Adequateness of Applying the Zmijewski Model on Serbian Companies *

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Summary:
The aim of the paper is to determine the accuracy of the prediction of Zmijewski model in Serbia on the eligible sample. At the same time, the paper identifies model's strengths, weaknesses and limitations of its possible application. Bearing in mind that the economic environment in Serbia is not similar to the United States at the time the model was developed, Zmijewski model is surprisingly accurate in the case of Serbian companies. The accuracy was slightly weaker than the model results in the U.S. in its original form, but much better than the results model gave in the U.S. in the period 1988-1991, and 1992-1999. Model gave also better results in Serbia comparing those in Croatia, even in Croatia model was adjusted.

Key words:
bankruptcy prediction models, financial distress, Zmijewski Model, Belgrade Stock Exchange

Rezime:

Ključne reči:
modeli za predikciju bankrotstva, finansijske teškoće, Zmijewski model, Beogradska berza

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1. INTRODUCTION

Since 1968, the primary methods used for bankruptcy prediction model development are multivariate discriminant analysis (MDA), logit analysis, probit analysis, and neural networks. ([10], pp. 5) The statistical approach in developing prediction models for corporate financial distress includes discriminant analysis, regression analysis, logit analysis or probit analysis.

Discriminant analysis was a very popular method for model development in the early stages of bankruptcy prediction. However, further advancement and technology have made other above-mentioned methods (including logit analysis, probit analysis, and neural networks) more prominent. ([10], pp. 2)

Conditional probability analyses (CPA) primarily refers to the discrete choice group of models, of which logit and probit models are the most common in studies of corporate distress. Rees in 1990 defined the main difference between MDA and CPA. CPA appraises the probability of occurrence of a result, rather than producing a dichotomous analysis of failure/non-failure, as is the norm with basic discriminant techniques. ([23], pp. 74) Unlike discriminant analysis, logistic regression does not assume multivariate normality and provides several statistics that indicate the significance of each variable. ([26], pp. 13) Logit analysis and probit analysis began to appear in the late 1970's, but did not overtake MDA in popularity until the late 1980's. Logit analysis and probit analysis take into account the probability that the firm will go bankrupt. The another important difference between these two methods is that probit analysis requires non-linear estimation. ([10], pp. 7)

CPA is especially popular since an intuitive interpretation is that it identifies various responses to the risk of failure. ([23], pp. 75) The number of studies using probit analysis PA is much smaller than these using logit analyses LA, probably because PA technique requires more computations (Gloubos and Grammatikos, 1988; Dimitras et al., 1996). ([6], pp. 64)

<table>
<thead>
<tr>
<th>Year</th>
<th>Discriminant Analysis</th>
<th>Logit Analysis</th>
<th>Probit Analysis</th>
<th>Neural Networks</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960's</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1970's</td>
<td>22</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1980's</td>
<td>28</td>
<td>16</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>1990's</td>
<td>9</td>
<td>16</td>
<td>3</td>
<td>35</td>
<td>11</td>
</tr>
<tr>
<td>2000's</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Overa l</td>
<td>63</td>
<td>36</td>
<td>7</td>
<td>40</td>
<td>26</td>
</tr>
</tbody>
</table>

Sources: ([10], pp. 6)
It is interesting that the first model for bankruptcy prediction based on probit analysis (Hanweck, 1977) was published 43 years after the development of the probit analysis. Probit analysis is a type of regression used to analyse binomial response variables. It acts as a transformation from sigmoid to linear and then runs a regression on the relationship. The idea of probit analysis was originally published in Science by Chester Ittner Bliss in 1934. Bliss worked as an entomologist for the Connecticut agricultural experiment station and was primarily concerned with finding an effective pesticide to control insects that fed on grape leaves (Greenberg 1980). Therefore, Bliss developed the idea of transforming the sigmoid dose-response curve to a straight line. Today, probit analysis is still the preferred statistical method in understanding dose-response relationships. Probit analysis is used to analyse many kinds of dose-response or binomial response experiments in a variety of fields. [41]

