IS IT WORTH COMPARING DIFFERENT BANKRUPTCY MODELS?

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Abstract

DOLEJŠOVÁ MIROSLAVA. 2015. Is it Worth Comparing Different Bankruptcy Models? *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 63(2): 525–531.

The aim of this paper is to compare the performance of small enterprises in the Zlín and Olomouc Regions. These enterprises were assessed using the Altman Z-Score model, the IN05 model, the Zmijewski model and the Springate model. The batch selected for this analysis included 16 enterprises from the Zlín Region and 16 enterprises from the Olomouc Region. Financial statements subjected to the analysis are from 2006 and 2010. The statistical data analysis was performed using the one-sample z-test for proportions and the paired t-test.

The outcomes of the evaluation run using the Altman Z-Score model, the IN05 model and the Springate model revealed the enterprises to be financially sound, but the Zmijewski model identified them as being insolvent. The one-sample z-test for proportions confirmed that at least 80% of these enterprises show a sound financial condition. A comparison of all models has emphasized the substantial difference produced by the Zmijewski model. The paired t-test showed that the financial performance of small enterprises had remained the same during the years involved.

It is recommended that small enterprises assess their financial performance using two different bankruptcy models. They may wish to combine the Zmijewski model with any bankruptcy model (the Altman Z-Score model, the IN05 model or the Springate model) to ensure a proper method of analysis.

Keywords: prediction of bankruptcy, the Altman Z-Score model, the Zmijewski model, the IN05 model, the Springate model, evaluation of financial performance, small enterprises

INTRODUCTION

There is a whole range of models used to analyse an enterprise's performance. The options available in this respect include the Altman Z-Score model, the Fulmar model, the IN05 model, the Springate model, the Zmijewski model and others. Each of these models has been subject to testing by several different statistical and non-statistical methods. An enterprise's performance is often evaluated using either the z-test or the t-test.

Altman used the F-test to analyse five financial indicators. The sample tested included 33 bankrupt enterprises together with 33 financially sound enterprises. The original Altman model was 95% accurate (Altman, 1968).

The Altman Z-Score model has been tested several times (Grice and Ingram, 2001; Wang and Campbell, 2010; Yap, Yong and Poon, 2010).

Pitrová (2011) ran an analysis of financial indicators using the z-test. The author discovered that the greatest difference lies in variable X_1 (the ratio of working capital and total assets); the difference in variable X_5 (asset turnover) also has a substantial impact on the resulting Z-score value.

Imanzadeh, Maran-Jouri and Sepehri (2011) made comparisons between the Springate model and the Zmijewski model during the 2004–2008 period. The Wilcoxon ranked-sign test showed an important relationship between both of these models. The test statistic was 0.007, which was below the 0.05 level of significance. The same authors also tested another hypothesis: whether the Springate model is more conservative than the Zmijewski model. This hypothesis was verified using the paired t-test. The test showed there is a statistically significant difference between these models (the p-value was

0.003). Therefore, the Springate model is more conservative than the Zmijewski model.

The Zmijewski model was subjected to testing and revision by Grice and Dugan (Grice and Dugan, 2001; Grice and Dugan, 2003).

Klečka and Scholleová (2010) made a comparison between the Altman model and the IN05 model. These authors did not use any statistical tests.

The typical practice involves testing large enterprises instead of small one. This paper focuses on analysing the performance small enterprises (those that employ 10 to 49 employees). Small enterprises are more prone to bankruptcy than large enterprises.

The aim of this paper is to compare the performance of small enterprises in the Zlín and Olomouc Regions. The enterprises were analysed using four different bankruptcy models: the Altman Z-Score model, the IN05 model, the Zmijewski model and the Springate model. The data analysis was performed using suitable statistical tests: the one-sample z-test for proportions and the paired t-test.

The author of this paper has selected the following questions to support his research:

1. Can one expect that the percentage of financially poor small enterprises analysed using the Altman model would be less than 20%?
2. Is there a substantial difference in performance among small enterprises in the 2006–2010 period?
3. Is there any suitable model that should be recommended for the analysis of the performance of small enterprises?

