

BANKRUPTCY MODELS: VERIFYING THEIR VALIDITY AS A PREDICTOR OF CORPORATE FAILURE

Kovacova M., Kliestik T., Kubala P., Valaskova K., Radišić M., Boročki J.*

Abstract: Although the issue of corporate failure analysis is a hot topic for business research since the last century, even nowadays there are numerous researches focusing on assessing the financial health of companies. Within increasing internationalization and globalization the demand for bankruptcy prediction is important not only for owners of the companies, but also for other interested groups. We aim to test the validity of prediction models developed as partial results of our research project. Bankruptcy prediction models were constructed on the data set of Slovak companies covering the year 2015 and based on the various statistical methodologies. We provided the validity of these models and their prediction accuracy on the data set of Slovak companies covering the following year 2016.

Key words: bankruptcy, company, prediction accuracy

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Introduction

Each company goes through the different phases of their life cycle during its existence. Even a successful business phase can be replaced by the stagnation phase, or in the worst case the crisis phase, which can lead to bankruptcy of the company. This can happen on the basis of unforeseen events (Spahn, 2017; Braciniková and Matušinská, 2017). According to this the foresight of the prosperity or lack of prosperity of the company has been the subject of research by many authors for many decades. Their efforts have been dedicated to the prediction of the future financial situation of the company and this interest has brought a large number of prediction models (Zemguliene and Valukonis, 2018).

The possibilities of forecasting the company's financial situation and its future solvency and insolvency have been the subject of many economists around the world for many years (Esty, 2017; Baulina and Klyushin, 2017). Company's prediction models those are suitable not only for current but also for future decisions enable management to correctly interpret indicators of potential problems in the future. On the basis of these indicators, the negative tendency in the

* **Maria Kovacova**, Eng. PhD; **Tomas Kliestik**, prof. Eng. PhD; **Pavol Kubala**, Eng. PhD; **Katarina Valaskova**, Eng. PhD, University of Zilina, Faculty of Operation and Economics of Transport and Communications, Department of Economics; **Mladen Radišić**, Prof.; **Jelena Boročki**, Prof., University of Novi Sad, Faculty of Technical Sciences, Department of Industrial Engineering and Management.

✉Corresponding author: maria.kovacova@fpedas.uniza.sk

✉tomas.kliestik@fpedas.uniza.sk; kubala.pavol@dpb.sk;

katarina.valaskova@fpedas.uniza.sk; mladenr@uns.ac.rs; boročki@uns.ac.rs

company may be identified before it leads to more serious financial/economic problems, financial crisis. If there is no suitable solution for this crisis or the crisis is not addressed at all, these financial problems can end up with bankruptcy (Zvarikova et al., 2017).

There are various ways how to identify the company that encounters financial and economic problems. The most commonly used terms are: insolvency, default and bankruptcy. The most general term is business failure, which means that the company is not able to pay its creditors, has overdrafts, or is bankrupt in accordance with legal legislation (Zopounidis and Doumpos, 2002). Slovak law does not directly deal with the concept of bankruptcy. In Slovak legislation, the concept of bankruptcy is defined according to Act no. 7/2005 on bankruptcy and restructuring as: “the company is considered as bankrupt if it has more than one creditor and the value of its liabilities exceeds the value of its assets”. In addition to bankruptcy, we can find in the Slovak legislation also the new concept “crisis”, which according to the Act no. 513/1991 Coll. Commercial Code, is defined as: “*The company is in crisis, when it is bankrupt or is going to bankrupt. The company is going to bankrupt if its debt-to-equity ratio is less than 8 to 100.*”

