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Original Altman Bankruptcy Model And Its Use in Predicting Failure of Czech Firms

Abstract

The ability to successfully derive future values of key variables has always belonged with the objects of human interest and has not even avoided the business sector. For several decades, many economists have been trying to find a way how to assess the health of a business as accurately as possible, or predict bankruptcy. This article aims to assess the discriminatory power of one of the most famous and most discussed corporate predictive models, the Altman Z-Score from 1968. The research is focused on four main areas of assessing the discriminatory power of the model. The first part deals with the overall discriminatory power of the model; the second part is aimed at quantifying the impact of individual variables on misclassification of enterprises in bankruptcy. The third part quantifies the discriminatory power of individual variables of the model. The last part compares the classification accuracy of the original model and the modified Altman model which is also adapted to firms not traded publicly. The results are compared with the findings of other authors. The empirical research is based on the accounting data of Czech companies from the manufacturing industry.

Key Words

Altman, bankruptcy, corporate failure, predictive model, Z-score

JEL Classification: G33, M21

Introduction

The first studies focused on the prediction of failure were based on univariate analysis of ratios. These works dealt with a simple analysis of financial indicators, comparing the values of variables of failing and successful businesses. In 1930 the company Bureau of Business Research introduced study, which analyzed the development of 24 indicators in 29 failing companies. The benefit was to identify eight ratios that were considered to be indicators of poor health companies.[8]

The beginning of the real development of research in the area of bankruptcy prediction is dated to the sixties of 20th century, when Beaver [7] published his work. Beaver was the first financial analyst who used statistical techniques for predicting corporate bankruptcies and he identified six financial ratios that are crucial in order to assess the financial health of companies. He also came to the conclusion that multiple analysis of ratios and their connections to one model has a much higher predictive power than analysis of individual indicators. Thus began the era of development of predictive models. In the following years quite a number of other models were published. Altman [3] introduced his multivariate linear discriminant model in 1968; Ohlson [17]

introduced his logit model in 1980. Mr. and Mrs. Neumaier with their indexes IN have been pioneers in assessing the financial health of Czech firms. The last one called IN05 was published in 2005.[16]

The aim of this article is to assess the discriminatory power of one of the most famous and most discussed corporate predictive models, the Altman Z-Score from 1968, especially to quantify the discriminatory power of each variables of the model and its impact on misclassification prediction of companies in bankruptcy. Many authors addressed the discriminatory power of the model as a whole, but not the discriminatory power of the individual variables of the model. The determination of key variables that influence the resulting value of the Z-Score is a necessary step to the correct application of the model and, in particular, to the detection of any erroneous predictions.

Somebody could argue that the original model is not intended for companies which can not determine the real market value of equity. Altman [2] states, even though the replacement of the market value of equity by the value accounting is regarded as incorrect modification, this is one of the most frequent modification of the original model (see chapter 1) and in practice it is often used. It will be interesting in the end of this article to assess whether the original model (with mentioned modification) achieves higher predictive power than the model for nonlisted companies on capital market.

1. Altman's Bankruptcy Predictive Model

The best-known version of this model was constructed in 1968. E. I. Altman [3] compared 33 medium-sized American companies (their registered capital amounting to USD 1 – 25 mil.) which ceased to exist with the same number of adequate booming companies. He was the first one to apply multiple discriminant analysis to estimate weights of individual ratios which were included in the model as variables. At first, Altman included 22 financial ratios in his model. He then reduced them only to the five most important. By means of his analytical method he got the following formula known as the Altman's bankruptcy predictive model or the Z-Score model, which is used for **companies listed at the capital market**:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5, \quad (1)$$

where X_1 = working capital / total assets, X_2 = retained earnings / total assets, X_3 = EBIT / total assets, X_4 = market value of owner's equity / book value of total liabilities, X_5 = sales / total assets. In our analysis variable X_4 = book value of owner's equity / book value of total liabilities.

If the score is above 2.99, the firm is healthy. If it is below 1.81, the firm is viewed as failing. Values ranging from 1.81 to 2.99 represent the so-called grey area, when there is no clear prediction.

Practice has proved that the application of the Altman's Index to predict the business failure is the most reliable two years prior to bankruptcy. The model is less effective and reliable when predicting bankruptcies in the distant future (see Table 1).

