

## THE NEWEST CZECH MODELS FOR PREDICTION OF FINANCIAL CORPORATE BANKRUPT

**Michal Kuběnka**

**University of Pardubice**

**michal.kubenska@upce.cz**

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### **Abstract:**

Since 2005 only 2 bankrupt models have appeared in the Czech Republic and Slovak Republic that would reflect/accentuate changes in national economies after the economic crisis in 2008 and would have a clear methodology. The bankrupt index of Karas and Režňáková (BIKR) and so called P' model of authors Delina and Packová are concerned. The accuracy of BIKR model is expressed as the weighted average of sensitivity and specificity and achieves the value 91.71%. The predictive power of model P' is expressed by the bankrupt prediction accuracy 21.26% and the bankrupt prediction return of 71.84%. The performed research has shown that the P' model achieves higher model accuracy. The sample of 1220 active and 286 bankrupted companies (based on simple average of sensitivity and specificity) has achieved the accuracy of 84.46%. Undertaken research results lead to recommendation to apply the P' model in business practice.

### **Introduction**

Even the first half of 20<sup>th</sup> century was related to the effort to find the way how, based on financial data contained in account books, to predict the company bankrupt. But until in 1968 Altman brought the first multivariate analysis (MDA) in his bankruptcy model Z score (Altman, 1968) that works with five financial ratios. In 1980 Ohlson used for the first time the logit linear probability for creation of his bankruptcy model (Ohlson, 1980). In the year 1985 the factor analysis was used in order to get independent variables for the logit model (Zavgren, 1985). Later the progress has led to methods of artificial intelligence that mainly use the neural networks (NN) for creation of prediction models since nineties of last century. Tam and Kiang (Tam, 1991), (Tam & Kiang, 1992) belong to pioneers of NN usage. Particular methods (MDA vs. Logit vs. NN) of models creation were compared many times. The results show NN as the most suitable method as proven by (Pendharkar, 2005) (Liang, 2005) (Rafiei, Manzari & Bostanian, 2011).

After the passage to the market economy (nineties 20th century) the bankrupt models also started to origin in the Czech Republic and Slovak Republic in order to predict the company bankruptcy. These models should regard the market specificity of these countries. The model (index) IN95 (Neumaierová & Neumaier, 2002) has appeared as the first one, being designed as the creditor's model, as it is mostly used for subjects in the creditor's position (banks and business partners). In 1999 the same authors brought the so-called ownership's model, named IN99. Its function consists in the prosperity prediction based on the positive economic value added (EVA). In 2001 they created the model IN01 that connected properties of both previous models, i.e. it predicts the bankruptcy as well as the prosperity. Just in the year 2005 it was updated to the version called index IN05 (Neumaierová, 2005).

Before the economic crisis two models focused on the agriculture appeared in Slovakia. It was CH-index from 1998 (Chrastinová, 1998) and G-index from 2002 (Gurčík, 2002).

After the economic crisis in 2008 only 2 bankruptcy models appeared at the territory of the Czech Republic and the Slovak Republic, i.e. P' model (Delina & Packová, 2013) and the bankruptcy Index of Karas and Režňáková (BIKR) (Karas & Režňáková, 2013). Čámská emphasizes that the application of these types of model is „user friendly as they do not require any specific mathematic and statistic knowledge of the user“ (Čámská, 2013). The authors of model BIKR determine the model accuracy 91.71% (calculated as the weighted average of sensitivity and specificity). The authors of model P' determine the bankruptcy prediction accuracy 21.26% and the bankruptcy prediction return at 71.84%.

Let's suppose that the bankruptcy model is accurate at maximum when applied in the region (country) of its origin (due to the differences of accounting methods, market environment, etc.). Let's also suppose that the market environment in the Czech Republic and the Slovak Republic is still very close. Thus we shall test just last two mentioned models (BIKR and P' model) in order to define their accuracy and to create the recommendation use in practice in the future.

## 1. Tested models

### 1.1. P' model

The authors of model Delina and Packová (2013) have got their inspiration in three existing models. The Altman Z score (purely bankruptcy model) and Index of creditworthiness belong to the most mentioned ones in the foreign literature. The third model IN05 is mainly known inland where it was created. IN05 is different as it combines the bankruptcy prediction and the prediction of economic value added.