**Table 2. Probit models**

<table>
<thead>
<tr>
<th>Application</th>
<th>factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanweck (1977): Banks</td>
<td>6</td>
</tr>
<tr>
<td>Zmijewski (1984): General</td>
<td>6</td>
</tr>
<tr>
<td>Gentry, Newbold and Whitford (1985): General</td>
<td>8</td>
</tr>
<tr>
<td>Gloubos and Grammatikos (1988): Greek firms</td>
<td>5</td>
</tr>
<tr>
<td>Skogsvik (1990): Swedish mining &amp; manufacturing firms</td>
<td>17</td>
</tr>
<tr>
<td>Theodossiou (1991): Greek manufacturing firms</td>
<td>8</td>
</tr>
<tr>
<td>Lennox (1999): UK firms</td>
<td>9</td>
</tr>
</tbody>
</table>

Modified according to: ([10], pp. 6)

Lin and Piesse cited that logit and probit models are commonly used in...
Qualitative response studies, frequently giving very similar results in empirical research. ([23], pp. 4) Jones (1987) also concludes that most bankruptcy prediction models have similar classification accuracy, since they include the same general factors (e.g. liquidity, leverage, profitability). He also concludes that conditional probability models (i.e., probit or logit models) are at least as accurate as models based on multiple-discriminant analysis. ([7], pp. 20) Press and Wilson (1978), Lo (1986); Collins and Green (1982) also found that, in practice, the explanatory power of probit and logit models is similar to that of discriminant analysis DA. ([21], pp. 347-348)

In contrast to previous studies and recent studies ([21], [40], [5]) indicate that well-specified probit and logit models are superior to the DA model. The comparison, however, between logit and probit is not clear-cut. Logit slightly outperformed probit on the estimation sample, while probit slightly outperformed logit on the holdout sample. Taking into account factors such as the computational difficulties associated with the estimation of probit model, logit may appear a better alternative. ([40], pp. 711-716)

Figure 2: Individual model predictive accuracies

Source: ([5], pp. 26)

2. DESIGN / APPROACH / METHODOLOGY

Focus of the research in this paper is to test the accuracy of Zmijewski model on Serbian companies. This research was based on financial statements published on Belgrade Stock Exchange web page and Serbian Business Registers Agency (SBRA). The sample consists of 62 successful non-banking sector companies which were part of the BELEXline (general, benchmark index of the Belgrade Stock Exchange), in September 2009. Because of its strong impact, BELEXline was considered without Oil Industry of Serbia (NIIS). In the second group of the sample, are 32
unsuccessful companies which bankrupted during the 2009 and 2010. All (94) companies were classified as big entities. In the research, only companies with completed data are included. Including all companies would lead to inconsistent sample, and data comparison would not be reliable. This lack of reliable data is a constant problem influencing all analyses on Serbian capital market.

3. ZMIJEWSKI MODEL

In his paper, “Methodological Issues Related to the Estimation of Financial Distress Prediction Models” Zmijewski assumes that equation A1 appropriately describes the probability of bankruptcy as a probit equation where a firm is observed to file a petition for bankruptcy (B = 1) when B*, an underlying response variable, exceeds zero:

\[
P(B = 1) = P(B* > 0) \]

\[
B* = a_0 + a_1 \text{ROA} + a_2 \text{FINL} + a_3 \text{LIQ} + u \quad (A1)
\]

\[
P(B* > 0) = P(-u < a_0 + a_1 \text{ROA} + a_2 \text{FINL} + a_3 \text{LIQ})
\]

Where:

\( P(.) \) = probability of (.),

\( B = 1 \) if bankrupt, 0 otherwise,

\( \text{ROA} \) = net income to total assets (return on assets),

\( \text{FINL} \) = total debt to total assets (financial leverage),

\( \text{LIQ} \) = current assets to current liabilities (liquidity), and

\( u \) = a normally distributed error term.

