OVERVIEW OF SELECTED BANKRUPTCY PREDICTION MODELS APPLIED IN V4 COUNTRIES

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Abstract: *Bankruptcy prediction models are often an applied tool for detecting unfavourable development of the financial situation of the company. The prediction of financial health of business entities is the most important information because of dynamic development of the business environment. Many prediction models are known nowadays. They are different by their reliability (predictive ability), the composition of used variables, trade union orientation, the degree of consideration of domestic market conditions etc. It is clear from this that it is not possible to create a universal, unified prediction model that would be able reliably and with sufficient time to indicate unfavourable company financial development leading to bankruptcy applied in all sectors or regions. Introductory part of contribution is devoted to the literature review of issues and the definitions of the concept of bankruptcy based on the so-called non-prosperity indicators (profit, total liquidity and equity/liabilities ratio), that take into account the current legislation of this issue in the Slovak republic. Then the contribution discusses the role and significance of prediction models in corporate practice, compares the advantages and disadvantages of models containing accounting and market indicators. The authors also devoted the space to identifying restrictions on the usability of known foreign bankruptcy models in economic conditions of V4 countries and to define a set of the most frequently applied models taking into account specific economics conditions in these countries.*

Keywords: *Bankruptcy Prediction Models, Financial Health, V4, financial ratios*

JEL Classification G33 · C5

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1. INTRODUCTION

Financial health is a term reflecting the overall financial situation of a business entity. It is possible to consider a business entity financially healthy if it is able to finance its liabilities with assumption of continuous existence and development. The basic aspects of business entity's financial health include profitability, liquidity and financial stability.

The efforts to achieve early recognition of the business entity financial instability led to establishment of new methods for financial analysis, so-called prediction models. They act as indicators of early warning of business entity's negative financial development - forecasting - based on the history of entity's results. Such models are based on the prerequisite that business entity heading towards bankruptcy shows specific financial differences, symptoms in comparison with financially healthy entity (problems with current ratio, net working capital, profitability, etc.) for certain period of time beforehand. Similarly, it is necessary to emphasize that none of the financial analysis prediction methods may be deemed as 100% reliable and it is not possible to include conditions specific for entity's environment.

2. BANKRUPTCY PREDICTION MODELS

2.1 History

Historically, the development of business entity bankruptcy prediction may be divided into several time periods with characteristic application of different methods for development of bankruptcy prediction models. The early studies were in the form of a simple financial analysis based on financial ratio analysis (a single-dimension analysis) a comparison of values between successful and failing business entities. 1930 was one of the most significant milestones when the Bureau of Business Research published a report on the Study of Indicators of Failing Manufacturing Business Entities. The study analysed 24 indicators in 29 business entities with the goal to determine basic characteristics of failing business entities. The indicators of each business entity were then compared with average values of indicators to enable observation of differences, basic characteristics of failing business entities and trends. In 1942, Merwin published results of his study that focused to small business entities. The study confirmed that in case of comparison of successful and failing business entities, the basic signs appear as early as 4 to 5 years before the insolvency. For the first time in the history of financial pressure modelling, Chudson (1945) discovered that within a certain industry, business entity size and profitability, it is possible to see a characteristic behaviour of surveyed values of indicators. He named the occurrence "clustering of ratios".

The period of 1930-1965 may not be considered, from the methodology point of view, as a period of development of bankruptcy prediction models, it was more or less a financial analysis of ratios. A significant milestone in this matter came by Beaver's study (1966), which was the first to introduce the bankruptcy prediction model upon application of a single-dimension analysis. This study could represent the second generation of prediction model evolution, up to the end of 1980s. At the conclusion of his study, Beaver recommended for the future to consider simultaneous evaluation of several indicators at the same time. Promptly, this requirement was picked up by Altman (1968) who caused a small revolution in perception of business entity financial pressure prediction. The Altman's model is the first ever bankruptcy prediction model from the point of using a multi-dimension analysis.

Altman's work (1968) served as motivation for other academicians and researches who emphasized mainly limiting assumptions of discriminant analysis from the statistical point of view. Their main

answer was development of conditional probability models with main models based on logit and probit method. The first model using logistic regression (logit) was Ohlson model (1980) with benefit that it was not necessary to meet basic statistic preconditions such as linearity, homoscedasticity, etc. Balcaen and Ooghe (2008) who summarize models for the past 35 years until 2006 in their study, present that such model outlasted the prediction ability of Altman's model. The Zmijevski model (1984) was developed in the similar fashion; it used probit analysis for development of bankruptcy prediction model. Such two methods, often with various variations, have been used to this day.

