BANKRUPTCY PREDICTION MODELS: A COMPARATIVE STUDY OF THE BALTIC LISTED COMPANIES

Irina Berzkalne
Mg.oec., PhD student, Faculty of Economics and Management
University of Latvia
e-mail: irina.berzkalne@inbox.lv

Elvira Zelgalve
Dr.oec., professor, Faculty of Economics and Management
University of Latvia
e-mail: elzelg@lu.lv

Abstract

Purpose – The purpose of the research is to evaluate performance of seven commonly applied bankruptcy prediction models in the Baltic listed companies and how these models can be applied in investment decision-making process.

Design/methodology/approach – Analysis is conducted on a sample of 75 listed companies (Baltic Stock Exchange) over the period from 2002 to 2011. The research methods: monographic, graphical, analysis of statistical data, correlation and comparative analysis.

Findings – The lowest type II error is obtained by the Zmijewski model (type II error is less than 20%) regardless of the point in the business cycle. Low type II error is shown also by Altman Z' and Altman Z'' models during the economic upward phase, however type II error is sensitive to the changes of the business cycle and increases significantly during economic downturn. The results of correlation analysis show that if type II error increases for one model, then same can be expected for other models. The authors recommend using Zmijewski model in investment decision-making process and as a rule of thumb to use at least two models (with the smallest type I and II errors); however, during the economic downturn it is not advisable to use any model at all.

Research limitations/implications – Type I error occurs when a model does not predict bankruptcy. Type II error means that the model mis-predicted a solvent company as bankrupt. This paper evaluates and analyses mostly type II error.

Practical implications – The results of this paper can be used to evalute the effectiveness of several bankruptcy prediction models for the Baltic listed companies, and how they can be applied in the investment decision-making process.

Originality/value – Authors of the paper focus on type II error, previous research by other authors is mainly concerned with type I error. In addition this study is innovative, because type II error dynamics are analyzed within the business cycle change.

Keywords: bankruptcy prediction models, insolvency, financial ratios

1. INTRODUCTION

When a company falls into bankruptcy, it affects many stakeholders. Company owners lose some (or all) of the money they have invested in this company. Lenders also may lose all investments and loans. Employees lose their jobs and government receives less tax. Therefore, it is only logical that many companies, investors, lenders, auditors and others use different techniques to try to evaluate and predict corporate performance in the near future. Performance evaluation is especially significant in the light of recent turmoil in the credit markets.

At the moment, many bankruptcy prediction models exist, since they are easily understandable and easy to use. One the other hand, one needs to be cautious, when using bankruptcy prediction models, because several problems exist. First, there are a variety of bankruptcy prediction models

and one needs to make a well-founded decision when the appropriate model is selected. Second, one must take into consideration type I and type II errors. Type I error occurs when a model does not predict bankruptcy, however, type II error means that the model mis-predicted a solvent company as bankrupt. The authors of this paper do not argue that the type I error is more costly than type II error (it is more costly to invest in a company that goes bankrupt versus not to invest in a company that remains solvent). Nevertheless, type II error is still significant and usually is higher than type I error. The final decision should be done by not only basing on bankruptcy prediction models, but also by taking into consideration other factors (cash flow, future prospects, growth, company management, etc.).

The **purpose of the research** is to evaluate the performance of seven commonly used bankruptcy prediction models in the Baltic listed companies, and how they can be applied in investment decision-making process. **The tasks of the research** are as follows:

- To overview the results of previous research on the bankruptcy prediction models and type II error;
- To evaluate the performance of bankruptcy prediction models;
- To make conclusions on the performance of bankruptcy predictions models and work-out recommendations on how these models can be applied in investment decision-making process.

This paper examines the performance of seven commonly applied bankruptcy prediction models: the Altman Z-Score model, modified Altman Z-Score models Z' and Z'', Fulmer, Springate, Zmijewski and Sorins/Voronova models.

Analysis is conducted on a sample of 75 listed companies (Baltic Stock Exchange) over the period from 2002 to 2011. In the research paper, the following qualitative and quantitative **methods of research** are applied: the monographic method, graphical method, analysis of statistical data, correlation analysis, comparative analysis. The research is based on published papers on bankruptcy prediction models, as well as information provided by the Baltic Stock Exchange. Correlation analysis is done using the Statistical Package for the Social Sciences (SPSS).

