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SCHOOL OF BUSINESS ADMINISTRATION
DEPARTMENT OF ACCOUNTING AND FINANCE
MASTER IN ACCOUNTING AND FINANCE

DISSERTATION

Bankruptcy Prediction Models: An Empirical Analysis of Altman's Z-Score model in Forty Greek Companies in the Period of Economic Recession

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Submitted as a prerequisite for obtaining the Master Diploma in Accounting and Finance

October 2015

I would like to thank Dr. Athanasios Noulas and
Dr. Fotios Siokis for the inspiration and knowledge they provided me. Additionally, I want to thank my family, as well as, Christina, Giannis and Maria for their endless support!

Abstract

This paper examines the efficiency of Altman's model (1968) about predicting corporate bankruptcy in Greece. After a short presentation of other bankruptcy models, Altman's model is analyzed. The sample used in the present paper is consisted of forty Greek companies, all listed on the Hellenic Stock Exchange. The years of the data used are from 2005 to 2013. The methodology used is similar to the one Altman used in 1968. The basic ratio components are presented and compared between bankrupt and non-bankrupt companies. Additionally, the results of the test are presented and compared to those of Altman's regarding predicting accuracy. Moreover, the efficiency of the model is tested in sample collected in a period when the macroeconomic environment is heavily disturbed due to the Greek economic recession.

Contents

Chapter 1
Introduction

Corporate bankruptcy has been a major research question for a long period. Several theories, models and techniques are trying to predict whether a company is about to face bankruptcy. The first attempts to predict corporate bankruptcy date back to 1930. At the time the kind of method used was actually based on calculating the financial ratios of bankrupt companies and compare them to those of non-bankrupt firms. This kind of analysis is characterized as univariate [(Fitzpatrick, 1932), (Merwin, 1942), (Horrigan, 1965)]. The first actual model for predicting corporate bankruptcy is the one of Beaver's in 1966. The models that came up afterwards can be categorized as parametric and non-parametric. In the first category, many models can be found such as Beaver's (1966). In contrast to Beaver's univariate model, later on, multivariate models were created. A multivariate model can be characterized as Discriminant Analysis or Multi Discriminant analysis (MDA) [(Altman, 1968), (Altman, 2000), (Altman, Haldeman and Narayanan, 1977),]. The evolution of MDA models came with probability models like Probit and Logit or Ohlson's model (1980). The most recent techniques for predicting corporate failure are based in methods such as hazard models, linear programming, neuronal networks and other non-parametric techniques.

The purpose of this paper is to test if the model created by Edward Altman in 1968 can be used to make accurate predictions of corporate failure in another time period and in another operating environment. Additionally, the model will be tested under disturbed macroeconomic circumstances like the ones in Greece for the years 2005-2013.

In order to test the hypotheses a sample of twenty bankrupt and another twenty non-bankrupt companies will be used, all listed on the Hellenic Stock Exchange (ATHEXGROUP). The period of the study includes the years from 2005 to 2013.

The first section of the present paper presents a literature review of other similar studies. Afterwards Altman's model is presented and analyzed. The third part of the

paper introduces the sample used and presents the methodology used for the purposes of the present research. Continuing, the data of both bankrupt and non-bankrupt firms are presented and compared. Finally, the last part of the paper presents the results of the test and discusses the findings, comparing the accuracy of the model using present data to that of Altman's in 1968.

Chapter 2
The Development of Altman's Model

In this chapter the first Altman's model is presented, as well, as its evolution and revisions made by Altman himself.

The Original Altman's Model

Edward Altman (1968) published his study about corporate failure. At the time ratio analysis as an instrument of predicting corporate bankruptcy was heavily criticized by theorists. Altman in order to test this hypothesis -of financial ratios importance regarding bankruptcy prediction- used a multi discriminant analysis model. Altman's point of view regarding the best method of predicting bankruptcy was clearly in favor of a multivariate model. He mentions that the traditional ratio analysis used at the point, was mainly univariate, which in most cases worked as an indicator of bankruptcy and not as a predictor. The reason for using multi discriminant analysis was the nature of the model, which used a binary variable as depended, trying to explain this way the behavior of two different groups. By the time multi discriminant analysis was used by behavioral and biological sciences. (Altman, 1968).

After the decision made regarding the type of the model, Altman chose his sample. This sample consisted of 66 companies, 33 of them being bankrupt. All 66 companies were manufacturers. The Group 1 consisted of 33 companies which had filed a bankruptcy petition. The years of study were from 1946 to 1965. The mean asset size of those companies ranged from $0.7 million to $25.9 million, with an average of $6.4 million. In order to achieve homogeneity in his final sample of both bankrupt and non-bankrupt companies, Altman had to carefully choose and match the non-bankrupt companies, given that the selection of bankrupt companies was totally random. The limitation Altman used in order to form his Group 2 was that neither small firms (assets < $1million) nor large firms will be included. In order to match a bankrupt and a non-bankrupt company Altman used two criteria. The first was that

the total assets of both companies should be approximately equal and the second was that both firms should operate in the same industry.

After forming the final sample, Altman collected data from balance sheets and income statement of all companies. Using previous studies he found 22 ratios with potential statistical significance regarding bankruptcy prediction. After running a series of test in all variables, Altman ended up with 5 variables of either independent statistical significance or of high importance regarding the inter-correlation with the other variables of the sample. The final model had the following form:

$$Z = 0.012 (X1) + 0.014 (X2) + 0.033 (X3) + 0.006 (X4) + 0.999 (X5)$$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets.

The relative contribution of each variable to the final sample according to Altman is the following. X3 is the most important followed by X5, X4, X2 and X1.

At first Altman set a scale to classify whether a company should be considered bankrupt using the final z-score. If the z-score of a company lied beneath 1.81 then the firm was clearly a bankrupt entity. If the z-score was above 2.99 then the company was clearly non-bankrupt. The area of z-scores between 1.81 and 2.99 was defined as “grey area” and no classification could be made. Afterwards, running some tests, Altman considered 2.675 as the critical value of z-score regarding the non-bankrupt classification.

Altman introduced two types of errors in the final results. The Type 1 error occurs when a bankrupt company has a z-score that classifies it as non-bankrupt. The Type 2 error is the exact opposite, namely when a non-bankrupt company’s z-score is beneath 1.81.

The results of Altman's test indicated that bankruptcy could be predicted with an accuracy of 95% one year before it happened, 72% two years before, 48% three years before, 29% four years before and 36% five years before it happens.

Later Altman transformed his original model to a more convenient form regarding the calculations of the ratios. This form is the most commonly used regarding tests of this mode.

Z-score = 1.2 (X1) + 1.4 (X2) + 3.3 (X3) + 0.6 (X4) + 1.0 (X5)

The only difference here is that the X1 to X5 ratios are multiplied by one hundred in order to use the ratio instead of their absolute value.

Revisited Altman's Models

Altman revisited his model several times, trying to come out with variations that can fit to different types of companies.

Later on, Edward Altman (2000) introduced a model that could fit private firms whose stocks are not listed on a stock exchange market. In order to accomplish that, Altman replaced the X4 variable of his original model –market value of equity / book value of total debt– with the one that uses the book value of equity instead of the market value. Thus the new X4 variable is able to be calculated for non-listed firms as well. The form of the model is:

Z' = 0.717 (X1) + 0.847 (X2) + 3.107 (X3) + 0.420 (X4) + 0.998 (X5)

Where:

X1 = Working capital/Total assets

X2= Retained earnings/Total assets

X3=EBIT/Total assets

X4= Book value of equity/Total Liabilities

X5= Sales/Total assets

The discrimination zones for this model are different than the ones in the first Altman's model (1968). If the Z'-score of a company is less than 1.23 then the

company is considered to be bankrupt. If the Z'-score is above 2.9 then the company is considered to be non-bankrupt. Z'-scores between 1.23 and 2.9 belong to the "gray area".

In the same paper Altman (2000) refers to another Z-score model that could fit to non-manufacturing companies and companies which operate in emerging markets. This new model uses all the variables of the model for private firms except the X5 variable which measures the total sales / total assets. The form of the model is:

$$Z'' = 6.56 (X1) + 3.26 (X2) + 6.72 (X3) + 1.05 (X4)$$

Where:

X1 = Working capital/Total assets

X2= Retained earnings/Total assets

X3=EBIT/Total assets

X4= Book value of equity/Total Liabilities

The discrimination zones for this model are different. If the Z''-score of a company is above 2.6 then the company is considered to be safe. Z''-scores bellow 1.1 belong to the hazardous zone and finally Z''-scores between 1.1 and 2.6 belong to the "gray area".

Chapter 3
Literature review

In this chapter ten papers regarding Altman's model are reviewed in order to get a better understanding about the model. The cases reviewed are from different countries (and continents), the data in these papers are from different time periods and the type of companies, as well, as the industries they operate differ.

China real estate

Wang Yi (2012) wrote a paper in which he tested the Altman model in the Chinese real estate sector. His research motives were to determine the future of the industry after the global financial crisis and to see the impact of some regulations the Chinese government posed on the real estate industry. In order to predict future failure of the Chinese real estate companies, Wang Yi used the revised Altman's model (Altman, 2000) for listed, non-manufacturing companies, which is as follows:

$$Z=6.65X1+3.26X2+6.72X3+1.05X4$$

Where:

X1 = Working capital/Total assets

X2= Retained earnings/Total assets

X3=EBIT/Total assets

X4= Book value of equity/Total Liabilities

Z-scores beneath 1.23 indicate a bankrupt company or a company with high bankruptcy probability. Z-scores between 1.23 and 2.9 are defined as "grey area" and so it is hard to make predictions. Finally, Z-score above 2.9 indicate a healthy and stable financial entity.

The sample selected by Wang Yi, consisted of 40 real estate companies, listed on the Shanghai and Shenzhen A-share market. 10 of those companies were in crisis and 30 were normal. The testing years are 2008 and 2009.