Tab. 1 Accuracy of Altman's Company Bankruptcy Predictions

Number of years prior to bankruptcy	Correct prediction (number of companies)	Wrong prediction (number of companies)	Correct prediction (%)
1	31	2	95
2	23	9	72
3	14	15	48
4	8	20	29
5	9	16	36

Source: [3, p. 604]

After publishing the model, a discussion on how the Z-score model could be used for “nonstock companies” started. Modification of the original model consisted in the total revaluation of the model and the market value of owner's equity in variable X_4 was substituted with the book value of owner's equity. In 1977 Altman [1] published the final model applicable to companies **nonlisted at the capital market** and it is as follows:

$$Z' = 0.717 X_1 + 0.847 X_2 + 3.107 X_3 + 0.420 X_4 + 0.998 X_5. \quad (2)$$

Classification ranges for this model have been changed. If the score is above 2.9, the company is healthy. If it is below 1.23, the company is regarded as going bankrupt. Values ranging from 1.23 to 2.9 represent the so-called grey area, when there is no clear prediction. It is obvious that the grey area for this model is wider as opposed to the original Altman's model.

The original model has been modified in many other ways. Altman adjusted the model in such a way so that it could be applied to emerging markets too.[5]

The reliability of the Altman models has been verified by the author himself and other analysts many times. Russ et al. [19] concluded that the accuracy of the Altman model is sufficient. The model was tested on a sample of several thousands of firms. The resulting Type I error (misclassification of a company in bankruptcy) was 20.6 % and the Type II error (misclassification of going concerns) was 28.4 %. Lacher et al. [14] belongs among next authors who found the accuracy of the modal to be sufficient. The Type I error was 17 % and the Type II error was 4.3 % in their set of firms. In contrast to it, Boritz et al. [10], who assessed the reliability of the model in predicting bankruptcy of Canadian companies, found the predictive power of the model insufficient. The model revealed only 41.7 % of bankruptcies. The predictive power of the model for Czech companies was tested by e.g. Vochozka [21], Maňasová [15], or Kopta [13]. The Czech authors mentioned above came to the conclusion that the Altman Z-Score could unequivocally detect the bankruptcy one year prior to the bankruptcy itself in circa 63 – 73 % of companies. Circa 10 % of companies were erroneously assessed as prosperous.

2. Material and Methodology

2.1 Collection and Characteristics of Input Data

Given the nature of the research, the input data are composed of the financial indicators of selected manufacturing firms. The manufacturing industry has been chosen for its dominant position within the Czech economy. Due to the comparability, firms from other industries have not been included into the analysis. The sample analyzed consists of both prosperous and failing companies. The method of selecting companies corresponds to the selection of enterprises in other professional studies or works.

The group of thriving companies is made up of 47 firms that Čekia, a.s. as well as Coface Czech found successful. An indisputable advantage of these charts is their attempt to assess the overall situation of firms; it is a comprehensive assessment of firms' performance. The rating ČEKIA Stability Award [9] provides an independent view of the financial and non-financial standing of the company. It expresses its current condition, financial situation, including the prediction of future risk. The analyzed flourishing companies took the highest places in the aforementioned charts in 2009 and 2010. For reasons of comparability, a longer period of time was not taken into account. The financial ratios of firms were monitored in the period from 2008 to 2010.

Thirty-eight companies were ranked among those in bankruptcy and their financial ratios for the period of 1 – 3 years prior to the declaration of bankruptcy were monitored. The only condition for including a company in this group was the court decision to declare bankruptcy issued from 2007 to 2011. In order to compare the input data, we did not take a longer period of time into account. The sample of bankruptcy companies was chosen by non-random selection (due to data availability). The bankruptcy manufacturing companies that published the financial statements for observation periods were included in the sample. The data availability, especially for companies in bankruptcy, is very low. The company Creditreform publishes information on compliance of obligation to publish the financial statements by Czech companies. At the end of 2010, only 21 % of limited liability companies and 35 % of joint stock companies saved the financial statements for the year 2009 in Collection of Documents. Czech companies includes to the worst in Europe.[11] The non-random samples of firms are also used in the construction of the predictive models themselves, for example Altman [3][4], Taffler [20], Ohlson [17]. Some authors found that if a failure prediction model is estimated on samples that are non-random it may give inefficient predictions.[6][21] In contrast, Zmijewski [23] found that non-random samples do not significantly affect the overall accuracy rates.