2. LITERATURE REVIEW

Bankruptcy prediction models began to develop with Beaver's (1966) univariate study. He compared 30 ratios of 79 failed and 79 non-failed firms in 38 industries. Beaver found that net income to total debt has the highest predictive ability (92% accuracy one year prior to failure). The first multivariate study was conducted by Altman (1968). Sample was composed of sixty-six companies with thirty-three companies in each of the two groups (bankrupt, non-bankrupt). Later Altman modified models for private firms (Z') and for non-manufacturer industrials & emerging market (Z''). Since Altman model the number of bankruptcy prediction models increased substantially – 28 studies in the 1970's; 53 studies in the 1980's; 70 studies in the 1990's (Bellovary *et al*., 2007).

Higher model accuracy is not assured with a greater number of factors, some models with two factors are just as capable of accurate prediction as models with 21 factors. Several methods can be used for model development. Most common is multivariate discriminant analysis (MDA), also logit analysis, probit analysis, and neural networks (Bellovary *et al*., 2007). Therefore, this study uses and analyzes models that are developed using multivariate discriminant analysis. Although recent studies were conducted with new techniques, for example, neural networks, on the other hand, several new models were created still using the discriminant analysis, for example, Georgeta and Georgia (2012). Abbas and Rashid (2011) elaborated a model of three variables (sales to total assets, EBIT to current liabilities, cash flow ratio), which achieves 77% prediction accuracy.

Table 1 provides information on recent studies, where existing bankruptcy prediction models were tested.

Table 1

Recent studies on verification of bankruptcy prediction models

Author, year	Tested models
Boritz *et al.*(2007)	Altman, Ohlson, Springate, Altman and Levallee, Legault and Veronneau
Gerantonis *et al.*(2009)	Altman
Kordlar, Nikbakht (2011)	Altman, Ohlson, Zmijewski, Shumway
Genriha I. *et al.* (2011)	Altman, Altman Z', Altman Z'', Sorins/Voronova, Springate, Zmijewski, Savicka, Lis, Taffler/Tisshaw, Irkutsk
Alkhatib J., Bzour A.E.(2011)	Altman, Kida
Ghodrati H., Moghaddam (2012)	Altman, Shirata, Ohlson, Zmijewsky, CA Score, Fulmer, Springate, Farajzadeh Genetic, McKee Genetic

Source: summarized by the authors

To sum up, the most common model subjected to testing is the Altman model, however, Springate and Zmijewski models are also being analyzed in recent studies.

Several studies have been done on bankruptcy prediction models in Latvian companies. Genriha *et al.* (2011) found type II error for Altman Z (43%), Altman Z' (56%), Altman Z'' (52%), Sorins/Voronova (11%), Springate (35%) and Zmijewski (30%). Sneidere (2009) research shows that for predicting insolvency of Latvian companies Altman Z'' and Fulmer bankruptcy prediction models can be used. Type II error of Zmijewski model varies from 0% to 7.1%, Altman Z' from 1.8% to 12.2%, Altman Z'' from 7.3% to 10.7%, Fulmer from 9.8% to 22.1% and Sorins/Voronova from 5.4% to 16.6%. The sample consists of 163 companies (513 annual reports) from 2000 to 2004.

In order to remain consistent with previous research on Latvian companies (Genriha *et al.*(2011) and Sneidere (2009)), the authors of this study use the same models – Altman Z, Altman Z', Altman Z'', Springate, Fulmer, Zmijewski and Sorins/Voronova.

Springate (1978) tested 40 manufacturing companies and achieved 92.5% accuracy rate. Fulmer (1984) used a sample of 60 companies and had type I error of only 4% and type II error of 0%. Zmijewski (1984) analyzed 120 companies and achieved an accuracy rate of 78%. Sorins and Voronova (1998) amended the Altman Z model for Latvian companies, using data on companies from 23 different industries. They also replaced earnings before interest and taxes with earnings before taxes (X3) and market value of equity was replaced by the book value of equity.

Table 2 below summarized bankruptcy prediction models included in the study.