The paper noted that the closest the year to the bankruptcy event, the highest the predictability of the model. The findings of Wang's research are that the model is 80% (lower than in Altman's research (Altman, 1968)) accurate in predicting financial distortion regarding the Chinese real estate industry. According to the author this is because Altman's sample consisted of USA companies, so the macroeconomic environment as well as, the structure of the whole economy is different. Additionally, Altman's sample consisted of listed, non-manufacturing companies of several industries so the predictability percentage emerged out of all the used industries.

Manufacturing Firms in Lebanon

El Khoury and Al Beaino (2013) tested the hypothesis that Altman's model could be used in order to classify firms according to the classification given to them by financial institutions. To do so they did not use the classic Altman's model, but the revised one for non-manufacturing firms, operating in emerging economies from 1983. The model is as follows:

$$Z= 0.717 X1 + 0.847 X2 + 3.10 X3 + 0.420 X4 + 0.998 X5$$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Book value of equity/Book value of total debt,

X5= Sales/Total assets

Z-scores beneath 1.23 indicate a bankrupt company or a company with high bankruptcy probability. Z-scores between 1.23 and 2.9 are defined as "grey area" and so it is hard to make predictions. Finally, Z-score above 2.9 indicate a healthy and stable financial entity.

The sample used by El Khoury and Al Beaino (2013) consisted of companies that had been audited in order to be granted a loan. There were 4 small and medium

companies and 7 large. The classification was done by the amount of the loan. The years of the research are form 2009 to 2011.

The findings of the paper indicate that the Altman's model (1983) has a high percentage of predictability. Additionally, the companies' classification using z-score as an indicator, is really similar to the one made by the banks of Lebanon. The authors mention that there are some limitations regarding their research, mainly because of the differences in the structure of the two economies, the one of the USA where Altman's model was formed and the Lebanese. Additionally, there is a significant difference between the Generally Accepted Accounting Principles used by the USA firms in Altman's model and the International Financial Reporting Standards used by the Lebanese firms.

Textile Companies of Pakistan

Fawad H., Iqtidar A., Shakir U. and Madad A. (2014) tested whether Altman's model is able to correctly predict company failures in the economy of Pakistan. Their research motive based on the assumption that Pakistan's textile industry is one of the largest in the country but still encounters many difficulties.

In order to determine the accuracy of Altman's model they used its original form, designed by Altman in 1968:

$$Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5$$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets

If a company's Z-score is above 2.99, the company is considered to be safe. A Z-score beneath 1.81 indicates a problematic firm, which will face insolvency problems.

Finally, Z-scores between 1.81 and 2.99 are in a "grey zone", so no predictions can be made.

Fawad, Iqtidar, Shakir and Madad (2014) used data from 21 textile firms all listed in the Karachi stoke exchange market, from years 2000 till 2010. Among those 21 firms 9 were bankrupt.

The results of the paper show that the closest to the default year, the most accurate the prediction is. For bankrupt companies the year before the bankruptcy the correct prediction percentage was 78% and for the years 2, 3 and 4 before bankruptcy 67%, 67% and 56% accordingly. For non bankrupt companies the percentage of accurate predictions were 81%, 67%, 58% and 42% for the 4 years before year zero. The average predictability percentage of Altman's model in the textile industry of Pakistan is 65%, significantly less than in Altman's paper. As mentioned before this deviation is due to the differences in the structure of the operating environment of firms between Altman's US sample and the authors' sample of Pakistan's textile firms.

The Construction Industry of Poland

Oleg Kaplinski (2007) tested the Altman's model in the construction industry of Poland. The author assumes that a firm must take under advice not only the factors that lead to its development but the elements that can lead to downfall as well.

In order to examine if Altman's model performs efficiently in the Polish economy, Kaplinski used several studies regarding the Polish construction industry. The studies used pretty much every model, including the original[1].

The samples used in all the studies consisted of construction firms that were on the Warsaw Stock Exchange Market.

[1] $Z = 1{,}2\ X_1 + 1{,}4\ X_2 + 3{,}3\ X_3 + 0{,}6\ X_4 + 0{,}999\ X_5$
$Z = 0{,}717X_1 + 0{,}847X_2 + 3{,}107X_3 + 0{,}420X_4 + 0{,}998X_5$
$Z = 6{,}56\ X_1 + 3{,}26 \cdot X_2 + 6{,}72 \cdot X_3 + 1{,}05 \cdot X_4$

The findings indicate that Altman's model become more accurate at the shortest period before the bankruptcy. Kaplinski (2007) also mentions that a synthetic z-score model is more effective and It should be adjusted to each economy and if possible to each industry. Additionally, the macroeconomic environment is mentioned to be important, where it is possible for other operational conditions to change in a time period, in which some companies tend to adopt easier than others.

The case of US Airlines

Stepanyan A. (2014) used the Altman's model in order to examine if the American Airline firms are going to face bankruptcy. The main incentive for this research was the vulnerability of the airline industry to changes in its general operational environment. After 9/11 and during the global financial crisis many airline firms applied for bankruptcy protection. (Stepanyan, 2014). The model used by the author is the classic Altman's model (Altman, 1968):

$$Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5$$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets

The sample used by Stepanyan (2014) consisted of the seven largest US airline companies and the research period was from 2007 to 2012.

The results of the test indicated that all the firms used are potential bankruptcy candidates. All the z-scores were beneath 2.9 and most of them did not even reach the 1.8 threshold. The predictability of the model did not reach Altman's percentages. This is mainly because the airline industry is extremely sensitive to changes in the structure of the economy, especially regarding competition regulation and volatility in fuel prices.

USA case and Comparison to Ohlson's Model

Begley J., Ming J. and Watts S. (1996) wrote a paper researching whether bankruptcy prediction models are accurate. Their research motive run of the changes in bankruptcy laws, so several firms chose to go default for strategic reasons and the change in leverage that took place in the 80's, when most companies increased their debt. Begley, Ming and Watts (1996) used the original form of Altman's model (1968):

$$Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5$$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets

In order to form their sample, the authors picked firms listed either on the New York Stock Exchange, on the American Stock Exchange or on NASDAQ. The time period was from 1980 till 1989.

The findings of the paper shown that the prediction ratio of both Altman's and Ohlson's model is decreased. Additionally, Ohlson's model seems to be better than Altman's because it has a lower combined error rate. Finally, after re-estimating both models, Altman's continues to be worse than Ohlson's. The reasons behind this lower performance are mainly the changes in the structure of the economy of USA during the 70's and the 80's.

Case of Retail Firms in Contemporary Times

Hayes S., Hodge K. and Hughes L. (2010) wrote a paper examining the efficiency of Altman's Z-score, regarding public sector retail firms. The research motive emerged out of the high and still increasing number of bankruptcies filed by public sector

retail firms. In order to determine whether these bankruptcies could be predicted the run a test using the Altman's re-estimated model for non-manufacturing firms (Altman, 2000):

$Z'' = 6.56\,X1 + 3.26\,X2 + 6.72\,X3 + 1.05\,X4$

Where:

X1= (current assets – current liabilities) / total assets

X2= retained earnings / total assets

X3= earnings before interest and taxes / total assets

X4= book value of equity / total liabilities

The sample contained 8 couples of bankrupt (2007 and 2008) public sector retail firms and 8 financial healthy.

The results of the test indicate that 94% of bankruptcies filling could be predicted and in 90% of the cases Z-score could predict financial distress. The authors suggest the further examination of the formula used, in order for it to be able to fit various sets of data regarding the structure of the economy applied and the size of the firms.

The case of the FMGC sector in India

Bal G. (2015) wrote a paper in which he tested whether FMGC companies in India are about to face financial distress in the future. The model that Bal used is the one for listed non-manufacturing firms, created by Altman (2000):

Z=6.65X1+3.26X2+6.72X3+1.05X4

Where:

X1 = Operating assets/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Owner's equity/Total liabilities

The sample was formed by 5 Indian FMGC firms and the years of the study are from 2011 till 2015.

The findings of the paper indicate that all the firms in the sample are not going to face any financial distress in the future.

The case of Thailand

Meeampol S., Lerskullawat P., Wongsorntham A., Srinammuang P., Rodpetch V. and Noonoi R. (2014) published a paper regarding potential financial distress of listed companies of Thailand and the percentage that Altman's model fits to the data of these companies. The researchers used two models designed by Altman, the original (Altman, 1968) (1) and the revised for emerging markets (Altman, 2000) (2):

(1) $Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets

If a company's Z-score is above 2.99, the company is considered to be safe. A Z-score beneath 1.81 indicates a problematic firm, which will face insolvency problems. Finally, Z-scores between 1.81 and 2.99 are in a "grey zone", so no predictions can be made.

and

(2) $Z= 3.25+ 6.56x + 3.26x + 6.72x +1.05x$

Where:

X1 = Current Assets - Current Liabilities / Total Assets

X2 = Retained Earnings / Total Assets

X3 = Earnings Before Interest and Taxes / Total Assets

X4 = Book Value of Equity / Total Liabilities

In this model if z-score is beneath 1.1 the company is about to face financial distress in the future, if the z-score is above 2.6 the company is considered to be safe and if the z-score lies between 1.1 and 2.6 the company belongs to a gray area.

The sample used by the authors consisted of 31 firms, all listed in on the Stock Exchange of Thailand (SET).

The results of both tests (model 1 and 2) showed that both models can predict more accurately when a larger number of years are used for data. Furthermore, the original model (Altman, 1968) is far more accurate, predicting 85% of the future's financial distress. The reviewed model (Altman, 1993) predicted correctly only 66% of the cases.

