OECONOMIA
COPERNICANA

2017 VOLUME 8 ISSUE 1, MARCH

p-ISSN 2083-1277, e-ISSN 2353-1827
www.oeconomia.pl

ORIGINAL PAPER

Citation: Zvarikova, K., Spuchlakova, E., & Sopkova, G. (2017). International comparison of the relevant variables in the chosen bankruptcy models used in the risk management. *Oeconomia Copernicana*, *8*(1), 145–157. doi: 10.24136/oc.v8i1.10

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Received: 8 December 2016; Revised: 29 January 2017; Accepted: 5 February 2017

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International comparison of the relevant variables in the chosen bankruptcy models used in the risk management

JEL Classification: *C38; G33*

Keywords: *company failure; bankruptcy prediction models; relevant variables; transit economy*

Abstract
Research background: It does not matter if the company is operating in the domestic or in the international environment; its failure has serious impact on its environment. Because of this fact it is not surprising that not only owners of the companies, but also another interested groups are focused on the prediction of the company´s financial health.
Purpose of the article: The first studies concerned with this issue are dating back to 1930 but from this time a hundreds of bankruptcy prediction models have been constructed all over the world. Some of them are known world-wide and some of them are known only on the national level. Many researchers share their opinion, that it is not appropriate to use foreign models in the domestic conditions non-critically, because they were constructed in the different conditions. One of the main problems are used variables.

Methods: We mention three studies which were focused on the used variables in the bankruptcy prediction models. Our comparative study was concerning with 42 models constructed in the seven chosen transit economics with the aim to realize which variables are relevant and which could be reduce from the bankruptcy prediction models. We focused only on the used variables and abstracted from the used methodology, the date of their construction or the model´s power of relevancy.
Findings & Value added: The result of our comparative study is the identification of 20 variables, which were used in three or more prediction models, so we assume that these variables have the best prediction ability in the condition of transit economics and their application should be consider in the construction of new models.

Introduction

Regardless of whether the company is operating in the domestic or in the international environment, its failure has serious impact on its environment. The failure itself can have various forms, performances or results, which all interested groups have to bear with in the market economy whether they are owners, employees, business partners, competitors, state etc. The failure affects not only company´s competitiveness but also its own existence. If the company is operating in the international environment, the consequences are even beyond the borders of the state. For this reason, it is very important for the company and other interested groups to identify situations, which are able to lead the company to its failure. And this identification is the object of the risk management focused on the risk reduction by using of the various methods and techniques of the risk prevention with the aim to prevent problems or negative effects.

The management of economic and financial risks is also a part of the risk management and its aim is to detect the situations which can have an impact on the economical or financial stability of the company. So we persuade that risk evaluation and risk management represents very important step to prevent bankruptcy. And financial analysis plays an important role in the company´s future performing estimating. So the aim of the financial situation estimating is the early detection of retrogressive financial stability of the company before the situation arises at the point that it is no longer possible to take corrective measures to reverse this bad situation. Because of the mentioned above, the information gained from the bankruptcy prediction models, which are the subject of our interest in these papers, take an important role in the risk management.

In the literature we can recognize different terms: corporate failure prediction, financial difficulty prediction, bankruptcy prediction, default prediction, credit risk assessment, early warning systems etc. Despite differently used terminology, the aim of these papers is common — to anticipate

corporate insolvency, because the reason is obvious — the insolvency is the essential cause for failure of the company (Cisko & Klieštik, 2013).

There are hundreds of prediction models differing in approaches and methods applied for their construction, input data demand, number of variables, form of interpretation of results, etc. The existence of large number of models is caused by the fact that there is not universal application in various sectors and economic conditions. It is obvious that the aim of the prediction models creators is to create a model that is able to provide a required value of prediction capability within the longest possible period of time; however, it is very difficult in the environment of ever-changing market conditions (Kral & Bartosova, 2016, pp. 189–197). And the main challenge, they have to tackle in the construction of the model, is how many and what type of the relevant variables is necessary to use in the model.

In the terms of assessing the overall results of the financial analysis is tendency that financial analysis have indicators which could be able to recognise if the company is doing well or poorly. There are a number of studies that are aimed at addressing the problem of partial indicators for assessing the company's financial situation with the answer how much weight to attribute to them, and how to express them in the form of a single characteristic — a summary indicator (Misankova *et al*., 2015, pp. 411–417).