The analyses sample of Slovak companies includes 1560 of accounting statements from the period 1993-2007. 1457 companies (93.40% of the whole sample) are the active companies and 103 are the bankrupted ones (6.60%). The authors do not show the specific branch, they only divide the sample in production companies (36.60%), business companies (25.71%) and service companies (37.69%). The authors tested following chosen models (Z score, Prosperity Index, IN05) and found that they had low prediction capability:

**TAB. 1: Validation of Models - Results**

	No. of bankrupt prediction	Incorrect prediction	Accuracy of bankrupt prediction	Return of bankrupt prediction
Altman	428	375	53	
		87.62%	12.38%	51.46%
Prosperity Index*	273	213	60	
		78.02%	21.98%	58.25%
IN05	521	445	76	
		85.41%	14.59%	73.79%

\*made by Beerman, 1976. Source: Delina & Packová, 2013

Due to this reason Delina and Packová (2013) proposed their own bankruptcy model using the ration indexes used in analyses models (Z-score, Creditworthiness Index, IN05) and regression analysis. The so-called P' model has the following form:

$$P' = 2.86 - 0.0001278X_1 + 0.04851A_2 + 0.2136A_3 - 0.000071A_4 + 0.0001068B_1 - 0.0006116B_4 \quad (1)$$

where:

$X_1$  = (Financial assets – short-term liabilities) / (Operating expenses – depreciations)

$A_2$  = Retained Earnings / Total Assets

$A_3$  = Profit before interests and taxes / Total Assets

$A_4$  = Registered capital / (Long-term + short-term liabilities)

$B_1$  = Cash flow / Total liabilities

$B_4$  = Earnings before taxes / Total Operating Revenue

The evaluation scale does not contain the interval of non-specified values of P' model. The critical limit for the company classification is at the value 2,856. When  $P' < 2.856$  the company tends to bankrupt, when  $P' \geq$  the company is financially healthy and the bankruptcy probability is very low. The authors of P model present its accuracy and return of bankrupt prediction.

**TAB. 2: Accuracy of P' model**

	<b>No. of bankrupt prediction</b>	<b>Incorrect prediction</b>	<b>Accuracy of bankrupt prediction</b>	<b>Return of bankrupt prediction</b>
P' model	348	274	74	
		78,74%	21,26%	71,84%

Source: Delina & Packová, 2013

### *1.2. Bankruptcy index of Karas and Režňáková (BIKR)*

This is the newest model with different structure of variables calculation. All know bankruptcy models (based on author's knowledge) use 4 ratio indexes at minimum, whereas BIKR use only two of them. The first one (X2) is the assets turnover and the second one (X3) is the ratio of quick assets and sales. In addition, it contains the variable of absolute amount (X1) that represent the value of total assets in EUR. The index authors, Karas and Režňáková (Karas & Režňáková, 2013), created the model based on the sample of 880 financially stable and 628 bankrupted companies. Data were drawn from the accounting statements from the period 2007 to 2012. All 1508 companies belonged to the processing industry, based on their business activity, (NACE rev. 2, section C: Manufacturing).

In their text the authors (Karas & Režňáková, 2013) state that the model construction is based on the connection of linear discrimination analysis and the Box-Cox transformation variables. The model is shown as follows:

$$\text{Index} = 1.841 \cdot \frac{(X_1 + 16783.91)^{0.02941} - 1}{0.02941} + 1.112 \cdot \frac{(X_2 + 1)^{-0.35627} - 1}{0.35627} +$$

$$+ 13.55 \cdot \frac{(X_3 + 1.12)^{-2.97955} - 1}{2.97955} - 17.319 \quad (2)$$

where:

$X_1$  = value of total assets (EUR)

$X_2$  = turnover of total assets

$X_3$  = quick assets a sales ratio

It can be positively considered that the evaluation scale does not include the grey zone (indecision zone) and in spite of it it achieves a very high accuracy. The division limit was determined by the 0 value. Then the company with achieved value  $\text{BIKR} > 0$  should be financially healthy and with  $\text{BIKR} < 0$  there should a risk of bankruptcy.