These research questions were mirrored by the following statistical hypotheses:

1. The maximum percentage of financially poor enterprises is 20%.
2. The financial performance of small enterprises showed improvement in 2010 compared to the situation in 2006.

MATERIALS AND METHODS

Data Resources

The data was sourced from the Bisnode Czech Republic online database of enterprises. This database contains 355 enterprises from the Zlín Region and 260 enterprises from the Olomouc Region whose line of business is focused on office

hardware and computers. The analysed enterprises had to meet the following prerequisites:

1. A head count of 10 to 49 people.
2. Their interest expenses must be greater than zero.

There were 32 enterprises selected from the database, 16 of which were from the Zlín Region and the other 16 from the Olomouc Region. The chart that classifies business operations contains all the selected small enterprises in Section J: Information and communication operations (Tab. I).

Financial statements subjected to the analysis were from the period between 2006 and 2010.

Models Employed for Evaluating Financial Performance

The Altman Model for Companies Not Listed on a Stock Exchange

$$Z = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.420X_4 + 0.99X_5, \quad (1)$$

where

X_1 ..... working capital/total assets,
X_2 ..... retained earnings/total assets,
X_3 ..... earnings before interest and tax (EBIT)/total assets,
X_4 ..... the book value of equity/total liabilities,
X_5 ..... sales/total assets.

The Springate Model

$$Z = 1.3A + 3.07B + 0.66C + 0.4D, \quad (2)$$

where

A ...... working capital/total assets,
B .... EBIT/total assets,
C .... earnings before taxes (EBT)/current liabilities,
D ...... sales/total assets.

The Zmijewski Model

$$Z = -4.3 - 4.5E + 5.7F + 0.004G, \quad (3)$$

where
E .... net income/total assets,
F .... total debt/total assets,
G ...... current assets/current liabilities.

I: *Segmentation of business operations of small enterprises in the Zlín and Olomouc Regions*

Section J – Information and communication operations		
Division	**The Zlín Region**	**The Olomouc Region**
61 Telecommunication operations	3	2
62 Information technology operations	11	13
63 Information operations	2	1

Source: The author's own processing produced in accordance with the classification of business operations defined by the Czech Statistical Office

The IN05 Model

$$Z = 0.13I + 0.04J + 3.97K + 0.21L + 0.09M, \qquad (4)$$

where
I........total assets/total debt,
J........EBIT/interest expenses,
K ......EBIT/total assets,
L.......sales/total assets,
M ..... current assets/current liabilities.

Statistical Tests Used

The One-sample Z-test for Proportions

The one-sample z-test for proportions is used to determine whether the sample proportion p equals the hypothetical value. The test is subject to standardised normal distribution with the number of elements below 30. Kovářík and Klímek (2011) state the following prerequisites for using the proportional test: the number of observations (n) multiplied by the hypothetical value to be verified (p_0) must be at least 5, while the number of observations (n) multiplied by the difference ($1 - p_0$) must also be at least 5. The test is calculated using the following formula:

$$U = \frac{p - p_0}{\sqrt{p_0(1 - p_0)/n}}. \qquad (5)$$

The Paired t-test

The paired t-test is used for testing dependent samples. Each unit is subject to double measurement. Each measurement is used to define the differences. The test involves a null hypothesis that says that the differences are zero, which is contrary to the alternate hypothesis that states that there are actually differences. Performing the test requires an identification of the mean difference and the sample variance of difference:

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i = \bar{x} - \bar{y},$$

$$s_d^2 = \frac{1}{n-1}\sum_{i=1}^{n}(d_i - \bar{d})^2 = \frac{1}{n-1}\sum_{i=1}^{n} d_i^2 - \bar{d}\sum_{i=1}^{n} d_i. \qquad (6)$$

Kovářík and Klímek (2011) state the following prerequisites for using the paired t-test: compulsory paired samples, large samples and normal differences. The test statistic is then determined using the following formula:

$$t = \frac{\bar{d}}{s_d}\sqrt{n}, \qquad (7)$$

where
s_d......standard deviation of differences between the samples.

RESULTS

Tabs. II and III show a comparison of the numbers of small enterprises from the Zlín and Olomouc Regions. Small enterprises located in the grey zone are considered to be sound enterprises.