The study of Dimitras et al. (1998) included also other methods and models applied during 1980s and 1990s. Such authors mention for example work of Frydman et al. (1985) utilizing the recursive distribution algorithms method, Gupta et al. (1990) applied mathematical programming for the business entity failing prediction issue. Other studies applied the survival analysis (Luoma and Laitinen, 1991), expert systems (Messie and Hansen, 1998) and multi-factor model (Vermeulen et al., 1998). Furthermore, there were other methods recorded, using decision management, such as Zollinger (1982), Zopounidis (1987), Siskos et al. (1994), Andenmatten (1995), Dimitras et al. (1995).

The late 1990s brought opportunities by utilization of IT equipment and machine learning. That meant exploitation of artificial intelligence techniques of which development has been going on until present day and it is still not over. Kumar and Ravi (2007) provide a very good overview of bankruptcy prediction models in their paper, being a complex overview of papers utilizing statistical methods and artificial intelligence methods used for bankruptcy prediction of business entities and banks.

Finding the suitable bankruptcy prediction model is the task for economists and analysts from all over the world. Despite a large number of various models, which have been created by using different methods with the aim to achieve the best results, it is still challenging to predict bankruptcy risk, as corporations have become more global and more complex (Kovacova, Kliestik, 2017).

Research in the field of bankruptcy prediction has been a much discussed topic recently. Currently, it is possible to observe some kind of hybridisation in the field of bankruptcy prediction, combining various elements of the aforesaid methods, thus creating one complex model integrating their advantages. If we compare advantages and disadvantages of utilizing statistical methods versus methods utilizing machine learning and artificial intelligence, the basic advantage of statistical methods is in their simplicity. Moreover, it is definitely possible to establish that models based on accounting data and statistical models are clear and applicable for managerial decisions as well as for company practice. To the contrary, advantages of models utilizing complex programming techniques and algorithms are in higher prediction ability in comparison with statistical models. Such advantage is consequently negated by reduced applicability in managerial practice since majority of such models (such as neural networks) include input parameter values and output value of a dependant variable. However, for a manager, it is not clear which variable and to what extent contributed to the resulting value of a dependant variable.

2.2 Definition of bankruptcy

Tinoco and Wilson (2013) emphasize that using definition of bankruptcy from the legal point of view is not the best solution when creating a bankruptcy prediction model. Their argument is that insolvency of a business entity may last for longer and date of bankruptcy, according to a corresponding regulation, does not have to correspond with the actual date of origin of business

entity's financial problems. Moreover, the authors continue that due to frequent changes in legislation regarding bankruptcy during model assessment, capturing for example financial reports for the last 5 years, the results may be distorted causing reduced prediction ability of a model. Balcaen and Ooghe (2008) provide the following disadvantages regarding definition of bankruptcy according to a legal regulation:

- Legal definition of bankruptcy varies according to a country for which the bankruptcy prediction model was established. If we want to compare a legal definition of bankruptcy in studies from various countries, it is clear that each country has own specific modifications of legal framework when it comes to bankruptcies.
- The moment of legal bankruptcy fails to reflect the actual date of bankruptcy. There may be a great difference in time between the actual bankruptcy and bankruptcy according to legal framework.
- It is even possible that a business entity showing characteristics of being bankrupt does not have to declare bankruptcy legally.
- There is a possibility that companies having problems may combine with another entity or taken over by another entity, instead of filing for bankruptcy. In such case, they would not be registered together with companies with financial difficulties, even despite the fact of having financial difficulties.

There are various terms used to name the financial difficulties of a business entity, which may cause difficulties with interpretation of results, such as financial distress, financial problems, financial health of a business entity, insolvency, liquidation, dissolution. According to such definitions, it is necessary to distinguish between financial distress and bankruptcy.

Altman and Sabato (2010) define financial distress upon Basel II as a situation when the obligor is past due more than 90 days on any material credit obligation to the bank. During our studies we also came across other definitions, such as one that the business entity is subject to financial distress if EBITDA < financial costs (interests, cost of debt) for the minimum of two consecutive years or financial distress represents first year in which its cash flow is less than the actual repayments of long-term liabilities (Tinoco, Wilson, 2013). The majority of the aforesaid definitions mention importance of cash flow as a basic prerequisite having preventive impact from financial problems of the business entity. We would like to remind that not all definitions of financial distress may be used in conditions of economies of Central and Eastern Europe due to lack of developed financial market. The reason being is that calculation includes factors and indicators using market values of shares or bonds.

Bankruptcy is defined as financial insolvency or legal proceedings for solving financial commitments of an insolvent debtor (being person or entity). The purpose of bankruptcy proceedings is to distribute assets to creditors in a fair way and (in majority of cases) release the debtor from further financial commitments. Bankruptcy may be declared by debtor alone (voluntary bankruptcy) or by creditors (involuntary bankruptcy).