Testing Altman's Model Efficiency in Different Time Periods

Grice J. and Ingram R. (2001) conducted a research trying to answer in three questions regarding Altman's model. The first is whether this model is able to predict financial distress for companies of another time period. The second question examined by the researchers is the ability of Altman's model to predict bankruptcy of non-manufacturing firms in the same percentage as with manufacturing. The final question examines if the model is able to predict financial distress conditions, other than bankruptcy. The model used is the one designed by Altman in 1968:

$$Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5$$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets

If a company's Z-score is above 2.99, the company is considered to be safe. A Z-score beneath 1.81 indicates a problematic firm, which will face insolvency problems. Finally, Z-scores between 1.81 and 2.99 are in a "grey zone", so no predictions can be made.

In order to be able to compare the performance of the model, Grice and Ingram (2001) re-estimated the coefficients of the original model (Altman, 1968) using their sample of firms and the technique Altman used in his research in 1968.

The samples used by the authors were two. The first included 972 firms, 148 of which were distressed and the years of the data were from 1985 till 1987. The second sample included 1002 firms, 148 of which were distressed, for the years 1988-1991. The first dataset was used in order to re-estimate the coefficients in Altman's model.

The authors summarizing the results of the tests contacted, state that when applying Altman's model to a set of data from another time period the accuracy declining, specifically from 83.5% overall accuracy in Altman's paper in 1968, to 57.8% in their research. Additionally, the coefficients seriously changed after re-estimating them in their sample. Furthermore, after examining the manufacturing firms apart from the non-manufacturing, the accuracy of the model increased significantly, form 57.8% in the whole sample of manufacturing and non-manufacturing firms, to 69.1% to a sample of only manufacturing firms. Thus the model is considered to be sensitive to industry classifications. Grice and Ingram (2001) suggest that any further researcher using Altman's model should re-estimate the coefficients, because their findings were significantly better after the re-estimation. Additionally, they recommend a careful selection of the sample because a non-proportional selection of bankrupt and non-bankrupt companies can lead to underestimation of Type 1 error and overestimation of Type 2 error.

Chapter 4
Test and Results

In this chapter the sample, data, methodology and results are presented. Additionally, there is a comparison of the ratios between Group 1 and Group 2. Moreover the accuracy of the model using the present dataset is compare to the one of Altman's.

Sample and Data

According to Altman (1968) the sample should be consisted of companies listed on a stock exchange market. Additionally, for each bankrupt firm there should be a non-bankrupt of the same size (regarding assets) and operating in the same industry. As in Altman's paper, the group of bankrupt companies was collected totally randomly and then there was the matching with the non-bankrupt ones.

Forming the sample for this paper was not an easy job. The final sample consists of 20 bankrupt and another 20 non-bankrupt companies. All of them were listed at the Hellenic stock exchange market (ATHEXGROUP). For each company data was collected for 5 years before bankruptcy took place and in the case of non-bankrupt companies the year that bankruptcy took place for the matching bankrupt company of the pair. The years of the data are from 2006 to 2012. The source of the data is the website of the Hellenic stock exchange market. Most of the data came from the annual financial report being published for each listed company.

In the end, two groups formed the final sample. The first one is Group 1 and consists of bankrupt companies or companies whose operation is detained, all listed in ATHEX. Detained companies are not technically bankrupt, but still they are considered to be financially distressed and they do not being bought and sold in the stock exchange market (they are off the board). In the most cases, if not in all, a company whose operation is detained is considered to be almost bankrupt. The second, Group 2 consists of strictly non-bankrupt companies. The definition of a non-bankrupt firm is mainly this of a firm which is fully operational, never listed for

bankruptcy and its stocks continue to be bought and sold in the stock exchange market.

As mentioned previously, Altman had set two main "rules" regarding the matching of bankrupt and non-bankrupt companies. Following Altman's methodology this paper uses these two main rules in order to compose the final sample:

1) The size of the company: the average assets of companies forming a pair should be equal.
2) The industry: the two firms of a pair must operate in the same industry.

Methodology

The methodology used in this paper is the same as in Altman's (1968). First the sample was determined. As mentioned previously, the sample consists of two large groups. The first one or Group 1, consists of twenty randomly selected, bankrupt or financially distressed companies. The second group or Group 2 consists of twenty non-bankrupt firms. All 40 companies of the sample were listed in the ATHEXGROUP for the years of the study. The matching between bankrupt and non-bankrupt firms was made using two criteria. The first one is that the two companies that form a pair should be of same size regarding assets. The second one is that both companies in a sample should be operating in the same industry. After matching the companies in Group 1 and Group 2 the model was determined. The model used is the same discriminant analysis model as the one used by Altman, in his paper in 1968.

$$Z = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5$$

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets.

The model attempts to calculate a company's z-score using the X ratios as independent variables. Then each company is classified as bankrupt or non-bankrupt according to its final z-score. The model is supposed to be able to predict bankruptcy, with significant accuracy, up to five years before bankruptcy takes place. If a company's z-score is beneath 1.81 this company is considered to be bankrupt. If the final z-score of a company is above 2.67 then this company is considered to be non-bankrupt. Z-scores between 1.81 and 2.67 are considered to be in the so called "gray area". Companies whose z-score belongs to the gray area, which means that these companies cannot be classified neither as bankrupt nor as non-bankrupt.

The first variable, X1, of the model is the "working capital/ total assets" ratio. This ratio examines the short term liquidity of the firm regarding its assets. The working capital component of the ratios is actually the difference between current assets and current liabilities. According to theory a firm with consecutive losses will have relatively lower current assets regarding its total assets. This financial ratio is supposed to be one of the most reliable ratios regarding a firm's liquidity and it is even better than current ratio or quick ratio (Altman, 1968).

The second variable of the model, X2, is the "retained earnings/ total assets" ratio. This ratio provides information about the cumulative profitability of company. This ratio is supposed to contain information about the age of a company, because a relatively "young" company will provide a low "retained earnings/ total assets" ratio because it is difficult for it to have formed retained earnings. Additionally, this ratio is a way to insert a counter of leverage in the model. If a company's retained earnings/ total assets ratio is relatively high, this can be interpreted as the company uses a high amount of retained earnings to finance its activities and not debt. The final pool of information coming out of this ratio is the growth potential of the company. The retained earnings term refers to the amount of non distributed dividends. This amount of money is being retained from the shareholders in order to mainly finance new investments on behalf of the company.

Moving on with the third variable, X3, we have the "earnings before interests and taxes/ total assets" ratio. The purpose of this ratio is to calculate the actual

productivity of a company's assets, regardless of any tax or the level of leverage the company is using. Additionally, this ratio can provide information about the management of a company and whether the people running the company can combine and use efficiently the assets of the company in order to produce the maximum outcome. Essentially, the management of each company is trying to maximize the company's EBIT with given assets.

The fourth variable in Altman's model, X4, is the "market value of equity/ book value of total debt" ratio. Quoting Altman "The measure shows how much the firm's assets can decline in value (measured by market value of equity plus debt) before the liabilities exceed the assets and the firm becomes insolvent". (Altman, 1968) This ratio inserts the market dimension to the model. In order to be able to calculate the "market value of equity" part of the ratio, the total number of common and premium stock is multiplied by the market price of the stocks, which is given by the ATHEXGROUP. The denominator of the ratio "book value of total debt" is given by the balance sheet of each company. Altman found that this ratio appears to be a more significant predictor of bankruptcy than other ratios, such as "net worth/ total debt". (Altman, 1968)

The final variable of the model, X5, is the "total sales/ total assets" ratio. This ratio measures the total sales of a company regarding its total assets. In other words this ratio is useful in measuring the management's ability to deal with competition. According to Altman (1968) this ratio is the least significant in an individual level comparing with the other four ratios of the sample and it is not even statistically significant. The reason of using it in the final model is the highly importance when it comes to its relationship with the other variables of the model.

In order to come up with the final z-score of a firm, the five ratios used for each company are calculated using Microsoft Excel. Afterwards, these financial ratios are inserted in the model and there are five z-scores per company, for each of the five years prior to bankruptcy. Then the assessment of the z-scores takes place and each company is classified as bankrupt or non-bankrupt. Here it is important to mention

that this study is happening ex-post. Thus there are two types of errors in the results. The first one, Type 1 error happens when a bankrupt company gets a z-score by which it should be classified as non-bankrupt. The second one, Type 2 error, is the opposite and occurs when a non-bankrupt company's z-score indicate that this company should be classified as bankrupt. These types of errors are the main reason why the sample should be really symmetrical regarding the number and the size of bankrupt and non-bankrupt firms. For example, if a sample contains a significantly larger number of non-bankrupt firms, there will be way more Type 2 errors in the results.

After the classification takes place, the final results are presented and compare to those of Altman's. Afterwards, a comparison of predicting accuracy between this paper and this of Altman's will be presented.

Ratio components[2]

As mentioned above in order to calculate a company's z-score, one must use one of Altman's formulas. In this paper the first Altman's model (1968) is used. This model uses 5 variables, all describing a financial ratio. For better understanding of the final z-scores it is considered useful to examine and compare the components of these financial ratios and compare our two samples over the years prior to bankruptcy.

The X1 components

Previously, the model used in this paper was presented. The first variable is the "working capital/total assets" ratio. The working capital is given by subtracting current liabilities from current assets (current assets – current liabilities). In general this ratio is useful providing information about the liquidity of the firm. According to Altman, it is the most appropriate ratio of liquidity and major importance is given to it.

[2] The amounts are in thousands Euros.