Type I errors are the misclassification of bankrupt firms as non-bankrupt. Type II errors are the misclassification of non-bankrupt firms as bankrupt. It is also generally agreed that type I errors are more costly than type II errors (Bellovary *et al*., 2007). At the same time, the authors of this paper believe that it is necessary to analyze type II error as well, because, based on this error, incorrect investment decisions (not to invest) can still be made. As pointed out by McKee (2007), importance of misclassification costs depends on who is impacted. For example, auditors generally consider type II bankruptcy misclassifications as more expensive than type I bankruptcy misclassifications. High type II error of mis-predicting a solvent company as bankrupt was stressed in the study by Li (2012). Li concludes that there appears to be a need for a model for the prediction of solvent firms.

Table 2

Bankruptcy prediction models examined in the paper

Model	Description	Criterion
Altman (1968)	Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5 X1 – Working capital/Total assets X2 – Retained earnings/Total assets X3 – Earning before interest and taxes/Total assets X4 – Market value equity/Book value of total debt X5 – Sales/Total assets	Z > 3.0 "Safe" zone 1.81 < Z < 2.99 "Grey" zone Z < 1.80 "Distress" zone
Altman Z' (2000)	Z' = 0.717X1 + 0.847X2 + 3.107X3 + 0.420X4 + 0.998X5 X1 – Working capital/Total assets X2 – Retained earnings/Total assets X3 – Earnings before interest and taxes/Total assets X4 – Book value of equity/Book value of total debt X5 – Sales/Total assets	Z' > 2.9 "Safe" zone 1.23 < Z' < 2.9 "Grey" zone Z' < 1.23 "Distress" zone
Altman Z'' (2002)	Z'' = 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4 X1 – Working capital/Total assets X2 – Retained earnings/Total assets X3 – Earnings before interest and taxes/Total assets X4 – Book value of equity/Total liabilities	Z'' > 2.6 "Safe" zone 1.1 < Z'' < 2.6 "Grey" zone Z'' < 1.1 "Distress" zone
Springate (1978)	Z = 1.03V2 + 3.07V8 +0.66V9 +0.40V18 V2 – Working capital/Total assets V8 – Net profit before interest and taxes/Total assets V9 – Net profit before taxes/Current liabilities V18 – Sales/Total assets	Z < 0.862 "Distress" zone Z > 0.862 "Safe" zone
Fulmer (1984)	H = 5.528V1 + 0.212V2 + 0.073V3 + 1.27V4 – 0.120V5 +2.335V6 + 0.575V7 + 1.08V8 + 0.894V9 – 6.075 V1 – Retained earnings/Total assets V2 – Sales/Total assets V3 – Net profit before taxes/Book value of equity V4 – Cash flow/Total liabilities V5 – Total liabilities/Total assets V6 – Current liabilities/Total assets V7 – Fixed assets/Total assets V8 – Working capital/Total liabilities V9 – Earnings before interest and taxes/Interest expenses	H < 0 "Distress" zone H > 0 "Safe" zone
Zmijewski (1984)	X = -4.3 – 4.5X1 +5.7X2 – 0.004X3 X1 – Net profit/Total assets X2 – Total liabilities/Total assets X3 – Current assets/Current liabilities	X > 0 "Distress" zone X < 0 "Safe" zone
Šorins/Voronova (1998)	Z = -2.4 + 2.5X1 + 3.5X2 + 4.4X3 + 0.45X4 +0.7X5 X1 – Working capital/Total assets X2 – Retained earnings/Total assets X3 – Net profit before taxes/Total assets X4 – Book value of equity/Total liabilities X5 – Sales/Total assets	Z < 0 "Distress" zone Z > 0 "Safe" zone

"Safe" zone – model does not predict bankruptcy.
"Distress" zone – model predicts bankruptcy.
"Grey" zone – cannot make significant conclusions (company may or may not be insolvent).

Source: summarized by the authors

3. SAMPLE AND RESEARCH METHODOLOGY

This section introduces insolvency statistics, sample characteristics and research methodology used in the study. Table 3 provides information on corporate insolvencies in the Baltic countries for the period of 2005-2011.

