Ohlson´s Model and its Prediction Ability in Comparison with Selected Bankruptcy Models in Conditions of Czech SMEs

Ohlsonův model a jeho predikční schopnost ve srovnání s vybranými bankrotními modely v podmínkách malých a středních firem v České republice

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Abstract

In this paper are presented the results of a study examining the ability of Ohlson's Logit model assessing and predicting the financial condition development of SMEs in comparison with the other models outcomes. Ohlson´s model was created using logit regression, which allows in the evaluation of the financial situation involve qualitative and discrete variables. The aim of the study is to determine whether the method used to derive the model influences the final assessment of the financial condition and indication of bankruptcy. The solution is based on the comparison of the resulting assessment of these four models, value of which were calculated on the same sample of Czech firms. As compared models were selected Z-score model, derived in the terms of US enterprises, IN05 model, which was derived in the conditions of Czech companies and Taffer´s model, derived in the conditions of UK firms. The sample consisted of 1996 small and medium firms in the manufacturing industry in Czech Republic. Data were obtained from the database of Albertina for the period of the years 2012 and 2013. It was found that the assessment of the firm´s financial situation matches in case of the results of Ohlson´s model and Taffler´s model, greater differences were found between the resulting values of Ohlson´s and Taffler´s model on one side and IN05 and Altman's model on the other side. Ohlson´s model and the Taffler´s model confirmed a good financial situation of companies in about 90 per cent of firms, Altman´s model and IN05 model in about 40 per cent of firms. The influence of the method used to derive the model on the assessment of the financial condition of companies was not proven.

Keywords

bankruptcy models, Ohlson´s model, Z-score, IN05, Taffler´s model, logit regression analysis, financial condition, prediction ability

Abstrakt

V tomto článku jsou porovnávány výsledky hodnocení finanční situace malých a středních podniků, které byly zjištěny při aplikaci Ohlsonova modelu, s hodnoceními, které byly zjištěny na základě jiných modelů. Ohlsonův model je odvozen s využitím logitové regresní metody, která dovoluje zapojit do posuzování finanční situace kvalitativní parametry a nespojité veličiny. Cílem studie je zjistit, zda metoda použitá pro odvození

modelu ovlivňuje výsledné hodnocení finanční situace a indikaci bankrotu. Metodou řešení je komparace hodnocení zjištěných jednotlivými modely v jediném souboru malých a středních firem v ČR a porovnání jejich výsledných hodnot. Jako porovnávaný model byl zvolen Altmanův model Z-score pro nekótované firmy, odvozené z podmínek amerických firem, IN05, který byl odvozen z podmínek českých podniků, a Tafflerův model odvozený z podmínek firem ve Velké Británii. Analyzovaný soubor zahrnoval 1996 firem, působících v odvětví zpracovatelského průmyslu v České republice. Data za období 2012 a 2013 byla získána z databáze Albertina. Bylo zjištěno, že hodnocení finanční situace firem na základě Ohlsonova modelu se shoduje s výsledky zjištěnými na základě Tafflerova modelu. Větší rozdíly byly zjištěny mezi hodnocením podle Ohlsonova modelu a Tafflerova modelu na jedné straně a modelů Z-score a IN05 na druhé straně. Ohlsonův a Tafflerův model identifikoval velmi dobrou finanční situaci u 90 % firem, Altmanův model a IN05 model u 40% firem. Vliv metody, která byla použita pro odvození modelu hodnocení finanční kondice firem, nebyl prokázán.

Klíčová slova
bankrotní modely, Ohlsonův model, Z-score, IN05, Tafflerův model, logitová regresní analýza, predikční schopnost, finanční situace

JEL Codes
G33, M21

Introduction

The recent developments of the global economy have affected the thinking and decision-making of many economic entities. Company managers, owners, investors and other stakeholders as well as academics have shifted their attention to various methods and tools that allow reliably identify companies' financial situation. More than ever before, there has been a strong demand after such methods and tools that could indicate potential problems in advance and thus making it possible to adopt corrective measures before any critical events actually occur. This has increased focus on the prediction models. Using appropriately selected indicators, these models should predict whether a company would be successful within its further business activity or whether it would face serious problems. Originally, these models had been developed with a view to identify potential financial problems in the future. Consequently, they have been referred to as bankruptcy prediction models. However, the general practice later required more detailed characteristics of an overall financial situation – not only information about potential financial problems, but also the specification of the degree of financial health or in which area there are the threats. This triggered the creation of models that measure the financial health of a company using rating scale and allowed more detailed assessment.

One stream of the researchers focuses on the older models and their prediction reliability in the current or national conditions. Other direction of research interest is focused on creating new models reflecting the new conditions of companies operations as well as the advancement in economic modeling and mathematical processes applicable for this purpose. The financial situation of companies is affected by new factors, original factors change in their intensity; in addition to financial and quantified characteristics, various qualitative characteristics are gaining ground. The financial situation is significantly

affected by such factors as market position, long-term contracts, past developments in the form of court disputes, profit generation, etc. Consequently, the construction of new models is associated with various efforts. The aim of these research efforts is to increase the number of parameters, included in the financial situation assessment as well as efforts aimed at involving parameters outside of financial statements. Limitation of the former method used for models derivation consists in the limited range of indicators that could be included in the evaluation as well as the necessity of the subsequent limits definition to separate healthy companies, "grey area" companies, and companies headed to bankruptcy. All these facts shift the attention to other methods. The econometric method of logit regression is the method that offers opportunities for these new demands.

