

## Comparison of selected accounting-based prediction models

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**Abstract:** Prediction models were designed to predict bankruptcy of enterprises based on various methods. The most common used models are statistical-mathematical methods or artificial intelligent methods called neural networks. The aim of the paper is to provide overview of selected accounting-based prediction models and to sum up their advantages and disadvantages. Subject of analysis were models based on statistical-mathematical methods such as Altman model, Ohlson model, Zmijewski model and Index IN.

**Keywords:** bankruptcy, financial distress, accounting-based prediction model.

JEL codes: M41, G33

### 1 Introduction

Since financial crisis in 2008 and 2009 till nowadays, detection of financial distress and oncoming bankruptcy is in spotlight of interest of entrepreneurs, suppliers, banks, shareholders and other third parties. Basis for enterprise financial distress identification and financial stability assessment are information drawn from accounting. Priority function of accounting is to provide information for executives and financial management of company. (Baštinová, 2017; Pakšiová, 2017) Information from accounting system presented in financial statements are sources for assessment of financial performance and prediction of future development. (Lovciová, 2017; Šlosárová et al., 2016) Correct and understandable reporting of information in the financial statements is the basis for the financial analysis. (Kubaščíková and Juhászová, 2016; Procházka and Pelák, 2016) Financial analysis of enterprise is evaluation tool for financial situation assessment. Šlosárová and Blahušiaková (2017) defines financial analysis as investigation of economic processes or phenomena. At the beginning, financial statement analysis was used to assess credit worthiness of debtor by lenders. (Beaver et al., 2010) Nowadays, financial analysis is a widespread tool, which includes numerous ratios and indicators for wide variety of users. Both, external and internal users of information from financial statements are interested in future development of enterprises, so financial analysis indicators were subject of lot of researches and papers. Michalovič (2017) pointed out four qualitative conditions of the enterprise financial situation, in the concrete financial health, financial distress, financial crisis and at last bankruptcy. Users are interested not only about the amount of profit and growth, but more about the consequences of the financial situation deterioration, respective about upcoming bankruptcy. Financial distress refers to insolvency, to the inability to pay obligations on time. (Beaver et al., 2010; Kravec, 2014) According to Geng et al. (2015) financial distress of enterprise refers to the situation when negative net assets exceed the operating cash flow. Hassan et al. (2017) define financial distress as situation of failure, insolvency, default or bankruptcy. Definition of financial distress and bankruptcy vary in different countries due to legal framework and accounting rules and procedures. Geng et al. (2015) and Mihalovič (2017) pointed out that problems in enterprises must not have financial reasons, but most of them causes weakening of profitability and will be eventually reflected in a deteriorated financial situation and the may have bankruptcy or financial restructuring as outcome.

### 2 Methodology and Data

The object of investigation are selected accounting-based prediction models such as Altman model, Ohlson model, Zmijewski model and Index IN05. The aim of the paper is to highlight

common and different features of selected accounting-based prediction models and to point out the limitations of model application.

In paper were applied scientific methods of investigation, mostly selection method, method of comparison, analysis and synthesis. From literary resources by selection method were pointed out useful information needed to appropriate description of the investigated issue. Literary resources include mainly book publications, papers in proceedings and journals. Firstly, is needed to be explained the background of the application of accounting-based prediction models such as sources of financial information, basic concepts and terms. Subsequently, by analysis method were identified prediction models' characteristics and simultaneously by comparison method were pointed out their common and different features. In conclusion we summarized our findings using synthesis.

### 3 Results and Discussion

Up to present, forecasting of financial distress or bankruptcy of enterprise was the object of numerous studies. Wide range of prediction models is available and used in practice, but in rapidly changing environment their usability should be continuously reviewed. Prediction models represent timely warning systems based on examination of selected indicators that has the ability to indicate a threat to the financial health of an enterprise. (Rybářová et al., 2016) Prediction models are differentiated based on input data, which can be data from market (market-based) or enterprises' accounting and financial statements (accounting-based). Accounting based prediction models are divided to three categories based on applied methods they use: mathematical-statistical methods, scoring methods, neural networks.

The most well-known prediction models use mathematical-statistical methods such as logistic regression and multivariate discriminant analysis. The advantage of mathematical-statistical methods is that the conclusions are exact and not affected by experts' experiences and subjective views. (Jenčová, 2014) Mathematical-statistical methods are applied in following models: Altman model, Fulmer model, Beerman model, CH- index, Index IN, Springate model, Taffler model, Ohlson model, Zmijewski model. Altman model, Ohlson model, Zmijewski model and Index IN05 will be undertaken to detailed analysis and subsequent comparison.