Zmijewski examined the “choice-base” sample bias and “sample selection” bias typically faced by financial distress researchers. Contrary to the common 1:1 failure/non-failure matching, he used the probit model on six sets of data where the ratio of failure/non-failure varied from 1:1 to 1:20. The results indicated that the choice-based sample bias decreased as the failure/non-failure ratio approached the population probability. In addition, with regard to the sample selection bias, the results indicated a significant bias existed in the majority of the tests conducted. However, for both issues, the results did not indicate significant changes in overall classification and prediction rates. ([22], pp. 72)

Equation A2 below uses the PROBIT coefficients from the 40 Bankrupt/800 Not-Bankrupt estimation sample reported in Panel A of Zmijewski’s ([44], pp. 69):

\[
\text{ZFC} = -4.336 - 4.513(\text{ROA}) + 5.679(\text{FINL}) + .004(\text{LIQ}) \quad (A2)
\]
Where:

\[ AFC = \text{an estimate of Zmijewski's financial condition index}, \ ROA = \text{return on assets (the ratio of net income to total assets)}, \ FINL = \text{financial leverage (the ratio of total debt to total assets)} \text{ and } LIQ = \text{liquidity (the ratio of current assets to current liabilities).} \]

The decision is made by calculating the probability of achieving the status of default as follows:

\[ P = \frac{1}{1+e^{-y}} \quad \text{where } e \text{ is } 2.71828 \]

Firms with probabilities greater than 0.5 were classified as bankrupt. ([44], pp. 65) The chosen model, developed by Mark Zmijewski, in the U.S. showed better results than Altman’s model. Zmijewski model in its original version, for the total sample of 3880+96 showed a high accuracy of 98%, or an error of 2% (see table 3). For the successful companies, the accuracy was 83%, and for unsuccessful (which went bankrupt) 99%. In the second case, the error amounted to 1%. By comparison, the same accuracy on the total sample had both White and Turnbull (1975) of 2%, but with considerably less accuracy in companies that have gone bankrupt (only 53%). Altman’s model from 1968 had for a total population the accuracy of 95%, for successful companies 97%; for unsuccessful companies, its accuracy was 94%. ([44], pp. 61)

As shown in the table 2, Zmijewski was not a pioneer in applying probit analysis in bankruptcy prediction, as Balcaen and Ooghe suggest. ([6], pp. 64) However, he is the first who developed a general probit model, and undoubtedly, the creator of the most famous and most popular probit model for predicting bankruptcy. There are numerous web pages which provide the use of Zmijewski model by importing company’s data on line.

Grice and Dugan noted that Zmijewski’s model is one of two frequently cited notable bankruptcy prediction models. ([18], pp. 151) The fact that Casterella, Lewis and Walker (2000) considered that disclosure of Zmijewski’s index in the audit report would help to justify a decision to issue a clean audit opinion to soon-to-be-bankrupt companies, testifies to the popularity of this model. ([14], pp. 526) Except Casterella, Lewis and Walker also applied the Zmijewski model in their research concerning why do bankrupt companies receive unmodified opinions (1999). Bankruptcy index was calculated using the Zmijewski (1984) model in several studies concerning auditing profession. For example, Carcello and Palmrose (1994) used the Zmijewski model in their study which examines whether modified audit reports issued prior to bankruptcy protect auditors from certain effects of legal liability. Carcello and Palmrose [12] and Bamber, Bamber and Schoederbek [7] use results from Zmijewski’s model to proxy financial condition for the non-financial client’s in their research concerning factors.
which determine the length of time external auditors require to complete the audit.

Table 3: Summary of Sample Composition and Error Rates in Financial Distress Researches

<table>
<thead>
<tr>
<th>Research study</th>
<th>Number of firms in the sample</th>
<th>Error rates (incorrectly classified)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distressed firms</td>
<td>Nondistressed firms</td>
</tr>
<tr>
<td>Altman (1968)</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Deakin (1972)</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>White and Turnbull (1975)</td>
<td>34</td>
<td>2,303</td>
</tr>
<tr>
<td>Altman et. al. (1977)</td>
<td>53</td>
<td>58</td>
</tr>
<tr>
<td>Deakin (1977)</td>
<td>63</td>
<td>80</td>
</tr>
<tr>
<td>Ketz (1978)</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>van Frederikslust (1978)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Norton and Smith (1979)</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Damboleva and Khoury (1982)</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Zmijewski (1983)</td>
<td>96</td>
<td>3,880</td>
</tr>
</tbody>
</table>

According to: ([44], pp. 61)

4. RESULTS OF THE RESEARCH - Testing the Zmijewski Model on the Serbian Companies

The results of testing the Zmijewski model on companies in Serbia, on the described sample, are shown in table 4. Weighted average values of Zmijewski model were calculated on aggregate data basis. Model average values were calculated as mean. Low values of standard deviation show that there is no significant deviation from the mean.