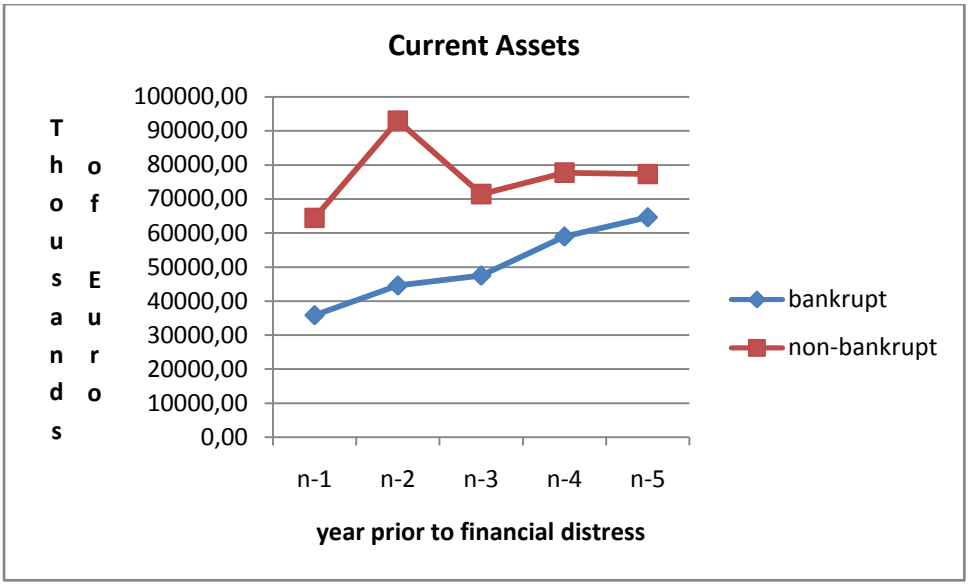

Diagram 1: Current Assts of the two Groups

The chart above used the average prices of current assets for both bankrupt (blue line) and non-bankrupt (red line) companies for each of the 5 years before the bankruptcy. The range of the observations for bankrupt firms is from 64560 (year n-5) as the largest one, to 35820 (year n-1) as the smallest. For non-bankrupt companies the range of observations increases significantly from 77680 to 64390 with the exception of the n-2 year with 92980.

In general, a firm with consecutive loss will have a balance sheet with shrunken current assets. In the chart above this statement seems to be right. It is obvious that as the firm is moving towards the year of the financial distress its current assets sees to diminish. In the case of non-bankrupt firms a general stability is observed, with the exception of the year n-2. It is more than obvious that bankrupt companies have a significant difference in current assets in comparison with the healthy firms of the sample.

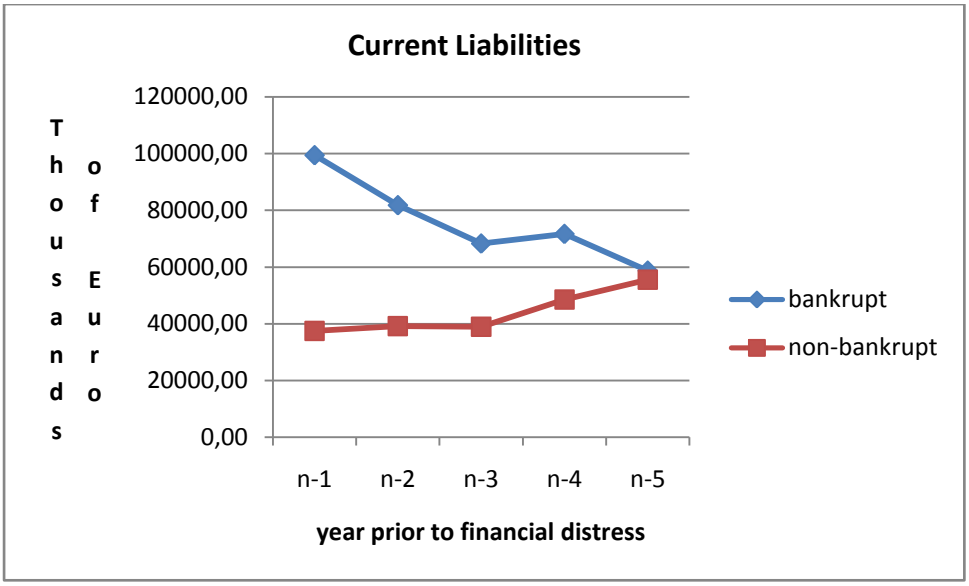

Diagram 2: Current Liabilities of the two Groups

In chart number 2 the current liabilities of both bankrupt (blue line) and non-bankrupt (red line) firms are presented for all 5 years before the bankruptcy occurred. The range of observations for bankrupt companies lies between 58691 (year n-5) and 99381 (year n-1). The range of observations for non-bankrupt firms is from 55533 (year n-5) to 37398 (year n-1).

In theory, a useful indicator of potential financial distress is an increase in current liabilities without an increase of at least the same amount in current assets. In this case it is obvious that the bankrupt firms show an increasing trend in their current liabilities, while the non-bankrupt companies seem to handle more carefully their liquidity components.

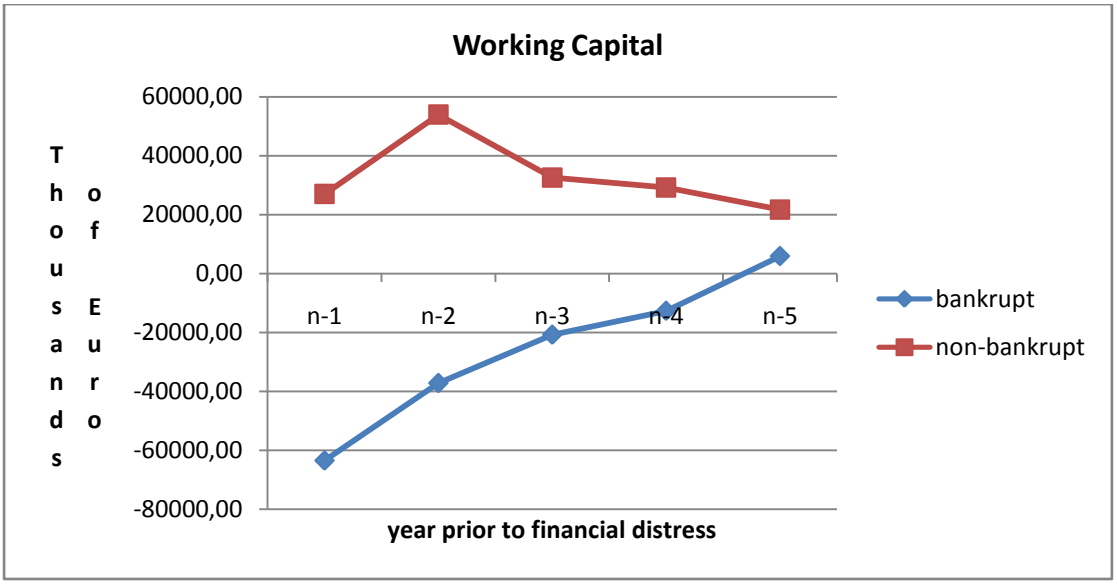

Diagram 3: Working Capital of the two Groups

The diagram 3 is a summation of the two previous ones. In this one the working capital of both bankrupt (blue line) and non-bankrupt (red line) firms is presented. In the case of bankrupt companies the average of their working capital over the years lies between 5869 (year n-5) and -63560 (year n-1). On the other hand, the non-bankrupt companies' working capital ranges between 53915 (year n-2) and 21727 (year n-5), but it tends to be somehow linear in all years with the exception of the year n-2.

According to Altman (1968) the X1 variable is one of the most important in his model because it measures the liquidity of a firm. In the present research a huge difference is observed among bankrupt and non-bankrupt firms. The first ones have a significantly decreasing trend, while non-bankrupt firms seem to operate with generally linear trend of working capital. Other researchers mention that Altman overweighed the importance of liquidity in his model because the concept of borrowing changed in the next decades (80's and 90's), with companies giving less importance to high levels of liquidity, using thus way bigger leverage. Still, the working capital is an indicator of major importance in the present paper.

The X2 components

The second variable in Altman's model is the "retained earnings/total assets" ratio. The aim of this ratio is to calculate the cumulative profitability (or cumulative losses) of a company. Additionally, this ratio can saw the level of leverage the company uses. A company with low level of retained earnings, or even losses uses mainly borrowing as a resource of financing its activities. Another thing shown by this variable is the prospects of growth for the company. Many researchers criticized this ratio, because a relatively young firm is not able to form retained earnings. Altman (1968) argues that the first three years of a firm's existence are the most critical and many firms don't manage not to fail in this period.

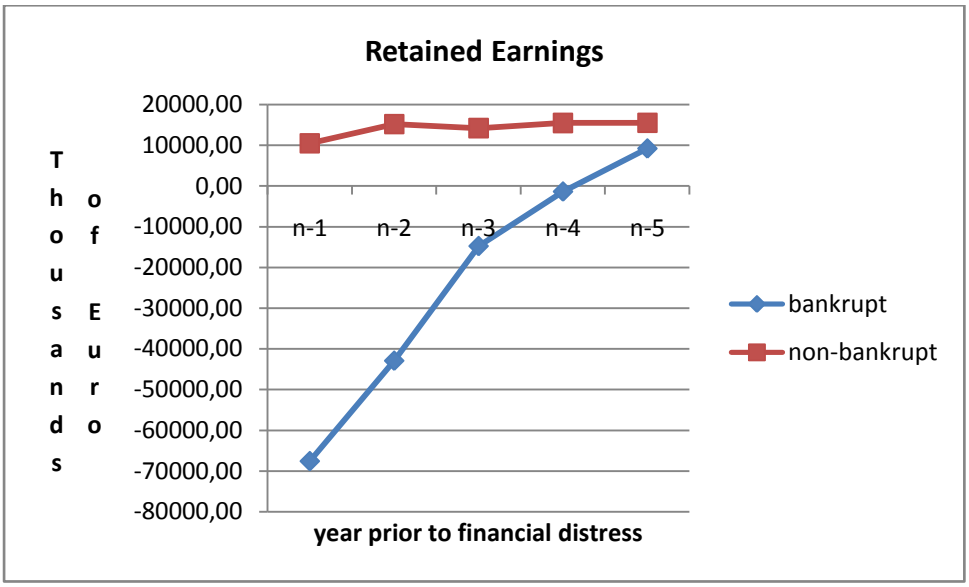

Diagram 4: Retained Earning of the two Groups

The graph above shows the average retained earnings for both bankrupt (blue line) and non-bankrupt (red line) firms for 5 consecutive years before the bankrupt took place. The range of the average retained earnings (or consecutive losses) for bankrupt firms lies between 9208 (year n-5) and -67574 (year n-1). On the other hand, it is obvious that observations for non-bankrupt firms follow an almost linear path. The values range from 15514 (year n-5) to 10515 (year n-1).

