

Which Altman Model Do We Actually Use?

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Abstract: *The aim of this paper is to critically evaluate the terms that are described by various authors in Czech literature, compare those terms with the terms used by the original Altman model, use data from selected enterprises to show whether enterprises could be considered at risk of bankruptcy due to such inaccuracies and verify whether the average Z-score values for small enterprises within the Zlín Region are greater than 3. The data were analysed using a one-sample t-test and the Altman model for enterprises that are not publicly-traded. Financial statements for 2007 through 2011 were used in the data analysis.*

The one-sample t-test showed that the sample of 32 small enterprises from the Zlín Region had good financial health. The largest percentage change that was associated with a decline in performance was demonstrated when adding net profit to retained earnings (-16.64%). The largest percentage change that was associated with an improvement in performance was demonstrated when using current assets instead of working capital (33.07%). Replacing retained earnings with net profit reduced the enterprise's performance (a percentage change of -24.43%). Adding funds from profit and net profit to retained earnings reduced performance by 0.17 percentage points.

We recommend using net working capital to calculate the X1 ratio. Retained earnings should be used to calculate the X2 ratio. Only sales should be used to calculate the X5 ratio. For manufacturing enterprises that are not publicly-traded, we recommend using equation (8). Publicly-traded enterprises may use equation (2). Enterprises that provide services and enterprises in emerging markets may use equation (4).

Key words: Prediction of bankruptcy · Altman model · Misinterpretation · small enterprises · one-sample t-test

JEL Classification: G33 · G34 · C12 · C81

1 Introduction

There are several models that can be used to evaluate a business's performance. Knápková & Pavelková (2010) argue that the most commonly-used models include the Altman model. In the Czech Republic, the IN05 credibility index is a popular and commonly-used model. The Springate model, the Tamari model and the Zmijewski model are used abroad.

1.1 Altman's first study

The first analysis focusing on evaluating business performance was based on a single-variable analysis. This type of analysis was considered to be inadequate by Altman. Altman asked himself the following questions (Altman, 1968, p. 591):

1. Which ratios are the most important for predicting bankruptcy?
2. What weights should be assigned to these ratios?
3. How should these weights be objectively determined?
4. This was the reason why the multiple discriminant analysis began to be used.

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The sample consisted of 66 manufacturing corporations. The first group was contained of 33 corporations that went bankrupt during the period 1946 - 1965. It turned out that choosing a 20-year period was not the best solution, mainly because the average values of ratios tend to change over time. In addition, some data were not available. For the first group, assets ranged from \$0.7 million to \$25.6 million. The average amount of assets for the first group was \$6.4 million.

The second group consisted of corporations in good financial health. These corporations were classified by both industry and size. For the second group, assets ranged from \$1 million to \$25 million. The average amount of assets for the second group was \$9.6 million.

Since the original sample of corporations was very heterogeneous, it was necessary to limit the sample to corporations with assets ranging from \$1 million to \$25 million.

Once the sampling of corporations was completed, financial statements were analysed. The main task was to find ratios that were important for predicting bankruptcy. Eventually, 22 ratios were selected. A ratio characterises the relationship between two financial statement items. These ratios were divided into five groups: liquidity ratios, profitability ratios, leverage ratios, solvency ratios and activity ratios.

The resulting discriminant function is written as follows (Altman, 1968, p. 594):

$$Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5, \quad (1)$$

where: X_1 = working capital/total assets, X_2 = retained earnings/total assets, X_3 = earnings before interest and taxes/total assets, X_4 = market value of equity/book value of total debt, X_5 = sales/total assets, Z = Z-score, i.e. the resultant value of the Z score coefficient.

1.2 Altman Zeta Model

Previous analyses based on the original Altman model were inadequate. Therefore, the original Altman model had to be modified. The main reasons were the following:

1. There had been an increase in the number of corporations filing for bankruptcy.
2. The latest data available were required for conducting an analysis.
3. Besides industrial companies, other types of companies were also included in the model.
4. Data analysis must be based on up-to-date changes in accounting standards and accepted bookkeeping principles.