One of the models, construction of which is based on the logistic method, is the model of J. A. Ohlson, professor of Accounting at the New York University Stern School of Business. The model was created in 1980, relying on accounting data – similarly as other models – which were complemented by the non-accounting indicators. It was the indicator describing the development of the price level and inflation and to indicators describing the profit development. The basic model of J. A. Ohlson of 1980 has gradually been updated. Significant sensitivity of the model to signals dating back to the period, in which the model was derived, resulted in the construction of updated variants (1993, 2003, and 2010). Close relation to national conditions, in which companies operate, was reflected in the construction of models for individual national economies (United States, Turkey, China, Iran).

The Czech economic literature does not mention the Ohlson´s model as often as the Altman Z-score. Consequently there is no sufficient information about the model´s accuracy and reliability. The aim of this paper is to compare the firms´financial situation assessment of the Ohlson´s model with the assessments of selected models, Altman Z-score and IN05.

1 Literature Review

Assessment of the financial situation of companies under bankruptcy models and comparing their predictive ability in the national economy is studied by many authors in various national condition. In the Czech economic literature P. Šlégr (2013) compared the results of the model Z-score and IN05 on a sample of fifty largest Czech companies in the period 2006 to 2010 and found that the evaluations of both two models are not identical. Evaluation based on the model IN05 seems to be significantly worse than that one based on the Z-score model. However, this prediction - according to available information – was not confirmed by the real development.

Klecka and Sholleová (2010) compared the evaluation of glass making firms based on three models: the Altman Z-score, Credibility index and IN05 model. In relation to the tested models stated that „these models could not predicate an actual crisis of these enterprises sufficiently in advance, … however could show in advance the bad financial condition and weakened immunity a longer time before the beginning of crisis… Concerning the influence of external factors, these models reflect right their consequences in economy and corporate finance, thereby such indication is practically effectual for

needs of management of enterprise only incase of gradual incidence of these influences" (Klecka, Sholleová, 2010, p. 8-9). Consensus or inconsistencies in the evaluation based on the individual models they did not comment on. Čámská and Hájek (2012) assessed the financial health of the firms in the whole glassmaking industry using the Altman model and IN05 model. They concluded that the results of the both models differ.

Kupilík in his study (2013) found that earlier versions of Ohlson´s model are inaccurate in assessment of Czech companies, while newer versions assessed the situation of Czech companies generally more sensitive. Evaluation by Ohlson's model mostly coincided with the evaluation compared models Z-score, IN05, Taffler model, solvency index, and also with the values of selected indicators of financial analysis. Moreover in case of firms, which had to close down their operations due to the financial distress, all variants of this model identified the real danger of bankruptcy in advance.

Adamec (2010) compared the resulting values of the model IN05, ZETA, Ohlson´s model and Shumway model. He concludes that one year before the bankruptcy the characteristics are already profiled in such an extent that the models are able to predict the bankruptcy with a relatively high accuracy. In the case of IN05 however the ability to predict the bankruptcy worsens two years before the decay.

In foreign literature are published much more research papers focused on this issue. The bankruptcy or financial failure prediction is investigated from different aspects. One group of researches assessed the predictive ability of existing models (Zeta, Ohlson, Shumway, Zmijewski, Shirata etc.) and verify their reliability in national conditions (Grice, Dugan, 2003, Moghadam et al. 2003, Kumar et al., 2012, Jouzbardand et al., 2012). The second group of researchers is focused on testing the predictive ability of existing models in the current conditions, including the search for new indicators of bankruptcy (Wang, Campbell, 2010, WU et al., 2010, Pongsatat et al. 2004, Shumway, 2001 etc.). The third group is trying to create new models using the same methodology, suitable for contemporary national economic environment (Liao, 1994, Gurčík, 2002, Chen et al., 2009). The other significant group of researchers focusing on the issue of input data, whose source is accounting, and verifies the influence of different accounting practices (including IFRS) on the explanatory power of indicators and default models (Kubíčková, Jindřichovská 2012, Lantto, A., Sahlström, P., 2009 etc.).

2 Methodology and Data Description

2.1 Logit Regression

Ohlson´s model has been built up on the base of logit regression (sometimes also referred to as "logistic regression"). In contrast to linear regression, which assumes continuous dependent variable ($Y = b_0+\Sigma b_i x_i$), logit regression operates with discontinuous independent variable. In case we assume that there are *n* realizations of the dependent variable y_n (financial problems yes=1, no=0 for *n* companies), then the following applies:

$y_i = 1$ with the probability of p_i and $y_i = 0$ with the probability of $1-p_i$,

In order to create a logit model, it is assumed that the variable η_i (y_i) has linear dependence on the independent variables x_1, x_2, … x_k. The resulting relationship can be described in the form of a linear dependence equation:

$$\eta_i (y_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots. + \beta_k x_{ki}, \qquad \text{where } i = 1,2, \ldots n \tag{1}$$