Table 3

Corporate insolvencies in the Baltic countries, 2005-2011

Country	2005	2006	2007	2008	2009	2010	2011
Latvia	830	1174	1272	1277	2322	2407	800
Estonia	429	352	333	366	693	504	256
Lithuania	773	808	647	731	1168	1496	1512
Total	**2032**	**2334**	**2252**	**2374**	**4183**	**4407**	**2568**

Source: Creditreform, 2012

Before the financial crisis (2005-2007), the total number of corporate insolvencies was between 2000 and 2400, it does not vary significantly. However, some increase in the case of Latvia can be seen for this period, when in 2006 the number of insolvencies increased by more than 300. Nevertheless, the most rapid change was in 2009, when the number of corporate insolvencies doubled in all Baltic countries. The high number of insolvencies remained in 2010, however in 2011 a significant decrease can be observed in the case of Latvia and Estonia, but in Lithuania the number of insolvencies increased.

Overall, one can state that the performance of bankruptcy prediction models is important, especially in the changing conditions of economic development. On the other hand, it is questionable whether any model can show good results during the economic downturn as rapid as in 2008-2009.

Figure 1 and 2 represent the average financial ratios of Baltic listed companies for the period of 2002-2011 (calculated by the authors).

As can be seen in Figure 1, profitability ratios ROS (return on sales), ROA (return on assets) and ROE (return on equity) show similar trends. Current ratio is around 2, no rapid changes can be observed. ROS varied from -11.5% (2009) to 7.2% (2005), it was negative in 2009 (-11.5%) and 2010 (-0.1%). ROA varied from -4.4% (2009) to 5.9% (2005), it was negative in 2008 (-0.4%) and 2009 (-4.4%). ROE varied from -4.1% (2009) to 36.5% (2005). Therefore, all ratios have similar dynamics – the lowest point reached in 2009, the highest in 2005.

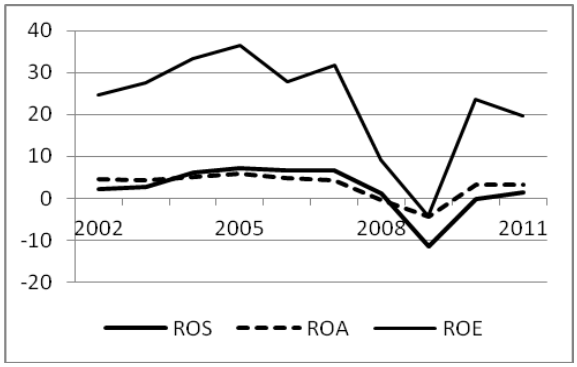

Figure 1. Profitability ratios of Baltic listed companies, 2002-2011

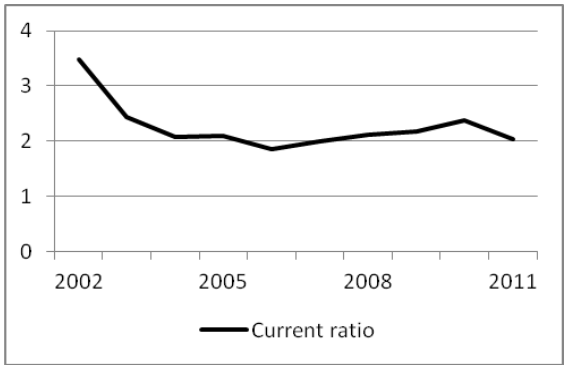

Figure 2. Current ratio of Baltic listed companies, 2002-2011

Source: the authors' calculations based on the Baltic Stock Exchange data.

The study is based on financial data collected from the financial statements of 75 Baltic listed companies (Baltic Stock Exchange). The financial and real estate companies are excluded from the study due to their distinct balance sheet structure. In order to calculate Z-Scores, financial ratio data were extracted from the annual reports.

The analysis is conducted using correlation analysis as well. The Pearson correlation ratio measures the degree and the direction of linear relationship between two variables. Correlation coefficient of +1 corresponds to a perfect positive linear relationship, coefficient of -1 corresponds to a perfect negative linear relationship, and 0 indicates no linear relationship between variables.

4. EMPIRICAL ANALYSIS AND DISCUSSION OF RESULTS

First, the authors of this study calculated and analyzed type II errors (see Table 4) of bankruptcy prediction models for all three Baltic countries.

