

Using discriminant analysis for credit decision

Gheorghita DINCĂ¹, Mădălina BOCIU²

Abstract: *This paper follows to highlight the link between the results obtained applying discriminant analysis and lending decision. For this purpose, we have carried out the research on a sample of 24 Romanian private companies, pertaining to 12 different economic sectors, from I and II categories of Bucharest Stock Exchange, for the period 2010-2012. Our study works with two popular bankruptcy risk's prediction models, the Altman model and the Anghel model. We have double-checked and confirmed the results of our research by comparing the results from applying the two fore-mentioned models as well as by checking existing debt commitments of each analyzed company to credit institutions during the 2010-2012 period. The aim of this paper was the classification of studied companies into potential bankrupt and non-bankrupt, to assist credit institutions in their decision to grant credit, understanding the approval or rejection algorithm of loan applications and even help potential investors in these companies.*

Key-words: *discriminant analysis, bankruptcy risk, the Z score function, the A score function, lending decision*

1. Introduction

Discriminant analysis is a classification algorithm able to predict the categories a new item with similar characteristics can be placed in (Sueyoshi, 2006).

Why is the discriminant analysis important? Because it can be applied in many areas, for example the decision to grant credit to individuals and legal entities, the decision to invest financial resources in a company's shares of stock or bonds as well as each individual's social life.

How can we use discriminant analysis in the lending decision? This paper aims to apply discriminant analysis on a sample of 24 Romanian companies from 12 different areas to identify the categories in which they fit and how this rating influenced or may influence the decision to grant credit to these companies. Our study started from the premise of using this analysis by the credit institutions.

¹ Faculty of Economic Sciences and Business Administration, Transilvania University of Brasov, Romania, gheorghita.dinca@unitbv.ro

² Faculty of Economic Sciences and Business Administration, Transilvania University of Brasov, Romania, master student

The paper is structured as follows: Section two summarizes the literature, highlighting discriminant analysis models and the results generated; The third section presents the data used, the models applied and empirical results, and finally to arrive at the interpretation of these results, verification of application models and conclusions.

2. Literature review

The application of discriminant analysis implies a bankruptcy risk analysis model, based on companies' financial information and performances. Since the crisis of 1929-1933, more and more academics and practitioners have studied this phenomenon of bankruptcy prediction, developing or using statistical models (Beaver, 1996; Altman, 1968; 1977; 2000; Edmister, 1972; Deakin, 1977; Conan and Holder, 1979; Anghel, 2002; Armeanu et al., 2012, Dinca and Gidinceanu, 2011).

Beaver (1996) was noted by research carried out on the basis of univariate analysis, applied to a sample of 79 bankrupt companies and 79 non-bankrupt companies. For the accuracy of prediction of the bankruptcy, his researches were carried out five years before bankruptcy occur, taking into account 33 variables of which he selected the most relevant five variables. The result showed that coverage of debt with cash flow is the best predictor, followed by return on assets.

Altman (1968) studied a sample of 66 companies, of which 33 were industrial companies with financial problems and 33 companies had no financial problems for the period 1946-1965. The analysis was initiated with 22 variables, of which finally selected five variables, the most discriminating. The key factor was considered return on assets, balanced with a value close to the other four indicators taken together. The results of this initial analysis has led to the idea that a company with an overall score of less than 1.81 is considered to be bankrupt. Since the original model could be applied only for listed companies, Altman (1977) has replaced variable market value keeping the other indicators, but recalculating their influence. To expand the application of the model to other areas of activity, not only for the industry, as foreseen in the initial model, the author has reconsidered score function, using only four variables. Developing a bankruptcy prediction model led to the conclusion that a lower score than 1.10 shows signs of bankruptcy for the companies analyzed, while a score of above 2.6 points out companies in the safe, non-bankruptcy area.

Edmister (1972) tried to apply previous studies for small companies, confirming that the prediction accuracy increases when the model includes more complex variables. Probabilistic model developed by Deakin (1977) brought a significant change to model Altman, embodied by improving predictive power for the analyzed companies by introducing initial reports used by Beaver.