II: *A comparison of financial soundness in the Zlín and Olomouc Regions in 2006*

	2006			
	the Zlín Region		The Olomouc Region	
	Sound	**Bankrupt**	**Sound**	**Bankrupt**
Altman	13	3	14	2
IN05	16	0	16	0
Zmijewski	4	12	4	12
Springate	11	5	14	2

Source: The author's own calculations

III: *A comparison of financial soundness in the Zlín and Olomouc Regions in 2010*

	2010			
	the Zlín Region		the Olomouc Region	
	Sound	**Bankrupt**	**Sound**	**Bankrupt**
Altman	13	3	14	2
IN05	11	5	14	2
Zmijewski	3	13	0	16
Springate	11	5	12	4

Source: The author's own calculation

Tab. II clearly shows that all the small enterprises evaluated using the IN05 model appeared financially sound in 2006. Of the enterprises evaluated using the Altman model, 27 showed a sound financial condition, while 5 small enterprises faced a risk of bankruptcy. The results obtained for 2010 were very similar. 2010 showed that not all the small enterprises analysed using the IN05 model had a sound financial condition. It was very interesting to learn that both regions and both years reflected in the analysis showed the same number of small enterprises demonstrating a sound financial condition when evaluated with the Altman model (13 enterprises in the Zlín Region and 14 enterprises in the Olomouc Region). Another interesting finding confirmed that the number of sound and bankrupt small enterprises in the Zlín Region subject to analysis with the Springate model was the same (11 sound enterprises, 5 bankrupt enterprises).

The first hypothesis to be tested was whether the maximum percentage of small enterprises showing poor financial soundness when analysed according to the Altman model would be less than 20%. The test verified the null hypothesis stating that at least 80% of the small enterprises showed a sound financial condition. The alternate hypothesis states that at least 20% of small enterprises showed a poor financial condition. It can be also stated that

IV: *A maximum of 20% of the small enterprises had a poor financial condition in 2006*

Model	Sample proportion	Test statistics	p-value	Significance
Altman	15.625%	–0.6187	0.7319	NO
IN05	0%	–2.8284	0.9977	NO
Zmijewski	75%	7.7782	3.66E-15	YES
Springate	21.875%	0.2652	0.3954	NO

Source: The author's own calculations

V: *A maximum 20% of the small enterprises showed a poor financial condition in 2010*

Model	Sample proportion	Test statistics	p-value	Significance
Altman	15.625%	–0.6187	0.7319	NO
IN05	21.875%	0.2652	0.395411	NO
Zmijewski	90.625%	9.9879	8.61E-24	YES
Springate	28.125%	1.1490	0.125268	NO

Source: The author's own calculations

there are at most 80% of the small enterprises that show a sound financial condition. The results are displayed in Tabs. IV and V.

The results obtained using the one-sample test for proportions indicated that at least 80% of these enterprises showed a sound financial condition. The prerequisite stating that the percentage of small enterprises showing a poor financial condition must exceed 20% was not confirmed at the 0.05 significance level.

Mutual comparisons of all models confirmed the statistically significant difference only with the Zmijewski model. Of the 32 small enterprises covered by the analysis, 24 were identified as having a poor financial condition.

A comparison of the financial conditions of small enterprises in 2010 brought similar results. The only small enterprises that showed a statistically significant difference were the ones analysed using the Zmijewski model. The number of small enterprises evaluated according to the Zmijewski model was greater than in 2006. There were 29 small enterprises found to have a poor financial condition according to the Zmijewski model.

Verification of the second statistical hypothesis started with the normality test. The origin of differences disclosed here was normal distribution. The p-value from the Kolmogorov-Smirnov test with a Lillieforse correction reached 0.08, which is

VI: *Statistical values calculated using the paired test for the Altman model*

Mean difference	–0.35125
Sample variance of difference between the samples	1.4899
Standard variation of differences between the samples	1.220615
Test statistics	–1.62926
Critical value	1.69
p-value	0.0565

Source: The author's own calculations

higher than the 0.05 level of significance. The paired t-test was used for testing the null hypothesis that stated that the financial performance of small enterprises did not change in 2010, which negates the alternate hypothesis that states that the financial performance of small enterprises would see substantial improvement in 2010. Tab. VI shows the characteristics calculated for utilisation of the paired test.