The accuracy for successful (non-distressed) companies in observed period 2006-2010 was in range from 93.5% to 96.8% (error type II from 3.23% to 6.45%) in average 95.2% (error type II 4.8%). For unsuccessful (distressed) companies Model has the average accuracy of 84.4% (error type I 15.6%) in period 2009-2010. Observing the total sample, the average accuracy was 94.15%. This is a little lower that the original Zmijewski data of 98%. In 2009, when the crisis escalated, Model has the lowest levels of accuracy. That is understandable because Model does not consider macroeconomics variable. In time of crisis indicators based on different balance sheet and
The Serbian economy is significantly affected by the global financial crises. The global financial crisis has just further encouraged the emergence of the structural abnormalities, occurred well before and during the process of transition in Serbian economy. ([37], pp. 353) It is uncertain how long the crisis will last and which dimension it will have. ([15], pp. 79) Nowadays situation is even harder, risk has grown into uncertainty. ([26], pp. 61)

Table 4: Results of Zmijewski model

<table>
<thead>
<tr>
<th>Balance Sheet year / Year of (non)distress</th>
<th>Non-distressed firms</th>
<th>Distressed firms</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighted average values</td>
<td>0.11</td>
<td>0.13</td>
<td>0.17</td>
</tr>
<tr>
<td>Model average values</td>
<td>0.15</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.01</td>
<td>0.01</td>
<td>0.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.64</td>
<td>0.99</td>
<td>0.61</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.06</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Sample</td>
<td>62</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>Accuracy for cut-off &gt;0.5</td>
<td>95.2%</td>
<td>96.8%</td>
<td>95.2%</td>
</tr>
<tr>
<td>Error Type I</td>
<td>4.84%</td>
<td>3.23%</td>
<td>4.84%</td>
</tr>
<tr>
<td>Accuracy for cutoff &gt;0.4</td>
<td>83.90%</td>
<td>85.50%</td>
<td>79.00%</td>
</tr>
<tr>
<td>Error Type I</td>
<td>16.13%</td>
<td>14.52%</td>
<td>20.97%</td>
</tr>
<tr>
<td>Source: Authors' calculations</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The number of predicted bankruptcies depends on the cut-off probabilities chosen for the models. For example, if the cut-off is equal to 0.1, a company for which the expected probability of bankruptcy exceeds 10% is predicted to go bankrupt, whereas a company for which the expected probability of bankruptcy is less than 10% is predicted to survive. One can therefore increase the number of companies predicted to fail by reducing the cut-off probability. ([21], pp. 359) "In many studies, this is an arbitrary cut-off probability, usually 0.5 (Palepu, 1986). This view is supported by Hamer (1983) who assumed that a firm will be labelled as a potentially bankrupt if the probability of failure using a logit model is greater than 50%. While this choice may have some intuitive appeal, it lacks any theoretical or empirical support. The choice of an optimal cut-off point requires knowledge
about 1) the costs of Type I and Type II errors and 2) the prior probabilities of failure and survival. Altman et al (1977) incorporated information of error costs associated with bank loans, claiming that the costs of Type I errors were approximately 35 times greater than those for Type II errors, although these rates are not considered to be the general case.” ([23], pp. 76) The results of the research of Weiss indicate that bankruptcy prediction models add little information value unless Type I errors are costly at least 25 times relative to Type II errors. [42] Such a model will pay more attention to accurately classifying the failing companies at the expense of more misclassifications of non-failing firms. ([6], pp. 76) For decreasing Type I errors, we fixed the cut off at (greater than or equal to) 0.4. As a consequence, Type II errors increased (see table 4).