Using 19 financial indicators, otherwise, the most used in previous studies was model 1978 Springate (Kiyak and Labanauskaite, 2012), which was developed on a sample of 40 companies and were chosen four relevant variables in predicting bankruptcy. The result was a score function that classifies a company as bankrupt if it shows a score below 0.862 with a success rate of 92.5%.

Conan and Holder (1979), two authors members of Continental School of Bankruptcy Prediction, included in their model five rates for 95 industrial SMEs in the period 1970-1975. They concluded that the risk of bankruptcy depends on scores limits. For example, a score between 0.04 and 0.1 reveals a problematic situation of the company, with a risk of bankruptcy hovering between 30% and 65%. A value less than 0.05 leads to failure, with a probability that the company will fail over 90%. These researchers also developed models for other sectors, such as construction and transport.

We can also mention Fulmer, which reached very high rates of success with the model 1984 (Yang, 2006), which selected finally nine variables from the 40 initially evaluated on a sample of 60 small and medium companies, with more than 500 employees. The model has shown a success rate of 98% for predicting bankruptcy if it is done in the year before bankruptcy and a success rate of 81% if performed more than two years before bankruptcy.

Another model very laborious and complex for bankruptcy prediction is developed by the Central Bank of France in 1985, mentioned by Anghel (2002). The model was applied to industrial companies with around 500 employees, over a period of three years before the bankruptcy, 1977-1979. Whereas in previous studies the focus was on two categories of companies, bankrupt and non-bankrupt companies, this time were classified as bankrupt firms, ordinary and vulnerable. The study imposed separation of normal companies, with a score of over 1.25 from those in need, with a lower score of -0.25. Companies in difficulty are separated in bankrupt or vulnerable. In this case, a score below -0.375 indicates that the company could go bankrupt and a score greater than 0.12 suggests signs of vulnerability.

Romanian school contribution to the development of bankruptcy prediction models began along the study conducted by Măneacuță and Nicolae (1996). These two specialists have developed a model for metallurgical enterprises. Based on empirical coefficient Pearson for choosing discriminant financial ratios on a sample of 59 companies, the study was based on a calculation matrix and eventually selected 14 rates, a fairly high number compared to other researchers. They concluded that a company which has a score below 1.56 is a deficit.

Using four variables without specifying the selection algorithm, Băileșteanu (1998) developed function B, considering that a level below 0.5 indicates company's imminent bankruptcy. A value of the function above 2 would indicate a favorable area, while the range between the two limits is an intermediate area.

Looking to improve his model, Băileşteanu (1998) used six financial ratios for 50 companies and he pointed out that a score below 0 expresses a state of imminent bankruptcy, while a score above 6 indicates a very low bankruptcy risk. In all cases and methodologies used, some caveats could however be applied, such as the time or data series might be too short thus not warranting a robust correlation (Drumea and Spataru, 2011).

The XXIst century brings about the Anghel model (2002) for the diagnosis and prediction of bankruptcy. The construction of the scoring model was based on a sample of 276 randomly selected companies, and a final number of four financial variables for the period 1994-1998. Unlike most models mentioned above, the calculation of the score function Anghel also took into account a constant. In his model, a company with a negative score is assessed to be bankrupt, and a result of over 2.05 ranks the company as non-bankrupt.

The latest Romanian model belongs to Armeanu et al. (2012). Development of the function score was based on a sample of 60 companies listed on the Bucharest Stock Exchange and has considered seven economic and financial rates. Results on a matrix calculation showed a success rate of 98.41% of the prediction and allowed the identification of three areas: a safe area with a very low probability of failure, a grey area for which the risk of bankruptcy is medium and an area with a high probability of bankruptcy.

The literature on bankruptcy prediction is very complex and the models above are just some of the many approaches to this issue. The researchers of the statistical models used as primarily value system financial and economic rates, but without taking into account the market or field of activity of the company. The models could refer also to

Taking as a basis the discriminant analysis, lending scoring method was developed by researchers to build a risk profile of a particular enterprise. "Score as the completion of the discriminant analysis thus constitute a diagnostic method which consists of measuring external and interpretation of risk to which the investor, creditor enterprise and the enterprise expose as a system in future work" (Anghel, 2002).

