PREDICTING CORPORATE BANKRUPTCIES IN POLAND AND LITHUANIA – COMPARATIVE ANALYSIS

Błażej Prusak

Gdańsk University of Technology
Faculty of Management and Economics
E-mail: pb@zie.pg.gda.pl

Abstract. The research on predicting bankruptcies of enterprises constitutes one of the most important areas of financial management. In developed countries, the first publications on the subject appeared in the early 20th century. The situation is different in the countries of Eastern Europe, which introduced the market system already at the beginning of the 1990s, which resulted in first corporate bankruptcies. The article compares experiences in the field of forecasting corporate bankruptcies in two countries of Eastern Europe, i.e. Poland and Lithuania, comparing them with the results of research conducted in developed countries. In conclusion, the similarities and differences between the two countries are identified and the future directions of research on this issue are proposed.

Keywords: corporate bankruptcy prediction, bankruptcy risk, fundamental analysis
JEL classification: G31, G33, C38

1. Introduction

The bankruptcies of enterprises constitute an indispensable element of a properly functioning market economy. They have a negative impact on many stakeholders, in particular the providers of capital, business partners and employees. Hence a particularly high emphasis is placed on creating models predicting the risk of corporate bankruptcy. While studying the literature in the area of corporate finance, one may note that this issue is vital and more and more scientists engage in research devoted to this subject. The corporate bankruptcy forecasting models are most often used to assess the risk of counterparty or borrower default. They also allow for determining company ratings. Such models

can also serve as synthetic measures of the financial condition of companies. In developed countries, models of such type have been created and used for many years, while Eastern European countries got interested in them only upon the change of the economic system – that is to say, relatively recently.

The purpose of this article is to conduct a comparative analysis of research on forecasting corporate bankruptcy in two countries of Eastern Europe, i.e. Poland and Lithuania, and to present them with the experiences of developed countries. This publication is an introduction to the implementation of more extensive analyses using information on a larger number of Eastern European countries. The research method used was the analysis of literature. The first part of the article provides an overview of research in the field of forecasting bankruptcy of enterprises in developed countries. The second part was devoted to listing the most important studies carried out in Poland and Lithuania. In the last section the experiences of both countries were compared and recommendations for further research were shown.

2. Overview of research on the phenomenon of forecasting corporate bankruptcy

The research on predicting corporate bankrupcies was initiated in the United States in the early 20th century. Originally it consisted in ratio analysis, within the framework of which attempts were made at predicting the risk of corporate bankrupcies based on several measures. The literature available to the author shows that already in 1908 Rosendale (1908, p. 187, as in Beaver in 1968, p. 114) tried to evaluate the risk of insolvency of companies on the basis of information on their current assets. Other authors involved in research in this area were: Ramser and Foster (1931, as in Back et al., 1997), Fitzpatrick (1932, as in Waśniewski and Skoczylas 1993, p. 438), Winakor i Smith (1935), Merwin (1942, as in Back et al., 1997) and Beaver (1966). The latter applied a one-dimensional discriminant analysis. On the basis of a number of financial measures he determined the discriminant strength of each of them separately. For this purpose, the percentage of correct and incorrect predictions in the five years preceding the bankruptcy of enterprises was calculated. The breakthrough came, however, in 1968 – after Altman's publication (1968). He also took into account the simultaneous impact of several indicators on the financial condition of the company by combining them into a single measure (Z-score), which was used to assess the threat of bankruptcy. He also used the technique of the multivariate linear discriminant analysis. Altman (2015), alone or in collaboration with other scientists, later developed numerous other models, dedicated to both the American companies and to companies from other countries (Altman and Narayanan, 1997). He found many followers in the United States and abroad, and the multivariate linear discriminant analysis has become the most popular

technique used to build corporate bankruptcy forecasting models (Bellovary et al., 2007; Aziz and Dar, 2006).

In the 1970s and early 1980s the linear multivariate discriminant analysis was criticized, which resulted in the emergence of the logit and probit analysis in studies in the field of forecasting corporate bankruptcy (Chesser 1974; Martin, 1977; Ohlson, 1980; Wiginton, 1980, as in Härdle et al., 2004; Zavgren, 1983; Zmijewski, 1984). In the 1970s and 1980s as an alternative to the linear multivariate discriminant analysis method and the logit and probit method studies were published in which the authors used other techniques, such as linear programming, the method of recursive division or cluster analysis. Another significant breakthrough came in the early 1990s. At that time the nonparametric methods began to be used in evaluating the threat of corporate bankruptcy – especially the artificial neural networks (Odom and Sharada, 1990; Raghupathi et al., 1991, as in Jo et al., 1997; Coats and Fant 1991-1992; Tam and Kiang, 1992; Fletcher and Goss, 1993; Rahimian et al., 1993; Wilson and Sharda, 1994; Boritz and Kennedy, 1995; Serrano Cinca, 1997).

