AN EMPIRICAL RESEARCH ON EARLY BANKRUPTCY FORECASTING MODELS: DOES LOGIT ANALYSIS ENHANCE BUSINESS FAILURE PREDICTABILITY?

Michalis Glezakos[1]
University of Piraeus, Greece
Email: migl@unipi.gr

John Mylonakis[2]
Hellenic Open University, Greece
Email: imylonakis@vodafone.net.gr

Katerina Oikonomou[3]
National Bank of Greece
Email: ek.ikonomou@nbg.gr

ABSTRACT

The forecast of bankruptcy is of grate value to investors, creditors, lenders and anyone who relies upon the company viability. As a consequence, numerous studies have tried to develop models enhancing early bankruptcy forecasting. To this end, Logit is the most frequently employed methodology, because it has been proved very effective. Within the framework of the present study, it was attempted to construct Logit models, which enable early identification of Greek non-viable companies. The results can be characterized, on average, as satisfactory, given that healthy companies are correctly classified up to 95% of the companies in the sample. However, the classification error of the bankrupt ones is high, ranging from 30% to 60%, thus limiting the models' practical applicability.

Keywords: Logit Analysis, bankruptcy forecasting, corporate failure, financial ratios
JEL Classification Code: G17, G33, C13, C51, C53

---

[1] Michalis Glezakos is a Professor at University of Piraeus, Department of Statistics and Insurance Sciences, 80 Karaoli & Dimitriou str., 185 34 Piraeus, Greece.
[2] Dr. John Mylonakis, Hellenic Open University (Tutor), 10, Nikiforou str., Glyfada, 166 75, Athens, Greece.
[3] Katerina Oikonomou, National Bank of Greece, Risk Management Department.

I. INTRODUCTION

It is extremely difficult to define bankruptcy, because its meaning differs according to the point of view it is considered. For example, from the economic point of view, a company is classified as bankrupt when it is definitely unable to face its long term obligations. On the other hand, legislation in force characterizes a company as bankrupt after the termination of any relevant judicial formality. Given that the later is announced when anyone knows the fact, this kind of information is of no interest to debt and equity holders. This is the reason that all the empirical studies, which have tried to develop bankruptcy forecasting models, focus on the prediction of economic bankruptcy only (Altman, 1968, Shumway, 2001, Hillegeist et al, 2004).

II. PAST LITERATURE

Among the first efforts to utilize the available data towards the forecast of corporate failure were those of Beaver (1967) and Altman (1968). Beaver was the first to compare the characteristics of bankrupt companies to the corresponding data of healthy ones, by using univariate discriminating tests. He depicted that certain financial ratios convey crucial information regarding the prospects of the company. As a result, these ratios could enhance one's ability to separate viable from unviable companies.

Altman (1968), introduced an alterative methodology, known as Multiple Discriminant Analysis (MDA), which enabled the formation of a "Z-Alman score" for each company. The Z-Alman score was almost 90% accurate in predicting bankruptcy one year ahead.

Deakin (1972), applying MDA, classified correctly 95% of the companies in the sample, 3 years before bankruptcy. Some years later, Altman et al (1977) developed the "ZETA model", which is an improved version of MDA.

Edmister (1971), successfully introduced Regression Analysis (RA). The two methodologies (RA and MDA) were compared by Collins (1980), who concluded that both of them were very effective, with MDA slightly superior. One year later, Scott (1981), evaluating RA, MDA and Z-Alman models, concluded that the latter was the best.

A new technique was devised by Martin (1977), named "Logit analysis". He applied Logit and discriminant analysis to explain the bankruptcy of 23

banks in the period 1975-1976. Logit was used also by West (1985), Lawrence (1992) and many other studies.

The relevant empirical research, with few exceptions (Altman, 1973, Castagna and Matolscy, 1981) exhibited that most of the suggested models could lead to satisfactory forecasts, by correctly classifying 70% to 90% of the companies in the sample.