Corporate failure can exist in various types and dimensions, and has different effects on stakeholders according to magnitude of the failure and its type. The rise of corporate failure in different types brought about the use of different definitions and different concepts connoting failure. Over the past 35 years, the topic of "business failure prediction" has developed to a major research domain in corporate finance. Many academic studies have been dedicated to the search for the best corporate failure prediction, based on publicly available data and statistical techniques (Kliestik, Kocisova, and Misankova, 2015).

The subject of our long-term research in the field of financial health prediction is also to determine conditions for unsuccessfulness of a business entity in Slovakia, arising due to a combination of

legal and accounting aspects. We created a universal benchmark for classification of an enterprise into successful or unsuccessful by using limit values of three financial ratios: **R -** return on assets (net), **L** - total liquidity**, Z** - indicator of financial independence, we named them **unsuccessfulness indicators** while taking into account valid legal regulations of the Slovak Republic stipulating conditions for unsuccessfulness of an enterprise.

According to our specified conditions, an enterprise has been marked unsuccessful, if it simultaneously fulfilled all three criteria:
- Total liquidity $L < 1$.
- Profit after tax gains a negative value (indicator R is negative)
- The ratio of equity to liabilities, i.e. indicator $Z < 0.04$.

Table 1 explains more closely the selected ratios in terms of input variables necessary for their quantification and verbal interpretation.

Table 1: Unsuccessfulness indicators

Indicator label	The calculation procedure (input variables)	Interpretation
R	(profit after tax) ÷ (liabilities)	how many euros of profit (net profit) accounts for 1 euro in capital
L	(short-term assets) ÷ (short-term foreign capital)	highlights the immediate ability of the company to settle all current liabilities through immediate liquidity and equivalents and monetization of short-term receivables and inventory
Z	equity ÷ foreign capital	represents the share of equity and foreign capital in assets financing - refers to the degree of coverage of foreign capital by own resources

Tinoco and Wilson (2013) state that bankruptcy prediction is important for various stakeholders, mainly owners, managers, employees, creditors, suppliers, customers and government. Development and application of models capable of bankruptcy prediction may be important for them mainly in two directions:
- An early warning system - such models are useful for all parties (managers, authorities) since it enables to adopt certain measures to prevent bankruptcy.
- The models may be helpful for decision-making of financial institutions, evaluation and selection of business entities to establish cooperation with or even to invest into.

Bankruptcy prediction models vary in the method applied for their structure as well as in the nature of indicators included subsequently. Some bankruptcy prediction models include current market as well as accounting indicators while the others include just accounting variables. Beaver et al. (2005) present 3 key reasons why market indicators are significant for bankruptcy prediction:
- market prices reflect complex mixture of information,
- values of market variables are easier to track in time - it is possible to capture their dynamic development, to the contrary with financial indicators, published quarterly, if so (in Slovakia, it is on annual basis),
- market indicator values may constitute the volatility indicator (models including also market indicators are of a higher quality in comparison with indicators including just accounting data).

Agarwal and Taffler (2008) compared the performance of bankruptcy prediction models including accounting as well as market indicators. The authors advocate opinion that models including accounting data are better, since:

- bankruptcy is not a sudden event, it is a result of poor performance for several years and such development for several years provides values of individual financial reports,
- credit terms provided by a bank to business entity are predominantly based on financial indicators and such information is a result of financial report analysis,
- quite often, the data necessary for market indicator models is not available.

On the other hand, Agarwal and Taffler (2008) state the following disadvantages of accounting data based models:

- accounting data represent past performance therefore it is not possible to be used for predictions,
- conservatism and historical expenses accounting mean that the actual value of assets may differ to a great extent from the recorded accounting value,
- accounting data is often subject to manipulation by management.

The majority of generally applied bankruptcy prediction models were developed in developed market economies thus limiting their applicability in transforming countries. A significant limitation of using foreign prediction models in the Visegrad Group (V4) countries is based mainly upon the following aspects: limited effectiveness of share market, narrow profiling of a model to specific industry, differences in size and capital power of a business entity, inconsistency of legal regulations, impact of macroeconomic environment, etc. In the following part of this paper, we provide basic knowledge representing the current state of the financial health prediction issue in the V4 countries.

2.3 Poland

Fijorek and Grotowski (2012) point out that in the last 20 years, there have been several attempts to create the bankruptcy prediction in the Polish economy environment. According to the authors, the fundamental problem for the process of company bankruptcy evaluation is lack of good quality data regarding business entities in the standardized form. If we look back, the most used method for creation of such models was by using discriminant analysis. Since 1990s to the present, there have been models developed by Mączyńska (1994), Pogodzińska and Sojak (1995), Gajdka and Stos (1996), Hadasik (1998) and Hołda (2001). From the most current models, there have been models applying logistic regression, neural networks and decision trees developed, e.g. Wędzki (2005) and Hołda (2006).