Theoretical background

The beginnings of the financial healthy researching are dated back to the 1930´s. Bureau of Business Research published a bulletin with results of a study of ratios of failing industrial companies. The study analysed 24 ratios of 29 firms to determine common characteristics of failing companies (Bellovary *et al*., 2007, p. 2). Among the first studies aimed at this issue we refer the work of P. J. Fitzpatrick (1932) which is focused on the essential differences between successful and failed companies whereby he used the ratio analysis to predict future bankruptcy. Other researches up to the mind-1960´s are also focused only on univariate (single factor/ratio) analysis. The most widely known univariate study is a study of Beaver (1966), who is consider to the first authors who successfully applied financial ratios to address the problem of the prediction of the company´s failure, however the using of simple financial ratios to predict the company´s failure was largely disputed. Beaver identified 30 ratios that were expected to capture relevant aspects. By a univariate discriminant analysis, these ratios were applied on 79 pairs of bankrupt/non-bankrupt firms (Bernhardsen, 2001, pp. 4–5). The

first multivariate study was published in 1968 by Altman and this study has remained popular in the literature until today. Altman´s model was a five-factor multivariate discriminant analysis model (nowadays the number of factors considered in the models ranges from one to xy factors) which was developed for manufacturing entities. Using data from these corporations he strived to identify the combination of variables which best serve to explain corporate bankruptcy. Other important studies which put the headstone in the development of the international predictive models of bankruptcy risk are the studies made by: M. Tamari (1976), J. A. Ohlson (1980), J. G. Fulmer (1984), Ch. Zavgren (1985), P. Kralicek (1990), C. Y. Shirata (2002), Alaminos *et al.* (2016) and others.

One of the essential problems of the models´ applicability in the international environment is the ability of the model to be applied in the conditions of the specific economies, what is caused by the fact that each economy has its own typical conditions. Because of this fact a lot of authors are aimed on the question of non-critical acceptance of the foreign models in the prediction of the company´s failure in the specific conditions of the country. Early in 1982 English economists Argenti and Taffler were interested in this issue. They deduce from their analysis that for example the limits of Altman Z-score differ for the American market from the limits characterizing English market. Among another conclusion of their study we include the knowledge that these differences are concerning not only with applying of the international models in the specific country´s condition but also in the applying them interprofessional within the same country. According to Virág and Kristóf (2005, pp. 403–425) it could be caused by the fact, that products made by different industries could have different life cycles, market position etc.

If we focus on non-critical applying of the Altman Z-score in the condition of the Slovak republic, we would like to point out that the ability of the indicator market value of the equity is different in the USA, where the capital market is advanced, compared to the conditions of the underdeveloped capital market in the condition of the Slovak republic. From the mentioned we can conclude that indicator — market value of equity / book value of total debt will be distorted for the Slovak companies and because of this fact it could not properly discriminant the companies correctly (Frajtova-Michalikova *et al*., 2015, pp. 228–236).

Nowadays we recognize hundreds of prediction models which are different by for example used mathematical-statistical methods, the time of construction, the place of construction or used variables for the predicting of the company´s financial health. Among the most common mathematical-statistical methods we include discriminant analysis, logit analysis and

probit analysis. But the forecast methodology is constantly evolving and significant progress has been made in recent years in the mathematical-statistical areas as well as in modelling procedures. Event recent empirical studies prove that neural networks provide a more reliable bankruptcy prediction method than previously used discriminant analysis and logistic regression which is caused by the lower predictor success of the statistical methods (Virág & Kristóf, 2005, pp. 403–425).

But in these papers the issue of choosing the correct methodology or the correct place of the model creation or the time when the model was created is not our aim. The aim of these papers is the adequacy of used variables in the prediction models. These relevant variables could be classified as:

- *quantitative variables* — communication and conflicts with interested groups, quality of the business environment, the way of the managing of the company, legal framework of the company etc.
- *qualitative variables*
  a) macroeconomic nature variables as GDP, the economic cycle, purchasing power, inflation etc.
  b) *microeconomi*c nature variables as competition.
  c) company´s variables as financial-economic indicators. And Anghel declares that the years of the company´s existence could not also be ignored (Macovei, n. d., p. 4).

At this point we would like to mention three studies focused on the used relevant variables. At first the study of Azis and Dar (2006, pp. 18–33), who analysed 89 empirical studies and came with the result that bankruptcy prediction studies have mostly used financial ratios to predict company´s failures. More than 60% of researched studies used financial ratios (as liquidity, solvency, leverage etc.) as the only explanatory variables, about 7 % used cash flow information and 33 % used a mix of financial rations and other variables (industry-specific location, firm specific variables etc.)