It should be noted, however, that the results of the several empirical works are hardly comparable, given that they vary systematically with the business cycle, the industry etc (Altman and Kao, 1992, Nickell et al, 2000, Cantor and Falkenstein, 2001).

Finally, it should be noted that financial ratios were considered as the best performing independent variables, although other types of explanatory variables (see Foster, 1986, Altman, 1982, Rose et al, 1982, Altman et al, 1977, Diakoyannis, 1989), contributed to satisfactory classifications of the bankrupt as well as the healthy companies of the utilized samples.

III. CONSTRUCTION OF BANKRUPTCY PREDICTION MODELS

The construction of a model in general, assumes the following procedure:

- Choice of the proper theoretical model
- Identification of the explanatory variables
- Estimation of the parameters and statistical hypothesis testing.

As far as the models under study are concerned, there exist several alternative choices, which include, among others, the following :

- Univariate Analysis,
- Linear and multiple discriminant analysis,
- Logit analysis.

The independent variables often include financial ratios and more rarely macroeconomic variables.

Univariate Analysis is the simplest and at the same time the weakest methodology (Zargren, 1983). However, there is evidence that it can produce effective estimates (Beaver, 1966, Schipper, 1977, Bathory, 1984).

Discriminant Analysis was introduced by Fisher (1935) and was successfully applied in a great number of empirical studies (Altman, 1968, Altman et al,

1977, Narayaman, 1977, Dekin, 1972, Libby, 1975, Dambolena and Kgoury, 1980, Casey and Bartczak, 1985, Grammatikos and Grubos, 1984).
This methodology is leading to determining a "Discriminant Function", based on which a score is estimated for each enterprise. According to this score, enterprises are categorized in two main groups, the healthy ones and those going bankrupt. Discriminant Analysis assumes the validity of certain assumptions, such as :
- The independent variables consist a multi-normal distribution.
- The within-group variance and covariance matrices of each group are equal.
- The a prior probability for accompany to be healthy is equal to the probability to go bankrupt.

To the extent that any of the above assumptions don't hold, the method produces inferior results.

Logit expresses the possibility of occurrence (P) of a particular event, i.e. bankruptcy. It assumes that this possibility is defined by the following equation :

$$P= E\left[Y = 1/ X_j\right] = \frac{1}{1+e^{-(\beta_0+\beta_i x_i)}} \qquad (1)$$

where: X_i = the independent variables of the model
α and β_i = the coefficients of (1)

Substituting $\beta_0+\beta_i x_i$ for Z, (1) is converted to equation (2), which is the cumulative logistic function :

$$P=\frac{1}{1+e^{-z_j}} \qquad (2)$$

Equation (2) can be converted into a linear function as follows:

$$\frac{P_j}{1-P_j} = \frac{1/(1+e^{-z_j})}{1-\left[1/(1+e^{-z_j})\right]} \quad \text{or}$$

$$\frac{P_j}{1-P_j} = e^{-z_j} \quad (3) \text{ or} \qquad L=\log\left(\frac{P_j}{1-P_j}\right)=Z_j = \beta_0 + \beta_j x_j \qquad (4)$$

Given that L's values range from 0 to +1, the estimation of the coefficients of relationship (4) takes place through the application of the method of the maximum likelihood.

It must be noted that, if the standardised normal distribution is used in the place of the logistic curve, the resulting function is the "Probit" model, which is much alike to Logit :

$$F(-\beta^{'}\chi_i)= \int_{-\infty}^{\frac{-\beta^{'}\chi}{\sigma}} \frac{1}{2\sqrt{\pi}} * \exp\{-\frac{t^2}{2}\}dt \qquad (5)$$

Although the two models produce similar results, the estimated coefficients β aren't comparable, except in the case that the β's of Probit will be multiplied by the term $\pi^2/3$, which is the variance of the logistic distribution.