As several authors emphasized, corporations have three types of financing sources at their disposal: debt, external equity and internally generated equity. It is however interesting to illustrate that debt financing can have benefic but also harmful effects on firms' risk and profitability (Keul and Drumea, 2009). According to the classification of loans in the Romanian economy, they are divided into five categories: standard, under observation, substandard, doubtful, loss (Ilie, 2005). The criteria applying this classification are debt service, financial performance and initiate of legal proceedings. Further, the study will analyze the influence of the financial performance of the companies analyzed by testing two of established risk of bankruptcy prediction models.

3. Data, methodology and empirical research results

The sample studied to determine the adequacy of the lending decision in the discriminant analysis includes 24 companies listed on the categories I and II of the Bucharest Stock Exchange, chosen from 12 different fields. Most analyzed companies were from the following areas: pharmaceutical, manufacturing industry, oil refining industry, machines and tools, namely tourism. Financial years for which the analysis will be conducted are summarized in 2010-2012.

Companies were chosen randomly and, according to annual financial results, eight of them were estimated as being in difficulty, namely Farmaceutica Remedia SA, Rompetrol Rafinare Constanta, Armatura Cluj-Napoca, Electroputere Craiova, Transilvania Constructii SA Cluj, VES S.A. Sighisoara, Romcarbon S.A. Buzau and CEMACON S.A.

Data for determining the score functions for each company were processed from the consolidated financial statements for the period 2010-2012 and from websites specialized in providing financial information, bvb.ro and ktd.ro.

To achieve careful study, we applied discriminant analysis by two risk bankruptcy prediction models, developed by two researchers remembered in the previous section: Altman, Anghel respectively.

While the Romanian and foreign specialists stopped just at developing bankruptcy prediction models, the current study aims to test the validity of the model applied by reporting the existence debt companies to credit institutions in the period analyzed using a simple binary variable, denoted 1 if the firm has recorded debts to credit institutions, or 0 if the company has not recorded debts to credit institutions. Of course, they were taken into account loans for a period longer than one year because are most relevant to the present analysis.

The first model applied to the sample is the model of Altman (1977), referred to as the Z' score function model. The form used in the present research is an extensive one and may be applicable to companies in any field. The function retains four most significant variables for predicting the risk of bankruptcy, each having a coefficient based on the research conducted by Altman. After applying the model, resulted a classification of the sample into three groups, depending on the range of the author. Score function Z' applied has the following form:

$$Z' = 6.56 X_1 + 3.26 X_2 + 6.72 X_3 + 1.05 X_4 \quad (1)$$

where:

- X_1 – Working Capital / Total Assets;
- X_2 – Retained Earnings / Total Assets;
- X_3 – Gross Profit / Total Assets;
- X_4 – Equity / Total Liabilities.

Range Z''	Appreciation
$Z'' < 1.10$	Distress Zone
$1.10 < Z'' < 2.60$	Grey Zone
$Z'' > 2.60$	Safe Zone

Table 1. Risk assessment model Z''

Source: Anghel I., 2002, p. 62

A prime objective of the study, radiography and bankruptcy prediction of the 24 companies listed on Bucharest Stock Exchange using model Altman, led us to results of Z'' scores of companies in the sample between -3.96 and 6.23 limits. According to the risk assessment described in the table above, 10 of the 24 companies are considered to be in difficulty or in a situation of bankruptcy. This is because the results are in the lower limit imposed by model Altman, below 1.10. The lowest belongs to RRC, a company that was placed from the beginning as having financial problems.

In contrast, over 40% of the sample and 10 companies are in a favorable situation and ranks significantly above the upper limit of 2.60 prediction. The company favorably located is PPL, with a score of 6.23. In the uncertain zone are only found four companies.

The results obtained in the sample, during the three years considered and their classification for assessing the risk of bankruptcy can be seen in Figure 1 below.



Fig. 1. Classification of companies according to Z score obtained

Considering the actual financial situation of companies analyzed, we can say that the model Altman offered a successful evaluation and prediction of the risk of bankruptcy. This assessment is based on a 83.3% success rate, based on the correct classification of 20 of 24 companies. Priori analysis of the success rate of Z" score showed that type I error (bankrupt companies classified as non-bankrupt) is 4.16%, and the type II error (non-bankrupt companies classified as insolvent) is 12.5%. Basically, four of the 24 companies were classified incorrectly.