Broadly speaking, a firm should retain part of its earnings in order to be able to finance partially its activities. Furthermore, a portion of the retained earnings should be invested in new activities of the firm. In lots of cases, the shareholders of a

company even prefer not to get a dividend and to reinvest the company's earnings in order to maximize their wealth (taxation). It is obvious from the diagram above that in the case of bankrupt firms, many years before the bankruptcy took place that the average retained earnings got replaced by cumulative losses. In the case of non-bankrupt firms, on average they tend to retain approximately €10-15 millions.

The X3 components

Altman used as a third variable in his model the ratio that measures the profitability of the company. The ratio is "earnings before interests and taxes (EBIT)/total assets". This ratio actually measures the ability of a company to create profit, using efficiently its assets, regardless of the level of leverage or the tax system it operates in.

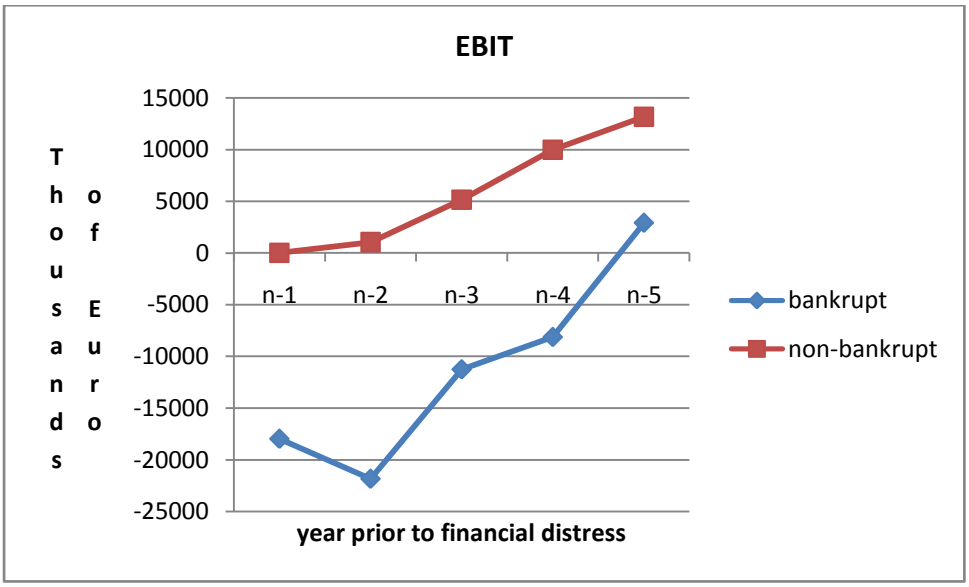

Diagram 5: Earnings Before Interests and Taxes of the two Groups

Graph 5 represents the average EBIT of both bankrupt (blue line) and non-bankrupt (red line) companies, for the 5 consecutive years prior to the bankruptcy. Regarding the bankrupt firms their EBIT ranges from -21855 (year n-2) to 2897 (year n-5). The range of average EBIT for non-bankrupt firms lies between 13161 (year n-5) and 18 (year n-1).

It is more than clear that one of the most important goals of a company is to maximize its EBIT. In the previous diagram both bankrupt and non-bankrupt firms

show a decreasing trend in their EBIT. The first ones even score negative EBIT for the years n-1 to n-4 which indicates a really poor financial condition. In the case of non-bankrupt firms this declining trend is an alarm for their future financial stability because EBIT should be stable through the years if not increasing.

The X4 components

The fourth variable in Altman's model (1968) is the "market value of equity/book value of total debt" ratio. In order to calculate the market value of equity, the number of both common and premium stocks is multiplied by the market price of the stocks. The book value of total debt includes long-term and current loans. This ratio measures to what extend can the value of the assets of a company shrink, before the liabilities become more than the assets, thus resulting to the company's insolvency. The advantage of this ratio is that it uses the market perspective. (Altman, 1968)

The next diagram visualize the average capitalization of both samples

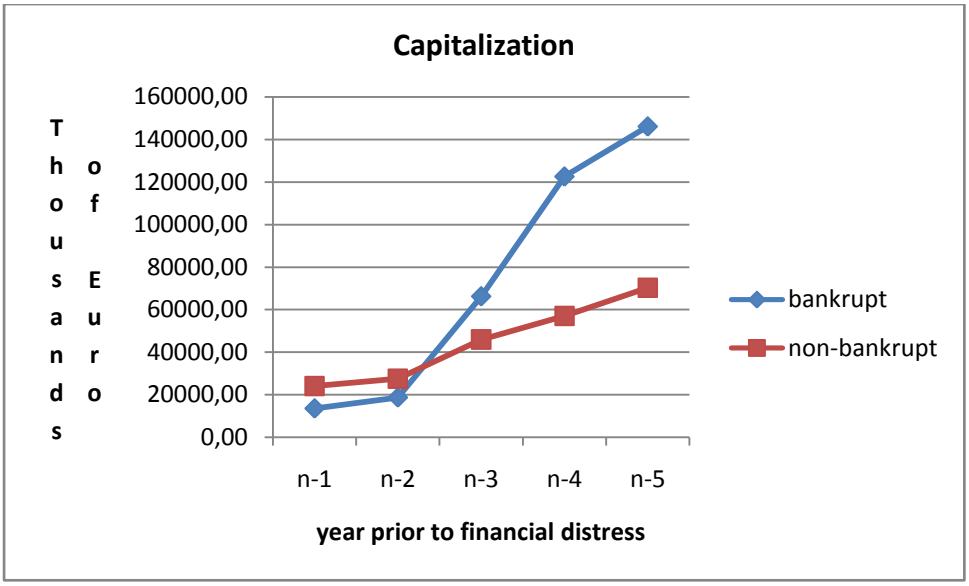

Diagram 6: Average Capitalization of the two Groups

As mentioned previously the capitalization of a firm equals the number of stocks multiplied by the market price of the stocks. The capitalization of bankrupt firms (blue line), for 5 years prior to bankruptcy, range between 146061 (year n-5) and 13476 (year n-1). The red line represents the average capitalization of non-bankrupt

firms for 5 consecutive years. The observations range from 70225 (year n-5) to 24015 (year n-1)[3].

The trend of capitalization for both bankrupt and non-bankrupt firms is declining. This can be partially explained by the general uncertain economic environment in Greece, due to economic recession in most of the years that this paper tested. Nevertheless, the magnitude of this decline for bankrupt firms is way bigger than for the non-bankrupt ones. This sharp capitalization decrease of bankrupt firms can be an indicator of their financial instability.

The other component of the X4 is the book value of the total debt. This can be calculated by summing up long-term and current liabilities. The following diagram represents the average book value of total debt for the 5 years prior to bankruptcy.

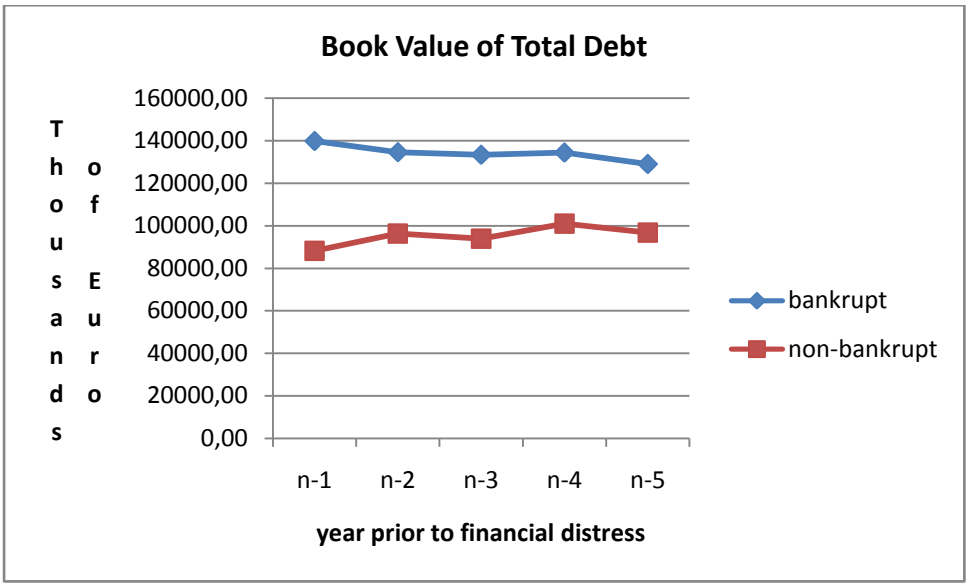

Diagram 7: Book Value of Total Debt of the two Groups

The blue line represents the average book value of total debt for bankrupt companies. The trend seems to be stable and the observations lie between 128934 (year n-5) and 139790 (year n-5). The red line visualizes the average book value of total debt for non-bankrupt firms. The range of the observation is from 88151 (year n-1) and 100950 (year n-5).

[3] The years studied in the present paper include mainly years from 2008 to 2012, thus the market price of all stocks is declining due to economic recession.

The total liabilities of bankrupt companies though stable, appear to be 25-30% more than those of non-bankrupt companies. This difference indicates lower prospects for growth for bankrupt firms, in comparison to those of non-bankrupt.