Literature Review

First studies dedicated to the issue of bankruptcy prediction arose in United States (Fitzpatrick, 1932). Since that time application of bankruptcy prediction models had been widely spread in advanced economies mainly in the western part of the world. Numerous researchers from all over the world have been trying to find a suitable company's bankruptcy forecasting model applying different methods with the aim to achieve the best prediction accuracy (Ravi Kumar and Ravi, 2007). The importance of bankruptcy prediction was confirmed and awoke a new wave of interest mainly after the year 2008, when the global financial crisis appeared (Dixon, 2016). The growing interest of researchers can be seen also in capitalist, socialist, and transitional economies (Brada, 1993; Narkunienė and Ulbinaitė, 2018; Kaminskyi and Versal, 2018). Boratynska (2014) pointed out the aspects of measurement of costs of corporate bankruptcy while predicting the bankrupt of the company. In Slovak Republic the prediction of bankruptcy has come to the attention after the successful transition in 1995, which initiated an institutional evolution proving remarkably robust. Thereafter a few studies dealing with the bankruptcy prediction had been published, but the main attention to this issue aroused similarly as in western part after the global financial crisis. Based on the expanding globalization and growing independency across economies, also Slovak companies had to cope with various types of financial difficulties (Schonfelder, 2003). The prediction ability of global Altman's model on the data set of Slovak companies was studied by Adamko and Svabova (2016). Validation of prediction accuracy of selected globally recognised bankruptcy prediction models was done by Weissova (2016) as well as Weissova and Durica (2016). In the same way Misankova et al. (2017) validated the prediction accuracy of models developed

in countries of Visegrad four on the dataset of Slovak companies. They assumed that the prediction accuracy of models developed in similar economic environment have higher prediction accuracy than models developed worldwide, in countries with different history and economic conditions, even though these models are globally recognised. On the other side Rybarova et al. (2016) applied in their analysis the Altman Z –score bankruptcy model only on the key sector of Slovakia, construction industry.

However, there can be found quite a lot of studies focusing on bankruptcy prediction in Slovakia, there is still a lack of model developed on the basis of Slovak environment, which will be accepted with high prediction accuracy. Delina and Packova (2013) validated three selected bankruptcy prediction models: Altman model, Beerman discriminatory function and Index IN05 in condition of Slovakia and according to gained results they proposed model for bankruptcy prediction using regression analysis. Regression analysis for bankruptcy prediction was applied also by Valaskova et al. (2018). Selection of one sector, in this case Slovak logistic sector, was proposed also by Brozyna et al. (2016). They proposed four bankruptcy prediction models based on discriminant analysis, logit, decision trees and k-nearest neighbours' method and validated prediction power of these models in comparison with Poland logistic sector. Similarly, Mihalovic (2016) highlights the need to develop model for bankruptcy prediction in Slovakia and proposed multiple discriminant analysis and logit models. The application of discriminant analysis can be found also in the work of Kliestik ed. (2018). Gavurova ed. (2017) applied in their study not only discriminant analysis, but also decision trees. Using decision trees they proposed a model with prediction accuracy almost 85% which can be even higher by applying the dynamic approach predictive ability of the decision tree. However, they did not derive the same result using the discriminant analysis method. Logit and Probit application for the bankruptcy prediction in Slovakia can be found in work of Kovacova and Kliestik (2017).

Different approach to bankruptcy prediction in Slovakia was applied by Wilson et al. (2016). Authors analysed the survival probability of privately owned small and medium sized enterprises (SMEs) in Slovakia during the post-communist period up to and including the recent recessionary period. They proposed the model within a failure prediction context developing transition' variables that relate to the origin and ownership of the company and found out that, to some degree, foreign ownership reduces failure probability. Despite a large number of various models, it is still challenging to predict potential of bankruptcy as companies have become more global and more complex. (Becser and Zoltay Paprika, 2016; Sadaf ed., 2018; Koiso ed., 2017) Although in Slovakia have been constructed some bankruptcy prediction models there is no generally accepted model, which can be used not only by researchers but also by practitioners and analysts to predict financial health of Slovak Republic. According to the above mentioned the primary focus in this study is to test the validity of prediction models developed as partial results of our research project. Namely models constructed via discriminant analysis (Kliestik

ed., 2018), multiple regression analysis (Valaskova et al., 2018), logistic regression and probit regression (Kovacova and Kliestik, 2017). Based on the provided calculations can be summarized the recommendations for development bankruptcy prediction model with the highest prediction accuracy. To accomplish given goal of this study, one scientific question was build: Is the prediction accuracy of models developed in Slovak Republic relevant for bankruptcy prediction?

Data and Methodology

This section of the presented research describes theoretical basis of applied models, data selection and quantification and sample design. To fulfil the given goal of presented study we verify four models created in the specific conditions of Slovak Republic, discriminant analysis model, multiple regression model, logit model and probit model. Based on the results of this verification a new bankruptcy prediction model can be created via one of these methods.