The sample consisted of 53 bankrupt corporations and 58 corporations in good financial health, including both industrial corporations and retail companies. 94% of the corporations went bankrupt in the period 1969 - 1975. The bankrupt corporations' assets averaged nearly \$100 million. Five corporations in good financial health were included in the model.

The model was named the Zeta model. The model included seven financial indicators (Altman, Haldeman & Narayanan, 1977): X_1 = return on assets, X_2 = stability of earnings, X_3 = debt service, X_4 = cumulative profitability, X_5 = liquidity, X_6 = capitalization², X_7 = size, i.e. total assets of the enterprise.

Over the years, the model was modified to the following formula:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1X_5 \quad (2)$$

Depending on the resultant Z-score, enterprises were classified into one of three zones:

$Z > 2.99$ Safe Zone (the enterprise is financially sound)

² According to Altman, capitalisation was understood as being five times the average value of market capital divided by total capital. The numerator included preferred stock at its liquidating value, long-term debt and capitalised leases.

| | |
|-------------------|---|
| $1.81 < Z < 2.98$ | Grey Zone (the enterprise has minor financial problems) |
| $Z < 1.80$ | Distress Zone (the enterprise has significant financial problems) |

This model is suitable for companies with publicly-traded securities. However, many enterprises are not publicly-traded on capital markets. Therefore, an additional adjustment to the Altman model was necessary. The only adjustment to the model consisted in replacing the market value of equity with the book value of equity, i.e. X_4 was the only ratio that changed. The 1983 revised Altman model can be written:

$$Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.42X_4 + 0.998X_5 \quad (3)$$

Depending on the final Z-score, enterprises were classified into one of three zones:

| | |
|--------------------------|---|
| $Z' > 2.90$ | Safe Zone (the enterprise is financially sound) |
| $1.23 \leq Z' \leq 2.90$ | Grey Zone (the enterprise has minor financial problems) |
| $Z' < 1.23$ | Distress Zone (the enterprise has significant financial problems) |

A further revision to the Altman model was required for non-manufacturing enterprises and enterprises in emerging markets.

$$Z'' = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4 \quad (4)$$

This revision does not contain the X_5 ratio, i.e. sales/total assets. The ratio was mainly excluded in order to minimize the influence of the industrial sector.

Depending on the final Z-score, enterprises were classified into one of three zones:

| | |
|---------------------------|---|
| $Z'' > 2.60$ | Safe Zone (the enterprise is financially strong) |
| $1.10 \leq Z'' \leq 2.60$ | Grey Zone (the enterprise has minor financial problems) |
| $Z'' < 1.10$ | Distress Zone (the enterprise has significant financial problems) |

The original Altman model was tested in various countries such as China, Greece and Malaysia (Gerantonis, Vergos & Christopoulos, 2009), (Wang & Campbell, 2010), (Yap, Yong & Poon, 2010).

Many authors have used a number of statistical tests to verify their research questions. Altman used the F-test to test the five financial indicators. The Altman model had a 95% accuracy rate (Altman, 1968). The Altman model has been tested repeatedly (Grice & Ingram, 2001), (Wang & Campbell, 2010), (Yap, Yong & Poon, 2010).

Pitrová (2011) tested the predictive ability of the Altman model on enterprises in the Czech Republic. A total of 50 enterprises were selected. 37 enterprises were in good financial health and 13 companies were bankrupt. The author used a two-sample t-test to test whether the average Z-score values for enterprises in good financial health were greater than the average Z-score values for enterprises that had gone bankrupt. It has been proven that the average Z-score values for enterprises in good financial health were greater than the average Z-score values for enterprises that had gone bankrupt.