IV. IDENTIFICATION OF THE EXPLANATORY VARIABLES

The choice of the proper independent variables seriously affects the predictive ability of the model. Financial ratios, particularly, are considered as the most suitable ones, because they include valuable information for the companies they concern, thus revealing their strengths and weaknesses. This is the main reason that they are widely used in the economic literature to appraise the viability of a company, its value, the effectiveness of its investment plans etc.
Depending upon the kind of information they convey, the ratios are classified in certain categories, like :

- Liquidity ratios,
- Profitability ratios,
- Capital structure ratios,
- Growth ratios etc.

According to the evidence which has been provided from the relevant empirical studies, liquidity ratios best serve the prediction of bankruptcy.

V. ESTIMATION OF THE COEFFICIENTS AND STATISTICAL HYPOTHESIS TESTING

The estimation of coefficients of explanatory variables takes place through the application of the model to the sample data. In order to verify the obtained results, one should test the findings in a confirmative sample.

The Sample
Our sample includes the accounting statements (balance sheet and profit and loss accounts) of 20 bankrupt companies, for the 3 years prior bankruptcy. It includes also the corresponding data for 40 healthy companies, which are quoted in the Athens Stock Exchange.

In order to avoid any bias resulting from the peculiarity which characterizes the financial ratios of the certain sectors, we excluded banks, insurance companies, leasing companies and Investment Companies. The most serious limitation (which is faced by all the relevant studies) is the arbitrary definition of the time point, beyond which company is considered bankrupt.
The whole sample was divided into the following 6 sub-samples:

Sub-sample 1: Includes the accounting statements of 10 bankrupt and 20 healthy companies, 3 years before bankruptcy.
Sub-sample 2: Includes the accounting statements of the remaining 10 bankrupt and 20 healthy companies, 3 years before bankruptcy.
Sub-sample 3: Includes the accounting statements of 10 bankrupt and 20 healthy companies, 2 years before bankruptcy.
Sub-sample 4: Includes the accounting statements of the remaining 10 bankrupt and 20 healthy companies, 2 years before bankruptcy.
Sub-sample 5: Includes the accounting statements of 10 bankrupt and 20 healthy companies, 1 year before bankruptcy.
Sub-sample 6: Includes the accounting statements of the remaining 10 bankrupt and 20 healthy companies, 1 year before bankruptcy.

Sub-samples 1, 3 and 5 are used to calculate the coefficients of the applied model, while sub-samples 2,4, and 6 consist the testing samples. It must be clarified, also, that the above 6 sub-samples were formed twice, that is one time using the first set of ratios and another time using the second set (see paragraph 6).

VI. RESEARCH METHODOLOGY

Towards the construction of our model, Logit was elected as the most effective theoretical model, in the sense that it produces reliable results (Frydman et al, 1985, Marais et al, 1984, Ohlson, 1980, Casey and Bartczak, 1985, Zavgren, 1985).
As far as the choice of the suitable financial ratios is concerned, it was decided to proceed as follows:
- To use a set of ratios which are usually used in similar studies (Beaver, 1966, Altman, 1966, Ohlson, 1980, Elam, 1975, Blu, 1974, Mensah, 1983, Deakin, 1972, Grammatikos, 1985, Glezakos and Karytinos, 1994).
- To repeat the estimations by using a second set of ratios, which focus on the liquidity, profitability and capital structure of the companies in the sample, which have been proved as effective variables in many other studies.
The resulted variables are the following:

Set 1
$R_{1.1}$= Quick Ratio
$R_{1.2}$= Return on Total Assets
$R_{1.3}$= Equity / Short Term Debt
$R_{1.4}$= Net Working Capital / Total Assets
$R_{1.5}$= Net Fixed assets / Total Assets
$R_{1.6}$= Net Profit / Sales
$R_{1.7}$= Long Term Debt / (Long Term Debt + Equity)
$R_{1.8}$= Current Ratio
$R_{1.9}$= Cash Flow / Total Funds
$R_{1.10}$= Return on Equity
$R_{1.11}$=Gross Profit Margin.