The result of this t-test implies that we are not able to reject the null hypothesis, as there was not a significant difference in the financial performance of small enterprises when comparing 2006 and 2010. The financial performance of small enterprises remained the same in both years subject to analysis.

The results of the paired t-test were the same even for the remaining models. The test statistic was 1.195 (IN05), 0.6958 (Zmijewski) and –0.7173 (Springate). It can therefore be claimed that the financial performance of small enterprises did not change in the two years analysed.

DISCUSSION

The results of the analysis confirmed our initial assumptions only to a partial extent. It was verified that more than 80% of the small enterprises in the Zlín and Olomouc Regions had a sound financial condition.

An assumption pertaining to the second research question is that the longer a small enterprise remains in operation (the longer its history), the better its financial condition. The number of small enterprises in the Zlín Region assessed using the Altman model remained unchanged. The number of small enterprises evaluated using the IN05 model showed a decrease in financially sound enterprises in 2010 by five. As far as the Zmijewski model is concerned, the number of small enterprises showing a poor financial condition rose to thirteen in the Zlín Region in 2010; all the small enterprises in the Olomouc Region were evaluated as being bankrupt.

The results of the paired t-test were inconsistent with the results obtained by other authors. Imanzadeh, Maran-Jouri and Sepehri (2011) discovered a substantial difference between the Springate model and the Zmijewski model. This could be because these authors ran their test on large enterprises, while the author of this paper only tested small enterprises.

The question is whether there is a potential model suitable for evaluating small enterprises. Enterprises and models differ. Is there any method to compare the models?

There are two options for assessing models that use statistical methods, and they can also be used to conduct comparisons between individual models.

As far as statistical methods are concerned, one of the options is the Kruskal-Wallis test, which can be used provided all the models are considered independent samples. The hypothesis to be verified states that independent samples are based on the same distribution, which is opposed to the alternate hypothesis that states that there is at least one sample subject to different distribution.

The test statistic for small enterprises in the Zlín Region equalled 26.37728 and the value for Olomouc Region was 39.75252. The critical value $\chi^2_{0.05(3)}$ is 7.815. The p-values are also below the 0.05 level of significance. If the test statistic exceeds the critical value, it is possible to accept the alternate hypothesis that states that at least one sample does not originate from the same distribution.

The questions addressing mutually different models can be resolved using the Nemenyi test of multiple comparisons. A vital factor for determining significant differences among the models is the sum of ranks T_i. The results for the Zlín Region are indicated in Tab. VII.

The critical value for N = 16 (the number of values in lines) and for K = 4 (four various bankruptcy models) at a 5% level of significance is equal to 270.6. The greatest difference existed between the Altman model and the Zmijewski model (539). There are other differences between the Springate model and the Zmijewski model (302), as well as the Altman model and the IN05 model (280).

The results for the Olomouc Region are shown in Tab. VIII.

The critical value is similar to the one for the Zlín Region; it is equal to 270.6. The greatest difference is between the Altman model and the Zmijewski model (638); this difference is even greater than that for small enterprises in the Zlín Region. Apart from that, there are differences between the IN05 model and the Zmijewski model (455), as well as between the Springate model and the Zmijewski model (433). Tab. VIII shows that the differences between

VII: *The Nemenyi test of multiple comparisons for the Zlín Region*

Altman: T_1 = 784	Springate T_4 = 547	IN05 T_2 = 504	Zmijewski T_3 = 245
A - S = 237	S - I = 43	IN - Z = 259	
A - I = 280	**S - Z = 302**		
A - Z = 539			

Source: The author's own calculations

VIII: *The Nemenyi test of multiple comparisons for the Olomouc Region*

Altman: T_1 = 774	IN05 T_2 = 591	Springate T_4 = 579	Zmijewski T_3 = 136
A - I = 183	I - S = 12	**S - Z = 443**	
A - S = 195	**I - Z = 455**		
A - Z = 638			

Source: The author's own calculations

IX: *A comparison of individual bankruptcy models*

Models	Number of the same financial indicators	Financial indicators
Altman + Springate	3	EBIT/total assets Working capital/total assets Sales/total assets
Altman + IN05	2	EBIT/total assets Sales/total assets
IN05 + Springate	2	EBIT/total assets Sales/total assets
IN05 + Zmijewski	1	Current assets/current liabilities
Altman + Zmijewski	0	-
Springate + Zmijewski	0	-

Source: The author's own calculations

the sums of ranks T_i are greater for small enterprises in the Olomouc Region than in the Zlín Region.