The resulting value η_i (y_i) may be both positive and negative. Consequently, it is necessary to apply logarithmic transformation $\eta_i = \ln (p_i / (1 - p_i)$ to the calculation. The matrix notation of the equation is as follows:

$$\eta = \beta X \tag{2}$$

where η (η_1, η_2, … η_n) are the dependent variable values, X is the matrix with n x (k+1) of independent variables; β (β_1, β_2, …β_k) are the inquired model parameters (variable weights). Adjustments lead to the relationship for the probability pi as follows:

$$\ln (p_i / (1- p_i) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots. + \beta_k x_{ki}, \tag{3}$$

$$p_i / (1- p_i) = \exp \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots. + \beta_k x_{ki}$$

$$p_i = \exp \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots. + \beta_k x_{ki} \; / \; (1- p_i) \tag{4}$$

The resulting matrix notation for the probability calculation is as follows (Šedivá, 2012):

$$P = \left(\frac{1}{1+ e^{-Q}} \right) \tag{5}$$

The result (dependent variable Y) gives the probability for the given event (i.e. potential bankruptcy) to occur (Liao, 1994).

2.2 Characteristics of the Ohlson´s model Construction

Basic form of Ohlson´s model

The basic form of J. A. Ohlson´s model was constructed in 1980. He is believed to be the first to develop a model using Multiple Logistic Regression (Logit) to construct a probabilistic bankruptcy model for the predicting bankruptcy and the first who explicitly consider the timing issue. The basic variant was derived from the corporate data in the United States that reflected the situation of the 1970s and 1980s (Ohlson, 1980). To derive the model he used data from the period of 1970-1976 for his study and worked with a relatively large sample of companies – 2,163 companies in total. In this sample, it was included 105 failing companies and 2,058 financially sound companies. His objective was not to find new, special indicators of financial distress, but to rely on simplicity and application of experiences gained so far: first six indicators were used, because they appear in most publications dealing with financial situation assessment/ bankruptcy prediction.

The model comprised nine financial ratios based on accounting data identified from the group of analyzed companies as most sensitively reacting to future financial problems. Weights are attributed to individual indicators, with their values being integrated within the resulting variable Q based on the following relationship:

$$Q = \beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \beta_3 * x_3 + \beta_4 * x_4 + \beta_5 * x_5 + \beta_6 * x_6 + \beta_7 * x_7 + \beta_8 * x_8 + \beta_9 * x_9 \quad (6)$$

where $\beta_1,\ldots\beta_9$ are weight coefficients for individual characteristics (financial and other ratios $x_1,.,.x_9$), β_0 is a constant by which the sum of weighted values of indicators is increased.

The characteristics ($x_1,\ldots.. x_9$) included in the model are constructed as follows:

$$X_1 = \log \frac{total\ assets}{GNP\ price-level\ index}$$

$$X_2 = \frac{total\ liabilities}{total\ assets}$$

$$X_3 = \frac{working\ capital}{total\ assets}$$

$$X_4 = \frac{current\ liabilities}{current\ assets}$$

X_5: X_5 = 1, if total liabilities > total assets, X_5 = 0, if total liabilities < total assets

$$X_6 = \frac{net\ income}{total\ assets}$$

$$X_7 = \frac{funds\ provided\ by\ operation}{total\ liabilities}$$

(where: funds provided by operations = net income + depreciations/amortizations)

X_8: X_8 = 1, if the sum of net income for the two previous periods is less than 0
X_8 = 0, if the sum of net income for the two previous periods is more than 0

$$X_9 = \frac{NI_t - NI_{t-1}}{|NI_t| - |NI_{t-1}|}$$

where: NI_t is the net income for the current period and NI_{t-1} is the net income for the previous period and $|NI_t|$ and $|Ni_{t-1}|$ are the absolute values of the net income for current / previous period.

Resulting variable Q is only an interim result that must be applied in the probability calculation relationship (see Formula (5)):

$$P = \left(\frac{1}{1+ e^{-Q}}\right)$$

The resulting value of the model (P) describes the probability that bankruptcy occurs for the company being analyzed with a predetermined period of time (i.e. one year, two years, or five years). It may have different values in the interval of ⟨0;1⟩. The probability calculation also suggests that the higher the value Q as the sum of values of individual indicators, the higher the propensity to bankruptcy; on the other hand, low Q values characterize stable situation:

- If $Q < 0$, then $P \rightarrow 0$ (P converges to 0);
- If $Q > 0$, then $P \rightarrow 1$ (P converges to 1);
- If $Q = 0$, then $P = 0.5$.

The indicators significance is characterized by positive or negative value – negative impact of an indicator with positive value, as it reduces the total Q. On the other hand, negative indicator value has a positive effect, as it increases the total Q. The indicator weight relates to the significance of the characteristic measured by the given indicator.

The fact that the results give immediate information about the company bankruptcy probability rate was considered the main benefit of models derived by means of logit regression by Ohlson (and probably the only benefit, according to the author himself). It does not require any artificial scales for the result interpretation, it allows more precise characterization and layering of the measured characteristics, and eliminates the problem of extreme values. The probability of 50 per cent is the limit for determining whether a company is headed for bankruptcy or whether it is financially sound. The interval of 45 per cent to 55 per cent is indicated as the "grey area" that eliminates the assessment insensitiveness around the 50 per cent limit.