1.3 Objective of this paper

The main impetus for writing this paper was the confusion of terms that are used in scientific publications in the Czech Republic, namely in the definition of financial ratios. This paper aims to:

Critically evaluate these terms as they are described by various authors:

1. Compare these terms with the original Altman model;
2. Use data for selected small enterprises to show whether such inaccuracies may cause small enterprises to be considered at risk of bankruptcy;

3. Verify whether there are significant differences in the average values for 32 small enterprises in the Zlín Region.

The author of the paper asked herself the following question:

1. Can we expect the average Z-score values for small enterprises to be greater than 3?

2 Materials and methods

2.1 Data sources

The Bisnode Czech Republic on-line database of enterprises was used as the data source. The database includes 355 enterprises in the Zlín Region, whose line of business focuses on computers and office equipment. The enterprises that were analysed had to meet the following conditions:

1. A headcount of 10 to 49 employees.
2. Interest costs may not be equal to zero.

The sample contains 32 small enterprises in the Zlín Region. These enterprises are mainly manufacturing enterprises. In terms of legal form, limited liability companies predominate. The sample also includes two cooperatives. The included enterprises are not publicly-traded on capital markets. Financial statement analysis was conducted for the 2007 to 2011 period.

2.2 Methods

The Altman model for enterprises that are not publicly-traded

$$Z = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.420X_4 + 0.99X_5 \quad (5)$$

where: X_1 = working capital/total assets, X_2 = retained earnings/total assets, X_3 = earnings before interest and taxes/total assets, X_4 = book value of equity/total liabilities, X_5 = sales/ total assets.

One-sample t-test

We use a one-sample t-test in cases where we know the population mean. This population mean is considered to be a constant. We are verifying the hypothesis that the sample comes from a population that has the same mean as the known constant. For this test, the population variance is unknown. The test statistic is calculated using this formula:

$$t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}} \quad (6)$$

where \bar{x} = sample mean, μ = expected population mean (this is a known value), s = sample standard deviation (the square root of the sample variance), n = sample size (the number of units analysed). Kovářik & Klímek (2011) specify the conditions under which a one-sample t-test can be used: the data must have a normal distribution or the sample size must be large ($n > 30$), population variance σ^2 is unknown.

The one-sample t-test was verified at a significance level of 5%.

3 Results

First, we analysed data for a randomly-selected small enterprise in the Zlín Region. Since these are small manufacturing enterprises that are neither publicly-traded nor operating in emerging markets, equation (5) was used to analyse the data. First, we analysed data for a selected small enterprise in the Zlín Region using the original Altman model. The results are shown in table 1.

Table 1 Ratios from 2007 to 2011 (the original Altman model)

| Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|----------------|---------------|---------------|---------------|---------------|---------------|
| X_1 | 0.1193 | 0.0718 | -0.0047 | -0.0490 | -0.1412 |
| X_2 | 0.2314 | 0.2080 | 0.2912 | 0.1513 | 0.1365 |
| X_3 | 0.0590 | 0.0590 | -0.3541 | -0.0861 | -1.0149 |
| X_4 | 0.1962 | 0.1715 | 0.1473 | 0.0849 | -0.0528 |
| X_5 | 3.1853 | 2.9863 | 2.6950 | 2.7523 | 2.8274 |
| Z-score | 3.7914 | 3.4966 | 2.7747 | 2.8534 | 1.7550 |

Source: Own calculation

Table 1 shows that the small enterprise was mainly located within the grey zone. In 2007 and 2008, the enterprise analysed was in good financial health.

Now, we will compare the results in table 1 with the different approaches adopted by various authors found in Czech literature. The most common modifications concern the X_2 ratio. Valach (1999) argues that we should add net profit to retained earnings. The results are shown in table 2.

Table 2 Addition of net profit to retained earnings

| Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---------------|---------------|---------------|---------------|----------------|
| X_1 | 0.1193 | 0.0718 | -0.0047 | -0.0490 | -0.1412 |
| X_2 | 0.2395 | 0.1729 | 0.1854 | 0.1139 | -0.1556 |
| X_3 | 0.0590 | 0.0590 | -0.3541 | -0.0862 | -1.0149 |
| X_4 | 0.1962 | 0.1715 | 0.1473 | 0.0849 | -0.0528 |
| X_5 | 3.1853 | 2.9863 | 2.6950 | 2.7523 | 2.8274 |
| Z-score | 3.7995 | 3.4614 | 2.6689 | 2.8160 | 1.4629 |
| Percentage change in the Z-score | 0.21% | -1.01% | -3.81% | -1.31% | -16.64% |

Source: calculated by the author

Table 2 shows that the results are similar to those of the original model Altman. The small enterprise is mostly located within the grey zone and in 2007 and 2008 it was in good financial health. By comparing the percentage change between the original Altman model and the results in table 2, we find that the greatest decline in performance occurred in 2011 (-16.64%). By contrast, Kislíngrová & Hnilica (2005) recommend adding net profit and funds from profit to retained earnings. Will an additional modification to the original Altman model change the Z-score value? The results are shown in Table 3.

