VERIFICATION OF MDA BANKRUPTCY PREDICTION MODELS FOR ENTERPRISES IN SLOVAK REPUBLIC

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Abstract

The prediction of bankruptcy has been the main aim of many studies. Many authors in different countries all over the world have been trying to find the best bankruptcy forecasting model based on various financial ratios of enterprises. For this purpose different multivariate statistical methods (e.g. multivariate discriminant analysis) have been used. Although classical Altman Z model and other models based on MDA are still widely used for failure prediction in many economics, in the paper we analyze the MDA bankruptcy prediction models created in recent 25 years in different countries all over the world. In our analysis we focus on financial ratios used as predictors in these models. With real data of Slovak enterprises we create the MDA bankruptcy prediction model together with its classification ability. We analyze whether the financial ratios used in our model are similar to that ones most-frequently used in selected MDA prediction models in another countries.

Key words: Bankruptcy prediction model; Failure prediction; Multivariate discriminant analysis; Financial ratios.

JEL Code: C38, G33

Introduction

Prediction of the financial situation of the company, or respectively prediction of the company's financial health, is a topic that is examined by many economists in various countries in the last decades. Apparently, the first work, published about the prediction of financial state of the companies, was by Beaver, who developed his prediction model in 1966. (Kliestik and Majerova, 2015) A well-known and often mentioned in the field of prediction of the financial health of the company is the work of Altman from 1968, where he published his model of Z-score. These two models, and of course other models, that have been developed since that time, focus on a prediction of financial state of the companies. Their task is to predict whether there exists some real risk that the next development of the company leads to a financial problems or even to a bankruptcy, or, on the other hand, whether the company is in

a good financial condition and its financial state is stable. This prediction uses to be made by various ways, according to the multivariate statistical method used. Altman's model of Z-score use for the prediction of financial health the multivariate discriminant analysis (MDA), that produce a prediction, whether with some probability level the particular company belongs to the group of companies threatened by bankruptcy or to the group of prosperous ones. This prediction ex-ante is very important for all the company stakeholders: owners, management, creditors, suppliers, customers, banks and last, but not least, the employees. All of them can use the bankruptcy prediction model as a tool for early warning of imminent financial failure of the company. (Misankova et al., 2015)

From the perspective of company management, prediction models are tools of evaluation of the financial situation of the company, giving them the opportunity to take the necessary precautions against impending problems even at a time, when the situation of the company is not yet non-recoverable. (Kliestik et al., 2015a)

2 Development of bankruptcy prediction models

From the times of Altman's MDA model of Z-score there have been developed many prediction models in various countries. Even the Altman model has been revised several times in order to adapt to changing conditions and to improve the classification ability. Currently, there exist many prediction models with various prediction abilities. (Lasova and Stachova, 2011)

Back et al. used MDA method for business companies in Finland, their model have 61,9 % prediction success. In Greece in 1999 Dimitras used MDA for creating prediction model of business companies with 90 % correctly classified companies. In Belgium Pompe and Feelderes created, among others, the MDA model for construction companies that correctly classified 70 % of companies.

Beerman used multivariate discriminant analysis (MDA) for classification of manufacturing companies in 1976 in Germany with level of prediction 61,9 %. In Australia, Booth created MDA prediction model for business companies in 1983 and achieved 85 % prediction ability. In India Bandyopadhyay (2006) created a model with 88 % correctly classified companies. In Argentina the model by Sandin and Porporato (2007) for business companies have 70 % prediction ability. (Kuruppu et al., 2003)

Azis et al. in 1988 developed the MDA model in the USA for business companies that classified companies with 88,8 % level. In the USA there exist several more MDA models: Brockman and Turtle in their model for business companies in the USA in 2003 have the

accuracy of the model 74,5 %. Similarly the model of Casey and Bartczak in USA in 2003 achieved 86 % classification level, Frydman et al. in 1985 created the model with 74 % classification ability, Gombola et al. in 1987 had 89%, Deakin in 1972 had even 97 % and in 1993 Coats and Fant have 87,9 % success of correct classification. In 1998 McGurr and DeVaney have 74,1 % correctly classified companies and similarly in 1999 Kahya and Theodossiou have 77,8 %. All these models were created for business companies or manufacturing companies. (Yim and Mitchell, 2014), (Korol, 2013)