Recent years have also seen a group of new methods from the area of forecasting corporate bankruptcy, categorized as the so-called soft computing techniques[1]. Such a direction of progress stems from the use of computer applications that enable the implementation of advanced computational processes. This type of methods, in addition to the above-mentioned artificial neural networks, may include i.a. genetic algorithms, the method of support vectors or fuzzy logic. In contrast to traditional statistical techniques, such as multivariate linear discriminant analysis or logit and probit analysis, these methods cope better with imprecisely defined problems, incomplete data, inaccuracy, imprecision and uncertainty. They process information in cases difficult to illustrate in the form of algorithms and do this in conjunction with the symbolic representation of knowledge (Korol, 2010b, p. 2).

3. Predicting corporate bankruptcies in Poland and Lithuania – research overview

3.1. Lithuania

In the period after the Second World War the Lithuanian bankruptcy law was adopted on 15 October 1992, while the first cases of corporate bankruptcies appeared only in 1993[2]. As a result, the interest in the problems of forecasting corporate bankruptcy appeared very late in comparison to many developed countries – it should be noted that it was the consequence of the fact

---

[1]   For more on this topic, see e.g. Korol (2010; 2013).
[2]   See Republic of Lithuania, Law of Enterprise Bankruptcy, http://www.litlex.lt/litlex/eng/frames/ laws/Documents/21.HTM (20.07.2016) and J. Spaičienė (2008).

that Lithuania became independent only in 1990, when the change of economic system also occurred. The pioneering research in the field of forecasting bankruptcy of Lithuanian enterprises took place only at the end of the 20th century, most likely due to the lack of or limited access to data. A detailed literature analysis of the research on forecasting the bankruptcy of Lithuanian enterprises was conducted by Kanapickiene and Marcinkevicius (2014). Due to the passage of time and access to other literature sources it has already been supplemented with additional publications and presented in Table 1. It shows that Lithuanian scientists used the models of other countries to assess the risk of bankruptcy of Lithuanian enterprises, in particular those estimated by Altman, Taffler & Tishaw, Springate, Zavgren and Chesser, relatively frequently. The analysis of literature on the basis of which the table was drawn up leads to the conclusion that the efficiency of the forecasts generated by these models in the individual trials was varied. This means that none of these systems can be considered to work best in conditions prevalent in Lithuania. It should also be noted that these studies were carried out on the basis of companies from different sectors and the sample size in some cases was very small. It is supposed that the first scientist who in 2003 built a model based on Lithuanian enterprises was Grigaravičius (2003). To do this, he used the logit method with a sample of 88 entities. The estimates of other models dedicated to the Lithuanian market were provided by Purvinis et al. (2005a and 2005b). They used the technique of linear multivariate discriminant analysis and artificial neural networks with the learning sample consisting of only 13 companies. In 2008, the same authors presented hybrid models combining the technologies of artificial neural networks and fuzzy logic (Purvinis et al., 2008). In this case, the study sample was larger and comprised of 30 healthy and 200 bankrupt companies. Their best performance model allowed them to obtain, based on a validation sample, the first degree efficiency of slightly more than 80%, which was still higher by 7 percentage points than the result obtained using the Altman's model. In 2006, on the basis of 56 companies, Stundžienė and Boguslauskas (2006) developed a model for assessing the risk of bankruptcy using cluster analysis. It ensured higher efficiency in relation to the Altman's one. In the same period, Merkevicius et al. (2006) modified, by using the technique of self-organizing maps, the weights in Altman's model so as to better adapt it to the conditions prevalent in Lithuania. Two years ago *Butkus et al.* (2014) built a number of models using the logit method. It is noteworthy that they had a sectoral nature (related to construction, trading, service and industrial companies) and were supplemented by additional models estimated for enterprises of various sizes. The last of the available models was developed by Šlefendorfas (2016). The author used a sample of 145 enterprises for this purpose and method of the linear multivariate discriminant analysis. The efficiency determined for learning sample was 89%.