The broader overview of research in Poland is provided by Prewysz-Kwinto and Voss (2015) who recorded 15 models developed by various authors, specified in detail in literature. The goal of their research was to introduce results of empirical studies related to application of financial analysis and bankruptcy risk identification carried out between Polish business entities. The authors also provide 3 reasons why it is not possible to apply foreign models for other countries: particularity of economies of individual countries, applied accounting standards, access to information.

One of the most recent models, not yet applied in Polish business entities, is the Firth model, developed by Kaczmarek (2016). The model applies logistic regression for classification of business entities to successful and unsuccessful. The sample consisted of 426 business entities subject to bankruptcy declaration in the previous year and 1,936 successful business entities

selected within the same period. According to the author, it has been the largest set of company data in the context of bankruptcy threat level modelling.

2.4 Hungary

In Hungary, the legal background for processes of bankruptcy and liquidation of business entities was constituted in 1991 therefore there is no long-term tradition of bankruptcy prediction in Hungary. The first model of financial health prediction in Hungary was developed in 1996 by Virág and Hajdu (1996), reviewed and updated by the same authors in 2001. The first model included data of companies from 1990 and 1991. The basic methodology included discriminant analysis and logistic regression. Out of 154 business entities undertaking in processing industry, included in the model, 77 were solvent and the same number of business entities were insolvent. All business entities included in the sample employed at least 300 employees. During the course of model development, there were 17 financial ratios evaluated (Virág, Kristóf, 2005).

The most recent model was introduced by Bauer and Endrész (2016), estimating probability of bankruptcy for Hungarian business entities, utilizing the probit method. The estimated model shows significant performance for recognition between failing and healthy business entities. The benefit of this model is combination of micro as well as macro information, enabling to capture aggregate risk level dynamics, mainly in times of on-going economic crisis.

2.5 Czech Republic

The first attempts to develop a prediction model in the Czech Republic came in 1995 when the Neumaier couple developed the first prediction model with the working title "IN95". The model was reviewed four years later; the emphasis was put mainly to development of company value as the main goal of its activities. The result was an "IN99" index.

In conjunction with "IN05" model, there were new attempts to create a prediction model that could be used as a support tool for decision-making to more stakeholders. Jakubík and Teplý (2008) developed a new index named "JT", evaluating financial stability of Czech business entities. The index is based on the financial scoring model while for model estimation, the logistic regression was used. Within development of the model, there were seven indicators of business entity bankruptcy assessed, one year before identification of business entity's financial distress.

One of the most up-to-date papers regarding prediction models in the Czech Republic comes from Kubíčková and Nulíček (2016) who strive to prepare structure of business entities' financial health model. The first part of research includes characteristics of prediction ability possibilities of discriminant analysis. The second part of research defines possible indicators/predictors of financial distress that could be, in a certain way, combined into a resulting bankruptcy model. The model alone compares various views of factors influencing financial situation of business entities and puts them into contrast with indicators used so far in scientific works (with special regard to models in transition economies). The result is a set of 39 indicators verified in the subsequent stage of the research by discriminant analysis.

2.6 Slovakia

In comparison with other countries, the research regarding financial health prediction in Slovakia is clearly undersized. From the view of a complex bankruptcy prediction model focused exclusively to Slovak business entities, we found just a small circle of models. One of them is a Ch-index Chrastinová (1998) and G-index Gurčík (2002) model, developed for evaluation

financial health of business entities undertaking in agricultural industry. Chrastinová (1998) utilized data of Slovak business entities and upon discriminating analysis; she developed an equivalent of a bankruptcy prediction model. CH-index is orientated to the agricultural industry only. For development of this prediction model, there were over 1,000 business entities undertaking in the agriculture industry analysed.

Mostly, there are prediction models from Czech Republic or worldwide-known models applied for Slovak companies; such models are considered as less suitable tools for bankruptcy prediction due to reliability of results.

3. CONCLUSION

There are various prediction models, differing in approaches and methods applied for their compilation, demand for input data, 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 understandable that creators of prediction models strive 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.

The difference of environment requires development of an optimum combination of indicators and development of original models designed for one particular economy. Due to the place of origin, structure of individual indicators and their weights in models, the possibility to use such individual models for business entities in conditions of Slovak economy is considerably problematic and limiting. Due to the aforesaid, we think it is important to develop a prediction model that would eliminate the aforesaid shortcomings and take the current economic situation of Slovakia into account. Only then, it is possible to provide a high prediction reliability of the model, being the decisive criteria for its quality.

ACKNOWLEDGEMENT

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