Albertina, the database of firms and institutions, and the collection of documents were the main sources of firms' financial data.

2.2 Methodology for Determining the Discriminatory Power of Variables

The impact of variables on the misclassification of companies in bankruptcy

As the high error rate was not recorded with going concerns, the influence of individual variables on misclassification was analyzed only with bankrupt companies. Companies whose resulting value of the Z-Score is lower than 1.81 ($Z < 1.81$), i.e. they are viewed as bankrupt by the model, are considered to be correctly classified as companies in bankruptcy. Companies that are assessed as prosperous by the model and whose resulting Z-Score is higher than 2.99 ($Z > 2.99$) are considered to be misclassified. Also companies which are ranked in the so-called grey area, i.e. their Z-Score is $1.81 \leq Z \leq 2.99$, are considered to be misclassified in the period of one year prior to bankruptcy. This condition is based on the assumption that the company predictive model should be able to unambiguously detect failure at least in the period immediately before the bankruptcy itself.

The effect of the i -variable on the misclassification of enterprises in bankruptcy p_i was quantified with the use of the following equation:

$$p_i = \frac{X_{i1} \cdot b_i - X_{i2} \cdot b_i}{Z_1 - Z_2} \cdot 100 = \frac{b_i \cdot (X_{i1} - X_{i2})}{\sum_{i=1}^5 b_i \cdot (X_{i1} - X_{i2})} \cdot 100, \quad (3)$$

where X_{i1} is the average value of the i -variable of correctly classified companies in bankruptcy, X_{i2} is the average value of the i -variable of erroneously classified companies in bankruptcy, b_i denotes the coefficient of the model i -variable, Z_1 is the average Z-Score of correctly classified companies in bankruptcy, and Z_2 denotes the average Z-Score of misclassified companies in bankruptcy.

Discriminatory power of the model variables

Prof. Altman [3] evaluated the discriminatory power of the variable i -th by its standard deviation σ_i weighted by the coefficient b_i . However, this assessment may fail in certain situations. This method of assessment assumes that a possible high variability is caused by different values of variables of companies in bankruptcy in comparison with thriving businesses. But that is not the rule. A high standard deviation of a variable caused by a high variability in both groups of companies is not a sign of high discriminatory power, i.e. the ability to distinguish thriving companies from those in bankruptcy. Therefore, it is preferable to choose a similar way as in assessing the influence of individual variables on the misclassification of companies. This method was also used by Taffler [20], and Joy and Tollefson [12]. The relative discriminatory power of variables, r_i , is calculated according to the following equation:

$$r_i = \frac{Y_{i1} \cdot b_i - Y_{i2} \cdot b_i}{T_1 - T_2} \cdot 100 = \frac{b_i \cdot (Y_{i1} - Y_{i2})}{\sum_{i=1}^5 b_i \cdot (Y_{i1} - Y_{i2})} \cdot 100, \quad (4)$$

where Y_{i1} is the average value of the i -variable of thriving businesses, Y_{i2} is the average value of the i -variable of companies in bankruptcy, b_i denotes the coefficient of the model i -variable, T_1 is the average Z-Score of prosperous businesses, and T_2 denotes the average Z-Score of companies in bankruptcy.

3. Results

3.1 Classification of Companies by Original Model

The following table No. 2 shows the classification of successful companies by the Z model in the individual observed years.

Tab. 2 Classification of prosperous firms by the original Z model

	Average value of Z-Score (Z)	Number of firms		
		$Z < 1.81$	$1.81 \leq Z \leq 2.99$	$Z > 2.99$
2010	4.092	2	9	36
2009	4.324	2	8	37
2008	4.352	1	6	40

Source: author's own elaboration, 2012

In the individual monitored years, the model accuracy in classification of the successful firms, i.e. the ability of the model to assess the thriving firms by the Z-Score value higher than 2.99 ($Z > 2.99$), was ranging from 77 % in 2010 to 85 % in 2008. In view of the conclusions of other authors (see the chapter 1) and in view of the fact that an objective business performance criterion cannot be set, we can state that the accuracy of the Z model in classification of thriving companies is sufficient. The majority of firms were classified as thriving or included in the grey zone. Only a negligible percentage of firms were assessed as bankrupt in the individual years. The future development of these firms should be observed. We expect and require the bankruptcy prediction model to be highly reliable especially when predicting bankruptcy. Due to the fact that a group of companies in bankruptcy includes only companies that have been declared bankrupt, it can be expected that at least one year prior to bankruptcy the model evaluate all monitored companies as the company threatened bankruptcy.