The data applied in calculations in presented study were obtained from annual financial reports of Slovak companies, available from the database Amadeus provided by the company Bureau van Dijk, covering the year 2016. In the introduction we determined terminological differences between bankruptcy and company in crisis. According to Slovak environment and its specifics have been detected more characteristics, which are relevant for the adequate grouping of the company between bankrupt and non-bankrupt group. So according to Slovak legislation and specifics detected by Svabova and Kral (2016) and Svabova and Durica (2016) the company is considered as bankrupt when it meets these criterions: value of company's liabilities exceeds the value of its assets, company has more than one creditor and liabilities 30 days after due date, company's debt-to-equity ratio is less than 8 to 100, negative value of earnings after taxes, the value of current ratio indicator is less than 1. So for the purpose of presented study the final grouping was done by applying the mentioned criterions, three criterions given by Slovak legislation and two criterions given by specifics of Slovak environment. Furthermore, the application of these criterions on results of financial analysis on set of Slovak companies and removal of detected outliers led to the designation of basic dataset serving as inputs for models verifications (Table 1).

Table 1. Data set for models construction

	No default	Default	Total	% of Default
Basic dataset	25 329	1 700	27 029	6.29%
Test dataset	1 000	1 000	2 000	50%

We provided two types of verification, first one on the whole basic dataset and second one on the test dataset, which represents the sample, consisted of 1000 bankrupt and 1000 non-bankrupt companies following the suggestion of Agrawal and Maheshwari (2016). The selection was done randomly from basic dataset. So no specifics, such as industry in which companies are doing their business, size or

the legal form of the companies were not taken into considerations. The random selection was done also to respect that models selected for verification were built also on various data set without industry, size or legal form restrictions.

Slovak Bankruptcy Prediction Models

For the verification presented in this study four bankruptcy prediction models have been chosen. These are partial results of research project and were built on various mathematical-statistical methods. All of presented bankruptcy prediction models were constructed on the data set of Slovak companies covering the year 2015.

The model constructed via multiple regression analysis was presented by Valaskova et al. (2018). This model was constructed on the data set of Slovak companies consisted of 62,533 companies, more than 15% of them experience some financial risks, are unsuccessful and unhealthy.

The final model contained nine explanatory variables and constant, namely: net return on capital (R1), cash ratio (L1), quick ratio (L2), current ratio (L3), net working capital ratio (L4), retained earnings to total assets ratio (Z1), current debt ratio (Z3), financial debt ratio (Z4) and current assets turnover (A2). The final regression model has the following algorithm (Eq. 1):

$$Y = 0.1952 - 0.000191R1 - 0.000142L1 + 0.000150L2 - 0.000151L3 - 0.061053L4 - 0.000115Z1 - 0.061173Z3 + 0.002049Z4 + 9.34E^{-08}A2 \quad (1)$$

The model quantifies correctly 61.29% of bankrupt companies and 68.49% of non-bankrupt companies.

Multiple discriminant analysis model was presented by Kliestik ed. (2018). This model was constructed on the data set of Slovak companies consisted of 74,957 companies, more than 26% of them were considered as bankrupt.

The final model calculated for the year 2015 contained four explanatory variables and constant, namely: cash ratio (L1), debt-to-equity ratio (Z5), return on assets (R4), net working capital ratio (L4). The final discriminant function has the following algorithm (Eq. 2):

$$Z - score_{SK}^{2015} = -0.024 + 0.003L1 + 0.000448Z5 - 0.004R4 + 0.000311L4 \quad (2)$$

For the classification between two groups of companies' discriminant analysis uses function of group centroids which is 0.024 for non-bankrupt and -0.066 for bankrupt, so the centre for classification is -0.021 (higher value is classified as non-bankrupt, lower value as bankrupt). The final model quantifies correctly 70.2% of non-bankrupt companies and almost 96% of non-bankrupt companies, which gives 77% prediction accuracy of this model. Third tested bankruptcy prediction model was developed by Kovacova and Kliestik (2017) via logistic regression. For the construction of this model the data set of 1000 Slovak companies was used as a basis, from which 50% of companies were considered as bankrupt.

