

# USING MATHEMATICAL-STATISTICAL METHODS TO EVALUATE THE FINANCIAL HEALTH OF SLOVAK MICRO COMPANIES

Michaela Kavčáková

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## Abstract

Currently, there are currently a large number of micro companies in which even a small change in the market can lead to bankruptcy. For this reason, it is very important for their managers to monitor financial health on the basis of different models. The aim of this paper is to use traditional models (Zmijewski X score, Altman Z score, IN 05 and Quick test) to predict the financial health of Slovak micro companies in the ICT sector and to identify the most suitable model for predicting financial health of micro companies in Slovakia. The data used in the analysis comes from datasets from the Slovak portal Finstat, analyzing the data of Slovak micro companies in the ICT industry in 2013-2017 period. The results of the individual financial health evaluation tests are compared based on the calculated classification indices. On the sample of data from Slovak ICT micro companies in the period 2013-2017 the best results were achieved with the correct classification of Zmijewski X score.

**Key words:** financial health, Zmijewski X score, Altman Z score, IN 05, Quick test

**JEL Code:** C30, C53, G30

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## Introduction

Every economy in the world is faced with a failure of businesses that can take various forms, various manifestations, consequences and implications. As Klieštík et al. (2019) points out, while in centrally managed economies the consequences of failure were borne by the state as a whole unit, in market economies they directly concern all subjects entering into relations with a given company - owners, creditors, suppliers, customers, employees, competitors, state, municipality and so on. For this reason, there are different types of models and methods for predicting the financial health of companies and the use of alternative methods for this purpose is also being explored, e.g. neural networks or Data Envelopment Analysis (DEA). Small and medium-sized companies are most often used for these analyzes, and therefore in

this article we will focus on micro companies, while we will evaluate which of the used models is the best for predicting their financial health.

The aim of this paper is to use traditional models (Zmijewski X score, Altman Z score, IN 05 and Quick test) to predict the financial health of Slovak micro companies in the ICT sector and to identify the most suitable model for predicting financial health of micro companies in Slovakia.

## **1 Literature preview**

Economists began to address the issue of the financial health of companies during the 1930s, when the Great Depression hit the world, and many companies disappeared during the period, resulting in declining industrial production and rising unemployment.

The first economist, who used a dichotomous classification t-test in one-dimensional framework and laid the foundations of prediction models, is Beaver (1966). His model belongs to the group of univariate discriminant analysis methods. Other well-known authors who followed Beaver and tried to find one universal indicator to determine the financial health of company, were for example Zmijewski (1984), Deakin (1972) or Ohlson (1980).

Another approach to evaluating the financial health of companies is multivariate discriminant analysis. The main representative of this group is Altman (1968) with his Z-score, which is the most used model in predicting financial health of companies. Well-known authors in Central Europe are the Neumaiers (1995), who in 1995 composed the so-called index IN 95.

This index has been updated over time, with its latest version dating from 2005 and being called IN 05. The last group of models used to evaluate the financial health of companies are the so-called scoring methods, represented mainly by Kralicek (1993) and Argenti (1983). In Slovakia, Delina and Packová (2013) also dealt with this issue, who created a so-called P' model through regression analysis.

## **2 Research method**

Financial health of company can be quantified through various models, which division we mentioned in the previous section. For our analysis, we have chosen one or two models from each group of methods to evaluate financial health of companies – Zmijewski X score model, Altman Z score model, IN 05 and Quick test. At the end of our analysis, we are going to compare their results through classification indices and to choose one model, which is the best for evaluating financial health of Slovak micro companies.

## 2.1 Zmijewski X score model

Zmijewski (1984) X score model is one of models, which uses a probit method to model bankruptcy of companies. It uses financial ratios measuring company's performance, leverage and liquidity. To construct his probit function, Zmijewski used 40 bankrupt and 800 healthy companies' data for the period 1972-1978.

$$\text{Zmijewski X score} = -4.3 - 4.5 * X1 + 5.7 * X2 + 0.004 * X3 \quad (1)$$

where

$X1 = \text{Net income} / \text{Total assets} = \text{ROA}$

$X2 = \text{Total liabilities} / \text{Total assets}$

$X3 = \text{Current assets} / \text{Current liabilities} = \text{Current ratio}$

$$\text{probability of bankruptcy} = \frac{1}{1 + e^{-X \text{ score}}} \quad (2)$$

A breakpoint for probability of bankruptcy for X score model is 0.5. For the purposes of this paper, we have added limits around this value to identify 3 main zones for evaluating the financial health of companies – zone of financial health, grey zone and bankruptcy zone:

- probability of bankruptcy  $\in < 0; 0.4$ ) - financial health zone,
- probability of bankruptcy  $\in < 0.4; 0.6 >$  - grey zone,
- probability of bankruptcy  $\in (0.6; 1 >$  - bankruptcy zone.