Table 3 Addition of net profit and funds from profit to retained earnings

| Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|-------------------------------------|---------------|---------------|---------------|---------------|----------------|
| X_1 | 0.1193 | 0.0718 | -0.0047 | -0.0490 | -0.1412 |
| X_2 | 0.2422 | 0.1218 | 0.1846 | 0.1164 | -0.1526 |
| X_3 | 0.0590 | 0.0590 | -0.3541 | -0.0861 | -1.0149 |
| X_4 | 0.1962 | 0.1715 | 0.1473 | 0.0849 | -0.0528 |
| X_5 | 3.1853 | 2.9863 | 2.6950 | 2.7523 | 2.8274 |
| Z-score | 3.8021 | 3.5103 | 2.6720 | 2.8185 | 1.4659 |
| Percentage change in Z-score | 0.28% | 0.39% | 0.23% | -1.22% | -16.47% |

Source: calculated by the author

Table 3 shows that the results are not substantially different from the original Altman model. The small enterprise is mostly located within the grey zone and in 2007 and 2008 it was in good financial health. Compared to the previous model (table 2), there are no frequent declines in the

small enterprise's performance. The greatest decline in the enterprise's performance was identified in 2011. This decline was 0.17 percentage points smaller.

Although Valach (1999), Kislingerová & Hnilica (2005) propose making modifications to the original Altman model, it is clear that these small modifications may affect the Z-score and, in turn, cause the enterprise to be classified within a different category.

Other modifications concern the X5 ratio. Landa (2008) argues that we should add own outputs, financial revenues and extraordinary revenues to revenues from the sales of goods, own products and services, revenues from the sale of durable assets and material and revenues from the sales of securities and interests. The results are shown in table 4.

Table 4 Addition of additional items to revenues from the sales of goods

| Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---------------|---------------|---------------|---------------|---------------|
| X1 | 0.1193 | 0.0718 | -0.0047 | -0.0490 | -0.1412 |
| X2 | 0.2314 | 0.2080 | 0.2912 | 0.1513 | 0.1365 |
| X3 | 0.0590 | 0.0590 | -0.3541 | -0.0861 | -1.0149 |
| X4 | 0.1962 | 0.1715 | 0.1473 | 0.0849 | -0.0528 |
| X5 | 3.1724 | 2.9709 | 2.7245 | 2.8398 | 3.0521 |
| Z-score | 3.7784 | 3.4812 | 2.8042 | 2.9409 | 1.9797 |
| Percentage change in the Z-score | -0.34% | -0.44% | 1.06% | 3.06% | 12.80% |

Source: calculated by the author

Table 4 indicates that – in 2007, 2008 and 2010 – the enterprise was in good financial health. In 2009 and 2011, the enterprise was in the grey zone. By comparing the results with the modifications to the Altman model as proposed by Valach (1999), we find that the small enterprise's performance improved. Improvement is also noticeable when making a comparison to the modifications to the Altman model according to Kislingerová & Hnilica (2005).

Tables 2 to 4 indicate that the modifications to the original Altman model produce almost identical results. There are significant differences in terms of percentage changes in the Z-scores. If we were to randomly select a different enterprise and analyse its performance, we might find significant changes in the Z-score values. What would happen if we were to use working capital expressed as the amount of current assets in the X1 ratio? The results are shown in table 5.