Set 2
$R_{2.1}$= Long Term Funds / Net Fixed Assets
$R_{2.2}$= Return on Total Assets
$R_{2.3}$= Cash Flow / Working Capital
$R_{2.4}$= Current Ratio
$R_{2.5}$= $R_{1.10}$= Return on Equity
$R_{2.6}$= $R_{1.11}$=Gross Profit Margin
$R_{2.7}$= Equity / Total Assets.

VII. ANALYSIS AND INTERPRETATION OF RESULTS

Before the application of the selected methodology, a comparison between bankrupt and healthy companies was made, to secure that their ratios exhibit remarkable differences. As Table 1 reveals, the ratios of the two groups don't differ significantly 3 yeas before bankruptcy, with the light exception of ratio $R_{1.6}$. One year later, ratios $R_{1.4}$ and $R_{2.7}$ exhibit statistically significant differences, suggesting that working capital and equity are affected more strongly than other financial parameters, when the viability of a company is questioned.

One year before bankruptcy, the differences are amplified. More particularly, the differences are significant as far as ratios $R_{1.4}$, $R_{1.6}$, $R_{1.9}$, $R_{1.10}$ and $R_{2.7}$ are concerned, while marginal differences are observed between ratios $R_{1.2}$ and $R_{2.2}$.
The results of Table 1 are suggestive that, one can't derive reliable conclusions regarding the possibility of bankruptcy of a company, by simply considering its ratios, two or more years ahead. As a result, more sophisticated methodologies should be applied, such as Logit or Probit models.

Table 1: Differences between Ratios 1 to 3 Years before Bankruptcy

	3 years before				2 years before				1 year before			
	B	H	H-B		B	H	H-B	B	B	H	H-B	B
	Mean %	Mean %	F-test	t-test	Mean %	Mean %	F-test	t-test	Mean %	Mean %	F-test	t-test
$R_{1.1}$	71.1	166.6	1.92	1.1	66.9	116.6	1.21	1.5	63.7	143.9	1.8	1.2
$R_{1.2}$	3.3	1.7	1.51	-0.1	2.1	8.5	2.39	1.7	0.3	143.9	1.9	1.8
$R_{1.3}$	60.9	137.4	1.09	-0.9	44.4	98.2	0.60	1.1	33.9	8.1	1.3	1.0
$R_{1.4}$	7.7	21.2	1.29	1.6	2.5	16.7	0.09	2.3	1.1	131.6	0.8	2.5
$R_{1.5}$	23.1	22.2	0.76	-0.1	24.2	25.1	0.61	0.1	24.8	18.7	0.2	0.0
$R_{1.6}$	-5.5	10.48	4.25	1.9	4.1	6.9	1.17	1.2	0.8	25.1	2.3	2.5
$R_{1.7}$	11.1	10.4	0.00	-0.1	14.4	11.3	0.65	-0.4	29.2	6.2	4.0	-1.4
$R_{1.8}$	109.4	204.1	2.27	1.1	103.6	154.5	2.54	1.5	103.3	184.6	2.2	1.2
$R_{1.9}$	7.5	-79.3	2.09	-0.6	7.1	20.4	2.67	1.7	4.2	20.5	4.1	2.2
$R_{1.10} = R_{2.5}$	19.5	21.3	0.37	0.1	12.3	28.1	1.54	1.0	-30.0	28.6	2.8	2.0
$R_{1.11} = R_{2.6}$	22.7	24.5	0.00	0.4	26.6	23.1	0.80	-0.7	23.9	22.2	0.1	-0.4
$R_{2.1}$	184.3	357.3	0.83	0.79	181.6	186.4	7.21	0.10	184.4	205.9	1.9	0.3
$R_{2.2}$	3.3	1.4	1.49	- 0.14	2.1	8.4	2.52	1.64	0.3	7.9	2.0	1.8
$R_{2.3}$	- 166.8	- 63.0	1.36	0.47	14.1	339.9	3.20	1.12	- 141.9	268.8	0.6	1.2
$R_{2.4}$	109.4	204.1	2.27	1.10	103.6	154.5	2.54	1.49	103.3	184.6	2.1	1.1
$R_{2.7}$	27.1	38.6	0.00	1.48	22.3	36.3	0.05	2.09	19.3	35.9	0.1	2.3