## 2.2 Altman Z score

Altman (1968) Z score is based on empirical data on failed companies over the past 5 years before bankruptcy and data for prosperous companies over the same period by using multiple discriminatory analysis.

$$Z \text{ score} = 0.717 * X1 + 0.847 * X2 + 3.107 * X3 + 0.42 * X4 + 0.998 * X5 \quad (3)$$

where

$X1 = (\text{Current assets} - \text{Current liabilities}) / \text{Total assets}$

$X2 = \text{Retained earnings} / \text{Total assets}$

$X3 = (\text{Profit before tax and interest}) / \text{Total assets}$

$X4 = \text{Equity} / (\text{Long - term payables} + \text{Short - term payables})$

$X5 = \text{Sales} / \text{Total assets}$

The Z score is compared with the following values:

- Z score > 2.9 – financial situation is good (currently and in the future),
- 1.2 < Z score < 2.9 – range of ambiguous results, bankruptcy is possible (grey zone),
- Z score < 1.2 – financial situation is dire, probable bankruptcy.

### 2.3 IN 05

The Neumaier spouses (2005) have compiled an alternative model to the Altman Z score for the conditions of the Czech Republic, the Index IN. This model has been modified several times, i.e. in 1995 (IN 95) or the latest version in 2005 (IN 05).

$$IN\ 05 = 0.13 * Y1 + 0.04 * Y2 + 3.97 * Y3 + 0.21 * Y4 + 0.09 * Y5 \quad (4)$$

where

$Y1 = Total\ assets / Total\ debt$

$Y2 = Earnings\ before\ interest\ and\ taxes / Interest\ expense$

$Y3 = Earnings\ before\ interest\ and\ taxes / Total\ assets$

$Y4 = Sales / Total\ assets$

$Y5 = Current\ assets / Short - term\ liabilities$

The results are interpreted as follows:

- IN 05 > 1.6 – financial health,
- IN 05 between 1.6 and 0.9 – grey zone,
- IN 05 < 0.9 – bankruptcy zone.

### 2.4 Quick test

Kralicek (1993) created a point scale, where he used one selected indicator from each significant area of analysis (stability, liquidity, profitability and economic outcomes). This model, called Quick test, is often used in Europe (mainly in central Europe) and represent a kind of transition between one-dimensional and multi-dimensional models.

According to Kralicek Quick test:

$R1 = Equity / Total\ assets$

$R2 = (Liabilities - Cash) / Cash\ flow$

$$R3 = \text{Cash flow} / \text{Sales}$$

$$R4 = \text{EBIT} / \text{Total assets}$$

The results of these indicators are compared to the table, with the corresponding points assigned to this indicator.

**Tab. 1: Quick test – score indicators**

Indicator	excellent (1)	very good (2)	average (3)	bad (4)	threat. insolvency (5)
Ratio of Own Equity in Total ( <i>R1</i> )	>30%	>20%	>10%	>0%	negative
Time Required to Pay off Debt in Years ( <i>R2</i> )	<3 years	<5 years	<12 years	>12 years	>30 years
Ratio of Cash Flow in Operation Income ( <i>R3</i> )	>10%	>8%	>5%	>0%	negative
Percentage of Return on Total Equity ( <i>R4</i> )	>15%	>12%	>8%	>0%	negative

Source: Bočánek (2018)

Finally, the points from all indicators are added together and the resulting value describes the financial situation of the company.

$$\text{Quick test} = B1 + B2 + B3 + B4 \quad (5)$$

where

*B1* is the number of points corresponding to the indicator *R1*

*B2* is the number of points corresponding to the indicator *R2*

*B3* is the number of points corresponding to the indicator *R3*

*B4* is the number of points corresponding to the indicator *R4*

The final score is interpreted as follows:

- 4 – 7 excellent results,
- 8 – 11 above-average results,
- 12 – 15 below-average results,
- 16 – 20 stagnant results.

For the purposes of this paper, the first two zones will be referred to as the financial health zone, the below-average results zone as the grey zone, and the lagging zone as the bankruptcy zone.

## 2.5 Assessment of the classification ability of the financial health diagnosis model

Mendelová and Bieliková (2017) classified the total number of  $n$  rated enterprises into six groups.

Group A	companies in financial distress included in the financial distress zone
Group B	companies in financial distress included in the grey zone
Group C	companies in financial distress included in the financial health zone
Group D	companies in financial health included in the financial distress zone
Group E	companies in financial health included in the grey zone
Group F	companies in financial health included in the financial health zone

Correctly classified companies are included in groups A and F. Neutrally classified companies are included in groups B and E and misclassified companies are included in groups C and D. Altman (1968) stated, that group D is Type I Error and group C is Type II Error.

Numbers of companies classified into group  $i$  we marked as  $n_i$ ,  $i = A, B, C, D, E, F$ .