Table 5 Inclusion of current assets when calculating the X1 ratio

| Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---------------|---------------|---------------|---------------|---------------|
| X1 | 0.5191 | 0.5445 | 0.4068 | 0.4354 | 0.4392 |
| X2 | 0.2314 | 0.2080 | 0.2912 | 0.1513 | 0.1365 |
| X3 | 0.0590 | 0.0590 | -0.3541 | -0.0861 | -1.0149 |
| X4 | 0.1962 | 0.1715 | 0.1473 | 0.0849 | -0.0528 |
| X5 | 3.1853 | 2.9863 | 2.6950 | 2.7523 | 2.8274 |
| Z-score | 4.1912 | 3.9693 | 3.1863 | 3.3377 | 2.3354 |
| Percentage change in the Z-score | 10.54% | 13.52% | 14.83% | 16.97% | 33.07% |

Source: calculated by the author

Table 5 shows that – compared to the original Altman model – the Z-score values increased significantly and percentage changes in the Z-score values also increased. The small enterprise is in good financial health. 2011 is an exception and the enterprise was in the grey zone.

Fortunately, in his article "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy" (Altman, 1968), Altman clearly shows that working capital is the difference between current assets and short-term liabilities. Working capital is calculated in the same way as in

the Czech Republic. The difference between current assets and short-term liabilities is defined as net working capital. Replacing working capital with current assets may cause us to incorrectly interpret the results.

What would happen if we were to use net profit instead of retained earnings in the X2 ratio? The results are shown in table 6.

Table 6 Use of net profit in calculating the X2 ratio

| Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---------------|---------------|----------------|---------------|----------------|
| X1 | 0.1193 | 0.0718 | -0.0047 | -0.0490 | -0.1412 |
| X2 | 0.0081 | 0.0114 | -0.1058 | -0.0374 | -0.2921 |
| X3 | 0.0590 | 0.0590 | -0.3541 | -0.0862 | -1.0149 |
| X4 | 0.1962 | 0.1715 | 0.1473 | 0.0849 | -0.0528 |
| X5 | 3.1853 | 2.9863 | 2.6950 | 2.7523 | 2.8274 |
| Z-score | 3.5680 | 3.3000 | 2.3777 | 2.6647 | 1.3263 |
| Percentage change in the Z-score | -5.89% | -5.62% | -14.31% | -6.61% | -24.43% |

Source: Calculated by the author

Table 6 shows that including net profit instead of retained earnings reduced the Z-score value. The small enterprise was in good financial health in 2007 and 2008, and it was in the grey zone from 2009 to 2011. In terms of percentage changes, the greatest decline in financial performance occurred in 2011 (-24.43%).

We used a one-sample t-test to verify the research question. We examined whether the average Z-score values were greater than 3. The one-sample t-test was used on data for 2010 on a sample of 32 small enterprises in the Zlín Region.

Null hypothesis H0: The average Z-score value is equal to 3 (H0: $\mu = 3$)

Alternative hypothesis H1: The average Z-score value is greater than 3 (H1: $\mu > 3$)

$$t = \frac{3.8712 - 3}{2.7273/\sqrt{32}} = \frac{0.8712}{0.4821} = 1.8071 \quad (7)$$

The test statistic is:

The critical value for a right-tailed test for 31 degrees of freedom of the Student's distribution is 1.70.

The test statistic is greater than the critical value. The p-value (0.04023) exceeds the significance level of 0.05. At a significance level of 0.05, we accept the alternative hypothesis that the average Z-score value is greater than 3. Therefore, we can conclude that the sample of 32 small enterprises from the Zlín Region are in good financial health.

4 Discussion

The results of the analyses confirmed our initial assumptions. We verified that the sample of 32 small enterprises from the Zlín Region are in good financial health. Also, we found that introducing additional input variables to the original Altman model may change the Z-score values. The absolute amounts of such changes in Z-score values are not easily noticeable; percentage changes are more evident.

The largest differences in Z-score values were found in the X1 ratio (working capital/total assets). If we consider working capital to only include current assets, the Z-score may be overestimated. This modification may cause an enterprise that would otherwise be assessed to be in the financial distress zone to instead be in the grey zone. Table 7 shows re-calculated Z-scores for the small enterprise with the lowest Z score.