Tab. 3 Classification of companies in bankruptcy by the Z model

Number of years prior to bankruptcy	Average value of Z-Score (Z)	Number of companies		
		$Z < 1.81$	$1.81 \leq Z \leq 2.99$	$Z > 2.99$
1	0.791	27	9	2
2	1.215	20	8	10
3	2.033	15	4	9

Source: author's own elaboration, 2012

It is evident from Table 3 that the model is less accurate in the classification of firms in bankruptcy than the thriving ones. One year prior to the bankruptcy itself, 71 % of firms were classified as those that were definitely at risk of going bankrupt. Two years prior to

bankruptcy, only 53 % of companies were classified as bankrupt and three years before bankruptcy only 39 % of companies analysed were considered bankrupt.

3.2 The Impact of the Individual Variables on the Misclassification of Companies in Bankruptcy

Table No. 4 which follows illustrates the impact of the individual variables on the misclassification of companies in bankruptcy according to the methodology described above.

Tab. 4 The impact of the variables on the misclassification of companies in bankruptcy (1 year prior to bankruptcy)

	X ₁ (WC/A)	X ₂ (RE/A)	X ₃ (EBIT/A)	X ₄ (BVE/BVTL)	X ₅ (S/A)	Z-score Z
Misclassification (average values)	-0.058	-0.063	-0.023	0.629	3.293	3.438
Correct classification (average values)	-0.453	-0.281	-0.291	0.011	1.602	-0.287
Z Model – coefficient	× 1.2	× 1.4	× 3.3	× 0.6	× 1.0	$\sum X_i \times b_i$
Misclassification ($X_i \times b_i$ coefficient)	-0.070	-0.088	-0.075	0.377	3.293	3.438
Correct classification ($X_i \times b_i$ coefficient)	-0.544	-0.393	-0.959	0.007	1.602	-0.287
Effect of variable $p_i(\%)$	12.725	8.188	23.732	9.933	45.396	

Source: author's own elaboration, 2012

It is obvious from the data in Table No. 4 that all variables reach higher average values with companies that were misclassified in comparison with the correctly classified ones. One year prior to bankruptcy there is the relatively highest difference in average values of the ratio X_4 . However, what is really significant for the resulting value of the Z-Score (Z) is the variable value weighted by the coefficient b_i . The variables $X_1 - X_4$ reach low or negative values, so they do not considerably increase the resulting value of the Z-Score (Z). It is evident though that the variable X_3 substantially decreases the resulting value of the Z-score of the correctly classified firms than the misclassified ones. The average values of the variable X_5 of the misclassified companies are above 3 and thus this variable substantially increases the Z-Score value. It follows that the variable X_5 significantly influences the differences in Z-Scores of correctly and erroneously classified companies in bankruptcy and so it has the greatest influence on the misclassification. We would arrive at the same conclusions if we analyzed the influence of variables on the misclassification of firms in the period of 2 and 3 years prior to bankruptcy. Quantification of the variables influence would be similar to the above-analyzed period of 1 year prior to bankruptcy.

3.3 Discriminatory Power of Individual Variables

When assessing the impact of variables on the Z-Score value, it is important for the variable to correctly distinguish bankrupt companies from thriving ones. Therefore, we

will focus on the relative discriminatory power of individual variables. The variable X_4 shows the biggest difference between the average value of thriving and bankrupt companies. However, due to its low coefficient its relative discriminatory power is same in comparison with the variable X_3 . Although X_3 shows the minimum difference in average values, it also shows the highest relative discriminatory power thanks to its high coefficient value. In comparison with that, the variable X_5 has higher values for companies in bankruptcy than in thriving companies; thereby it has a negative effect on the Z-Score value. This variable has the lowest ability to classify the thriving and bankrupt companies, and thus the lowest discriminatory power. Table No. 5 illustrates the situation in more detail. In the period of 2 years prior to bankruptcy the relative discriminatory power of individual variables has almost identical values and the order remains unchanged.