Comparing the accuracy of the original model presented in Zmijewski paper with the model accuracy on the example of Serbian economy, we should bear in mind that all models show a lower accuracy during subsequent testing also in the country in (for) which they has been developed. This result of Grice and Dugan (2001) suggests that the Zmijewski’s model is not stationary across time periods. The model correctly classified 58.7 (59.4) per cent and 86.1 (81.8) per cent of the distressed and non-distressed companies from the 1988–1991 (1992–1999) sample. Zmijewski’s study reported accuracy rates of 70.7 per cent and 99.5 per cent for his bankrupt and non-bankrupt groups. The separate accuracy rates for the 1988–1991 and 1992–1999 of nondistressed groups were significantly lower than those reported by Zmijewski. ([18], pp. 160)

Although Zmijewski model was developed on a sample of industrial firms, it is commonly used as a general model. Bearing in mind Agarwal and Taffler’s assertion that the specific nature of z-score models is that it can only be appropriately applied to the population of firms from which they were developed.” ([2], pp. 299) We have excluded from the sample non-industrial firms for which model has failed. The results are presented in table 5.

The accuracy for successful (non-distressed) companies (for cutoff > 0.5) in observed period 2006-2010 was in range from 94.0% to 98.0% (error type II from 2.0% to 6.0%) in average 96.8% (error type II 3.2%). For unsuccessful (distressed) companies Model has the average accuracy of 84.4% (error type I 15.6%) in period 2009-2010. Observing the total sample, the average accuracy was 95.39%. The accuracy for cutoff > 0.4 was lower, but with lower error type I.

The research results of Grice and Dugan, shows that “model was not sensitive to industry classifications for the samples used in this study”. ([18], pp. 163) Results from table 5 in our research are slightly better than those in table 4.
Table 5: Zmijewski model values without non-industrial firms

<table>
<thead>
<tr>
<th>Balance Sheet year / Year of (non)distress</th>
<th>Non-distressed firms</th>
<th>Distressed firms</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model average values</td>
<td>0.10</td>
<td>0.11</td>
<td>0.13</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.12</td>
<td>0.13</td>
<td>0.15</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.56</td>
<td>0.56</td>
<td>0.61</td>
</tr>
<tr>
<td>Median</td>
<td>0.05</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>Sample</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Accuracy for cutoff &gt; 0.5</td>
<td>98.00 %</td>
<td>98.00 %</td>
<td>96.00 %</td>
</tr>
<tr>
<td>Error Type I</td>
<td>0.00 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Type II</td>
<td>2.00 %</td>
<td>2.00 %</td>
<td>4.00 %</td>
</tr>
<tr>
<td>Accuracy for cut-off &gt; 0.4</td>
<td>92.00 %</td>
<td>94.00 %</td>
<td>88.00 %</td>
</tr>
<tr>
<td>Error Type I</td>
<td>0.00 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Type II</td>
<td>8.00 %</td>
<td>6.00 %</td>
<td>12.00 %</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations

5. DISCUSSION

Due to the fact that among Models’ parameters there is no market value of equity, the testing of the Model in transitional countries and emerging markets (and in Serbia) make sense. This is due to the fact that underdevelopment of the capital markets could distort and shorten the predictive ability of any model based on market values. It should be noted that the emerging capital markets cannot be seen in the same way as developed, not only due to greater volatility and significant deviations from normal distributions of returns, but also because of certain figure of non-synchronous trading.[33]

Besides the application of the Zmijewski model in USA and some other countries, testing its applicability has been made in Iran ([19], [20]), in Indonesia [29] and in some other countries. The model has sparked interest also in the region of South-Eastern Europe. While testing this model on Croatian companies, some adjustments of the Model have been done. For non-distressed firms Model has accuracy of 61.20%, for distressed firms 72.03%. Overall accuracy was 66.62%. [38]

According to the Grice and Dugan, the Zmijewski model is widely used even
though the existent literature provides minimal evidence as to their generalizability. Though Zmijewski developed his model using industrial firms, the model is routinely applied to non-industrial companies. Additionally, the coefficients of the model were estimated using companies from the 1970–1978 period, but these same coefficients continue to be used to evaluate the financial health of firms in recent periods.” ([18], pp. 152)

It seems that the accuracy of the Model was higher in Serbian then in USA in period 1988-1999. High accuracy of the model was also a consequence of the fact that, unlike the U.S., all companies that went bankrupt in Serbia were "black hole" firms. There were none of the "setback" firms, for which it is difficult to anticipate the failing definite date. Also there were no "failed growth" firms for which it is difficult to detect bankruptcy far in advance. (See more in: [1], pp. 23-32)

The accuracy in Serbia was higher also compared to results in Croatia, although in Croatia Model's coefficients were modified (adjusted). However, in Croatia the model was tested on small and medium entities while in Serbia on companies classified as big entities. Besides that, in Croatia sample was larger and time period was longer. Those two facts contribute to lower accuracy.