As noted in the brief overview of the literature, models developed by foreign researchers can be used for a particular area or economic period for which they were designed. But in the Romanian economy, which is still in a difficult situation, model Anghel is considered an important reference point in predicting the risk of bankruptcy.

So, to test the accuracy of the classification results on the same sample of 24 companies for the same period 2010 to 2012, we also applied score function model developed by Anghel (2002). The researcher used four financial variables and compared to Altman, introduced into the formula a constant.

The formula used is as follows:

$$A = 5.676 + 6.3718 X_1 + 5.3932 X_2 - 5.1427 X_3 - 0.0105 X_4 \quad (2)$$

where:

- X_1 – Net profit / Revenues;
- X_2 – Cash Flow / Total Assets;
- X_3 – Debts / Total Assets;
- X_4 – (Debts / Turnover) x 360.

Range A	Appreciation
$A < 0$	Distress Zone
$0 < A < 2.05$	Grey Zone
$A > 2.05$	Safe Zone

Source: Anghel I., 2002, p. 146

Table 2. Risk assesment model A

This time, radiography and bankruptcy prediction for the 24 companies listed on the Bucharest Stock Exchange, using the model Anghel, led us to results of companies in the sample A scores between 5.61 and -17.97 limits. According to the risk assessment described in the table above, 7 of the 24 companies are considered to be in difficulty or in a situation of bankruptcy. This is because the results are in the lower limit imposed by the model, below 0. The lowest belongs to CEON, the company that was placed from the beginning as having financial problems.

In contrast, over 54% of the sample and 13 companies are in a favorable situation and ranks significantly above the upper limit of 2.05 prediction. The

company favorably located is BCM. In the uncertain zone are found only four companies.

The results obtained in the sample, during the three years considered and their classification for assessing the risk of bankruptcy can be seen in Figure 2 below.



Fig. 2. Classification of companies according to A score obtained

Taking into account the real financial situation of companies analyzed, we can say that model Anghel provided a successful evaluation and prediction of the risk of bankruptcy. This assessment is based on a 95.8% success rate, based on the correct classification of 23 of 24 companies. Priors analysis of the success rate of function score A revealed that type I error (bankrupt companies classified as non-bankrupt) is 4.16%, and the type II error (non-bankrupt companies classified as insolvent) is 0%. Basically, one company of the 24 was classified incorrectly.

4. Discussions

After applying the models, it can be noted a high success rate of the discriminant analysis based on study of Anghel and applied to 24 companies in the sample. The significant financial variables are the net profits and debts recorded by each company in the sample. The limitative condition of the models is that they reveal only some indicators, thus discriminating other groups of indicators or factors that might influence the risk of bankruptcy prediction.

Following the study, assigning two values, 0 and 1, to the companies that have not recorded or recorded liabilities to credit institutions in the analyzed period resulted in the following figures.