Tab. 5 The relative discriminatory power of variables (companies in bankruptcy – 1 year prior to bankruptcy – Y_{i1} , and prosperous companies – year 2009 – Y_{i2})

	$Y_{i1} - Y_{i2}$	$b_i(Y_{i1} - Y_{i2})$	Relative power of variable (%)	Order
X_1 (WC/A)	0.716	0.859	24.310	3
X_2 (RE/A)	0.518	0.725	20.524	4
X_3 (EBIT/A)	0.389	1.284	36.358	1
X_4 (BVE/BVTL)	2.130	1.278	36.182	2
X_5 (S/A)	-0.614	-0.614	-17.374	5
Σ		3.533	100	

Source: author's own elaboration, 2012

3.4 Classification of Companies by Modified Model

It can be assumed that the modified model for companies nonlisted at the capital market (1.2) will achieve higher accuracy than the analyzed model, which is designed for listed companies (1.1). If we compare the results, we find that the accuracy of the modified and original model is comparable for the going companies. But the accuracy of modified model is lower for companies in bankruptcy. 1 year prior to the bankruptcy itself, only 55 % of firms were classified as those that were definitely at risk of going bankrupt. Two years prior to bankruptcy, only 37 % of companies were classified as bankrupt and three years before bankruptcy only 26 % of companies analysed were considered bankrupt. Only 8 firms (21 %) were viewed as bankrupt in all those observed years. These results cannot certainly be regarded as sufficient.

Tab. 6 Classification of companies in bankruptcy by the modified model

Number of years prior to bankruptcy	Average value of Z-Score (Z')	Number of companies		
		$Z' < 1.23$	$1.23 \leq Z' \leq 2.90$	$Z' > 2.90$
1	1.078	21	14	3
2	1.356	14	14	10
3	2.086	10	21	7

Source: author's own elaboration, 2012

4. Discussion

The analysis made above has brought several interesting findings. The predictive power of the original model in classification of companies in bankruptcy is rather low. The bankruptcy was unequivocally detected in the period immediately before the bankruptcy itself only in 71 % of cases (in the period of 2 and 3 years prior to bankruptcy the percentage was significantly lower). Many authors hold the view that the reliability of the model is sufficient if the Type I error accounts for 20 % (see the chapter 1). The achieved results confirm the findings of other authors who assessed the predictive power of the model and came to the same results.[15][21]

Another interesting finding is certainly the fact that the modified model for the companies nonlisted at the capital market achieves lower accuracy than the original model (although it should be the other way around). The same conclusions were also reached by other authors. [15][21]

A high value of total asset turnover ratio of companies in bankruptcy is another important finding. The value of this ratio for firms in bankruptcy is even higher than for thriving firms (However, the Z-model assumes that the total asset turnover decreases with the increasing probability of bankruptcy). Some foreign authors in their analysis of variables of foreign firms have come to the same conclusion. Wu, Gaunt and Gray [22] analysed values of selected variables of 887 American companies, which went bankrupt in the period from 1980 to 2006, and compared them with the values of thriving companies. The asset turnover of companies in bankruptcy was 1.35, while of the thriving companies 1.22. Ooghe and Balcaen [18] adapted coefficients of the Altman Z-model to the conditions of Belgian firms. A negative value of the coefficient was assigned to the asset turnover variable, which proves a higher value of this ratio of Belgian firms in bankruptcy in comparison with the thriving ones. In the Prof. Altman's set [3] the bankrupt companies had lower values of asset turnover on the average than the thriving firms but the difference was not statistically significant. A relatively high asset turnover of companies in bankruptcy may be caused by an effort of these companies to avert bankruptcy and obtain the necessary financial means by selling its assets.

Conclusion

Several conclusions have followed from the performed research aimed at the analysis of the discriminatory power of the original predictive model of Prof. Altman.

The model accuracy in classification of thriving companies is sufficient. However, the accuracy of the model is low when classifying companies in bankruptcy. The accuracy of the original model when classifying companies in bankruptcy is higher than the accuracy of the modified model, which is designed for companies in our analyzed file (for companies nonlisted at the capital market). This finding may be a topic for further research, which would analyze the cause of this fact.

The asset turnover variable has the most significant effect on the misclassification of companies in bankruptcy. The asset profitability variable also has significant influence. The asset profitability variable has the highest relative discriminatory power (the ability to correctly differentiate companies in bankruptcy from the prosperous ones). On the contrary, the assets turnover variable has the lowest relative discriminatory power. This variable has an opposite effect on the resulting value of the Z-Score.

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