The X5 components

The last variable in Altman's model is the "total sales/total assets" ratio. According to Altman (1968) this ratio is very commonly used and it estimates the ability of the firm to create sales with given assets. The significance of this ratio is big because it interacts with components of other variables of the model. Finally, it can provide information about the management's ability to cope with competition. The calculation of this variable is quite simple.

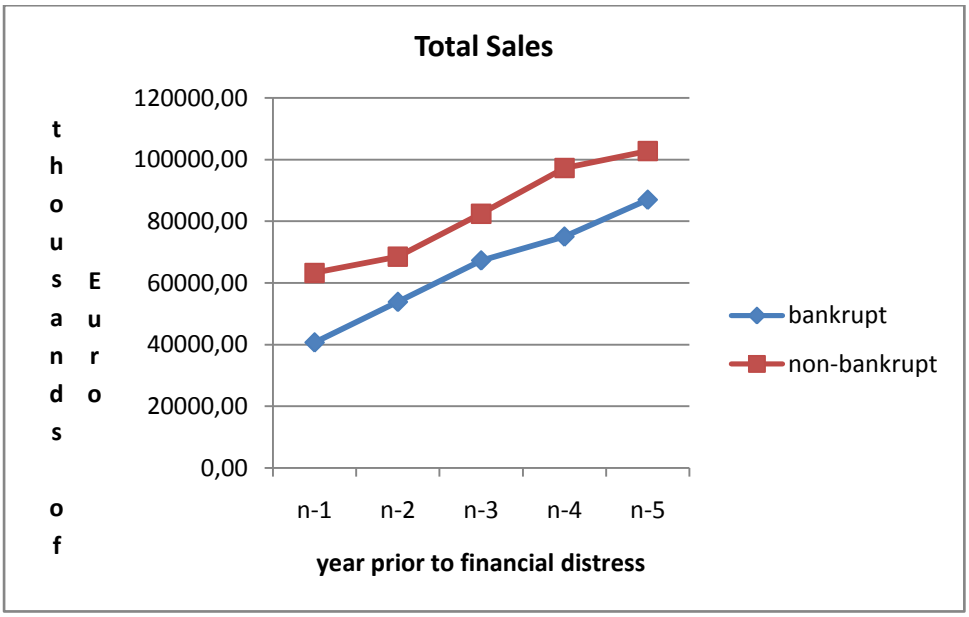

Diagram 8: Total Sales of the two Groups

The diagram 8 represents the average total sales of both bankrupt (blue line) and non-bankrupt (red line) firms for 5 consecutive years before the financial distress. The observations of bankrupt companies range from 86988 (year n-5) to 40677 (year n-1). The range of the average total sales for non-bankrupt companies is from 102745 (year n-5) to 63277 (year n-1).

The trend of total sales of both bankrupt and non-bankrupt is decreasing. A reason for this behavior is the economic recession taking place in Greece. Nevertheless, it is

obvious that the average total sales of bankrupt companies are 20-25% less than those of non-bankrupt. It is meaningless to mention that the more the value of sales the better the z-score of a company.

Summing up the previous diagrams, there is a pattern emerging. In all cases bankrupt firms underperformed in comparison with non-bankrupt. All bankrupt firms appear to have low current assets and high current liabilities leading to negative working capital, thus being vulnerable to liquidity problems. Additionally, all bankrupt companies have huge consecutive losses especially in the final two years before bankruptcy. Regarding their profitability, with the exception of the n-5 year, all bankrupt companies seem to have negative EBIT for four years before the bankruptcy took place. Moving with the fourth variable of the model, both bankrupt and non-bankrupt companies appear to face problems regarding their capitalization mainly because of the decrease of their stocks' market price. Additionally, bankrupt firms have a significantly larger amount of long term debt, indicating poor financial condition. Finally, as regards to total sales, both bankrupt and non-bankrupt firms tend to lose in total sales, but again there is a significant difference between the two.

The impact of these financial indicators on the final z-score of a company is shown in the next table.

Table 1: Impact of Ratio Components in the Final Z-Score

Indicator	**Direction of Change**	**Impact on Z-score**
Current Assets	↑/↓	↑/↓
Current Liabilities	↓/↑	↑/↓
Working Capital	↑/↓	↑/↓
Retained Earning	↑/↓	↑/↓
EBIT	↑/↓	↑/↓
Market Value of Equity	↑/↓	↑/↓
Book Value of Total Debt	↓/↑	↑/↓
Total Sales	↑/↓	↑/↓

Final Z-scores

The following tables (3 and 4) present the final z-scores of both bankrupt and non-bankrupt companies respectively. The data used for the calculation of those z-scores came out of each company's balance sheets. In order to come out with the five variables of the model Microsoft excel was used. According to methodology, the final values of X1, X2, X3, X4 and X5 got inserted in Altman's formula:

Z-score = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5

Where:

X1 = Working capital/Total assets,

X2= Retained earnings/Total assets,

X3=EBIT/Total assets,

X4= Market value of equity/Book value of total debt,

X5= Sales/Total assets.

The components of each "X" value were presented and compared previously. According to Altman's study (1968) every company can be classified as bankrupt, non-bankrupt or "in grey zone" with 95% accuracy for the year before the bankruptcy. The following table presents the classification of a company according to z-score:

Table 2: Discrimination Zones

Z-score	Classification
<1.81	Bankrupt
1.81<z-score<2.67	Grey area
>2.67	Non-bankrupt

Z-score of Bankrupt Companies

The following table contains the final z-scores of bankrupt companies for 5 consecutive years before the bankruptcy took place

Table 3: Z-Score of Bankrupt Companies (Group 1)

COMPANY NAME	YEAR OF FINANCIAL DISTRESS N	Z-SCORE N-1	Z-SCORE N-2	Z-SCORE N-3	Z-SCORE N-4	Z-SCORE N-5
PETZETAKIS	2011	-3,51	-1,14	-0,43	-0,69	-0,54
SHELMAN	2013	-1,76	-1,43	-0,91	-0,08	0,39
NEORION	2013	-1,05	-0,60	-0,15	0,26	0,32
IMPERIO	2012	-3,40	0,26	0,67	1,07	1,11
KARDASILARIS	2011	-3,69	-0,23	1,14	1,14	1,72
FINTEXPORT	2012	0,14	0,39	0,54	0,48	1,20
EMPORIKOS DESMOS	2011	-2,72	-1,08	-0,11	0,46	0,18
ALSINCO	2013	-1,40	-0,38	0,80	1,25	1,28
RIDENCO	2013	-60,38	-30,41	-3,44	0,13	0,57
TROPAIA HOLDINGS	2013	-3,15	-2,35	4,01	8,94	7,25
HATZIIOANNOY	2013	-2,17	-0,33	0,25	1,01	1,39
FASHION BOX	2011	0,80	1,40	3,19	3,43	3,07
EIKONA HXOS	2011	-3,28	-1,20	0,09	0,57	0,34
UNITED TEXTILES	2010	-2,64	-1,84	0,71	0,66	0,62
SPRIDER STORES	2013	-1,98	0,57	1,71	3,29	4,02
AVENIR	2012	3,55	4,75	8,83	13,05	-1,50
BABIS VOVOS	2012	-0,70	-1,18	0,20	0,23	1,04
CERAMICS ALLATINI	2012	-0,29	-0,03	-0,25	-1,15	-1,43

MICROLAND	2011	-17,91	-24,05	-11,93	4,72	3,96
EDRASI	2013	-3,03	-2,23	-1,41	-1,32	0,69
Average Score		**-5,43**	**-3,06**	**0,18**	**1,87**	**1,28**
Minimum Score		**-60,38**	**-30,41**	**-11,93**	**-1,32**	**-1,5**
Maximum Score		**3,55**	**4,75**	**8,83**	**13,05**	**7,25**
Accuracy		**95%**	**95%**	**85%**	**75%**	**80%**

The year that bankruptcy took place is referred as year "N", so n-1 is the year before bankruptcy, n-2 is the year two years before bankruptcy and so on and so forth.

The reader can observe that mainly the z-scores of bankrupt companies' trend to be negative, with some exceptions, for the years n-1 and n-2. The z-scores that are highlighted with yellow colour state that this company should be classified as non-bankrupt because its z-score is above 2.67. Every other z-score (not highlighted) is clearly beneath 1.81 so the "bankrupt" classification is correct. Starting with the n-1 year, it is obvious that the model is 95% accurate, which is exactly as Altman mentions. The average z-score of bankrupt firms for this year is -5.43 which is 7.24 points before the "gray area" and 8.1 before the safe zone of 2.67. The lowest observation is -60.38[4] and the highest 3.55, thus "AVENIR" should be classified as non-bankrupt according to the model (Altman, 1968). Proceeding to n-2 year, the accuracy of the model continues to be 95%. The average price for this year is -3.06, 5.73 points away from safety. The lowest z-score is -30.41 and the highest 4.75. Again the only misclassification is "AVENIR". Moving to n-3 year it is becoming obvious to the reader that the accuracy of the model is declining, as mentioned in Altman's study (1968). For this year the average z-score becomes positive (0.18) and the range of observations is narrower (-11.93, 8.83). Here there are three misclassifications and all of them are in the non-bankrupt zone. The average z-score of companies four years before bankruptcy is 1.87. This score indicates that on

[4] Ridenco firm sold many of its assets, so the z-score in the last two years is way too low.

average every firm can be identified as a "grey area" company. However, if someone takes a more careful look at table 3 will notice that none company's z-score is between 1.81 and 2.67. The highest z-score in n-4 year is 13.05, which is way above the non-bankrupt threshold of 2.67, so "AVEVIR" in 2008 would considered to be more than safe! On the other hand, the lowest observation is -1.32. In this year the model's accuracy is 75%. In the last year (n-5) of observations, the average z-score is 1.28. The range of values is from -1.5 to 7.25. Although -1.5 is a normal score, the 7.25 is a really high one even for a non-bankrupt and completely healthy company. The accuracy of the model in the last year is 80%.