Table 7 Inclusion of current assets when calculating the X1 ratio

| Ratio | 2007 | 2008 | 2009 | 2010 | 2011 |
|-----------------------------|---------|---------|--------|--------|---------|
| X1 | 0.4162 | 0.3385 | 0.3063 | 0.4352 | 0.4519 |
| X2 | 0.0078 | -0.0029 | 0.0718 | 0.1026 | 0.1261 |
| X3 | 0.0761 | 0.4610 | 0.3169 | 0.2815 | 0.1953 |
| X4 | 0.0338 | 0.0935 | 0.1333 | 0.1367 | 0.1283 |
| X5 | 0.1297 | 0.1530 | 0.1262 | 0.1284 | 1.5015 |
| The re-calculated Z-score | 0.6636 | 1.0431 | 0.9544 | 1.0842 | 2.4030 |
| The original Z-score | 0.1634 | 0.6764 | 0.6252 | 0.7604 | 0.6484 |
| Percentage change in the Z- | 306.12% | 54.21% | 52.66% | 42.58% | 270.65% |

Source: Calculated by the author

We recommend that the X1 ratio be expressed as net working capital divided by total assets. We subtract short-term liabilities from current assets and divide the result by total assets.

Another recommendation concerns the X5 ratio (sales/assets). If – as suggested by Landa (2008) – we add additional sales-unrelated items to sales, the Z-score value may be overestimated. Revenues from the sales of own products and services are part of own outputs, which also include any changes in own product inventory and activation. While such changes in own product inventory and activation may not be high, they can affect the X5 ratio, i.e. sales/total assets.

We recommend that only sales be used to calculate the X5 ratio (sales/total assets) and that any additional sales-unrelated items be disregarded.

Another recommendation concerns the X2 ratio (retained earnings/total assets). Retained earnings (or net profit from prior years) are a clearly-defined item within financial statements. By adding funds from profit and net profit from the current accounting period to retained earnings, the enterprise's financial health may improve. Usually, funds from profit are not very high and have little effect on the Z-score. Net profit for the current accounting period may be both positive and negative, which may have some effect on the Z-score. Tables 2 and 6 demonstrate how the Z-score values changed for two small enterprises.

We recommend that retained earnings, i.e. net profit from prior years, be used to calculate the X2 ratio (retained earnings/total assets). The calculation will be in accordance with the original Altman model.

For publicly-traded enterprises, we recommend using equation (2). Enterprises that provide services and enterprises in emerging markets may use equation (4).

The proposed Altman model formula for manufacturing enterprises that are not publicly-traded is written as follows:

$$Z' = 0.717 X_1 + 0.847 X_2 + 3.107 X_3 + 0.42 X_4 + 0.998 X_5, \quad (8)$$

where: X1 = net working capital/total assets, X2 = retained earnings/total assets, X3 = earnings before interest and taxes/ total assets, X4 = book value of equity/total liabilities, X5 = sales/total assets.

5 Summary

The main reason for writing this article is the confusion of terms that are used to define financial ratios in Czech literature. The aim of this paper was to critically evaluate the terms that are described by various authors, compare those terms to the terms used by the original Altman model, use data for selected enterprises to show whether enterprises could be considered at risk of bankruptcy due to such inaccuracies and verify whether the average Z-score values for small enterprises within the Zlín Region are greater than 3. The data were analysed using the Altman model for non-publicly-traded enterprises and a one-sample t-test. Financial statements from 2007 to 2011 were used to compare the original Altman model with the modifications proposed by other authors. To verify the research question, data from 2010 were used.

The one-sample t-test showed that the sample of 32 small enterprises were in good financial health.

The largest percentage change that was associated with a decline in performance was demonstrated when adding net profit to retained earnings (-16.64%). Adding funds from profit to retained earnings and net profit reduced performance by 0.17 percentage points. The largest percentage change that was associated with an improvement in performance was demonstrated when using current assets instead of working capital (33.07%). Including net profit instead of retained earnings reduced financial performance (a percentage change of -24.43%).

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