A mutual comparison of the bankruptcy models reveals that three of the four models show the same financial indicators. For a comparison of the models, see Tab. IX.

The Altman and Springate models contain the most financial indicators. This similarity is not casual, because the Springate model is based on the Altman model. These models have not been found to be significantly different from one another.

The IN05 model and the Altman and Springate models have two financial indicators in common. The IN05 model is also based on the Altman model, with certain modifications for conditions unique to Czech Republic. The only occasion where there was a significant difference found between both models occurred for small enterprises in the Zlín Region. The difference was significant, yet not as great as that between the Altman and Zmijewski models.

The IN05 model and the Zmijewski model share one financial indicator in common. There was a significant difference found for small enterprises in the Olomouc Region.

There are no common financial indicators shared by the Zmijewski model and the Springate model and the Altman model. That is why the greatest significant differences were found between both regions subject to this analysis.

Is there actually a reason that justifies measuring the financial performance of small enterprises when each model produces different results? Is there any one bankruptcy model that should be recommended?

Small enterprises should be interested in their own financial soundness for their own sake. It is recommended that small enterprises assess their financial performance using multiple bankruptcy models and compare the results. Combining the Altman model and the IN05 model or the IN05 model and the Springate model can bring the same or even slightly different results. The question is whether the Zmijewski model can be combined with one of the above-mentioned models for convenience. The Altman model, the IN05 model and the Springate model use financial indicators that include EBIT/total assets, while the Zmijewski model has a set of indicators that includes net income/total assets instead. The Altman model also incorporates the retained earnings/total assets indicator. The amount of retained earnings may be different from net income and EBIT. Another useful approach observes the ratio between sales and total assets. However, the Zmijewski model does not contain any financial indicators relevant to sales.

CONCLUSION

The main reason for writing this paper was to implement statistical tests compared to those used to evaluate the financial performance of enterprises. The paper focused on 32 small enterprises from two regions: the Zlín Region and the Olomouc Region. Small enterprises were analysed using the Altman model, the IN05 model, the Zmijewski model and the Springate model. The financial statements that were analysed were from 2006 and 2010. The statistical data analysis was performed using the one-sample test for proportions and the paired t-test.

The outcomes of the evaluation using the Altman model, the IN05 model and the Springate revealed the enterprises to be financially sound, while the Zmijewski model identified them as being insolvent. Of the small enterprises analysed in accordance with the Altman model in 2006, 27 of them were financially sound, whereas 5 enterprises faced bankruptcy. All the enterprises analysed in accordance with the IN05 model were declared to be financially sound. Both regions and both years subject to analysis using the Altman model showed the same number of financially sound enterprises (81.25% of the enterprises in the Zlín Region and 87.5% of the enterprises in the Olomouc Region). The number of sound and bankrupt small enterprises in the Zlín Region subject to analysis according to the Springate model was the same (68.75% of the enterprises were financially sound, 31.25% of the enterprises were bankrupt).

The results obtained through the one-sample test for proportions confirmed that at least 80% of these enterprises showed a sound financial condition. The prerequisite stating that the percentage of small enterprises in poor financial condition must exceed 20% was not confirmed at the 0.05 significance level. A comparison among all models revealed a statistically significant difference only with the Zmijewski model. The results apply to both 2006 and 2010.

The paired t-test run at the 0.05 significance level of did not confirm that the financial performance of small enterprises significantly improved. The financial performance of small enterprises remained the same in both years.

It is recommended that small enterprises assess their financial performance using two bankruptcy models. As stipulated by the Nemenyi test of multiple comparisons, the greatest differences were found between the Zmijewski model and the Altman model. A comparison of other models with the Zmijewski model revealed slight differences. Another suitable approach could be a combination of the Zmijewski model with the Altman model, the Springate model or the IN05 model respectively.

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