The final logit model involved eight explanatory variables and constant, namely: net return on total income (R3), current ratio (L3), net working capital ratio (L4), retained earnings to total assets ratio (Z1), debt ratio (Z2), current debt ratio (Z3), debt-to-equity ratio (Z5), current assets turnover (A2). The final logistic regression model has the following formula (Eq. 3):

$$P_1 = \frac{1}{1 + e^{-(248,882 - 57,992 * R3 + 15,337 * L3 - 15,250 * L4 + 2,686 * Z1 - 260,981 * Z2 - 7,6 * Z3 - 316,811 * Z5 + 11,137 * A2)}} \quad (3)$$

The final logit model quantifies correctly 96.2% of non-bankrupt companies and 97.8% of non-bankrupt companies in training data and 94.6% of non-bankrupt companies and 78.8% of bankrupt companies in test data. This gives the prediction accuracy 97% on training data and 86.7% on test data. The last tested model is probit regression model constructed also by Kovacova and Kliestik (2018) on the same dataset as logistic regression model. The final probit model contains all selected 14 explanatory variables and constant, namely: net return on assets (R1), gross return on assets (R2), net return on total income (R3), cash ratio (L1), quick ratio (L2), current ratio (L3), net working capital ratio (L4), retained earnings to total assets ratio (Z1), debt ratio (Z2), current debt ratio (Z3), financial debt ratio (Z4), debt-to-equity ratio (Z5), asset turnover (A1) and current assets turnover (A2). The final probit regression model has the following formula (Eq. 4):

$$P_1 = \Phi 131.8074 - 10.09076 * R1 + 7.299365 * R2 - 23.84973 * R3 + \\ + 0.233393 * L1 - 0.316407 * L2 + 7.095480 * L3 - 6.464321 * L4 + \\ + 1.892825 * Z1 - 138.0107 * Z2 - 3.126644 * Z3 + 0.14 * Z4 - \\ - 168.0274 * Z5 + 0.879841 * A1 + 4.962289 * A2 \quad (4)$$

The prediction accuracy of final probit model is 96.8% of non-bankrupt companies and 97.8% of non-bankrupt companies in training data and 94.8% of non-bankrupt companies and 78.4% of bankrupt companies in test data. This gives the prediction accuracy 97.3% on training data and 86.6% on test data.

To provide appropriate verification and test selected models we used generally known metrics, such as confusion matrix (Adamko and Svabova, 2016; Shi et al., 2017). Confusion matrix is referred usually as contingency table comparing the number of correct and incorrect companies' classification based on the actual and predicted values, where: Type I. error (false positive) – percentage of bankrupt companies predicted by the model as non-bankrupt, Type II. error (false negative) – percentage of non-bankrupt companies predicted by the model as bankrupt, sensitivity (positive predictive value) - percentage of correct classification of non-bankrupt companies, specificity (negative predictive value) - percentage of correct classification of bankrupt companies, model accuracy – overall prediction ability of the model according to data set of companies also known as accuracy of prediction model.

Results

To fulfil the given goal of the presented study we have provided calculations and verifications of four bankruptcy prediction models developed in conditions of Slovak Republic in the year 2015 on the dataset of Slovak companies covering the year 2016. First verification was provided on the full dataset (27,029 companies) and results are shown in following table 2 and table 3.

Based on the results can be assumed that highest prediction accuracy was gained by multiple regression analysis model (93.71%). This assumption is not good according to other relevant characteristics, because this model can correctly classify 100% of non-bankrupt companies, but 0% of bankrupt companies were classified correctly. On the other side discriminant analysis model classified more than 99% of non-bankrupt companies correctly, but only 24.19% of bankrupt companies. This gives the model the overall accuracy only 28.92%.