2.3 Ohlson´s model and its Variants

In the original study in 1980 Ohlson derived three model variants. All the variants comprise nine financial ratios $x_1 – x_9$ (see equation (6)) and differ in the weights of these indicators. In all three variants the highest weight and negative impact is attributed to indicator x_2, which describes the company indebtedness level. Significant impact is also attributed to indicator x_5, which describes the company´s debt from different perspective (if the total debt exceeds total assets, ie. overindebtedness) and corrects the impact of the indebtedness indicator through its negative value. Significant positive impact on the overall financial situation (high weight) is attributed to the net income in the past two years (indicator x_8) and return on assets after taxation (indicator x_6).

The first model should predict bankruptcy within the period of one year. It means that in case the resulting model value is more than 50 per cent, the company is at risk of bankruptcy or serious financial problems (as appropriate) in the current or in the following year.

The second model of the original study was supposed to predict bankruptcy in the period of next two years: in case the results suggest bankruptcy for a company, it should not take place during the current year, but rather during the next year and the year after that. The third model was supposed to predict company bankruptcy/serious financial problems one or two years in advance, i.e. not in the next year, but during the year after next year or in the year after that.

In the followings years, Ohlson's prediction function was verified in various economic environments – in the United States, Turkey, Iran, and other countries - and also with longer period from the model creation. The results of these verifications brought important findings that later have encouraged the creation of other model variants. Subsequent verifications confirmed that, the first model of 1980 with one yeart prediction horizon predicts the company´s development most accurately.

The first three variants of the models, more precisely their weights of indicators, as well as the weights of indicators in the following model versions are presented in the Table 1.

In 1993, the models of Altman and Ohlson were tested in order to determine whether the respective model parameters changed over time compared to the original variants (Jin, 1993). A new version was constructed using data of 99 failing companies and 1 980 prosperous companies from the period of 1981-1990. Intentionally were omitted companies from the sector of transportation and finance. Two variants were constructed (1993/1, 1993/2); the first one should have predicted bankruptcy one year in advance, the second one two years in advance. Original indicators and their calculation were used in the new model; changes occur in terms of weights attributed to individual indicators and in the constant included in the calculation.

In the following years the test results of this model under different conditions revealed that indicators and coefficients are sensitive to the conditions and period, from which they originated. The model accuracy decreased depending on the period passing the time when it was created: being the highest in the time closest to the period the model was created (1988-1991), next years (1992-1999) gradually declining. Therefore, Ohlson decided to recalculate the model. The work was associated with deliberations on whether it is necessary to link prediction to bankruptcy or whether it would be more useful to focus to the prediction of a "moderate variant", i.e. the financial distress prediction. Relied on a relatively large sample of companies the new model was derived in 2003 (for USA conditions). The new model was created in the three variants (2003/A, 2003/B, 2003/P), i. e. three new sets of coefficients (weights) of the initial nine indicators were derived: the first variant, general (A), was derived from the entire sample, the second one (B) from the subset with unstable companies only (i.e. with financial problems), and the third one (P) from the subset with industrial companies only. Compared to the previous model of 1993, the constant was omitted. The testing confirmed the prediction accuracy of the three new model variants is higher than the previous ones. Once again was also confirmed, that prediction accuracy is higher for models, the derivation of which is closer to the period, from which the tested data originate. Furthermore, the final assessment unambiguously focused on the prediction of serious financial problems, and not bankruptcy/end of com-

pany operations. This model can be considered as the last "international variant" (Wang, Campbell, 2010).

In 2009 insufficient reliability of the existing Ohlson's model variants under the conditions of Turkish economy led to a new variant of this model (2009 T), which was created based on the data of relatively small set of Turkish companies (70 companies) (Muzir, & Çağlar, 2009). The structure of indicators was the originally one including the constant, the only differences were in the indicator´s coefficients (weights of the indicators).

In 2010, the Ohlson's model was recalculated by economists from the University of Queensland in Australia that tried to find new weights of indicators (Wu, Gaunt, & Gray, 2010). Following the results of verification and recalculation, a new model was created (2010), in which indicators used in all of the aforementioned models have been included, only the coefficients have changed. Compared to the previous variants the calculation was based on much larger sample of companies: 50,611 companies, of which 887 were failing companies, and 49,724 financially healthy companies, used data from the period of 1980 to 2006.

In 2010 Chinese economist Ying Wang and American Professor Michael Campbell created the Ohlson's model variants for the Chinese economy (Wang, Campbell 2010). Using data from Chinese companies from the period of 1998 to 2008, they constructed (similarly as Ohlson in 1980) three model variants (2010 C1, 2010 C2, 2010 C3), with different period of prediction of bankruptcy, more preciously of serious financial problems: model C1 is to predict financial problems one year in advance, model C2 within two years, C3 one or two years in advance.

In the same year 2010, as a result of doubts whether the number of variables included in the model is justified and whether all indicators in fact contribute to the model sensitivity, were constructed new versions of model for the Chinese economy (2010 CU1, CU2, CU3). With the aim to increase the explanatory power and simply the model application, three new alternative models were constructed (Wang, Campbell 2010). They included only five variables/indicators selected from the original model: x_2 (indebtedness), x_3 (working capital to assets), x_4 (current liabilities to current assets), x_5 (excessive debt), and x_8 (income development in the past two years). The constant is also used. By assigning weights to individual indicators (based on the set of firms), three model variants were constructed– varying in the time horizon for prediction of problems (as in the previous case).