Table 4

Type II errors of bankruptcy prediction models in Latvia, Estonia and Lithuania, 2002-2011, %

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Altman Z	24	31	27	21	27	34	46	55	48	45	36
Altman Z'	14	10	19	9	17	20	31	37	29	22	21
Altman Z''	20	16	13	13	9	17	31	37	32	27	22
Fulmer	58	49	45	31	35	48	66	68	58	58	52
Springate	51	38	30	30	47	44	61	68	60	53	48
Zmijewski	4	7	6	0	4	6	13	18	9	10	8
Šorins/Voronova	53	47	41	41	46	44	61	64	56	53	51
Average	32	28	26	21	26	31	44	50	42	38	

Source: the authors' calculations based on the Baltic Stock Exchange data.

In 21 cases type II error is smaller than 20%, however in 17 cases type II error exceeds 50%. Altman Z' and Altman Z'' models showed good results from 2002 to 2007, however, during the economic downturn the type II error of these models increased significantly. Overall, the best results are given by Zmijewski model, where type II error is smaller than 20% for the whole period in question (in 2005 the model predicted correctly that all 67 companies are non-bankrupt). In addition, it should be pointed out, that during the economic downturn type II error of Fulmer, Springate and Sorins/Voronova models exceeds 60%.

In summary, based on the results of the Baltic countries, it can be stated that:

- Type II error is sensitive to the business cycle - starting with 2008, type II error increases for all models (> 50% for Fulmer, Springate and Sorins/Voronova);
- The best results are obtained by the Zmijewski model (average error of the period is 8%), even during the economic downturn, the error is less than 20%;
- Good results are shown also by Altman Z' and Altman Z'' models during the economic upturn phase.

The results of the Latvian companies are presented in Table 5.

Table 5

Type II error of bankruptcy prediction models in Latvia, 2002-2011, %

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Altman Z	12	40	26	16	23	26	42	55	42	43	32
Altman Z'	8	7	16	3	13	16	32	39	19	20	17
Altman Z''	12	10	13	10	6	13	23	32	32	27	18
Fulmer	58	42	38	32	43	63	62	77	67	65	55
Springate	46	33	29	26	42	45	58	74	65	53	47
Zmijewski	0	0	3	0	0	6	10	13	6	7	5
Šorins/Voronova	35	33	39	35	39	42	52	61	55	57	45
Average	24	24	23	17	24	30	40	50	41	39	

Source: the authors' calculations based on the Baltic Stock Exchange data

In 26 cases type II error is less than 20% and in 16 cases it exceeds 50%, therefore, one can conclude that for Latvian companies the bankruptcy prediction models show better results than on average for all three Baltic countries. Once again Zmijewski model has the smallest type II error (in 4 periods error is 0%). In addition, in the case of Latvia, average type II error is even smaller than for the whole sample of all three countries, 5% and 8% (average result of Zmijewski model for all three Baltic countries in Table 4 and average result for Latvian companies in Table 5), respectively. Also for Latvian companies type II error increased significantly for all models during the economic downturn. Three models on average show good results (error < 20%) – Altman Z', Altman Z'' and Zmijewski. These results are consistent with previous research by Sneidere (2009).

Table 6 includes the results of Estonian companies.

In 20 cases type II error is less than 20% and in 24 cases type II error exceeds 50%. Poor results are provided by the Fulmer model (in 2004 error is 100%) and Sorins/Voronina model. Similar to Latvian results, the smallest error is given by the Zmijewski model, however, in three periods it exceeds 20% and the average performance is 15%. Also, just like in the analysis of Latvian data, the most sensitive models to changes in business cycle are Fulmer, Springate and Sorins/Voronova models.

Table 6

Type II error of bankruptcy prediction models in Estonia, 2002-2011, %

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Altman Z	43	57	43	33	25	33	33	54	46	46	41
Altman Z'	29	43	29	17	17	17	17	31	31	15	24
Altman Z''	57	43	29	17	8	17	25	38	23	23	28
Fulmer	33	67	100	36	9	36	64	69	54	62	53
Springate	57	57	29	25	17	17	50	69	62	54	44
Zmijewski	14	43	29	0	8	0	8	23	8	15	15
Šorins/Voronova	71	57	57	50	33	33	58	62	62	54	54
Average	44	52	45	25	17	22	36	49	41	38	

Source: the authors' calculations based on the Baltic Stock Exchange data

A different situation can be found in Lithuania (Table 7).

