$$w_6 = \frac{sales\ revenues}{balance\ sheet\ total}$$

The interpretation of the results of the discriminant function for this model is as follows:

- negative value of indicator Z indicates a company at risk of bankruptcy,
- positive value, yet less than 1, indicates a weak company, but not at risk of going bankrupt,
- positive value within the range of 1-2, a rather sound company,
- value above 2, a company in a very good financial condition.

3.2 The model by Gajdka and Stos

Another model providing an early warning against possible failure of a company is the model built by Gajdka and Stos. A group of 40 companies was tested operating in the manufacturing, construction and trade sectors and listed on the stock exchange. In this model, the discriminant function is given by (Gajdka, Stos 1996: 59-63):

$$Z_{GS} = 0{,}7732059 - 0{,}0856425 w_1 + 0{,}000774 w_2 \\ + 0{,}9220985 w_3 + 0{,}6535995 w_4 \\ - 0{,}594687 w_5 \qquad (3)$$

where:

$$w_1 = \frac{sales\ revenues}{average\ value\ of\ assetss\ in\ total}$$

$$w_2 = \frac{short - term\ liabilities\ average\ value}{production\ costs\ of\ the\ goods\ sold} \times 360$$

$$w_3 = \frac{net\ profit}{average\ value\ of\ total\ assets}$$

$$w_4 = \frac{gross\ profit}{sales\ reveues}$$

$$w_5 = \frac{total\ liabilities}{total\ assets}$$

Interpretation of the model:

$$Z_{GS} > 0{,}45\ company\ is\ not\ at\ risk\ of\ bankruptcy$$
$$Z_{GS} < 0{,}45\ company\ at\ risk\ of\ bankruptcy$$

3.3 The Poznański model

The Poznański model was developed by M. Hamrol, B. Czajka and M. Piechocki on the basis of investigating financial statements of a 100 Polish commercial companies between 1999 and 2002 (half of the companies were represented by healthy enterprises). The companies considered to be bankrupt where

those for which bankruptcy procedure or arrangement procedure was conducted. The selection of healthy companies was based on the comparable amount of assets (Kisielińska, Waszkowski 2010: 24). The Poznański model is expressed by the following formula (Analizy-Prognozy 2016):

$$Z_p = 3{,}652w_1 + 1{,}588w_2 + 4{,}288w_3 + 6{,}719w_4 - 2{,}368 \qquad (4)$$

where:

$$w_1 = \frac{net\ profit}{total\ assets}$$
$$w_2 = \frac{current\ assets - inventory}{short - term\ liabilities}$$
$$w_3 = \frac{fixed\ capital}{total\ assets}$$
$$w_4 = \frac{net\ sales\ profit}{sales\ revenues}$$

Interpretation of the model:

$$ZP < 0 - a\ difficult\ financial\ situation\ of\ the\ entity$$
$$ZP > 0 - a\ good\ financial\ standing\ of\ the\ entity$$

3.4 Hadasik's model

In developing her model, the author used a sample of firms whose ownership structure varied and largely comprised state enterprises, limited liability companies, joint stock companies and cooperatives. The companies which filed petition for bankruptcy in the Voivodship Court in Poznań, Piła or Leszno between 1991 and 1997 were considered to be bankrupt. They varied in terms of size (it was measured according to the value of the balance sheet total) and in terms of economic sectors they operated in. The model is given by (Hadasik1998):

$$Z_H = 0{,}365426 \times w_1 - 0{,}765526 w_2 - 2{,}40435 \times w_3 + 1{,}59079 \times w_4$$
$$+ 0{,}00230258 \times w_5 - 0{,}127826 \times w_6$$
$$+ 2{,}36261 \tag{5}$$

where:

$$w_1 = \frac{current\ assets}{short-term\ liabilities}$$

$$w_2 = \frac{current\ assets - inventory}{short-term\ liabilities}$$

$$w_3 = \frac{total\ liabilities}{balance\ sheet\ total}$$

$$w_4 = \frac{net\ working\ capital}{total\ liabilities}$$

$$w_5 = \frac{receivables}{sales\ revenues}$$

$$w_6 = \frac{inventory}{sales\ revenues}$$

Interpretation:

$$Z_H < 0 - a\ difficult\ financial\ situation\ of\ the\ entity$$

$$Z_H > 0 - a\ good\ financial\ standing\ of\ the\ entity.$$

4. The application of the discriminant models on the selected examples

The study covered the following three business entities: Bioton S.A., Global Cosmed S.A., Miraculum S.A. The analysis was carried out on the basis of separate financial statements from the years 2013-2015. The businesses under study are joint

stock companies listed on the stock exchange, operating in the pharmaceutical industry. In order to assess the financial conditions of the enterprises the models developed by Mączyńska, by Gajdka and Stos, and the Poznański model as well as Hadasik's model were used. The tables below present the values of the discriminant functions for those companies and their interpretation. Table 1 contains the results obtained for the company Bioton S.A.

Table 1. The value and interpretation of the selected models for the company Bioton S.A.

	Mączyńska's model		Gajdka and Stos's model		The Poznański model		Hadasik's model	
year	value Z_M	interpretation	value Z_{GS}	interpretation	value Z_P	interpretation	value Z_H	interpretation
2013	0.552	weak	1.193	No risk	6.926	Good standing	1.69	Good standing
2014	5.450	Very good	1.640	No risk	7.189	Good standing	1.74	Good standing
2015	-21.3	At risk	-1.051	At risk	4.759	Good standing	1.73	Good standing

Source: Authors' own elaboration.

Table 2 shows the values of the functions for individual models and their interpretation for the company Global Cosmed S.A.

Table 2. The value and interpretation of the selected models for the company Global Cosmed S.A.