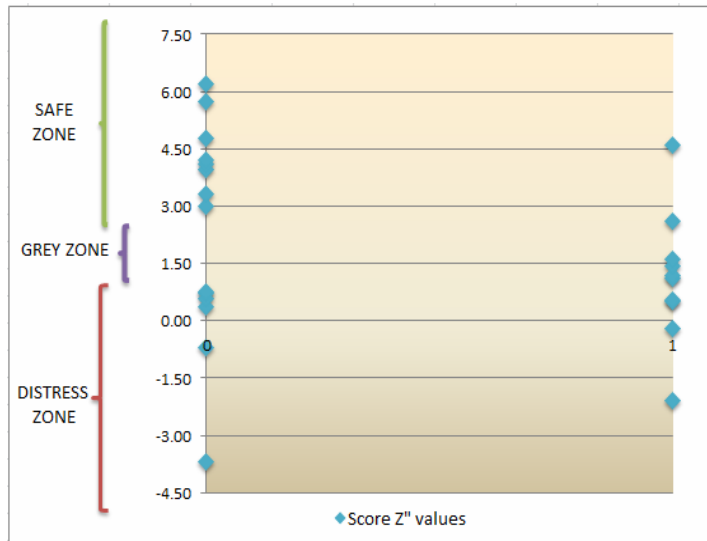


Fig. 3. Ranking of function Z'' depending on loans taken

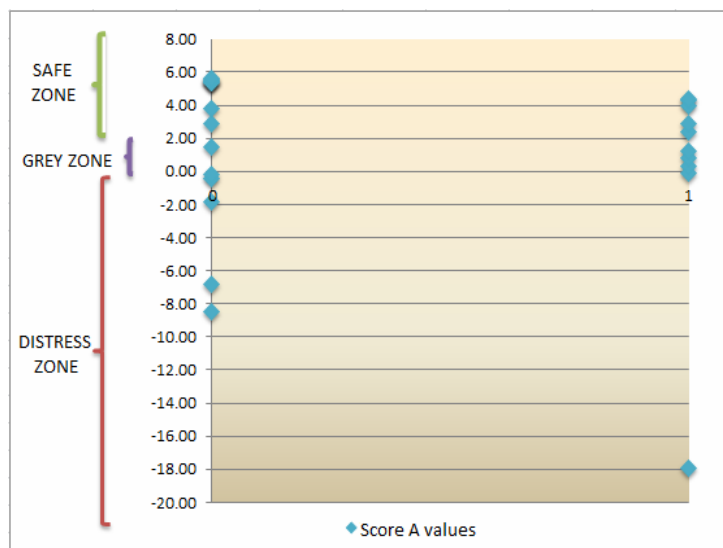


Fig. 4. Ranking of A function depending on loans taken

From the above figures, analyzing from the point of view of a financial and banking institution, the A score function model (Anghel, 2002) is a better predictor for the risk of bankruptcy of a company. The first graph shows a larger distribution of the credited companies in the grey zone, mainly companies which already manifest risk of bankruptcy in the coming years, while the second graph represents the distribution healthy in terms of banking risk in the grey, mainly towards the non-bankruptcy zone. The only exception is the company CEON which, although it is in difficulty, managed to get a credit, most likely in a period in which it had a better financial situation.

After discriminant analysis applied to lending decision, and considering that the model Anghel is a new model that resulted from research of other models developed by its predecessors, it can be concluded that the best model to predict the risk of bankruptcy, between the two models, is the model Anghel. The A score function values distribution is correct, meaningful and can be used successfully in the decision to grant medium and long term credit to these companies, through the classification given by the discriminant analysis. Naturally, the banks aim to develop new methodologies for risk assessment of a company, ranking them according to a certain score. The financial criteria are most important, accounting for a share of about 50% in the model, but alongside these criteria are taken into account other variables such as organization, scope, guarantees, technical and technological facilities (Anghel, 2002).

I consider that developing a lending scoring model based on discriminant analysis would increase the efficiency and performance of Romanian banks, especially through intensive study and comparison of performance and non-performing loans.

This research may be extended, taking into account other economic and financial variables and without limitation to the number of four indicators used in Altman's and Anghel's models.

5. Conclusions

The main purpose of the paper is to apply Anghel and Altman models on a sample of Romanian private companies, to classify them in three categories and verify that the applicability of those models on the lending decision was reached. Following the empirical results and related discussions revealed that Anghel model is more effective in the classification of a sample of companies, thanks to the success rate in relation to the financial condition known of the companies. The model can be applied without difficulty in the lending decision, specifying that just discriminant analysis based on financial performance is not enough. The analyst must consider

the legal situation of the company and possibly credit history in order to observe its payment behavior.

The relevance of this analysis is surprised also in the second part of the study, namely debt recorded by these companies in the analyzed period. As we have seen, most companies that already had a medium or long term loan were concentrated around the uncertain area, sign that score function can be a good predictor for the risk of bankruptcy. Since most models use accounting measures (operating profit, net profit, equity and so on) a direction for improving these models could be the use of value-based measures, such as economic value added (Nenning and Krause, 2009), cash value added (Ottoosson and Weissenrieder, 1996), or adjusted net present value (Dinca M.S., 2005).