In the UK El Hennawy and Morris developed in 1983 a model with 97,72 % prediction ability for business companies. Later in 1992 Piesse and Wood created the prediction model for automotive companies and in 2001 Neophytou et al. achieved in their model the prediction ability of 93,75 %. Taffler have various models for English business or manufacturing companies, the highest prediction ability has the oldest model from 1979 with 98,9 % success of correct classification. Beynon and Peel in 2001 created, among others, MDA model for manufacturing companies in the UK with classification of 78,3 %. (Lin, 2014)

In Poland Gajdka and Stos (1996) used MDA for predicting bankruptcy of manufacturing companies with 70,7 % success. In 1998 Prusak created the model for Polish business companies with 91,3 % classification level. Later, also in Poland, in 2004 Hamrol et al. have 96 % success in classification and in the same year Maczynka (2004) have 94,2 % for stock exchange listed companies.

In Hungary in 1987 Pantalone and Platt created their model by MDA with 96 % classification level. In Czech republic there exist known NN models by Neumaierova and Neumaier. The highest success of classification, 94 %, have model from year 2005. (Kliestik et al., 2015b)

And also in Slovakia there exist several MDA models: in 2000 model by Binkert and Zallay for business companies, in 2002 Gurcik developed a model for agricultural companies, in 1998 Chrastinova created a model for agricultural companies too. (Stachova et al., 2015)

3 Methodology

In this paper we focus on MDA models that have been developed by various scientists in the countries all over the world in the last two decades. We analyze this models, the variables used in the models and the prediction accuracy of the models. Then we focus on the variables, used in the models. We will make an analysis of the variables in the field of their importance

in the models from the frequency of the occurrence point of view. We will found the variables with the highest frequency of occurrence in the MDA models from the last 25 years.

Next step of our research is to create the prediction model by MDA for companies in Slovakia. For this purpose, we used the data about Slovak companies. Similarly as in all prediction models have been made, we will create the MDA model for bankruptcy prediction of Slovak companies based on the values of financial ratios. These ratios come from the financial statements of the companies. Our prediction model for Slovak companies was created by MDA by stepwise method. The criterion of including and excluding the variable into the model was the following. We include the variable into the model if there was 0,05 probability level, the removal probability level was 0,10. By this process we get the best bankruptcy prediction model that is able to predict the group membership for a particular company, where the groups are: bankrupt companies and non-bankrupt companies. Then we compare this Slovak prediction model with the models included in our research. We analyze whether in our model occur some of the most used variables, financial ratios, used in the other prediction models from the last 25 years.

3.1 Data used for creation of prediction model

For the purpose of creating the bankruptcy prediction model we have real data about financial ratios of 109 550 Slovak companies. For every one of them we have the values of 11 various financial ratios computed from the financial statements of the companies. By the ratio of indebtedness of the company we classify the company into one of the following group: bankrupt (non-prosperous, default) and non-bankrupt (prosperous, non-default). The rule to distinguishing the companies into the group of prosperous and default ones is the value of indebtedness ratio.

By using these mentioned financial ratios we will create the MDA model for prediction of bankruptcy of Slovak companies. Then we compare the variables in the resulting prediction model with the most used variables in the MDA models from the last 25 years. For this comparison we used 24 prediction models that have been created during 1991-2015. The basic information about these models are in Table 1.

Our intention is to analyze whether these models, created in various economies in last years, use for predicting bankruptcy the same variables. We want to compare our model created by MDA with the variables used in these 24 recent MDA models and find similarities between them in terms of predictors used.