The years of the study include the years of the economic recession in Greece, so it is expected that the z-scores of both bankrupt and non-bankrupt firms will be lower than in other studies that were conducted in a different time period.

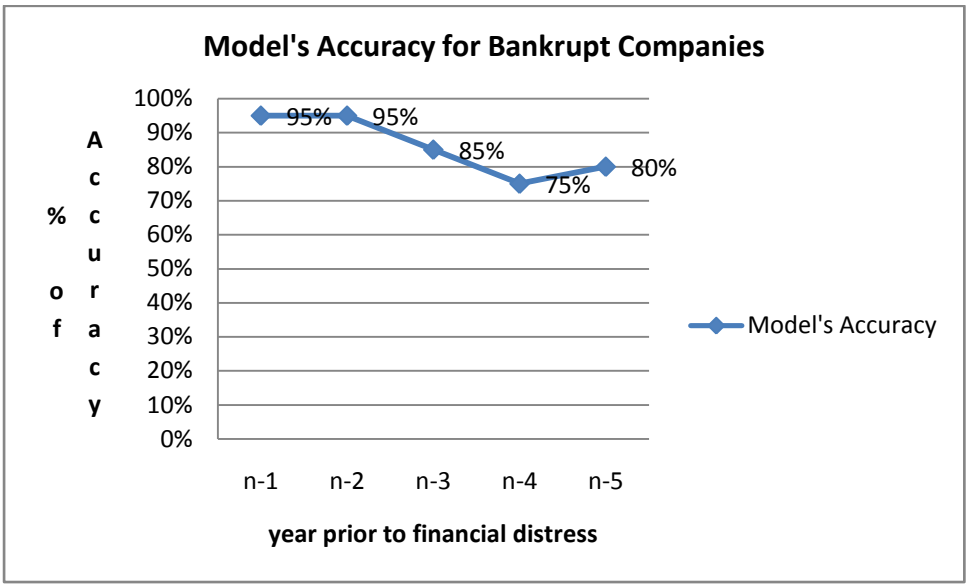

Diagram 9: Accurate Predictions for Group 1

Diagram 9 describes the accuracy of the model regarding predictions of bankruptcy. As in Altman's study (1968), the percentage of accurate predictions decline from year n-2 to year n-4 and then it increases in year n-5. The percentage of accurate prediction is really high, for the first two years, which are the most relative.

As mentioned previously, in table 3 the average z-score of bankrupt companies is below 1.81 (even below 0 for the n-1 and n-2 years), with the exception of the n-4 year, when it increases to 1.87, fact that can explain the decrease in model's

accuracy for this year. In general, the predictability of the model for bankrupt firms seems to be sufficient.

Z-score of Non-bankrupt Companies

The following table presents the final Z-score of all non-bankrupt companies for 5 consecutive years before bankruptcy occurred.

Table 4: Z-Score of Non-bankrupt Companies (Group 2)

COMPANY NAME	YEAR OF FINANCIAL DISTRESS N	Z-SCORE N-1	Z-SCORE N-2	Z-SCORE N-3	Z-SCORE N-4	Z-SCORE N-5
PLASTIKA KRITIS	2011	2,47	2,69	2,61	3,06	2,67
ATHENA S.A.	2013	0,16	0,16	0,61	0,82	0,8
FOURLIS	2013	1,76	1,64	2,1	2,53	2,32
NEXANS	2012	1,5	2,11	2,07	3,31	2,73
KARAMOLEGOS	2011	0,75	0,69	0,77	0,58	0,58
MINERVA	2012	0,83	1,18	1,61	1,91	2,06
NAFPAKTOS TEXTILE INDUSTRY	2011	1	0,71	0,98	1,49	2,64
LANAKAM	2013	1,19	1	1,11	1,45	1,91
MOUZAKIS	2013	-0,05	0,04	0,39	0,61	0,77
ELTRAK	2013	1,66	1,62	1,56	1,8	1,93
BIOKARPET	2013	0,37	0,94	0,7	0,95	1,36
DROMEAS	2011	0,54	0,91	0,94	1,56	2,28
DOUROS	2011	-0,07	0,48	0,61	1,3	1,71
KARELIA	2010	2,78	2,82	2,24	3,94	2,88
SELECTED TEXTILES	2013	0,17	0,45	0,28	0,21	0,55
YAMAHA MOTOR-GR	2012	1,21	1,99	3,1	3,41	3,34

LAMDA DEVELOPMENT	2012	0,62	1,22	1,07	0,94	1,71
KEKROPS	2012	0,59	0,48	0,73	1,14	3,13
M.L.S.	2011	4,65	4,2	2,87	3,68	3,74
FG EUROPE	2013	1,2	1,11	0,29	1,81	1,54
Average Score		**1,17**	**1,32**	**1,33**	**1,83**	**2,03**
Minimum Score		**-0,07**	**0,04**	**0,29**	**0,21**	**0,55**
Maximum Score		**4,65**	**4,2**	**3,1**	**3,94**	**3,74**
Accuracy		**10%**	**15%**	**10%**	**25%**	**30%**

In the case of non-bankrupt companies the results indicate the existence of problems, either in the whole Greek economy or in the model itself. In table 4 highlighted red are the z-scores of companies which are misclassified according to Altman's scale and should be financial distressed. Highlighted blue are companies that belong to the "gray area" according to Altman's model. The few "white" z-scores belong to non-bankrupt and out of danger companies.

For the year before year "N", the average z-score of non-bankrupt companies is 1.17, which actually belongs to the bankrupt area. The minimum score is -0.07 which is negative! The Maximum z-score is 4.65 which indicate a perfectly healthy company. In the case of non-bankrupt companies, is becoming obvious from table 4 that the accuracy of the model is really low. In n-1 year the model classified accurately only 10% of the companies, which is significantly worse than in Altman's study. One company belongs to the "gray area" with z-score equal to 2.47. Moving to n-2 year the average z-score is increasing slightly to 1.32 but still can be classified as score for bankrupt companies. In this year the lowest observation is positive, but still very close to 0 with 0.04. The highest z-score is 4.2. In this case the predicting accuracy of the model remains extremely low but slightly increased in comparison to n-1 year. In this year two companies belong to the "gray area". Continuing with n-3 year the average z-score is 1.33 which is similar to the one of n-2 year. The minimum z-score in this year is 0.29 which is very low for a non-bankrupt company, while the maximum is 3.1 which should be the value of a really average performance of non-

bankrupt companies. The predictability of the model in this year decreases to the lowest 10%. In year n-3 the number of companies that can be put to the "gray area" increased to four. In the n-4 year the average z-score is 1.84, which overpasses the threshold of bankrupt classification. The lowest z-score in this year is 0.21 and the highest 3.94. Additionally, three companies' z-score can be classified as belonging to the "gray area". The accuracy of the model reaches 25%. Finally, for the n-5 year the average z-score for non-bankrupt companies is 2.03 which still belong to the "gray area". The minimum observation is 0.55 and the maximum 3.74. In n-5 year the most "gray area" z-scores appeared. Six of the non-bankrupt companies scored Z that classifies them in the "gray zone". The accuracy of the model is the highest of all years and equals to 30%.

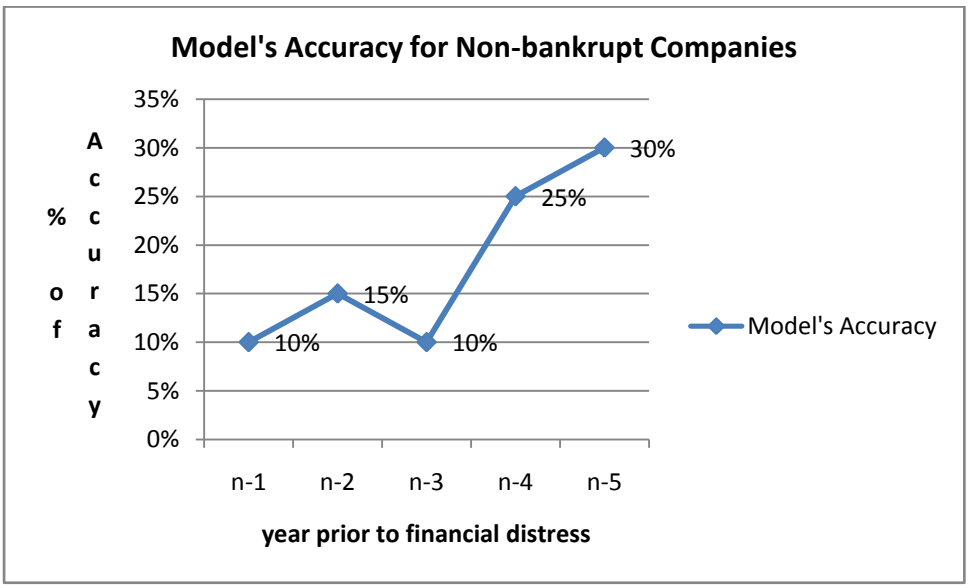

Diagram 10: Accurate Predictions for Group 2

Diagram 10 visualizes the percentage of accurate predictions according to the model. The pattern in this case is really opposite to the one in Altman's study. Here the accuracy of the model actually increases as moving backwards in time, with the highest percentage of predictability achieved in n-5 year. It becomes more than obvious in table 4 that the average z-score of non-bankrupt companies is really low. This indicates that the accuracy of the model will be low too. Still as the average z-score increases, the model's predicting accuracy increases too.

Type I and Type II Errors

Altman (1968) introduced the Type I and the Type II errors. According to him each misclassification of bankrupt company as non-bankrupt is called Type I error. The opposite, a non-bankrupt company that should be classified as bankrupt is a Type II error.

The following table presents the Type I errors of the test.