This paper has made additions to the applicability of the discriminant analysis method on credit scoring, demonstrating that early prediction of the financial situation of a company can contribute to the decision to grant or deny credit to such companies.

6. References

- Altman, Edward I. 1968. "Financial ratios, discriminant analysis and the prediction of corporate bankruptcy". *The Journal of Finance* XXIII, 589-609.
- Altman, E.I., R. Haldemon, and P. Narayanan. 1977. "Zeta Analysis. A new model to identify bankruptcy risk of corporations". *Journal of Banking and Finance*, June, 29-54.
- Altman, Edward I. *Corporate Credit Scoring Models*. Stern School of Business, New York University. [online] Available at <http://people.stern.nyu.edu/ealtman/zscorepresentation.pdf>. Accessed on January 8, 2015.
- Altman, Edward I. 2000. *Predicting financial distress of companies: revisiting the Z-score and ZETA models*. New Yor: Stern School of Business, New York University.
- Anghel, Ion. 2002. *Falimentul. Radiografie și predicție*. București: Editura Economică.
- Armeanu, Ș.D., G. Vintilă, M. Moscalu, M.O. Filipescu, and P. Lazăr. 2012. "Using Quantitative Data Analysis Techniques for Bankruptcy Risk Estimation for Corporations". *Theoretical and Applied Economics* XIX, 86-102.
- Băileșteanu, Gheorghe. 1998. *Diagnostic, risc și eficiența în afaceri*. Timișoara. Editura Mirton.
- Beaver, William H. 1966. "Financial Ratios as Predictors of Failure". Selected Studies, *Supplement to Journal of Accounting Research*, 71-131.

- Conan, J., and M. Holder. 1979. *Variables explicatives de performances et contrôle de gestion dans les PMI*, Thèse d'Etat en Sciences de Gestion Université, Paris.
- Deakin, E. 1977. "Business Failure Prediction: An Empirical Analysis. Financial Crises Institutions and Markets in a Fragile Environment". Altman, E. and Sametz, A., John Wiley & Sons.
- Dincă, Marius S. 2005. "Caracteristicile utilizării metodei valorii actualizate ajustate". *Revista Tinerilor Economişti*, nr. 4, 67-70.
- Dinca, M.S. and M.R. Gîdinceanu. 2011. "The analysis of the management of Romanian Investment Funds using econometric methods". *Journal of Applied Economic Sciences*, 2011, Summer Edition
- Drumea, C., and E.C. Spatariu. 2011. "On the Competitiveness, between Inputs and Outputs. Romania's Case in the EU." *Ovidius University Annals, Economic Sciences Series* 11.2, 385-390.
- Edmister, R. 1972. "An empirical test of financial ratio analysis for small business failure prediction". *Journal of Financial and Quantitative Analysis*, 7 (2).
- Ilie, D. 2005. *Creditare durabilă*. Craiova: Sitech Publishing House.
- Keul, M. and C. Drumea. 2009. "Risk and profitability as capital structure determinants." *Annals of University of Oradea, Faculty of Economics Science* (1963): 237-241.
- Kiyak, D., and D. Labanauskaite. 2012. "Assessment of the practical application of corporate bankruptcy prediction models". *Journal of Economics and Management*, 17 (3).
- Măneacuță, C., and M. Nicolae. 1996. "The construction and the use of score function for diagnosing the effectiveness of economic operators". *Journal of Finance, Credit and Accounting*, 5, 47-54.
- Nenning, G. and Ph. Krause. 2009. "Increasing Sales Performance Levels by Means of Value-based Remuneration", Stern Stewart Research//Volume 31
- Ottosson, E., and F. Weissenrieder. 1996. "Cash Value Added—A new method for measuring financial performance". *Financial Economics Review*, no.1/1996
- Sueyoshi, T. 2006. "DEA-Discriminant Analysis: Methodological comparison among eight discriminant analysis approaches". *European Journal of Operational Research*, Elsevier.
- Yang, H.H. 2006. "Bankruptcy situation model in small business: the case of restaurant firms". *Hospitality Review*, 24, article 5.