Table 1: *Summary of research on the prediction of corporate bankruptcy in Lithuania*

Research authors	Traditional multi-dimensional foreign models of enterprise bankruptcy forecasting													Other modern models of forecasting bankruptcy of enterprises, including those built using the sample of Lithuanian businesses
	Two-factor [0]	Altman [1]	Altman [2]	Altman [3]	Altman [4]	Taffler & Tisshaw	Springate	Lis	Fulmer	Zavgren	Chesser	Ca-Score	Seifulin & Kadykov	
Mackevičius, Poškaitė – 1999		X												
Tvaronavičienė – 2001		X												
Grigaravičius – 2003														X[1]
Grigaliūnienė, Cibulskienė – 2004	X		X	X	X	X	X		X			X		
Mackevičius, Rakštelienė – 2005		X	X	X	X									
Purvinis, Šukys, Virbickaitė –2005		X				X	X							X[2]
Purvinis, Šukys, Virbickaitė –2005														X[3]
Mackevičius, Silvanavičiūtė –2006		X				X	X			X	X			
Merkevicius, Garsva, Girdzijauskas – 2006														X[4]
Nedzveckas, Jurkevičius, Rasimavičius – 2006	X	X					X						X	
Stundžienė, Boguslauskas – 2006		X												X[5]
Stoškus, Beržinskienė, Virbickaitė – 2007														X[6]
Garškaitė – 2008	X	X	X			X	X	X						
Kanapickienė, Rudžionienė, Griauslytė –2008		X				X	X			X	X			X[7]
Purvinis, Virbickaitė, Šukys – 2008		X												X[8]
Karalevičienė, Bužinskienė –2012													X	X[9]
Budrikienė, Paliulytė – 2012		X				X	X	X		X	X			
Kiyak, Labanauskaitė – 2012			X				X			X	X			

Models / Research authors	Traditional multi-dimensional foreign models of enterprise bankruptcy forecasting													Other modern models of forecasting bankruptcy of enterprises, including those built using the sample of Lithuanian businesses
	Two-factor [0]	Altman [1]	Altman [2]	Altman [3]	Altman [4]	Taffler & Tisshaw	Springate	Lis	Fulmer	Zavgren	Chesser	Ca-Score	Seifulin & Kadykov	
Jurevičienė, Bercevič – 2013			X			X	X	X		X	X			
Kanapickiene, Marcinkevicius – 2014			X	X	X	X	X			X	X			
Butkus, Žakarė, Cibulskienė –2014														X[10]
Šlefendorfas – 2016														X[11]
SUMA	3	11	6	3	3	8	10	3	1	6	6	1	2	

[0] - this model was developed in the USA in 1960's.

Altman [1] - model dedicated to companies listed on the stock exchange

Altman [2] - model dedicated to companies not listed on the stock exchange

Altman [3] - model dedicated to service companies

Altman [4] - a model designed for companies from emerging markets

[1] The Grigavičius model built using the logit method for companies listed on stock exchange. Most probably the first model ever developed based on a sample of Lithuanian enterprises.

[2] The model of Purvinis, Šukys and Virbickaitė built using the method of artificial neural networks.

[3] The model of Purvinis, Šukys and Virbickaitė built using the method of linear multivariate discriminant analysis.

[4] Modified Altman model for companies not listed on a stock exchange. Merkevicius, Garsva and Girdzijauskas modified the weights of the Altman's model using the method of self-organizing maps (one of the methods of artificial intelligence), so that this hybrid provides higher efficiency in predicting corporate bankruptcy.

[5] The model of Stundžienė and Boguslauskas built using cluster analysis.

[6] The model of Purvinis, Šukys and Virbickaitė built using the method of linear multivariate discriminant analysis.

[7] Models: Grigavičius, Stundžienė and Boguslauskas.

[8] The model of Purvinis, Virbickaitė and Šukys built using the method of artificial neural networks and fuzzy logic.

[9] Models: Begley, Ming and Watts - 1996, Shumway - 1999, model dedicated to Romanian companies - 1999-2002 Grigaravičius - 2003; Inka and Neumaier -2005, Boritz et al. - 2007, Sandin and Porporato - 2007, Stoškus et al. - 2007, Bonity index - 2009.

[10] Models of Butkus, Zakar and Cibulskienė built using the logit method.

[11] The model of Šlefendorfas built using the method of linear multivariate discriminant analysis.