In 2011 was created the latest variant of Ohlson's model (2011 I). It resulted from the testing of the four most famous bankruptcy prediction models (Ohlson, Zmijewski, Shumway, and Altman) for the economy of Iran. The application of these models promoted the construction of a new Ohlson's model variant (Kordlar & Nikbakht, 2011). It was derived from data of more than 1 500 Iranian companies, of which 142 ended their activities due to financial problems (no financial and transportation companies were included). The new model applied again the set of nine indicators and a constant, only attributing new weights to indicators based on the conditions of the Iranian economy.

Table 1: Overview of coefficients used in the Ohlson´s bankruptcy model variants

	x_1 = log (assets / price index)	x_2 = liabilities / assets	x_3 = net working capital / assets	x_4 = current liabilities / current assets	x_5 = liabilities>assets a) yes =1; b) no = 0	x_6 = net income / assets	x_7 = funds provided by operations / liabilities	x_8 = income for past two years<0:a) yes=1;b) no =0	x_9 = income increase / absolute income increase	Constant
Q	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_0
1980/1	-0.407	6.03	-1.43	0.0757	-2.47	-1.83	0.285	-1.72	-0.521	-1.32
1980/2	-0.519	4.76	-1.71	-0.297	-2.74	-2.18	-0.780	-1.98	0.4281	1.84
1980/2	-0.478	5.29	-0.990	0.062	-4.62	-2.25	-0.521	-1.91	0.212	1.13
1993/1	-0.1659	1.7518	-0.8496	0.035	-0.2911	-2.5018	-2.362	0.9512	- 0.5192	- 2.2473
1993/2	-0.1639	0.8749	-2.0623	-0.2224	-0.0916	-6.1045	-1.6608	-0.1286	-0.3576	-0.7325
2003A	-0.777	3.224	-0.323	0.589	0.041	-2.86	-2.854	0.372	0.206	0
2003B	-0.881	3.931	0.054	0.166	0.645	-0.548	-2.886	0.656	-0.3	0
2003P	-0.706	2.204	-1.25	0.455	0.553	-3.79	-4.591	0.157	0.309	0
2009 T	-0.228	7.186	-0.073	0.613	-1.714	3.264	-4.187	0.438	-0.154	-4.582
2010	-0.17	3.69	-1.87	0	-0.54	0.03	-0.06	1.16	-1.02	-7.2
2010 C1	-0.8983	0.9546	-0.9234	0.00248	2.9508	-0.0109	-0.033	3.2088	0.5871	-1.3128
2010 C2	-0.2786	-0.2152	-0.2132	-0.0207	1.4666	-0.00755	-0.0541	-4.157	-0.9292	-5.5238
2010 C3	-0.5974	-0.4991	-0.4699	-0.00164	2.0091	-0.01	-0.042	3.7182	-0.1823	-2.48
2010 CU1	0	-0.9925	-0.9865	0.00237	3.3802	0	0	3.11	0	-7.5113
2010 CU2	0	-0.1404	-0.1591	-0.0231	1.5255	0	0	4.2852	0	-7.4331
2010 CU3	0	- 0.417	-0.4086	0.00177	2.1839	0	0	3.8624	0	-6.7685
2011 I	-0.14	14.58	2.92	-0.6	-0.17	-1.4	-2.6	3.79	-0.25	-12.87

Source: own elaboration based on literature

2.4 Models Used for Comparison

In this research was compared the prediction ability of four models: Ohlson´s model, model IN05, Altman´s Z-score model and Taffler´s model.

Ohlson´s model, used in our research, was that one from the 2003 for the industry. This selection was made with regards to the set of analysed firms. The other reason of this selection was that the newer version of this model reflect the specific conditions of countries with economies, different from Czech Republic. The structure of this model is as folows:

$$Q\ (2003)\ P = -0{,}706\ x_1 + 2{,}204\ x_2 - 1{,}25\ x_3 + 0{,}455\ x_4 + 0{,}553\ x_5 - 3{,}79\ x_6 - 4{,}591\ x_7 + 0{,}157\ x_8 + 0{,}309\ x_9 \quad (7)$$

where: $x_1 - x_9$ are the indicators included in the original model mentioned above.

Probability calculation will be according formula mentioned above (5).

IN05 model is a model, that was created based on the conditions and accounting data of Czech firms. Its structure is as follows (Neumaier, Neumaierová, 2005):

$$IN05 = 0{,}13 * x_1 + 0{,}04 * x_2 + 3{,}97 * x_3 + 0{,}21 * x_4 + 0{,}09 * x_5 \quad (8)$$

where: x_1= total assets/liabilities, x_2=EBIT/interests, x_3=EBIT/total assets,
*x_4 = revenues/total assets, x_5 = current assets/shortterm liabilities**
) shortterm liabilities = shortterm debts + shortterm bank loans)

Interpretation of the value IN05:

IN > 1.6	- the firm is in a good financial situation and creates value for the owners,
IN < 0.9	- the firm is financially unstable and value do not constitute
0.9 < IN < 1.6	- about the financial situation of the firm cannot be said anything definite (grey zone).