Table 7

Type II error of bankruptcy prediction models in Lithuania, 2002-2011, %

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
Altman Z	38	10	24	20	33	44	56	55	55	47	38
Altman Z'	19	5	20	12	22	26	37	38	39	27	24
Altman Z''	19	14	8	16	11	22	44	41	35	30	24
Fulmer	75	60	54	28	39	38	72	59	52	50	53
Springate	56	38	32	38	67	56	70	62	55	53	53
Zmijewski	6	5	4	0	7	7	19	21	13	10	9
Šorins/Voronova	75	62	40	44	59	52	74	69	55	50	58
Average	41	28	26	22	34	35	53	49	43	38	

Source: the authors' calculations based on the Baltic Stock Exchange data

In 21 cases type II error is smaller than 20% and in 29 cases type II error is bigger than 50%. Therefore, in general, selected bankruptcy prediction models showed their worst performance in Lithuania. Once again, one exception is the Zmijewski model, where the average type II error is

only 9%.

Overall, from the analysis of type II error, one can conclude:

- Best results (smaller type II error) are given by the Zmijewski model for pooled data of three countries and for each country individually;
- Type II errors are sensitive to changes in business cycle, for all models errors increased significantly starting from 2008 (Fulmer, Springate and Sorins/Voronova models especially stand out);
- During the upturn phase of the business cycle good results are provided also by Altman Z' and Altman Z'' models (especially in the case of Latvia);
- In the case of Lithuania, the bankruptcy prediction models showed the worst results.

Table 8 provides the Pearson correlation matrix of type II error of bankruptcy prediction models included in the study:

- As can be expected, type II errors of Altman Z, Altman Z' and Altman Z'' models are highly positively correlated (correlation coefficient > 0.70);
- Type II error of Zmijewski model is also highly positively correlated with Altman Z, Altman Z', Altman Z'' models;
- Since Fulmer model has the highest number of variables, which are not included in other models, one can also expect a relatively low correlation with type II errors of other models (actually, it varies from 0.39 to 0.54);
- All correlation coefficients are positive, which indicate a direct relationship between type II errors of all models.

Therefore, the results of correlation analysis have illustrated that there is a direct positive relationship among type II errors of all models. If type II error increases for one model, then the same can be expected for other models.

Finally, the authors compared the results of this study with previous studies by Genriha *et al.*(2011) and Sneidere (2009). The results are presented in Table 9.

Table 8

Pearson correlation matrix for Baltic listed companies, 2002-2011

	Altman Z	**Altman Z'**	**Altman Z''**	**Fulmer**	**Springate**	**Zmijewski Z**	**Šorins/ Voronova**
Altman Z	1.00						
Altman Z'	0.861** (0.000)	1.00					
Altman Z''	0.774** (0.000)	0.762** (0.000)	1.00				
Fulmer	0.425* (0.019)	0.402* (0.027)	0.387* (0.034)	1.00			
Springate	0.645** (0.000)	0.628** (0.000)	0.623** (0.000)	0.484** (0.007)	1.00		
Zmijewski	0.685** (0.000)	0.747** (0.000)	0.708** (0.000)	0.532** (0.002)	0.426* (0.019)	1.00	
Šorins/Voronova	0.591** (0.001)	0.598** (0.000)	0.726** (0.000)	0.537** (0.002)	0.729** (0.000)	0.527** (0.003)	1.00

*** Correlation is significant at the 0.001 level (2-tailed).*

**Correlation is significant at the 0.05 level (2-tailed).*

Source: the authors' calculations based on the Baltic Stock Exchange data

Table 9

Comparison of results by previous and this study (Latvian data). %

Model	Genriha and Voronova (2010) Genriha *et al.*(2011)	Sneidere (2009)	This study	
			Average	Year 2005
Altman Z	43		32	16
Altman Z'	56	1.8 - 12.2	17	3
Altman Z''	52	7.3 - 10.7	18	10
Springate	35		47	42
Fulmer		9.8 - 22.1	55	32
Zmijewski	30	0 - 7.1	5	0
Sorins/Voronova	11	5.4 - 16.6	45	39

Source: summarized by the authors.