VIII. ESTIMATION OF THE MODEL PARAMETERS

The required Logit models were formed as follows:

- The coefficients of the first set of the selected ratios (Set 1) were calculated for three distinct periods:
  - 1 year before bankruptcy (utilizing sub-sample 5)
  - 2 years before bankruptcy (utilizing sub-sample 3)
  - 3 years before bankruptcy (utilizing sub-sample 1).
- The calculations were repeated many times, by subtracting each time the coefficient with the lower z-statistic.

The models which resulted from the above procedure (Table 2) enabled the calculation of a score for each company, ranging from zero to one. Assuming a cut-off point of 0.55, the companies of the sample were classified in two groups, the healthy and the bankruptcy candidates (Table 3).

Table 2: Initial Logit Models

P R O B I T A N A L Y S I S - Parameter Estimates (LOGIT model:			
(LOG(p/(1-p))) = Intercept + BX):			
1 year before bankruptcy			
	Regression Coeff.	**Standard Error**	**Coeff./S.E.**
$R_{1.4}$	5.81063	2.25943	2.57172
$R_{1.6}$	16.26984	7.62222	2.13453
2 years before bankruptcy			
$R_{1.4}$	10.75929	3.43646	3.13093
$R_{1.5}$	7.11267	2.70160	2.63276
$R_{1.10}$	3.98581	1.83523	2.17183
$R_{1.11}$	-7.63617	3.70021	-2.06371
3 years before bankruptcy			
$R_{1.6}$	26.06491	9.30537	2.80106

Table 2 shows that only 5 out of 11 ratios were finally included in the formed models. Moreover, profitability ratios exhibit a stronger explanatory power towards the prediction of corporate failure. The predictive ability of the models is satisfactory for healthy companies only. More particularly, 85% to 92.5% of this category of firms were correctly classified (= Type II error

7.5% to 15%), as opposed to 55% to 60% (= Type I error 40% to 45%) of the failed companies.

Table 3: Classification on the basis of the Calculated Scores

	Companies to be bankrupt	***Healthy***	***Total***
1 year before bankruptcy			
% of correct classification	*60%*	*92.5%*	*82%*
% of wrong classification	*40%*	*7.5%*	*18%*
		2 years before bankruptcy	
% of correct classification	*55%*	*92.5%*	*80%*
% of wrong classification	*45%*	*7.5%*	*20%*
		3 years before bankruptcy	
% of correct classification	*55%*	*85%*	*75%*
% of wrong classification	*45%*	*15%*	*25%*

It must be stressed that Type I error (= a candidate for bankruptcy is considered as healthy) is more dangerous, given that the prospective loss may be extended up to the whole invested (or lend) capital. On the other hand, the loss from an error of Type II, could not be higher than the corresponding opportunity cost of the non-invested capital.

In an attempt to enhance the predicting ability of the above models, they were reconstructed by using the same explanatory variables but applying them to different samples, that is to sub-samples 2.4 and 6.
The results, which are summarized in Tables 4 and 5, are similar to the previously presented ones.