Companies which reach the value below 0.9 will reach a bankruptcy with probability of 0.97 and with probability of 0.76 will not create value for owners. Companies which have reach the value ranging from 0.9 to 1.6 reach the bankruptcy within two years with probability of 0.50 and with probability of 0.70 will form the value for owners. Firms above the upper limit 1.6 then do not run the bankruptcy with probability of 0.92 and with probability of 0.95 will create value for owners.

The Altman´s model Z-score is aimed to identify the possible serious financial problems of the firms in the future of two years. It was created in some variation. For the purpose of our research we used the formula designed for the assessment of companies that are not listed on the regulated capital markets in USA, derived in 1983 (Altman, 2010):

$$Z_o = 0{,}717*x_1 + 0{,}847*x_2 + 3{,}107*x_3 + 0{,}420*x_4 + 0{,}998*x_5 \quad (9)$$

where x_1 = *Net Working Capital / Total Assets*
x_2= *Retained Earnings / Total Assets*
x_3 = *EBIT / Total Assets*
x_4 = *Equity / Total Liabilities*
x_5 = *Sales / Total Assets*

Interpretation of the value of Z-score is divided into three levels according to value Z_o:
a) Values higher than 2.7- the firm is in good condition, there is not a threat of bankruptcy in the next two years
b) Values between 2.7 – 1.2 - further development cannot be specified more precisely (grey zone),
c) Values lower than 1.2 - the firm is threatened by the serious financial problems in the next two-three years

Taffler´s model is also a model aimed to predict possible bancruptcy of the firms. The model was published in 1977 designed for assessment of UK SMEs (Taffler, 1982). We used the modificated version of the model that includes four indicators:
R_1 = EBT / short term liabilities
R_2 = current assets / liabilities
R_3 = short term liabilities / total assets
R_4 = revenues / total assets

The formula for the calculation of this model is:

$$TZ = 0{,}53 * R_1 + 0{,}13 * R_2 + 0{,}18 * R_3 + 0{,}16 * R_4 \quad (10)$$

Interpretation of the value TZ is as follows:

TZ > 0,3 =	very low posibility of the firms´ bankruptcy
0,2 < TZ < 0,3 =	grey zone, there cannot be said nothing precisely of the firm financial condition
TZ < 0,2 =	high posibility of the firm´s bankruptcy

2.5 Data Source and Sample of Firms Definition

The data of firms were obtained from the database Albertina. The criterion for sample of firms selection was the legal form (a limited liability company, joint-stock company) and the criteria to define small and medium-sized enterprises, which is number of employees smaller than 250 and turnover lower than 50 mil. EUR or a balance sheet total of less than 43 mil. EUR. The fourth criterion in definition of SMEs is the independence of the firm, that means that in the firm has not a share in the extent 25 per cent or more any other firm who is not SME. To respect this criterion we have no enough information. We try to fill it so that in the sample we included only the Czech firms and companies the owner of which was originally from the Czech Republic. The other criteria for the selection of companies was the main field of activity (manufacturing industry), the availability of the financial statements in the full extent of from the years 2012 and 2013, the seat in the municipalities of over 1000 of the population and at the same time the seat outside the town of over 500 thousand inhabitants. This criteria should unify the conditions in which the companies operate. Thus the selected file included 2086 companies. Verification of the completeness and reliability of the data this file reduced to a finite number of 1996 companies.

3 Achievements of the Research

Based on algorithms of the four models have been calculated resulting values of each firm identifying their financial condition, i. e. four resulting values of 1996 firms, which were included in the sample. The basic characteristics of resulting values´ descriptive statistics are presented in Table 2.

Table 2: Resulting values of the models – statistical description

	Ohlson´s model	**Z-score model**	**Model IN05**	**Tafler´s model**
Number of firms	*1996*	*1996*	*1996*	*1996*
Average	**0.087 (0.13)**	**2.36**	**1.545**	**0.956**
Category on average	**Stable financial situation**	**Grey zone (uper level)**	**Grey zone (uper level)**	**Stable financial situation**
Median	**0.001**	**2.47**	**1.391**	**0.693**
Minimum	**0.000**	**-128.84**	**-27.987**	**-5.812**
Maximum	**1.000**	**44.34**	**35.468**	**18.890**
Variance	**0.056**	**15.985**	**6.055**	**1.523**
Standard deviation	**0.238**	**3.998**	**2.461**	**1.234**

Source: own calculations

Values of the Ohlson´s model is expected in the interval ⟨0;1⟩. They represent the probability of the bacruptcy, more preciously of serious financial difficulties. In the analysed set of firms the values of this model were dispread in the whole interval, although great deal of the firms reach the value near the value of zero. Values lower than 0.001 (i. e. 0.1 per cent) were reached in the half of the firms (1042 firms, 52 per cent), values higher than 0.999 (i. e. 99.9 per cent) were in 63 firms (3 per cent). Based on this results can be concluded that the financial condition of firms according to Ohlson´s model is assessed as very stabil and without any threats of bancruptcy. That corresponds to the average value reached in the set of firms on the level of 9 per cent, which means the posibility of bancruptcy on average 9 per cent.

The resulting values of Ohlson´s model were then adjusted for the extremely low and extremely high values (less than 0.001, more than 0.999). The average value of the indicator has due to this correction increased to 0.13. It also indicates a very low average level of risk. On the other hand, in the 63 companies the value is higher than 0.999, that indicate the future plight almost certain. The resulting values distribution were compared with the results of other models (between Ohlson´s model and Z-score model, including Ohlson model and IN05, and the Z-score and IN05). Test conformity of the resulting models values distribution was not confirmed, the values of the models differ significantly.