Source: *1) Grigaravičius (2003); 2) Purvinis et al. (2005a); 3) Purvinis et al. (2005b); 4) Merkeviciuis et al. (2006); 5) Nedzveckas et al. (2006); 6) Stundžienė, Boguslauskas (2006); 7) Stoškus et al. (2007); 8) Purvinis et al. (2008); 9) Butkus et al. (2014); 10) Kanapickiene, Marcinkevicius (2014); Šlefendorfas (2016).*

3.2. Poland

In Poland, in the post-war period a bankruptcy and reorganization law was in force, supplemented by appropriate ministerial ordinances[3]. Due to the nature of the economic system, however, it was not applied in practice. As a result of the economic transformation, the first corporate bankruptcies took place in 1990. In 2003, a new bankruptcy law was introduced, which, with later amendments, is still in force[4]. On 1 January 2016, it was supplemented with a new restructuring law[5]. The problems of forecasting corporate bankruptcies in Poland has been of interest to the researchers only since mid-1990s, although it must be said that since then the number of studies dealing with this issue has been significant. For this reason, below only an overview of the most important literature on this topic is presented. The pioneering research was aimed at using foreign models, particularly the Altman model, to predict bankruptcies of Polish enterprises (Mączyńska, 1994; Gasza, 1997; Łukaszewski and Dąbroś, 1998; Bławat, 1999; Zdyb, 2001). Zdyb (2001) proposed i.a. adjusting the cut-off point in Altman's model to Polish conditions, so that it generates more efficiency. In the similar period the Polish researchers also started using the ratio analysis (Wędzki, 2000; Stępień and Strąk, 2003; Michaluk, 2003; Kniewski, 2004; Prusak, 2005), as well as building first models allowing for predicting corporate bankruptcies (Pogodzińska and Sojak, 1995; Gajdka and Stos 1999; Hadasik, 1998; Wierzba, 2000). Due to the limited access to or scarcity of data, these models were created using small samples and based on multivariate linear discriminant analysis. Later, a number of other models were created using the same statistical technique and the sizes of learning samples were mostly higher (Hołda, 2001; Sojak and Stawicki, 2001; Mączyńska, 2004, Appenzeller and Szarzec, 2004; Michaluk, 2004; Korol, 2004; Hamrol et al., 2004; Prusak, 2005; Siudek, 2005; Jagiełło, 2013; Juszczyk and Balina, 2014). As in the developed countries, newer statistical techniques also began to be used, such as the logit method (Gruszczyński, 2003; Michaluk, 2003; Wędzki, 2004; Stępień and Strąk, 2004; Prusak and Więckowska, 2007; Jagiełło, 2013; Pisuła et al., 2013; Pociecha et al., 2014), artificial neural networks, genetic algorithms or classification trees (Michaluk, 2003; Korol, 2004; Pisuła et al., 2013; Pociecha et al., 2014). Korol (2010b) also applied the method of support vectors and fuzzy

---

3   Rozporządzenie Prezydenta Rzeczypospolitej z dnia 24 października 1934 r. Prawo upadłościowe, Dziennik Ustaw 1934 no. 93 item 834 and Rozporządzenie Prezydenta Rzeczypospolitej z dnia 24 października 1934 r. Prawo o postępowaniu układowym, Dziennik Ustaw 1934 no. 93 item 836.

4   Ustawa z dnia 28 lutego 2003 r. Prawo upadłościowe i naprawcze, Dziennik Ustaw 2003 no. 60 item 535, as amended.

5   Ustawa z dnia 15 maja 2015 r. - Prawo restrukturyzacyjne, Dziennik Ustaw 2015 item 978.

logic. It is worth noting that in addition to universal models many sectoral models were created, dedicated to i.a.

- transport, construction, service, trading and industrial companies (Jagiełło, 2013),
- shipping companies (Juszczyk and Balin; 2009), or
- cooperative banks (Siudek 2005).

4. Conclusions

In the area of forecasting corporate bankruptcy there are both similarities and differences between the analysed countries. The former include i.a.:

- an interest in this subject started in the 1990s, which is a consequence of the development of the institutional order adapted to the functioning of market economies and at the same time the emergence of actual corporate bankruptcies;
- the first studies, which consisted in adapting foreign models to predicting the bankruptcy of domestic enterprises, and the fact that, with the emergence of enough data related to bankrupt entities, local researchers started to create national models.