	Mączyńska's model		Gajdka and Stos's model		The Poznański model		Hadasik's model	
year	value Z_M	interpretation	value Z_{GS}	interpretation	value Z_P	interpretation	value Z_H	interpretation
2013	1.767	rather good	0.556	No risk	2.651	Good standing	1.31	Good standing
2014	1.388	rather good	0.453	No risk	2.907	Good standing	1.18	Good standing
2015	0.922	weak	0.445	At risk	2.793	Good standing	0.96	Good standing

Source: Authors' own elaboration.

Table 3 shows the values of the functions of the models and their interpretation for the company Miraculum S.A.

Table 3. The value and interpretation of the selected models for the company Miraculum S.A.

	Mączyńska's model		Gajdka and Stos's model		The Poznański model		Hadasik's model	
year	value Z_M	interpretation	value Z_{GS}	interpretation	value Z_P	interpretation	value Z_H	interpretation
2013	-0.593	At risk	4.480	No risk	3.349	Good standing	-1.04	Difficult situation
2014	-0.277	At risk	3.069	No risk	3.980	Good standing	0.10	Good standing
2015	-0.876	At risk	0.585	No risk	4.105	Good standing	0.33	Good standing

Source: Authors' own elaboration.

5. concluding remarks

According to Mączyńska's model, Bioton S.A. was considered to be a company in a poor financial situation. In 2014, the function value increased significantly compared to the previous year and the company was considered to have a very good financial standing. Its situation significantly deteriorated in 2015 (considerable increase in financial costs resulting in net losses) with the company running the risk of bankruptcy, according to the model in question. Hadasik's model indicated a difficult situation in 2013, whereas in the years 2014-2015 showed that the company had a good financial standing. The model by Gajdka and Stos does not predict the company's failure in 2013-2014, however, in 2015 the company was considered to be at risk of bankruptcy. Moreover, the Ponański model assesses the financial situation of Bioton as good for the entire period in question.

According to Mączynska's model, the company Global Cosmed was considered to be a rather good enterprise in the years 2013-2014, yet, in 2015 its financial situation was perceived as poor. The model by Gajdka and Stos indicated that the company was facing difficulties in 2014 (the value of the discriminant function was at the limit value separating the sets) and in 2015 it was at risk of bankruptcy.

According to the Poznański model, at the time in question the company had a good financial standing. Hadasik's model showed the company having a good financial standing in the years 2013-2015, although it could be observed that the function value decreased. While analyzing the financial statement, it could be noticed that in 2015 the company's net profit decreased by 38%, compared with the previous year.

The analysis of the financial situation of the company Miraculum with the application of Mączyńska's model reveals that the company has been at risk of bankruptcy throughout all the years the study covered. The model by Gajdka and Stos qualifies the company as not being at risk of bankruptcy, however, it should be noted that the function value in 2015 decreased significantly compared to the previous years, staying close to the limit value (0.45), which implies a deteriorating financial situation (in 2015, the company recorded net losses). The function value in the Poznański model indicates that in the years 2013-2015 the company had a good financial standing. Hadasik's model indicated the company's difficulties only in the year 2013, while the company's financial situation in the years 2014-2015 was described as good.

The analysis suggests that the classification of a company as either being at risk of failure or not can differ depending on the model selected. The changing situation of the companies under study is not always reflected in the value of the discriminant functions. The authors consider the Poznański model to be the least sensitive to changes of all the models used in the study. According to this model, in all the years covered by the analysis the companies had a good financial standing and were not at risk of bankruptcy. Considering that the company Miraculum saw in the years 2014-2015 its financial results deteriorating which was reflected in, for example, net losses, decrease in sales revenues, increased production costs of the goods sold, the Poznański model should be recognized as inefficient and failing to indicate the risk of bankruptcy. A similar situation occurred for the company Global Cosmed where the Poznański model failed to show the risk of bankruptcy despite the drop in operating profits and net profits in 2015, compared to the years before. Therefore it seems reasonable to base the assessment of a company's bankruptcy risk on an analysis which uses more than just one discriminant model. Since the companies

operate in the same industry and the sample encompassed only three enterprises, it is should be pointed out that the above findings ought to be treated with caution.

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Zastosowanie modeli dyskryminacyjnych do oceny zagrożenia upadłością przedsiębiorstwa

Streszczenie

Cel: Celem artykułu jest dokonanie przeglądu polskich modeli dyskryminacyjnych oraz ich zastosowanie do oceny zagrożenia upadłością na przykładach wybranych spółek akcyjnych w latach 2013-2015.

Metoda badawcza: Artykuł został napisany na podstawie badań literaturowych z omawianego zakresu. Ponadto autorki przeprowadziły badania własne spółek akcyjnych, notowane na GPW. Na podstawie sprawozdań finansowych wybranych spółek dokonana została analiza dyskryminacyjna za pomocą modelu Mączyńskiej, Gajdki i Stosa, Hadasik oraz poznańskiego.

Wnioski: Z przeprowadzonych badań wynika, że nie wszystkie modele dyskryminacyjne odzwierciedlają zmiany kondycji finansowej przedsiębiorstwa. Modele te są jednak dobrym narzędziem do oceny zagrożenia upadłością, pod warunkiem zastosowania więcej niż jednego modelu.

Oryginalność / wartość artykułu: Modele dyskryminacyjne mają charakter uniwersalny, co oznacza, że można je stosować do każdego przedsiębiorstwa, niezależnie od branży w której funkcjonują. Wyniki rozważań można traktować jako podstawę do dalszych badań dotyczących trafnego dostosowania poszczególnych modeli dyskryminacyjnych do spółek, w zależności od rodzaju prowadzonej działalności.

Słowa kluczowe: bankructwo, upadłość przedsiębiorstwa, modele dyskryminacyjne.
JEL: G30.