The fact that Serbia does not consistently apply legislation on bankruptcy should be considered as a limitation of this research. A more detailed analysis of the group of successful companies, for which the model incorrectly predicted bankruptcy, shows that accounts of some companies were blocked continuously 361 days, which would automatically be the reason for the bankruptcy. Unfortunately the website of the National Bank of Serbia gives information only about the blockades in the last 365 days, which makes a deeper analysis (the existence of the database with information about the extended periods of illiquidity would make testing easier).

We should bear in mind also the small samples and short windows of time. On the other hand, all bankrupt firms classified as large legal entities, have been taken in to consideration. The expansion of the sample with medium and small firms would not be justified, since the model was originally developed for large legal entities. Short windows of time can be justified by the fact that other studies that developed and tested bankruptcy prediction models used small samples and short windows of time (see: Altman, 1968; Deakin, 1972; Mensah, 1983 and Zavgren, 1985). According: [18]

A longer period of time would probably lead to less accuracy, keeping in mind that Mensah’s findings that models can change in such short subsequent time periods as two years. Philosophov, L.V., Batten, J.A, Philosophov, V.L. also observed that the predictive power of the accounting ratios decreased noticeably between a sample of firms from the 1980s and the current sample from the late 1990s and 2000s. [31] This result was also
consistent with Grice and Ingram. ([17], pp. 53-61)

6. CONCLUSION

In this paper, Zmijewski model was tested in Serbia on sample of 62 successful non-banking sector companies which were part of the BELEXline in September 2009, and all 32 big entities which bankrupted during the 2009 and 2010 (32 unsuccessful companies). This research was the first research of usefulness of Zmijewski model in Serbia.

The accuracy for successful (non-distressed) companies in observed period 2006-2010 was in range from 93.5% to 96.8% (error type II from 3.23% to 6.45%) in average 95.2% (error type II 4.8%). For unsuccessful (distressed) companies Model has average accuracy 84.4% (error type I 15.6%) in period 2009-2010. Observing the total sample the average accuracy was 94.2%, which is little lower that the original Zmijewski data of 98%

Accuracy of the model in Serbia is a unexpectedly high because the parameters were not adjusted (modified) and due to the fact models show a lower accuracy during subsequent testing also in the country in (for) which it has been developed. Usefulness of the model will be even lower if economic environment is more different in the country where the model has been developed in relation to the state in which are in country where the model is tested. Since the economic environment in the U.S. has nothing in common with current economic situation in Serbia, low accuracy of the model has been expected.

Testing model Zmijewski on the presented sample gave results that were slightly weaker than the model results in the U.S. in its original form. However, it was better than the results the model gave in the U.S. in the period 1988-1991 and 1992-1999. Accuracy is higher than obtained by testing in Croatian companies, which was unexpected since the model has been adjusted for Croatian market. The explanation can be found in the fact that the model is tested on a larger sample in Croatia. In addition, Croatia’s model is tested on small and medium enterprises, while in Serbia, only tested on sample of companies as big classified entities.

According to Grice and Dugan, evidence of the generalizability of the Zmijewski model should interest researchers who continue to use prediction models to evaluate firms’ financial conditions across industries and time”. ([18], pp. 152) Applying the models to time periods and industries other than those used to develop the models may result in a significant decline in the models’ accuracies ([18], pp. 151)

Excluding from the sample non-industrial firms Error II decreased from 4.84% to 3.2%, or the accuracy of the model was increased from 94.15% to
95.39%.

Considering the limitations of the research, and the fact that the crisis will reduce the accuracy of the model, such a high accuracy in forecasting bankruptcy in the future, cannot be expect. But, it is certain that the model can be widely used for identifying companies experiencing financial distress, especially in the industrial sector.

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