Tab. 1: MDA bankruptcy prediction models created in 1995-2015

Author	Country	Number of ratios included in the model	Effectiveness of the model [%]	Year
Altman	USA	5	80	2008
Huijuan Lin	UK	5	88	2014
Purvinis et al.	Latvia	4	92	2007
Bandyopadhyay	India	5	88	2006
Yim and Mitchell	Japan	3	71	2004
Galvao et al.	GB	4	57	2004
Li and Sun	China	5	81	2011
Leksrisakul and Evans	Thailand	5	60	2005
Vuran	Turkey	5	84	2009
Altman	International	4	NA	2014
Chung et al.	New Zealand	4	NA	2008
Naidoo	South Africa	3	85	2006
Anghel	Romania	4	98	2000
Rashid	Pakistan	3	77	2011
Altman	USA	5	NA	1993
Laitinen	Finland	5	NA	1991
Laitinen	Finland	4	NA	1992
Luoma, Laitinen	Finland	3	NA	1991
Emel et al.	Turkey	5	91	2013
Kuruppu et al.	New Zealand	11	71	2003
Theodossiou	Greece	5	93	1991
Gajdka and Stos	Poland	5	93	1996
Maczynka	Poland	4	88	2004
Sandin and Porporato	Argentina	2	NA	2007

Source: own elaboration

4 Results

The above mentioned models, namely 24 MDA models, use various financial ratios of the companies for predicting bankruptcy. In these models is used roughly 60 different variables. We analyze, which ones of them are mostly used, i.e. are the most important ones for predicting bankruptcy. In the following Table 2 are the variables with highest frequencies of occurrence of variables in the analyzed 24 models.

We want to compare the most used variables with the variables that will be in the prediction model for Slovak companies.

For deriving this classification model was used stepwise MDA method with probability as a criterion of including and excluding variable into the model. The resulting model contains 5 variables.

Tab. 2: Order and frequency of occurrence of variables in MDA models

Variable	Frequency of occurrence in the models
Net Profit/Total Assets	9
Sales/Total Assets	8
EBIT/Total Assets	7
Retained Earnings/Total Assets	7
Working Capital/Total Assets	7
Equity/Total Liabilities	6
Equity/Total Assets	5
Revenues From Sales/Total Assets	4
Total Liabilities/Total Assets	4

Source: own elaboration

The coefficients of discrimination function are in the following Table 3.

Tab. 3: Discrimination function in bankruptcy prediction model for Slovak companies

Standardized Canonical Discriminant Function Coefficients	
	Function
Current Assets/Current Liabilities	0,250
EBIT/Total Assets	0,510
Current Liabilities/Sales	-0,207
Working Capital/Total Assets	0,282
Equity/Total Liabilities	0,618

Source: own elaboration

The part of discrimination function is a table of centroids used to classify the particular company into a group of bankrupt companies or a group of non-bankrupt ones. The company belongs to that group which centroid is closer to the value of discrimination function.

Tab. 4: Group centroids

Functions at Group Centroids	
Default	Function
non-default	0,020
default	-0,061
82,2% of original grouped cases correctly classified.	

Source: own elaboration

The model created for bankruptcy prediction of Slovak companies has sufficiently high prediction ability. It correctly classifies 82,2 % of companies into the right group of default companies or non-default ones.

Among the 5 variables in the prediction model there are 3 variables that belong to the most frequently used variables in MDA prediction models (see Table 2 and 3). So that some of the prediction models from other countries could be used for Slovak companies, regarding to the variables used in them, and vice-versa. But their functionality and level of correct classification of Slovak companies must be individually verified for each prediction model.

Conclusion

In this paper we focused on bankruptcy prediction models that have been developed since 1991 until 2016 in various countries. We analyzed the prediction models created by multivariate discriminant analysis (MDA), similarly as was the well-known Altman's model of Z-score. From the times of Altman many models have been created with various prediction abilities in more countries. We focused on the predictors used in these models and found, which ones of them are the most frequently used, i.e. are, from this point of view, the most important for predicting bankruptcy. Then we created the MDA model for Slovak companies by the procedure of stepwise selection of variables into the model. In the created model was 5 financial ratios, among which 3 variables were the same as the most frequently used variables in analyzed 24 prediction models in other countries.

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