Altman Z-score gave a somewhat different track results. Good financial health indicates fewer companies. The average value was 2.35, which ranks companies in the sample in the gray zone, but closer to the upper limit, that indicates a good financial condition of companies. The resulting value of this model were adjusted of excluding extreme values (lower than -5.1 and greater than 5.1). The corrected average value reached of 2.57, which is slightly higher ratings then before correction and confirmes the overall pozitive evaluation. Median lower than the average of the corrected file but indicates the dominance of companies with lower than average levels. The test for normal distribution confirmed that the results of this model exhibit a normal distribution.

Rating by IN05 model was more sparsely compared with the first two models, but indicate good financial condition as well. The average value was reached at 1.545, that lies in the gray zone, but near the upper limit of it. Excluding outliers was achieved adjustment average value which was a bit higher. The relation of median and average value when median is lower than average reveals the greater proportion of lower values and a little worse situation in the whole sample. It can be explain by the extremly high values reached in some firms due to the some of indicators. One of the causes of extreme values was the indicator x2 (EBIT/interest). Low values of interests in some firms caused extremely high levels of this indicator. Despite the fact that in calculation the reccommended correction (Neumaier, Neumaierová, 2005) was applied (maximum value of |9.0|), the resulting values reached very high level in some firms. A similar effect had an indicator x1 (A/total liabilities). In case of low value of firms´ debt this indicator reach extremely high value.

Resulting ratings of firms of Taffler´s model was similar to the Ohlson´s model results. The average value of 0.956 reached in the sample indicates very good financial stability of the firms. Values greater than 0.3 indicating good financial situation were achieved in 88.9 per cent of the companies, values lower than 0.2, indicating the threat of bankruptcy were found in 6 per cent of companies. Also in case of this model the median is lower than average value and it means the larger share of values lower than average and somewhat reduces the very good assessment of the whole sample.

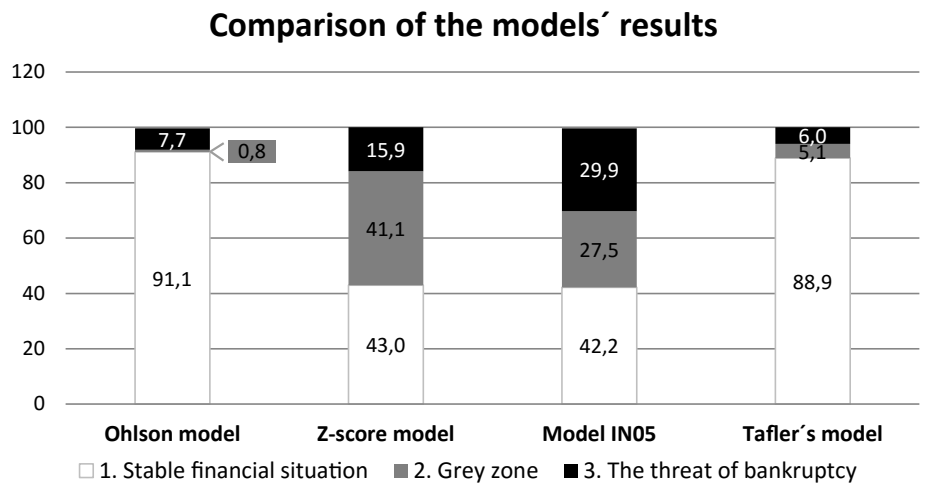
Frequency of individual categories of rating scale based on the compared models is shown in Table 3 and Figure 1.

Table 3: Assessment of the firm´s financial condition

Category	**Ohlson´s model**		**Z-score model**		**Model IN05**		**Tafler´s model**	
	Abs.	%	Abs.	%	Abs.	%	Abs.	%
1. Stable financial situation	1826	91.5	858	43.0	853	42.6	1774	88.9
2. Grey zone	16	0.8	822	41.2	550	27.6	102	5.1
3. The threat of bankruptcy	154	7.7	316	15.8	597	29.8	120	6.0
Total	*1996*	*100.0*	*1996*	*100.0*	*1996*	*100.0*	*1996*	*100.0*

Source: own calculations

Figure 1: Resulting classification of compared models



Source: own calculations

Classification of companies into categories according to the compared models slightly differ. In the case of Ohlson´s and Taffler´s model there is significantly greater proportion of companies which are positively assessed, while the results of Z-score and model IN05 show relatively worse situation: the same share of firms with stable financial situation and of firms in the grey zone. Model IN05 in comparison with the Z-score indicates greater share of firms with the threat of bankruptcy. As compared all the models the greatest share of firms in the grey zone identifies model Z-score. The largest share of endangered firms identifies model IN05. However, both in Z-score and in IN05 model prevails the share of firms with positive evaluation of financial situation. There is an interesting coincidence in the results layout of two pairs of models: Model Ohlson´s and Taffler´s rank much less companies into the category of endangered firms with the risk of bankruptcy (7.7 per cent and 6.0 per cent respectively). Models Z-score and IN05 identify the greater share of companies threatened of bankruptcy, despite there is a greater disparity between the shares (15.9 per cent and 29.9 per cent respectively).