In order to analyse these results, it is necessary to specify the samples used by Genriha *et al.* (2011) and Sneidere (2009):

- Type II errors of bankruptcy prediction models (by Genriha *et al.)* are included in two articles: "Insolvency Risk Models Validated on Latvian Enterprises" (Genriha and Voronova, 2010) and "Entrepreneurship Insolvency Risk Management: A Case of Latvia" (Genriha, Pettere and Voronova, 2011), but both papers did not include a detailed sample description. In their first article (2010) the authors state that "sample consists of 2858 companies, out of which 54 were qualified as insolvent", however, in other section they mention that "the authors use 2800 annual reports, out of which 54 were qualified as insolvent". In their second article (2011), the authors refer to a sample of 1272 companies (out of which 54 were qualified as insolvent), the total number of balance sheets was 2860 and the time period was 2003 – 2007. Even though the sample was better described in the second article, it still did not define, which industries were included.
- Sneidere (2009) uses a sample of 163 companies (513 annual reports) for the time period of 2000-2004 and has analyzed 4 industries – construction, service, manufacturing and trade. In Table 9, type II errors are defined as intervals because the research included type II error for each separate industry.

Sneidere (2009) reported the smallest number of type II errors. One reason might be the fact that the sample was analyzed for the period of 2000-2004, when financial crises did not occur. Results by Genriha (2010; 2011) show a significantly increased type II error, except for Sorins and Voronova model, even though the sample also included the data for the period of 2003-2007 (before crisis). The results of this study are similar to Sneidere (2009) in the cases of Altman Z', Altman Z'' and Zmijewski models. Type II errors are significantly higher in this paper for Fulmer and Springate models than in previous studies by Genriha (2010, 2011) and Sneidere (2009). Also, this study found a noticeably increased type II error for Sorins/Voronova model. To sum up, the results of Altman Z', Altman Z'' and Zmijewski models are in line with previous research, however type II errors of Springate, Fulmer and Sorins/Voronova models are considerably higher.

5. CONCLUSIONS AND RECOMMENDATIONS

The research covered Baltic listed companies for the period of 2002-2011 and evaluated the performance of seven commonly used bankruptcy prediction models and how these models can be applied in investment decision-making process. The study finds that:

- The performance of bankruptcy prediction models is important, especially in the changing conditions of economic development. On the other hand, it is questionable whether any model can show good results during economic downturn;
- The best results are obtained by the Zmijewski model, where type II error is smaller than 20% for the whole period of the study;
- Type II error is sensitive to the business cycle - starting with 2008, type II error increases for all models;
- Good results are shown also by Altman Z' and Altman Z'' models during the economic upturn phase;
- The results of correlation analysis show a direct positive relationship between type II errors of all models. If type II error increases for one model, then the same can be expected for other models;
- This study is partly consistent with previous studies in Latvia in this field. It is most likely that the gap exists due to differing samples.

The differences among the Baltic countries can be summarized as follows:

- For Latvian companies, the bankruptcy prediction models show better results than on average for all three Baltic countries. Three models on average show good results – Altman Z', Altman Z'' and Zmijewski (error of 5%);
- In the case of Estonia, good results are provided only by the Zmijewski model (error of 15%);
- Selected bankruptcy prediction models showed their worst performance in the case of Lithuania. However, the best performance was once again obtained by the Zmijewski model (error of 9%).

The following recommendations are suggested:

- To use Zmijewski model, when evaluating possible bankruptcy and in investment decision-making process;
- At least two models should be used as a rule of thumb in decision-making process – one model, which has the smallest type II error (based on this research this is the Zmijewski model) and another model, which has the smallest type I error;
- The authors of this paper suggest not to use models during the economic downturn because of the high error rate;
- The future research and bankruptcy prediction model development should consider including financial ratios of the Zmijewski model (net profit/total assets, total liabilities/total assets and current assets/current liabilities) since this model shows the lowest type II error and these financial ratios do not appear often in other models (at least not in the models included in this study).

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