Table 5: Type I Errors of the Test

Year	Number of companies	Correctly Predicted	Misclassifications	Nubmer of companies in the "grey area"	Percent Correct	Percent Error	Type I Error
n-1	20	19	1	0	95	5	5
n-2	20	19	1	0	95	5	5
n-3	20	17	3	0	85	15	15
n-4	20	15	5	0	75	15	15
n-5	20	16	4	0	80	20	20
Total	**20**	**17,2**	**2,8**	**0**	**86**	**12**	**12**

The table above presents the Type I errors of the results in this study. The magnitude of Type I errors increases as the accuracy of the model decreases. The more Type I errors are observed in the n-4 year and in the same year the accuracy of the model is the lowest among 5 years. The average percentage of accurate predictions is 86% for the group of bankrupt companies. The average percentage of Type I error for the five years before bankruptcy is 12%. In the group of bankrupt companies, none's z-score lies between 1.81 and 2.67, so there is not any company belonging to the "gray area".

The following table presents the Type II errors of the test.

Table 6: Type II Errors of the Test

Year	Number of companies	Correctly Predicted	Misclassifications	Nubmer of companies in the "grey area"	Percent Correct	Percent Error	Type II Error
n-1	20	2	17	1	10	90	85
n-2	20	3	15	2	15	85	75
n-3	20	2	14	4	10	90	70
n-4	20	5	12	3	25	75	60
n-5	20	6	8	6	30	70	40
Total	**20**	**3,6**	**13,2**	**3,2**	**18**	**82**	**66**

In the case of non-bankrupt firms it is made clear that the performance of the model is bad. Thus, it is expected the model to produce a big amount of Type II errors. In this case, as happens with the bankrupt companies, the higher the predicting accuracy of the model, the lowest the number of Type II errors. For example, in n-5 year when the accuracy of the model is the highest (30%), the model misclassified the least companies (8) and the Type II error is 40% which is the lowest among the 5 years of the study. The average percentage of accurate predictions regarding non-bankrupt companies is only 18%. Additionally, the average percentage of Type II error is 66%. Finally, the model ranks on average 3.2 companies in the “gray area” per year.

The following table combines the percentages of tables 5 and 6 provides the total accuracy of the model.

Table 7: Type I and II Errors of the Test

Year	Number of companies	Correctly Predicted	Missclasifications	Nubmer of companies in the "grey area"	Percent Correct	Percent Error	Total Type I and II Error
n-1	40	21	18	1	52,5	47,5	45
n-2	40	22	16	2	55	45	40
n-3	40	19	17	4	47,5	52,5	42,5
n-4	40	20	17	3	50	45	37,5
n-5	40	22	12	6	55	45	30
Total	**40**	**20,8**	**16**	**3,2**	**52**	**47**	**39**

As being shown in table 7 after combining the results of both bankrupt and non-bankrupt enterprises, the accuracy of the model in classifying correctly the companies of the sample is reducing significantly. The percentage of correct predictions on the whole sample is 52% and the combination of Type I and Type II errors is 39% on average.

In order the reader to able to compare the accuracy of Altman's in predicting bankruptcy both in this paper as well as in Altman's study, the following table and diagram are presented.

Table 8: Comparison of Predicting Accuracy, Altman's and Present Paper

Year prior to bankruptcy	n-1	n-2	n-3	n-4	n-5	Total
Altman's sample Accuracy	95%	72%	48%	29%	36%	**56%**
Present sample Accuracy	52,50%	55%	47,50%	50%	55%	**52%**

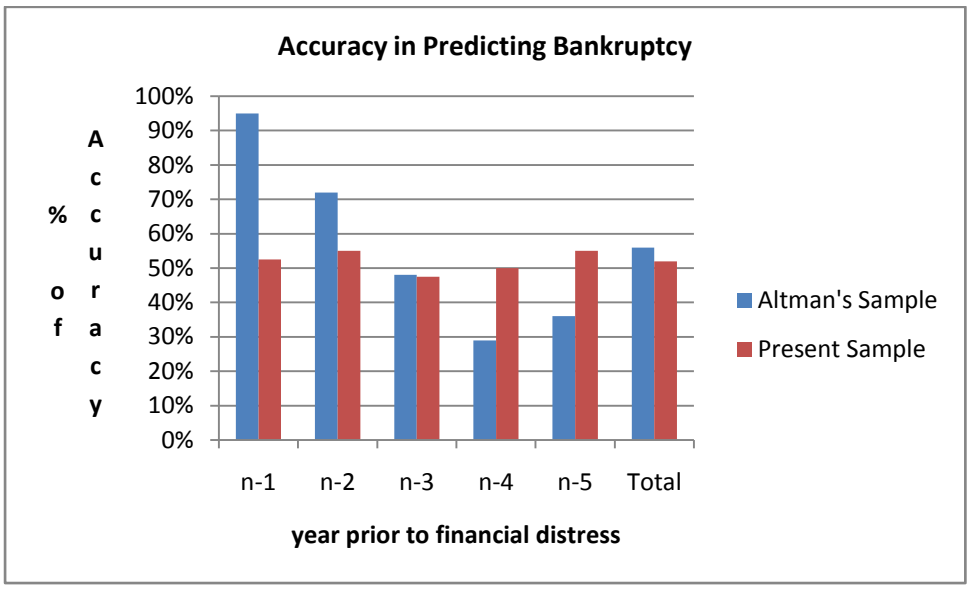

Diagram 11: Comparison of Predicting Accuracy, Altman's and Present Paper

Generally, the average accuracy of the model in both samples seems to be close, 56% in Altman's sample and 52% in the present sample. But according to Altman (1968), his model should be able to predict bankruptcy in a very high percentage one and two years before it happens. This is happening in his sample, where the accuracy in predicting bankruptcy declines from 95% in year n-1 to 29% in year n-4 and then increases again to 36%. On the other hand, the trend in the present sample is more

or less linear. The range of values is from 47.50% to 55%. This indicates that Altman's model is not sufficient enough in order to predict bankruptcy in the present sample. Although, the model seemed to be extremely accurate in the case of bankrupt firms, with prediction accuracy 86% on average, it performed really badly in the case of non-bankrupt companies, scoring only 18%. This indicates that the model overreacts. Additionally, it is obvious that the Z-scores of bankrupt companies, especially in the years n-1 and n-2 are well below 0. This indicates that the coefficients of the model should be re-estimated, in order to be able to produce accurate predictions in the case of Greek companies. Furthermore, the economic situation in Greece, with the economic resection is worsening the financial data of both bankrupt and non-bankrupt companies. This is another reason why the model needs to be re-estimated. Moreover, Altman's coefficients were estimated in a significantly different economy and time period. Even though, Altman states that the sample selection was pretty much random regarding the bankrupt firms, another sampling of bankrupt firms will not give similar coefficients because the proportion of firms from each industry will change. The structure of economy has changed several times from 1968. Companies now tend to form bigger debts than in the period of Altman's research, using a greater amount of leverage. This creates problems in the model, because two variables, X1 and X2, use the liabilities in their ratio. Thus the final z-scores tend to be smaller.

Conclusion

The purpose of this paper was to test if Altman's original model (1969) can predict corporate bankruptcy in the Greek financial environment of the last years. The sample used for the test consisted of forty companies listed on the Hellenic stock exchange. Twenty of these companies are bankrupt and the other twenty are non-bankrupt. The years of the data used are from 2005 to 2013. The results of the test were satisfying with what has to do with the classification of the bankrupt firms. The accurate classifications were more than 86%. The model failed to classify correctly the non-bankrupt companies. The average accuracy in non-bankrupt classification is only 18%. The average accuracy of the model in the whole sample is 52% which is close to the one achieved by Altman, but if someone look at the two years before bankruptcy will notice that the accuracy of the model regarding this sample is 52.50% and 55% respectively, while in Altman's was 95% and 72%. These being said, it is safe to say that Altman's model cannot be used in order to predict financial distress in the Greek economy. The main reasons for underperforming in prediction accuracy are:

1) The period of the data contains the years of the economic recession in the Greek economy. Looking at the ratio presentation above it is obvious, especially in the two years prior to financial distress that there is a reduction in all ratios. This phenomenon is more intense in the X4 variable, with a huge deterioration of the capitalization and in the X5 variable, with a significant reduction of the sales. So it is safe to assume that Altman's model isn't fitting in a disturbed economic environment.
2) The sample Altman used in 1968 consisted of US manufacturing companies and the data are from almost fifty years ago. The global financial environment has changed several times since then and as a result the mentality of companies worldwide. Nowadays companies use higher debt to finance their activities, as well as, the primary target of a firm may differ depending on the current situation of the economy and the market it operates (maximizing sales, increasing market share, creating competitive

advantages). This affects the variables the model uses. Additionally, the legal framework is different among countries as well as among time periods.

3) Finally, there can be differences regarding the amount of companies of each industry used in the two models. The financial ratios of an industry can be significantly different to those of another. Additionally, Altman did not include retail companies in his sample, so it is not safe to assume that this model can be used to all Greek companies. Altman himself revisited his model in 2000 in order to be able to use it on retail companies.

All the above reasons contribute to the assumption that Altman's model isn't effective in predicting corporate bankruptcy in the Greek economy. The model has to be re-estimated and adjusted to the conditions and the structure of an economy in order to be efficient.

Proposal for Future Research

If someone is interested in testing bankruptcy models it is highly recommended to:

1) Re-estimate the model in different time periods and compare the results to the original model.
2) Estimate the model for a specific industry in a block of countries e.g. Balkans, EU-28.
3) Use a model of each category (univariate, multivariate and on from a most resent time period e.g. neuronal networks) and apply them to the same sample of companies, used in the present study.
4) Try to introduce some new variables to the model that will be able to insert the notion of the macroeconomic environment.
5) Use only a group of medium and small companies which are perceived to be the back bone of the Greek economy.

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