On the other hand, some differences relate to the following issues:

- in Poland, a tendency of moving away from foreign models to predict the bankruptcies of domestic entities is observed, while in Lithuania such analyses are still prevalent;
- in Lithuania, in comparison to Poland, only few domestic models were estimated — moreover, they were based on rather traditional statistical techniques. There are also much fewer sectoral models. This may be due to differences in size of the two countries, which has an impact on the number of operating business entities and at the same time the number of researchers.

In comparison to the developed countries, it can be seen that the state and the advancement of research on issues of corporate bankruptcy in Poland and Lithuania does not differ significantly. It is obvious that due to considerations related to the nature of economic systems the interest in this issue emerged later than, for example, in the United States and the demand for this type of studies is much smaller. The review of global research in the field of forecasting corporate bankruptcy in the Google Scholar database allows for observing that the field is dominated by analyses of comparative effectiveness of different statistical techniques and the introduction of newer and newer mathematical solutions. Against this background, Poland performs better than Lithuania. Moreover, it is recommended for Lithuania to build sectoral models, of course subject to availability of data, as well as stop using the foreign models to evaluate domestic enterprises.

In addition, it is recommended to introduce into the used models not only variables such as financial indicators but also other economic measures, reflecting e.g. economic situation, competitiveness of entities, volatility of financial results etc. (Prusak, 2005, pp. 20-27). While in Poland such attempts have already been made (Korol, 2010a, Korol, 2008), in Lithuania the traditional approach based solely on financial indicators continues to dominate.

References

1. Altman, E.I. (2015). *Edward I. 2015 Honorary Doctor of SGH. Selected Articles*, Warsaw School of Economic Press, Warsaw.
2. Altman, E.I., Narayanan, P. (1997). An International Survey of Business Failure Classification Models, *Financial Markets, Institutions & Instruments* 6(2).
3. Altman, E.I. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy, *The Journal of Finance* XXIII (4): 589-609.
4. Appenzeller, D., Szarzec, K. (2004). Prognozowanie zagrożenia upadłością polskich spółek publicznych, *Rynek Terminowy* 1: 120-128.
5. Aziz, M., Dar, H. (2006). Predicting corporate bankruptcy – where we stand? *Corporate Governance Journal* 6(1): 18-33.
6. Back, B., Laitinen, T., Hekanaho, J., Sere K. (December 1997). *The Effect of Sample Size on Different Failure Prediction Methods, Turku Centre for Computer Science*, TUCS Technical Report No. 155.
7. Beaver, W.H. (January 1968). Alternative Accounting Measures As Predictors of Failure, *The Accounting Review* 43(1): 113-122.
8. Beaver, W.H. (1966). Financial Ratios as Predictors of Failure. Empirical Research in Accounting: Selected Studies, Supplement to Vol. 5, *Journal of Accounting Research*, 1967: 71-111.
9. Bellovary, J., Giacomino, D., Akers, M. (Winter 2007). A Review of Bankruptcy Prediction Studies: 1930 to Present, *Journal of Financial Education* 33: 1-42.
10. Bławat, F. (1999). Zagrożenie upadłością spółek akcyjnych w Polsce w: Gospodarka Polski w okresie transformacji*, Zeszyt nr 3*, (red.) Ossowski, J.Cz., Wydawnictwo Politechniki Gdańskiej, Gdańsk.
11. Boritz, J.E., Kennedy, D.B. (1995). Effectiveness of Neural Network Types for Prediction of Business Failure, *Expert Systems With Applications* 9(4): 503-512.
12. Butkus, M., Žakarė, S., Cibulskienė, D. (2014). Bankroto diagnostikos modelis ir jo pritaikymas bankroto tikimybei lietuvos įmonėse prognozuoti, *Taikomoji Ekonomika: Sisteminiai Tyrimai* 8.1: 111-132.

13. Chesser, D.L. (1974). Predicting Loan Noncompliance, *The Journal of Commercial Bank Lending*, 56(12): 28-38.

14. Coats, P., Fant, L. (1991-1992). A Neural Network Approach to Forecasting Financial Distress, *Journal of Business Forecasting* 10(4): 9-12.

15. Fletcher, D., Goss, E. (1993). Forecasting with Neural Networks: An Application Using Bankruptcy Data, *Information & Management* 24: 159-167

16. Gajdka, J., Stos, D. (1996). *Wykorzystanie analizy dyskryminacyjnej w ocenie kondycji finansowej przedsiębiorstw* w: *Restrukturyzacja w procesie przekształceń i rozwoju przedsiębiorstw*, (red.) Borowiecki R., Wydawnictwo Akademii Ekonomicznej w Krakowie, Kraków.