Bellovary *et al*. (2007, p. 42) in their study analysed 165 prediction models. They conclude that in the researched studies the number of considered factors is from 1 to 57 factors. In these models there were used altogether 752 different variables and 674 of them were used in no more than two models. At the end of their study, the authors are denominate 42 variables, which were used in more than 5 models (Table 1).

Ravi and Ravi (2007, pp. 1–28) followed up to some previous studies and they complemented them by their research in which they analysed 62 prediction models and the results are in the table 2.

Research methodology

As it was mention above, one of the essential problems of the model´s applicability internationally is the ability of the models to be applied in the specific economies, because each economy has its own typical conditions. Coming from these assumptions we determine the aim of these papers, based on the results of previously mentioned three studies, as detection of the relevant variables, which have the best classification ability for the prediction of the company´s failure in the transit economies. The result is to reduce the variables which are irrelevant for the company´s classification.

For the detection of the relevant variables used in the prediction models we focus on the comparative analysis of the prediction models used in the chosen post-communist countries, because the economic development in these countries is characterized by common features. This economics are called transit economics, because they have changed from central to market economy. Most of the transit economics had to face some short-term difficulties and long-term pressure to development. These changes were concerned with privatization of the state companies, legal reforms, macroeconomic stabilization etc. and these specific conditions often caused a problem for applying common used prediction models, what proves many studies made at the national levels. In these studies, the authors are aimed at examination of applicability and restrictions well-known prediction models in the condition of their country. They point the fact that the problems with applying international models in the conditions of domestic transit economy often lie in the fact, that western authors constructed their models in stable market conditions or in the time of the economic growth.

In our comparative analysis we focused only on the predictions models which were developed in the chosen post-communist countries. Analysis abstracted from the used methodology, the date of their construction or the model´s power of relevancy. The main criterion of model selection for the comparative study was the fact, that the model was constructed from the information basis of one of the 7 post-communist countries, which, as it was mentioned above, are specific by the development with common features. So we assumed that relevant variables used in these models could be common used for the prediction of the financial health of the company in each of these countries with adequate power of relevancy. Each of these analysed models is based on the financial ratios as the main determinant of the financial stability, so we focused our comparison only on used financial ratios. We compared financial ratios from the models with the aim to determine how often are used in chosen models and coming from this information we identified 20 variables which we consider to be the variables

with the best prediction ability, because they were used in the models most frequently.

Results

There were analysed prediction models of the 7 post-communist countries in our papers. Comparative analysis was made on the following models:

Slovak models — in this group 7 models were analysed, namely — Binkert and Zalai´s model, CH-index (Zalai, 2000), Boďa´s model (Boďa, 2009, pp. 3–6), G-index (Gurčík, 2002, pp. 373–378), Gulka´s model (Gulka, 2016, pp. 16–22), Kováč model (Kováč, 2013, pp. 112–117), P-model (Delina & Packová, 2013, pp. 101–112), model of Roháčová and Kráľ (Roháčová & Kráľ, 2013, pp. 76–82).

Czech models — 11 models were analysed, namely — Aspekt Global Rating model, Index of the Czech National bank, Grunwald´s model (Grunwald & Holečková, 2007), Doucha´s models — Balance sheet analysis I and II (Sedláková, 2014, pp. 160–165), JT model (Jakubík & Teplý, 2011, pp. 157–176), Janová *et al.* model (Vavřina *et al*., 2013, pp. 1177–1182), models of Neumaier and Neumaireová — 95, 99, 01, 05 (Zalai, 2000).

Polish models — there were analysed 10 models, namely — INE 6 model, Hadasik´s model, Poznanski´s model, model, Wierzba model (Zielińska-Chmielewska, 2015, pp. 363–370), model of Gajdka and Stos (Parvia & Szeliga-Kowalczyk, 2015, pp. 116–123), Prusak´s models — I and II (Prusak, 2005), Wrzosiec and Ziemba models — 2 models (Zmijewski, 1984, pp. 59–82).

Hungary models — two models of Virág and Hajdu (Hajdu & Virág, 2001, pp. 59–82).

Croatia models — 2 models of bankruptcy prediction, namely — model of Barać and Belak (BEX model), Sajter´s model (Knezevic, 2014, pp. 1475–1488).

Romanian models — 6 models, namely — Anghel´s model, Macovei´s model (Macovei, n. d.), model of Barbuta and Misu, Pavaloiaa´s model (Muntean & Solomon, 2011, pp. 276–285), Andreica´s model, Băileşteanu´s model (Armeanu, 2012, pp. 97–112.)