Index of correct classification  $I_{CC} \in [0,1]$  is

$$I_{CC} = \frac{n_A + n_F}{n} \quad (6)$$

index of neutral classification  $I_{NC} \in [0,1]$  is

$$I_{NC} = \frac{n_B + n_E}{n} \quad (7)$$

and index of incorrect classification  $I_{IC} \in [0,1]$  is

$$I_{IC} = \frac{n_C + n_D}{n} \quad (8)$$

Whereas  $\sum_{i=A}^F n_i = n$ , it must be true that  $I_{CC} + I_{NC} + I_{IC} = 1$ . The best situation is when values of  $I_{CC}$  are high and values of  $I_{IC}$  are low.

## 2.6 Data

Our database consists of the data of Slovak micro companies from Information Technology (ICT) sector for the period 2013-2017. We have filtered the sample to include companies:

- only micro companies,
- which have available data for 2013-2017 period.

### 3 Results and discussion

Because of the potential differences that may exist between different sectors of the economy, we have chosen only ICT sector to carry out the analysis.

The data consists of 100 financially health companies and 50 companies, that were identified as in financial distress in the next year. These companies were randomly selected from dataset. A company in financial distress was considered to be a company that in the following year met the criterion of defining a company in prolongation according to the valid legislation of the Slovak Republic, which means that the value of its payables exceeded the value of its assets, respectively the company reported negative equity.

**Tab. 2: Values of classification indices for selected models used to evaluate the financial health of companies for the years 2013-2017**

2013				
	Altman Z score	IN 05	Quick test	Zmijewski X score
<i>ICC</i>	62.67%	56.00%	62.00%	72.67%
<i>INC</i>	20.67%	14.67%	29.33%	11.33%
<i>IC</i>	16.67%	29.33%	8.67%	16.00%
2014				
	Altman Z score	IN 05	Quick test	Zmijewski X score
<i>ICC</i>	66.00%	68.00%	68.00%	81.33%
<i>INC</i>	24.00%	14.67%	22.67%	0.00%
<i>IC</i>	10.00%	17.33%	9.33%	18.67%
2015				
	Altman Z score	IN 05	Quick test	Zmijewski X score
<i>ICC</i>	67.33%	64.00%	64.67%	80.00%
<i>INC</i>	22.67%	16.00%	28.00%	10.00%
<i>IC</i>	10.00%	20.00%	7.33%	10.00%
2016				
	Altman Z score	IN 05	Quick test	Zmijewski X score
<i>ICC</i>	68.67%	56.67%	63.33%	21.33%
<i>INC</i>	21.33%	24.00%	26.00%	7.33%
<i>IC</i>	10.00%	19.33%	10.67%	71.33%
2017				
	Altman Z score	IN 05	Quick test	Zmijewski X score
<i>ICC</i>	69.33%	65.33%	65.33%	82.67%
<i>INC</i>	22.67%	16.00%	28.67%	4.00%
<i>IC</i>	8.00%	18.67%	6.00%	13.33%

Source: Own calculations

The analysis procedure is as follows:

- using chosen traditional models to evaluate financial health of companies based on the methodology, separately for each year (2013-2017 period),

- using the classification indices to evaluate the classification assessment of these models.

Based on the **Tab. 2**, we can state that the best results (the highest  $ICC$  values) were achieved by Zmijewski X score in all years ( $ICC$  values around 80%) except 2016. when the  $ICC$  value reached only 21.33%. This test incorrectly ranked from 10% to 18.67% companies and 71.33% companies in 2016.

The second-best results after a Zmijewski X score. the Altman Z score has achieved. This is the most used model in the field of financial health evaluation of companies. but that doesn't mean that guarantee the correct classification of the companies into appropriate category. As part of our analysis of Slovak ICT micro companies. Altman Z score reached  $ICC$  values from 62.67% to 69.33%. As we can see from the table. the success of this model ( $ICC$  values) is growing every year. Altman Z score neutrally classified about 20% of companies each year.  $IC$  values ranged around 10% and they decrease every year.

IN 05 and Quick test achieve approximately the same  $ICC$  values. but when we look at the  $IC$  values in the table. we see that the Quick test is a more successful model with  $IC$  values from 6% to 10.67%.

To sum up, based on our analysis, we conclude that the best model for evaluating financial health of ICT companies in the Slovak Republic is the Zmijewski X score. These companies can also use Altman Z score. but the results of this model are unlikely to be as reliable. However, we think that business managers should monitor the financial health of their company based on different traditional and alternative models used to evaluate financial health of companies such as neural networks or Data Envelopment Analysis.

## Conclusion

In today's rapidly changing market environment. business managers need to regularly evaluate the financial health of their companies. Owners of micro companies must be especially careful. where even a small change in the market can lead to bankruptcy.

In this paper. we found that on the sample of data from Slovak ICT micro companies in the period 2013-2017 the best results were achieved with the correct classification of Zmijewski X score.

Future research can use alternative methods to diagnose the financial health of companies such as Data Envelopment Analysis and we are going to compare this method to the mentioned traditional models and compare their classification abilities.



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**Contact**

Michaela Kavčáková

Technical University of Košice. Faculty of Economics. Department of Banking and  
Investments

Němcovej 32. 040 01 Košice. Slovak Republic

michaela.kavcakova@tuke.sk