17. Gasza, R. (1997). Związek między wynikami analizy typu Altmana, a kształtowaniem się kursów akcji wybranych spółek giełdowych w Polsce. *Bank i Kredyt* 3: 59-63.

18. Grigaravičius, S. (2003). Corporate Failure Diagnosis: Reliability and Practice, *Organizacijų vadyba: sisteminiai tyrimai* 28: 29–42.

19. Gruszczyński, M. (2003). *Modele mikroekonometrii w analizie i prognozowaniu zagrożenia finansowego przedsiębiorstw*, Zeszyty Polskiej Akademii Nauk, nr 23, Warszawa.

20. Hadasik, D. (1998), *Upadłość przedsiębiorstw w Polsce i metody jej prognozowania*, Wydawnictwo Akademii Ekonomicznej w Poznaniu, Zeszyt 153, Poznań.

21. Hamrol, M., Czajka, B., Piechocki, M., (2004). Upadłość przedsiębiorstwa – model analizy dyskryminacyjnej, *Przegląd Organizacji* 6: 35-39.

22. Hołda, A. (2001). Prognozowanie bankructwa jednostki w warunkach gospodarki polskiej z wykorzystaniem funkcji dyskryminacyjnej Z_H, *Rachunkowość* 5.

23. Härdle, W., Moro, R.A., Schäfer, D. (March 2004). *Rating Companies with Support Vector Machines*, German Institute for Economic Research, Discussion Papers, No. 416, Berlin.

24. Jagiełło, R. (2013). *Analiza dyskryminacyjna i logistyczna w procesie oceny zdolności kredytowej przedsiębiorstw*, Materiały i Studia, Zeszyt 286, NBP, Warszawa.

25. Jo, H., Han, I., Lee, H. (1997). Bankruptcy Prediction Using Case-Based Reasoning, Neural Networks and Discriminant Analysis, *Expert Systems With Applications* 13(2): 97-108.

26. Juszczyk, S., Balina, R. (2014). Prognozowanie zagrożenia bankructwem przedsiębiorstw w wybranych branżach, *Ekonomista* 1: 67-95.

27. Juszczyk, S., Balina, R. (2009). Prognozowanie upadłości przedsiębiorstw spedycyjnych jako bankowe narzędzie decyzyjne, *Zeszyty Naukowe SGGW - Ekonomika i Org. Gosp. Żywnościowej* 78: 161-174.

28. Kanapickiene, R., Marcinkevicius, R. (2014). Possibilities to apply classical bankruptcy models in the construction sector in Lithuania, *Economics and Management* 19(4): 317-332.

29. Kniewski, A. (2004). Wzór na bankruta, *Businessman* 10.

30. Korol, T. (2013). *Nowe podejście do analizy wskaźnikowej w przedsiębiorstwie*. Wolters Kluwer Polska, Warszawa.

31. Korol, T. (2010a). *Systemy ostrzegania przedsiębiorstw przed ryzykiem upadłości*, Wolters Kluwer, Warszawa.

32. Korol, T. (2010b). Prognozowanie upadłości firm przy wykorzystaniu miękkich technik obliczeniowych, *Finansowy Kwartalnik Internetowy „e-Finanse* 6(2).

33. Korol, T. (2008). Prognozowanie upadłości firm z wykorzystaniem zmiennych makroekonomicznych, *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu* 9(1209): 109-115.

34. Korol, T. (2004). *Ocena trafności zastosowania metod dyskryminacyjnych oraz sztucznych sieci neuronowych dla identyfikacji przedsiębiorstw zagrożonych upadłością,* praca doktorska, Gdańsk.

35. Łukaszewski, K., Dąbroś, P. (1998). Jak i gdzie znaleźć bankruta? *Prawo i Gospodarka* 49.

36. Łukaszewski, K., Dąbroś, P. (1998). Wskaźnik Altmana, *Prawo i Gospodarka* 0.

37. Martin, D. (1977). Early Warning of Bank Failure: A Logit Regression Approach, *Journal of Banking and Finance* 1: 249-276.