Russian models — there were analysed 3 models, namely — Lin´s model, Makeeva and Neretina models — 2 models (Makeeva & Neretina, 2013, pp. 256–271)

As it is mentioned above there were analysed 42 models from chosen 7 countries in our comparison. Relevant financial variables used in the ana-

lysed models were in the interval 3 to 18 variables in one model (the most frequent interval is from 4 to 7 variables per model). The median of the used variables in one model is 5 variables per model. Altogether there were analysed 128 different variables while up to 108 of the analysed variables were not used in more than two models. Only 20 of the variables were used three times and more. The table no. 3 depicted these relevant financial variables.

Conclusions

The number of used variables has substantial impact on the accuracy of the predictive ability of the model. Coming from this presupposes we can claim that the model with higher level of relevant variables should have a better discriminatory ability, but this assumption is not proved by the praxis. As we found out by the analysis, the most of the analysed prediction models use from 4 to 7 variables, but some of the models use as many as 18 variables. Because of this fact it is necessary to reduce irrelevant variables from the model without reduction of the model accuracy. As it is obvious in the table 1 and 2, even if the prediction methods were different, the rates used in all studies refer to the same variables — liquidity, profitability, debt leverage, solvability and company´s activity. The variables featured in these studies are very similar. But if we compare the results of these two studies with the results of our comparison we can recognize some differences in the used variables. This fact should be considered in a construction of the models in the transit economics, which, as we mentioned above, are characteristic by specific condition. Also we consider as appropriate to point out the fact that our comparison analysis was focused only on financial variables, but some of the models also includes non-financial variables with financial variables to detect company´s failure, but none of them were used more than once.

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Acknowledgements

This research was financially supported by the Slovak Research and Development Agency — Grant NO. APVV-14-0841: Comprehensive Prediction Model of the Financial Health of Slovak Companies.

Annex

Table 1. Relevant factors included in five or more studies

Factor	Number of studies that include
EAT / Total assets	54
Current ratio	51
Working capital / Total assets	45
Retained earnings / Total assets	42
EBIT / Total assets	35
Sales / Total assets	32
Quick ratio	30
Total debt / Total assets	27
Current assets / Total assets	26
EAT / Net worth	23
Total liabilities / Total assets	19
Cash / Total assets	18
Market value of equity / Book value of total debt	16
Cash flow from operations / Total assets	15
Cash flow from operations / Total Liabilities	14
Current liabilities / Total assets	13
Cash flow from operations / Total debt	12
Quick assets / Total assets	11
Current assets / Sales	10
EBIT / Interest	10
Inventory / Sales	10
Operating Income / Total assets	10
Cash flow from operations / Sales	9
EAT / Sales	9
Long-term debt / Total assets	8
Net worth / Total assets	8
Total debt / Net worth	8
Total Liabilities / Net worth	8
Cash / Current liabilities	7
Cash flow from operations / Current liabilities	7
Working capital / Sales	7
Capital / Assets	6
Net sales / Total assets	6
Net worth / Total liabilities	6
No-credit interval	6
Total assets (log)	6
Cash flow (using net income) / Debt	5
Cash flow from operations	5
Operating expenses / Operating income	5
Quick assets / Sales	5
Sales / Inventory	5
Working capital / Net worth	5

Table 2. Variables listed in the Ravi and Ravi (2007) study

Variable	Ranking
EAT / Total assets	1.
Retained earnings / Total assets	2.
Sales / Total assets	3.
EBIT / Total assets	4.
Current ratio	5.
Working capital / Total assets	6.
Cash ratio	7.
Market value of equity / Book value of total debt	8.
Total debt / Total assets	9.
Current assets / Total assets	10.
Quick assets / Total assets	11.
EBIT / Total debt	12.
Working capital / Total assets	13.
Quick ratio	14.
Total assets (log)	15.
Cash flow / Total debt	16.
Cash / Total assets	17.
Cash / Current liabilities	18.
Cash flow / Total assets	19.
Current liabilities / Total assets	20.

Table 3. Relevant financial variables used in the analysed models of the chosen transit economies countries

Factor	Number of studies that include
Current ratio	17
ROA	15
Quick ratio	11
Eat / Total assets	10
Total debts / Total assets	10
EAT / Equity	7
WCTA	7
Equity / Total assets	7
Earnings / Total assets	6
EBIT / Interest expenses	6
Cash flow/Total debt	6
Total assets / Total debt	5
ROE	5
Inventory / Daily sales	4
Cash flow / Total debt	4
EAT / Sales	3
EBITDA / Sales	3
Liabilities against suppliers / Daily sales	3
Cash / Current liabilities	3
Inventory/Sales revenues	3