Table 4: Reconstructed Logit Models

P R O B I T A N A L Y S I S - Parameter Estimates (LOGIT model:			
(LOG(p/(1-p))) = Intercept + BX):			
1 year before bankruptcy			
	Regression Coeff.	***Standard Error***	***Coeff./S.E.***
$R_{1.4}$	8.96981	4.44073	2.01990
$R_{1.6}$	13.61074	10.32954	1.31765
2 years before bankruptcy			
$R_{1.4}$	8.67464	3.70853	2.33910
$R_{1.5}$	9.33711	4.93027	1.89384
$R_{1.10}$	3.88885	1.84921	2.10298
$R_{1.11}$	-3.35151	4.54633	-0.73719
3 years before bankruptcy			
$R_{1.6}$	77.48896	39.49089	1.96220

Table 5: Classification on the basis of the Calculated Scores (-1 year)

	Companies to be bankrupt	***Healthy***	***Total***
1 year before bankruptcy			
% of correct classification	*60%*	*90%*	*80%*
% of wrong classification	*40%*	*10%*	*20%*
			2 years before bankruptcy
% of correct classification	*60%*	*85%*	*77%*
% of wrong classification	*40%*	*15%*	*23%*
			3 years before bankruptcy
% of correct classification	*40%*	*90%*	*73%*
% of wrong classification	*60%*	*10%*	*27%*

Another attempt to improve the predicting ability of the Logit models includes the utilization of the stated above Set 2 variables, which have exhibited the relatively highest performance in a great number of relevant

studies. Tables 6 and 7 summarize the constructed models for 1 , 2 and 3 years before bankruptcy. using sub-samples 1, 3 and 5.

The resulted models are clearly more efficient than all the previous, in all three years. Especially in the case of the healthy companies, misclassification error was quite small, ranging from 4.5 % to10%. The models were also more efficient in the case of the bankrupt companies, but the Type I error is still high, even one year before bankruptcy.

Despite the reconstruction of the above models by utilizing sub-samples 2, 4 and 6, no further improvement was achieved. Finally the whole work was repeated to develop Probit models, which were one by one inferior to their Logit counterparts.

Table 6: Reconstructed Logit Models

P R O B I T A N A L Y S I S - Parameter Estimates (LOGIT model:			
(LOG(p/(1-p))) = Intercept + BX):			
1 year before bankruptcy			
	Regression Coeff.	***Standard Error***	***Coeff./S.E.***
$R_{2.6}$	-3.302	2.488	-1.327
$R_{2.7}$	5.549	2.004	2.769
2 years before bankruptcy			
$R_{2.5}$	3.990	1.777	2.245
$R_{2.6}$	7.870	3.804	-2.069
$R_{2.7}$	10.034	3.005	3.339
3 years before bankruptcy			
$R_{2.2}$	29.456	9.777	3.013
$R_{2.6}$	-3.371	2.786	-1.210

Table 7: Classification on the basis of the Calculated Scores (-1 year)

	Companies to be bankrupt	***Healthy***	***Total***
1 year before bankruptcy			
% of correct classification	*70.0%*	*95.5%*	*85%*
% of wrong classification	*30.0%*	*4.5%*	*15%*
2 years before bankruptcy			
% of correct classification	*65.0%*	*92.5%*	*82%*
% of wrong classification	*35.0%*	*7.5%*	*18%*
3 years before bankruptcy			
% of correct classification	*60.0%*	*90.0%*	*78%*
% of wrong classification	*40.0%*	*10.0%*	*22%*

IX.CONCLUSIONS

The early identification of the companies which are going to be bankrupt is of great value primarily to investors and commercial banks. This is the reason that numerous studies tried to develop models which might enhance the ability to correctly classify a company as bankrupt, some years before failure.

Among the numerous methodologies, Logit is classified in the most powerful ones. It favours the rank of a company according to its vitality, given that it produces scores ranging strictly from 0 to 1. Besides, it takes financial ratios as explanatory variables, thus permitting the appraisal of any company, not only the quoted ones.