38. Mączyńska, E. (2004). Systemy wczesnego ostrzegania, *Nowe Życie Gospodarcze* 12/373.

39. Mączyńska, E. (1994). Ocena kondycji przedsiębiorstwa. Uproszczone metody, *Życie gospodarcze* 38.

40. Merkevicius, E., Garsva, G., Girdzijauskas, S. May 2006). *A Hybrid SOM-Altman Model for Bankruptcy Prediction in: Computational Science - ICCS 2006, V.N. Alexandrov, G.D. van Albada, P.M.A. Sloot, J. Dongarra (Eds.)*, 6 International Conference Reading, UK, Proceedings, Part IV, Springer: 364-371.

41. Michaluk, K. (2003). *Efektywność modeli prognozujących upadłość przedsiębiorstw w polskich warunkach gospodarczych* w: *Finanse przedsiębiorstw wobec procesów globalizacji*, (red.) Pawłowicz, L. i Wierzba, R., Wydawnictwo Gdańskiej Akademii Bankowej, Warszawa.

42. Nedzveckas, J., Jurkevičius, E., Rasimavičius, G. (2006). Testing of Bankruptcy Prediction Methodologies for Lithuanian Market, Mokslo taikomieji tyrimai Lietuvos kolegijose 3: 54-64. Retrieved July 20, 2016 from http://vddb.library.lt/fedora/get/LT-eLABa-0001:J.04~2006~ISSN_1822-1068.N_3.PG_54-64/DS.002.1.02.ARTIC.

43. Odom, M.D., Sharada, R. (1990). *A Neural Network Model for Bankruptcy Prediction*, Proceedings of IEEE International Conference on Neural Network, San Diego, CA, Vol. II.

44. Ohlson, J. (1980). Financial Ratios and the Probabilistic Prediction of Bankruptcy, *Journal of Accounting Research* 18(1).

45. Pisuła, T., Mentel, G., Brożyna, J. (2013). Predicting Bankruptcy of Companies from the Logistics Sector Operating in the Podkarpacie Region, *Modern Management Review* XVIII (20): 113-133.

46. Pociecha, J., Pawełek, B., Baryła, M., Augustyn, S. (2014). *Statystyczne metody prognozowania bankructwa w zmieniającej się koniunkturze gospodarczej,* Fundacja Uniwersytetu Ekonomicznego w Krakowie, Kraków.

47. Pogodzińska, M., Sojak, S. (1995). *Wykorzystanie analizy dyskryminacyjnej w przewidywaniu bankructwa przedsiębiorstw* w: *AUNC, Ekonomia XXV*, Zeszyt 299, Toruń.

48. Prusak, B., Więckowska, A. (2007). *Wielowymiarowe modele analizy dyskryminacyjnej w badaniu zagrożenia upadłością polskich przedsiębiorstw notowanych na GPW* w: *Ekonomiczne i prawne aspekty upadłości przedsiębiorstw*, (red.) Prusak, B., Difin, Warszawa.

49. Purvinis, O., Virbickaitė, R., Šukys, P. (2008). Interpretable Nonlinear Model for Enterprise Bankruptcy Prediction*, Nonlinear Analysis: Modelling and Control* 13(1): 61–70.

50. Purvinis, O., Šukys, P., Virbickaitė R. (2005a). *Bankruptcy Prediction in Lithuanian Enterprises Using Discriminant Analysis* in: *Ekonomika ir vadyba: aktualijos ir perspektyvos*, No. 5: 314-318.

51. Purvinis, O., Šukys, P., Virbickaitė, R.(2005b). Research of Possibility of Bankruptcy Diagnostics Applying Neural Networks*, Engineering Economics* 1(41): 16-22.

52. Prusak, B. (2005). *Nowoczesne metody prognozowania zagrożenia finansowego przedsiębiorstw*, Difin, Warszawa.

53. Rahimian, E., Singh, S., Thammachote, T., Virmani, R. (1993). *Bankruptcy Prediction by Neural Network* in: ed., Trippi, R.R., Turban, E., *Neural Networks in Finance and Investing*, Probus Publishing Company, Chicago-London.

54. Republic of Lithuania, Law of Enterprise Bankruptcy. Retrieved July 20, 2016 from http://www.litlex.lt/litlex/eng/frames/laws/Documents/21.HTM.

55. Rozporządzenie Prezydenta Rzeczypospolitej z dnia 24 października 1934 r. Prawo upadłościowe, Dz.U. 1934 nr 93 poz. 834.

56. Rozporządzenie Prezydenta Rzeczypospolitej z dnia 24 października 1934 r. Prawo o postępowaniu układowym, Dz.U. 1934 nr 93 poz. 836.

57. Serrano Cinca, C. (1997). Feedforward Neural Networks in the Classification of Financial Information, *European Journal of Finance* 3(3): 183-202.