The congruity in the classification of companies by Ohlson´s model and other models describe the data in Table 4.

This comparison shows that in the category companies with stable financial situation has been achieved similarity to the Ohlson´s model assessment in the extent of 84 per cent in classification of model IN05 and at the same time Taffler´s model (84 per cent), while the classification of Z-score model were quite different (47 per cent). In the classification of endangered firms were in relation to Ohlson´s model all the three models almost identical: 58, 52 and 59 per cent of firms respectively. The smallest conformity was reached in the classification of the three models in the grey zone, but the number of firms in this category is minuscule.

Table 4: Classification of Ohlson´s and other compared models

Category	**Ohlson´s model**	***Of which:***	***According to:***					
			Z score model		**Model IN05**		**Tafler´s model**	
	Number of firms		*Abs*	*%*	*Abs.*	*%*	*Abs.*	*%*
1. stable financial situation	*1826*	**stable financial situation**	**872**	**47**	**1535**	**84**	**1531**	**84**
		grey zone	763	42	149	8	149	8
		The threat of bankruptcy	199	11	149	8	146	8
2. grey zone	*16*	*stable financial situation*	4	25	3	19	2	13
		grey zone	**4**	**25**	**2**	**12**	**0**	**0**
		The threat of bankruptcy	8	50	11	69	14	87
3. the threat of bankruptcy	*154*	*stable financial situation*	31	20	56	36	26	17
		grey zone	33	22	18	12	22	14
		The threat of bankruptcy	**90**	**58**	**80**	**52**	**106**	**59**

Source: own calculations

4 Summary and Discussion

Performed calculations and comparisons showed that the models in the evaluation of financial situation of firms differ. Relatively greater consensus in the assessment of financial condition was found between the Ohlson´s model and Taffler´s model. On the contrary larger differences were observed in the results of Ohlson and Taffler´s model on one side and Z-score and IN05 on the other side. Ohlson´s model and Taffler´s model presented the financial situation of the companies significantly better. Model IN05 assessed the firms´ financial situation the most strictly. Final verifying which of the compared models predicted the future fate more precisely could bring subsequent analysis of the real data.

When calculating the value according to different models (IN05, Z-score and Taffler´s), has proven their high dependence on the ratio indicators, which include. The problem was not in the selection of indicators and their sensitivity for predicting bankruptcy, but in the possibility of some ratios to reach extreme values. The resulting model value then - in individual cases - loses its explanatory power and predictive capability within a validated rating scale and also limits the comparability of the value in space and time. In the analysed sample of companies proved as problematic the indicator debt ratio (A/Liabilities) and interest coverage (EBIT/Interests) and also the return on assets or return on equity

(EBIT/A, EAT/E). These indicators use items "interest" (IN05), "foreign capital" (IN05, Z-score) or profits at different levels. It is obvious that these indicators are significant of possible future distress. But values of these indicators may acquire in the particular circumstances of extreme values that do not correspond to lower / higher risk. The applicability of such model is thus limited.

In the case of Ohlson´s model, these obstacles did not occur. It can therefore be assumed that the problem is partially removed the another way of deriving the model (logit regression), which at the same time create space for other criteria for evaluation of financial situation. The resulting values of this model, however, show too soft evaluation. The reason may be that the model was derived in a different economic environment and at a different time. Sensitivity to the conditions and time the model was derived were the stimulus for construction different national models. To verify the reliability of the models based on logit regression in comparison with the models based on linear regresion or to construct the model variant based on the Czech environment should be the themes of further research.

Performed comparisons also drew attention to the financial data, which are the main source for the both derivation and subsequently calculation of the models. The role of accounting data and accounting methods (continental, anglosaxon, national) in the predictive ability of the models and the reliability of the final verdict still remains in the background of attention. The accounting principles and methods affect the data across accounting statements. They are not only different in different national environments, but also within a single the national environment itself (as a result of options in financial reporting).

5 Conclusions and Possible Future Research

Performed comparison of Ohlson´s model and selected three prediction models, model Z-score, model IN05 and Taffler´s model, revealed that the evaluation of companies financial situation using the model based on the logit regression differs significantly from the assessment based on models derived by linear regression, although this conclusion is not absolutely true: some similarities can be found with the assessment of Taffler´s model. Ohlson´s model identifies much better financial situation of companies than models Z-score and IN05. In the evaluation of financial situation coincide models of Z-score and IN05. The very favorable assessment of the firms could be explained by structure of indicators and the model application in different economic conditions and in the distance from the time of its construction, specifics of economic surroundings, etc.

The study raises a number of questions which can become a stimulus for further research. Problems to discussion and the theme for further research can be seen in the folowing areas:

a) What indicators – financial, non-financial - are the most sensitively to the future financial distress and what is discriminatory power of these indicators.
b) The methods used to derive the model and their impact on the model prediction accuracy of the real bankrupcy.

c) The degree to what is the model accuracy affect by the data entering the model derivation (distribution, outliers).

Acknowledgements

This paper was funded by The institutional support for long-term conceptual development of research organization, the University of Finance and Administration, Prague, as a result of Research project IGA VŠFS [No 7762] "Historical and cultural aspects of accountancy as a factor determining the process of IFRS implementation (with special accent on CEE countries)".

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