Given the above advantages of Logit, it was applied to a sample of companies which are quoted in the Athens Stock Exchange, in order to construct particular models, which might enhance our ability towards the early identification of non-viable Greek firms. However. the results are not promising. Although the developed models efficiently classify the healthy companies (up to 95.5% success), they fail to do the same with the bankrupt ones (misclassification up to 60%).

Given that Logit was successfully used in several countries, including Greece, the above findings may be due to shortcomings of the particular sample, ranging from peculiarities of the included companies to transitory effects on their data from the macroeconomic environment.

It is strongly suggested further research on this area, by analysing on a comparative basis, large samples from several developed and developing countries.

REFERENCES

Altman, E. (1968) Financial Ratios. Discriminant Analysis and Corporate Bankruptcy, *Journal of Finance*, Sept., pp. 588-609.

Altman, E.I. and Kao, D.L. (1992) Rating Drift of High Yield Bonds, *Journal of Fixed Income,* March, pp.15-20.

Altman, E.I., Halderman, R. and Narayanan (1977) Zeta Analysis: A New Model to Identify Bankruptcy Risk of Corporations, *Journal of Banking and Finance*, June, pp. 29-54.

Beaver, W. (1966) Financial Ratios as Predictors of Failure, Empirical Research in Accounting, Supplement to *Journal of Accounting Research,* pp.71-111.

Cantor, R. & Falkenstein, E. (2001), Testing for Rating Consistency in Annual Default Rates, *Journal of Fixed Income*, September, pp. 36-51.

Casey, C. & Bartozak, N. (1985) Using Cash-Flow Data to Predict Financial Distress: Some Extensions, *Journal of Accounting Research* 23(1), pp. 384-401.

Deakin, E. (1972) A Discriminant Analysis of Predictors of Business Failure, *Journal of Accounting Research*, Spring, pp.167-179.

Diacogiannis, G. and Larmour, R. (1989) The Usefulness of Share Prices and Inflation for Corporate Failure Prediction, Manuscript University of Warwick.

Edmister, R.O. (1972) An Empirical Test of Financial Ratio Analysis for Small Business Failure Prediction, *Journal of Financial and Quantitative Analysis*, March, pp.1477-1493.

Foster, G. (1986) Financial Statement Analysis. Prentice Hall.

Frydman, H., Altman, H. & Kao. D. (1985) Introducing Recursive Partitioning for Financial Classification: The Case of Financial Distress, *Journal of Finance*, March, pp.269-291.

Glezakos, M. & Karytinos, G. (1994) Forecasting Bankruptcy: The Case of the Greek Manufacturing Companies, *Spoudai*, Vol. 44.

Grammatikos, H. & Gloubos, G. (1984), Predicting Bankruptcy of Industrial Firms in Greece, *Spoudai*. Vol. 3-4.

Hillegeist, Stephen A., Elizabeth, K., Keating, Donald P., Cram and Kyle G. Lundsted (2004) Assessing the Probability of Bankruptcy, *Review of Accounting Studies*, 9 (1), pp. 5-34.

Marais, M., Patell, J. & Wolfson, M. (1984) The Experimental Design of Classification Models: An Application of Recursive Partitioning and bootstrapping to Commercial Bank Loan Classification, *Journal of Accounting Research,* Supplement.

Nickell. P. W. Perraudin and S. Varotto (2000). "Stability of Rating Transitions." Journal of Banking & Finance. 24. pp. 203-227.

Ohlson. J.A. (1980). "Financial Ratios and Probabilistic Prediction of Bankruptcy". Journal of Accounting Research. Vol. 18 No. 1. Spring 1980. pp.109-131.

Shumway. Tyler (2001). "Forecasting Bankruptcy more Accurately: A Simple Hazard Model". Journal of Business. Vol. 74. pp.101-124.

Zavgren. C. (1985). "Assessing the Vulnerability to the Failure of American Industrial Firms – A Logistic Analysis". Journal of Business Finance and Accounting. 12(1). pp. 19-45.