Table 2. Calculated confusion matrix of tested models

Multiple regression analysis model		Predictive value			
		0 (non-bankrupt)	1 (bankrupt)		
Actual value	0 (non-bankrupt)	25329	0	25329	100%
	1 (bankrupt)	1700	0	1700	0%
		27029	0	27029	93.71%
Discriminant analysis model		Predictive value			
		0 (non-bankrupt)	1 (bankrupt)		
Actual value	0 (non-bankrupt)	6127	19202	25329	24.19%
	1 (bankrupt)	10	1690	1700	99.41%
		6137	20892	27029	28.92%
Logistic regression model		Predictive value			
		0 (non-bankrupt)	1 (bankrupt)		
Actual value	0 (non-bankrupt)	23149	2180	25329	91.39%
	1 (bankrupt)	563	1137	1700	66.88%
		23712	3317	27029	89.85%
Probit regression model		Predictive value			
		0 (non-bankrupt)	1 (bankrupt)		
Actual value	0 (non-bankrupt)	23842	1487	25329	94.13%
	1 (bankrupt)	624	1076	1700	63.29%
		24466	2563	27029	92.19%

According to these results we can recommend to apply logit or probit model as these models provided both about 90% prediction accuracy, while both can classify correctly more than 90% of non-bankrupt companies and more than 60% of non-bankrupt companies. In spite of their prediction accuracy was lower than first tested model (multiple regression analysis model), other relevant characteristics of these models were highly better for future applications.

Table 3. Calculated characteristics of tested models

Model	Multiple regression analysis model	Discriminant analysis model	Logistic regression model	Probit regression model
Type I. error	100%	0.59%	33.12%	36.71%
Type II. error	0%	75.81%	8.61%	5.87%
Sensitivity	1	0.2419	0.9139	0.9413
Specificity	0	0.9941	0.6688	0.6329
AUC	-	0.540	0.660	0.697

Calculations of relevant characteristics regarding for assessment of tested models are provided in table 3. We can see that type I. error is 100% in multiple regression analysis model so its future application is not relevant and this model can't be recommended for application in practice. On the other side type II. error is relatively high in discriminant analysis model (almost 76%). Logit and probit model have comparatively good type II. error, but type I. error is more than 30%. However, these models still can be recommended for use in practice of Slovak companies.

Discussion

In order to assess the overall performance of tested bankruptcy prediction models, classification accuracy matrix was provided. There is a need to highlight the fact that verification of classification accuracy of models was provided on the whole dataset consisted of 27,029 companies and proving by selected test dataset, which was constructed by 1000 bankrupt and 1000 non-bankrupt companies from original dataset. Table 4 summarizes prediction accuracy of all tested models in comparison with prediction accuracy declared in original work.

Table 4. Comparison of prediction accuracy of tested models

Model	Original work	Basic dataset	Test dataset
Multiple regression analysis model	64.89%	93.71%	50.00%
Discriminant analysis model	77%	28.92%	62.60%
Logistic regression model	97% (86.7%)	89.85%	78.60%
Probit regression model	97.3% (86.6%)	92.19%	79.35%

Results of multiple regression analysis model on test dataset are quite similar to original work. On the other side verification on basic dataset provided very high prediction accuracy, but 100% type I. error does this model inappropriate for future use. This conclusion is also in accordance with findings of Alaka ed. (2018). Authors proved that in bankruptcy prediction models constructed via multiple regression analysis was gained highest type I. error, so they don't recommend to construct models using this method. Review provided by Peres and Antao (2017) suggests opportunities for improving the performance of discriminant models,

in terms of the data used and its treatment, which is also in accordance with our gained calculations. As we can assume that on the basic dataset the prediction accuracy was pretty low. Although the accuracy on test dataset was three times higher this is given by very high type II. error in the big dataset. In smaller dataset this error was significantly lower which led to increase prediction accuracy.

Comparing gained results with prediction accuracy of other models constructed in condition of Slovakia can be summarized that accuracy of tested logit and probit models overdo prediction ability of multiple discriminant analysis (approximately 62%) and logistic regression (approximately 73%) proposed by Mihalovic (2016). On the other side, he suggested the use of other relevant mathematical statistical prediction techniques including artificial intelligence expert system. This assumption was also proved by Mendelova and Bielikova (2017). They applied DEA analysis on the set of Slovak companies; however the prediction accuracy of their model was similar (78.5%) to prediction accuracy of tested logit and probit models. Furthermore, presented findings are in strong correlation with findings of other research studies confirming that there is a need to develop specific models for different countries. (Liang ed., 2015) So there is a need to develop generally accepted model for bankruptcy prediction of Slovak companies with high prediction accuracy, which can be used in the future practice of both researchers, as well as companies. Additionally, also new indicators, not only financial, should be included for forecasting in such surroundings (Tinoco and Wilson, 2013). The need for development of relevant bankruptcy prediction models based on the environment of Slovakia is proved by Delina and Packova (2013). Considering national environment and specific of individual economy is highlighted also by Szetela et al. (2016), as well as Antonowicz (2014).