58. Siudek, T. (2005). Prognozowanie upadłości banków spółdzielczych przy użyciu analizy dyskryminacyjnej, *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu* 7(5):86-91.

59. Smith, R., Winakor, A. (1935). Changes in Financial Structure of Unsuccessful Industrial Corporations. Bureau of Business Research, Bulletin 51. Urbana:University of Illinois Press.

60. Sojak, S., Stawicki, J. (2000). Wykorzystanie metod taksonomicznych do oceny kondycji ekonomicznej przedsiębiorstw, *Zeszyty Teoretyczne Rachunkowości* 3(59).

61. Spaičienė, J. (2008). *Bankruptcy Law Development in The Republic of Lithuania, Summary of the Doctoral Dissertation,*Vilnius, Retrieved July 20, 2016 from http://www.youscribe.com/catalogue/rapports-et-theses/savoirs/bankruptcy-law-development-in-the-republic-of-lithuania-bankroto-1426976.

62. Stępień, P., Strąk, T. (2004). *Wielowymiarowe modele logitowe oceny zagrożenia bankructwem polskich przedsiębiorstw* w: t. I, (red.) Zarzecki, D., Wydawnictwo Uniwersytetu Szczecińskiego, Szczecin.

63. Stępień, P., Strąk, T. (2003). *Objawy zagrożenia bankructwem polskich przedsiębiorstw – studium empiryczne* w: *Czas na pieniądz t. II*, (red.) Zarzecki, D., Wydawnictwo Uniwersytetu Szczecińskiego, Szczecin.

64. Stoškus, S., Beržinskienė, D., Virbickaitė, R. (2007). Theoretical and practical decisions of bankruptcy as one of dynamic alternatives in companies performance, *Engineering Economics* 2(52): 26–33.

65. Stundžienė, A., Boguslauskas, V. (2006). Valuation of Bankruptcy Risk for Lithuanian Companies, *Engineering Economics* 4(49): 29-36.

66. Šlefendorfas, G. (2016). Bankruptcy Prediction Model For Private Limited Companies in Lithuania, *Ekonomika* 95(1): 134-152.

67. Tam, K.Y., Kiang, M.Y. (July 1992). Managerial Applications of Neural Networks: The Case of Bank Failure Predictions, *Management Science* 38(7): 926-947.

68. Ustawa z dnia 15 maja 2015 r. - Prawo restrukturyzacyjne, Dz.U. 2015 poz. 978.

69. Ustawa z dnia 28 lutego 2003 r. Prawo upadłościowe i naprawcze, Dz.U. 2003 nr 60 poz. 535 z późn. zmianami.

70. Waśniewski, T., Skoczylas, W. (1993). Analiza symptomów zagrożeń przedsiębiorstwa, *Rachunkowość* 12: 437-443.

71. Wędzki, D. (2004). *Logitowy model upadłości dla gospodarki polskiej – wnioski z badania* w: *Czas na pieniądz. Zarządzanie finansami. Finansowanie przedsiębiorstw w UE,* t. I, (red.) Zarzecki, D., Wydawnictwo Uniwersytetu Szczecińskiego, Szczecin.

72. Wędzki, D. (2000). Problem wykorzystania analizy wskaźnikowej do przewidywania upadłości polskich przedsiębiorstw - studium przypadków, *Bank i Kredyt* 5: 54-61.

73. Wierzba, D. (2000). *Wczesne wykrywanie przedsiębiorstw zagrożonych upadłością na podstawie analizy wskaźników finansowych – teoria i badania empiryczne* w: *Zeszyty Naukowe nr 9*, Wydawnictwo Wyższej Szkoły Ekonomiczno-Informatycznej w Warszawie, Warszawa.
74. Wilson, R., Sharda, R. (1994). Bankruptcy Prediction Using Neural Networks, Decision Support Systems 11(5): 545-557.
75. Zavgren, C. (1983). The Prediction of Corporate Failure: The State of the Art, *Journal of Accounting Literature* 2: 1-38.
76. Zdyb, M. (2001). Ocena zagrożenia przedsiębiorstwa upadłością przy zastosowaniu finansowych wskaźników syntetycznych, *Controlling i Rachunkowość Zarządcza* 5: 36-40.
77. Zmijewski, M. (1984). Methodological Issues Related to the Estimation of Financial Distress Prediction Models, *Journal of Accounting Research* 20: 59-82.