**TAB. 3: Results of tested model BIKR 2013**

<b>Time</b>	<b>Active</b>	<b>Bankrupted</b>	<b>Total*</b>	<b>Error of I. kind</b>	<b>Error of II. kind</b>
1	97,89	69,91	91,71	30,09	2,11
2	95,60	65,56	89,65	34,11	4,29
3	94,38	65,23	89,19	34,38	5,50
4	93,04	65,42	88,56	34,11	6,83
5	91,47	61,18	87,81	38,82	8,39

\* weighted average of accuracy of active and bankrupted companies where the numbers of observation are weighted. Source: Karas & Režňáková, 2013

## 2. Data processing, methodology, results

### 2.1. Analysed set of companies and data processing

Tested group was sample of 286 bankrupt and 1220 non-bankrupt Czech companies. All of them were operating in the manufacturing industry. The non bankrupt companies were only without negative symptoms (insolvency, failure, extinction, execution, negative shareholders' capital) in the year 2012. Data source was the database of economic entities MagnusWeb of the company Bisnode. It is necessary to detail the calculation methodology. The items Balance Sheet (BS) and the items Profit / Loss Statement shall be processed as follows:

- a)  $X_1$  calculation (BIKR): Total assets of EUR (Exchange rate at 27 CZK/EUR).
- b)  $X_2$  calculation (BIKR): Sales are the sum of I. Sold Goods and II. Sold products and services.
- c)  $X_1$  calculation (P' model): Financial property = sum of B.III. Long term financial property+ C.IV.3. Short term financial property.
- d)  $X_1$  calculation (P' model): Operating expenses = sum of cost items from A. to I. (of P/L Statement)
- e)  $A_2$  calculation (P' model): Retained earnings = A.3. Funds from earnings + A.4.1. Retained earnings
- f)  $A_3$  calculation (P' model): Earnings before interests and taxes (EBIT) = \*\*\*EAT + Q. + S. + N.
- g)  $B_1$  calculation (P' model): Cash flow calculation: \*Operating profit + E. Depreciations - G. Change in reserves
- h)  $B_4$  calculation (P' model): Total Operating Revenue = Revenues from no. I. to no. IV.

### 2.2. Methodology of predictive power expression

We can be inspire in creation of evaluation methodology of models accuracy by the father of multiple-criteria models of bankruptcy prediction, by E. Altman (1968) as well as by other actual authors, for example Berzkalne and Zelgalve (2013), Huijuan (2015).

**TAB. 4: Accuracy-matrix**

Fact	Prediction	
	Bankrupt	Non-Bankrupt
Bankrupt	H1	$\alpha$
Non-Bankrupt	$\beta$	H2

Source: author

where:

$H_1$  – number of correct predictions of future bankrupt

$\alpha$  – Type I error is number of bankruptcy companies mistakenly classified as non-bankrupt

$\beta$  - Type II error is number of non-bankruptcy companies mistakenly classified as bankrupted.

$H_2$  – number of correct predictions of future non-bankrupt

Accuracy of bankrupt prediction (in %) for bankrupt companies (so called „sensitivity) can then be expressed as follows:

$$\text{Sensitivity (ABP)} = \frac{H_1}{H_1 + \alpha} \times 100 \quad (3)$$

Accuracy of non-bankrupt prediction (in %) for non-bankrupt companies (so called „specificity“) can then be expressed as follows:

$$\text{Specificity (ANP)} = \frac{H_2}{H_2 + \beta} \times 100 \quad (4)$$

$$\text{Total accuracy (TA)} = \frac{ABP + ANP}{2} \quad (5)$$

### 2.3. Results

According to construction of P' model (1) and Index of Karas and Režňáková (BIKR) were calculated the predictions of financial health for 1505 companies. Results are shown in the following table no. 5. Based on simple average of sensitivity and specificity higher prediction power has P' model.

**TAB. 5: Research results**

Model	Fact	Prediction		ABP	ANP	TA
		Bankrupt	Non Bankrupt			
BIKR 2013	Bankrupt	177	108	62,11%	98,44%	80,28%
	Non Bankrupt	19	1201			
P' model	Bankrupt	213	72	74,74%	94,18%	84,46%
	Non Bankrupt	71	1149			

Source: author

## Conclusion

Every day many subjects need to evaluate in fast manner the financial health of business partners, loan applicants, debtors, etc. To this purpose there have been developed many failure prediction models. Above all their accuracy depends on age of model, region (country) and company sector. On this basis author posed the question which model is best suited for Czech companies in manufacturing sector.

According to formulas (3), (4) and (5) was stated final accuracy of these two newest failure prediction models for 1220 non bankrupt and 285 bankrupt companies. Research showed greater prediction power of P' model in sensitivity (74.74%) with type I error 25.26%. Conversely BIKR model is better in prediction of prosperity non-bankrupt companies. Namely BIKR specificity is 98.44% with type II error only 1.56%. Comply with (5) is BIKR total accuracy amounting to 80.28%. Total accuracy of P' model is 84.46%. That is the reason why recommend P' model for business practice in manufacturing industry in Czech Republic.

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