The original Altman model was published in 1968, where by multivariate discriminant analysis were examined five indicators. (Beaver et al., 2010) Altman was the first, who used multivariate discriminant analysis to point out financial distress and oncoming bankruptcy. (Altman, 1984) The original Altman model was tested on the period 1946 – 1965 on 66 enterprises. Very large and very small enterprises were excluded from sample, which means that mean assets size of enterprises was 6.4 million dollars. (Altman, 1968) Later, Altman revised the original formula and developed model for private firms, for non-manufacturers and emerging markets. Regarding to Altman et al. (2016) "the coefficient of the model had significantly changed, which means that the relations between the financial ratios and the signs of financial distress had changed over time", due to overall accuracy rate of the model declined. Although, Altman's original model performed well for short-term distress prediction compared with market-based bankruptcy models. Altman et al. (2016) Further criticism of model concerns assumptions of normality, independent predictor variables and group distribution. (Ohlson, 1980; Jones, 1987; Geng et al., 2015)

Ohlson's accounting-based prediction model is based on logistic regression approach. For period from 1970 to 1976 Ohlson (1980) analyzed 2058 non-bankrupt and 105 bankrupt enterprises. Ohlson model uses values between 0 and 1, where point below 0.38 tells the enterprise is facing bankruptcy and point above reflect lack of financial distress. Ohlson criticized Altman model, because of the assumption of normally distribution of explanatory variable and do not agree with inclusion of variable for matching reasons rather than for predicting bankruptcy. (Ohlson, 1980) Not only Altman's model faced criticism, but Ohlson's model as well. Hillegeist et al. (2004) criticized two issues: firstly, the use of one and non-randomly selected observations referred as sample selection bias. Secondly, Hillegeist et al. (2004) does not agree with omission of time varying changes.

Zmijewski model uses probit model, which is a type of regression analysis, where dependent variable takes values 0 or 1. Compared to previous models the additional value is created by including external factors such as industry sector, economic cycle and size of the enterprise. Zmijewski examined all enterprises listed on the American and New York Stock Exchanges excluding financial, service and public administration firms, by this choice tried to avoid the selection-based sample bias. (Zmijewsky, 1984) Sample bias was one of the most criticized point of multivariate discriminant analyzes applied by Altman. The examination was realized for period 1972 till 1978. Shumway (2001) criticized Zmijewski model for strong correlation between variables total liabilities/total assets to net income/total assets. Interpretation of Zmijewski model is based on p-value in statistical matters, where p-value higher or equal to 0.5 classifies the enterprise as bankrupt. Enterprises should not bankrupt, if the p-value is lower than 0.5. (Zmijewsky, 1984)

Prediction model Index IN was designed by Neumaierová and Neumaier using discriminant analysis on large and medium sized enterprises in Czech Republic. Index IN05 represents the last modification, which was tested on data from year 2004 of enterprises in industry sector. Index IN is referred as Altman model for Czech Republic, notable difference compared to Altman model is that Index IN model does not require market value of equity, due to is suitable for emerging capital markets. (Neumaierová and Neumaier, 2005) Due to similar business environment in the Czech and Slovak Republic accuracy of Index IN05 is higher than Altman model for classification of enterprises as bankrupt or non-bankrupt. (Tumpach and Stanková, 2016)

A brief overview of prediction models is included in Table 1, where are listed the used statistical methods, the examined period and the most significant advantages and disadvantages of selected models.

**Table 1** Comparison of selected accounting-based bankruptcy models

	<b>Statistical method</b>	<b>Period of study</b>	<b>Advantages</b>	<b>Disadvantages</b>
<b>Altman (1968)</b>	Z-score model, multivariate discriminant analysis	1946 - 1965	Most common method Easily applicable	Many assumptions
<b>Ohlson (1980)</b>	Logit model	1970 - 1976	Uses value (0 to 1) Less restrictive assumptions compared to Altman 1960	Bias
<b>Zmijewski (1984)</b>	Probit model	1972 - 1978	External factors are included	Variables are highly correlated
<b>Index IN05</b>	Multivariate discriminant analysis	2004	Easily applicable Does not require market value of equity	Best fits to Czech and Slovak conditions

Source: own processing

Besides statistical-mathematical methods scoring methods and neural networks have also practical application. The essence of scoring methods is that to selected financial ratios are assigned scores and subsequently the level of financial health of enterprises is determined based on numerical scale. As scoring methods are classified the following: Argenti model, quick test, balance analysis of Doucha and Tamari risk index. (Šofranková, 2014)

Neural networks are a kind of artificial intelligent technics, "imitate the capabilities of neurons of the human brain's ability to model the course of dependencies between individual indicators and results." (Tumpach and Stanková, 2016) Neural networks applied in this field are able to model non-linear relationships between explanatory variables and a dependent variable. (du Jardin, 2009) Where explanatory variables are different indicators and factors which have influence on dependent variable. Dependent variable

represents the basis for classification of enterprise financial situation as appropriate or deteriorated. Tumpach and Stanková (2016) states that many studies concluded that in comparison to standard mathematical-statistical methods the neural networks are more accurate in prediction of bankruptcy.

## Conclusions

Various prediction models are widely used in practice for forecasting and evaluating the present and future financial health respectively financial distress of enterprises. Selected models, which were subject of analyzes were Altman model, Ohlson model, Zmijewski model and Index IN. The most common difference in these models arise from use of various statistical methods and different analyzed period. Common features are that they use accounting-based data, which are easily accessible from enterprise's accounting system. Secondly, calculations are clear without complicated computations and results are easy to interpret. Disadvantage of models are that they accuracy decline by time and changes in financial environment are not reflected. Best accuracy of models is for the same circumstances, based on which the model was created and changes in enterprise segment, time and environment can cause significant decrease of models' relevance.

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