Conclusions

The issue of bankruptcy prediction is widely spread worldwide. However, it has become important topic also in Slovakia and few models have been developed in recent years considering specifics of national environment generally accepted bankruptcy prediction model is still missing. Therefore, the goal of the presented study was to test the validity of prediction models developed as partial results of our research project. Original bankruptcy prediction models were constructed on the data set of Slovak companies covering the year 2015 and based on the various statistical methodologies. Namely multiple discriminant analysis, multiple regression analysis, logistic regression and probit regression. We provided the validity of these models and their prediction accuracy on the data set of Slovak companies covering the following year 2016. Verification of these models was done by their classification accuracy. Based on the results has been found that multiple regression analysis provided 100% type I. error, which makes this model absolutely inappropriate even the overall prediction accuracy was very high. Also multiple discriminant analysis model is not suitable for future use because of type II. error.

Provided research presents deep calculations and verification of previous researches in this field of study, otherwise several limitations should be taken into consideration. However, the dataset of companies was quite huge, there is no information about its composition, i.e. we didn't take into consideration the perception of companies size, sector classification and so on. Thus the verification may be confused by this information. On the other side the verification was calculated on the dataset of Slovak companies covering only one year. So the verification should be provided continuously during next years to gain reliable results.

Based on the provided calculations can be summarized that for the development of bankruptcy prediction model should be used logistic regression or probit regression as these are methods providing highest prediction accuracy. These models both provided relatively high prediction accuracy, high sensitivity and specificity and low type I. error and type II. error.

According to these characteristics can be assumed that these models appear as most relevant for future use in practice. Construction of such bankruptcy prediction models which will take into consideration specifics of national environment and potentially specifics of company itself (such as size and sector classification) can lead to prior detection of potential problems, bankrupt, default or insolvency of companies. Therefore, management of companies should continuously evaluate such data and criterions to avoid problems with stakeholders and other interested subjects.

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MODELE UPADŁOŚCI: WERYFIKOWANIE ICH WAŻNOŚCI JAKO CZYNNIK PROGNOSTYCZNY NIEPOWODZENIA KORPORACYJNEGO

Streszczenie: Chociaż kwestia analizy niepowodzenia korporacyjnego jest gorącym tematem badań biznesowych od zeszłego wieku, nawet obecnie prowadzone są liczne badania skupiające się na ocenie kondycji finansowej firm. W warunkach rosnącej internacjonalizacji i globalizacji zapotrzebowanie na prognozy bankructwa jest ważne nie tylko dla właścicieli firm, ale także dla innych zainteresowanych grup. Celem artykułu jest

sprawdzenie ważności modeli prognostycznych opracowanych jako częściowe wyniki projektu badawczego przez autorów. Modele przewidywania bankructwa zostały zbudowane na zbiorze danych słowackich firm w roku 2015 r. na podstawie różnych metodologii statystycznych. Zapewniona została poprawność tych modeli i dokładność ich prognozowania na zbiorze danych słowackich firm obejmująca rok 2016.

Słowa kluczowe: upadłość, przedsiębiorstwo, dokładność przewidywania

破产模型:验证其有效性 作为公司破产的预测者

摘要:虽然企业失败分析问题自上世纪以来一直是商业研究的热门话题,但是现在有很多关于评估企业财务健康的研究。在日益国际化和全球化的过程中,对破产预测的需求不仅对公司所有者而且对其他感兴趣的团体都很重要。

我们的目标是测试作为我们研究项目的部分结果而开发的预测模型的有效性。

破产预测模型是根据2015年斯洛伐克公司的数据集构建的,并基于各种统计方法。

我们提供了这些模型的有效性及其对2016年下一年斯洛伐克公司数据集的预测准确性。

关键词:破产, 公司, 预测准确性。