INTERNATIONAL CONFERENCE ON
INTELLECTUAL CAPITAL MANAGEMENT
7, 8 OCTOBER 2009
ZANJAN SCIENCE AND TECHNOLOGY PARK - INSTITUTE FOR ADVANCED STUDIES IN BASIC SCIENCES (IASBS)

Review of the prediction power of Altman and Ohlson models in predicting bankruptcy of listed companies in Tehran stock exchange – Iran

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Abstract: Current collapses of big companies and the worse fluctuations of the financial markets has evoked the awareness of the stakeholders and mangers to utilize suitable tools to predict the financial distress of companies. One of such tools is the application of financial ratios as independent variables and developing models to predict bankruptcy issue.

The objective of this study is first to test the prediction power of original Altman (1983) and Ohlson (1980) models on the dataset of Iranian listed companies and secondly by applying Multiple Discriminant Analysis (i.e. MDA) and Logit Analysis statistical techniques on the same dataset, develop a suitable prediction model for bankruptcy of listed companies in the economic environment of Iran.

It was Finally concluded that both original Ohlson bankruptcy prediction model in 1980 without any modification of multipliers and coefficients and Logistic regression technique showed better prediction results than original Atman model in 1983 or Discriminant analysis technique.

Keywords: bankruptcy, financial ratio, bankruptcy prediction models, multiple discriminant analysis, logistic regression

1. INTRODUCTION

Up until its demise in 2001, Enron was a large player in the natural gas industry. Events leading up to the eventual bankruptcy protection filing, caused investors to flee the common stock as creditors refused new lending. Enron went from a favored to a disdained company in record time. This company's common stock price plunged from $80 per share to $1 prior to the bankruptcy announcement, suddenly lost $25 billion in market value and cash bankruptcy expenses totaled $17.3 million, though the bankruptcy costs including accountants', advisors', and lawyers' fees were over $500 million by November, 2003[1]. Enron, World com, Owens Corning, Webvan and so many other companies that have been filed for bankruptcy in recent years are a kind of bitter experiences for the stakeholders of these companies.

Vast and horrible effects of the bankruptcy issue, has made it an important subject of the recent and elderly studies initiating almost from 1960s which so far, so many techniques and models have been developed by the academic and professional bodies to mitigate such risks for the stakeholders, nevertheless, though such attempts and awareness made by the auditors and financial analysts, bankruptcy cases are still filed at the regulatory authorities and many people lose.

The extensive and expensive impact of bankruptcy obliges us not to sit idle and try to work more on this matter and remove the uncertainties as many as we can in order to hedge the people concerning this fact, resulting in an efficient capital market presumed by the earlier scientist such as Modigliani and Miller.

A. Research Problem

The research questions addressed in this thesis are as follows:

- Whether the original Altman (1983) and Ohlson (1980) bankruptcy prediction models can be applied to Iran financial environment without any modifications in the variables and coefficients.
- Which of the most popular bankruptcy prediction models (logit and Multiple Discriminant Analysis) has the most prediction power in Iran?
- By re-estimation of the models in Iran environment, should new models with the original variables do the prediction with high accuracy yet?
- Whether the original variables can explain the bankruptcy prediction issue.

B. Research Hypothesis

Based on the aforementioned questions, the three hypotheses have been defined as follows:

1. Original Altman (1983) bankruptcy prediction model has more power in prediction bankruptcy issue on Iranian listed companies.
2. Original Ohlson (1980) bankruptcy prediction model has more power in prediction bankruptcy issue on Iranian listed companies.
3. Multiple Discriminant analysis technique has significantly more power than Logistic regression (Logit analysis) in prediction the bankruptcy issue of Iranian listed companies.

[1] **Houston Business Journal, 19 November 2003**

2. LITERATURE

Since the pioneering financial ratio model conceptualized by Beaver (1966), bankruptcy prediction models, such as the multivariate analysis technique by Altman (1968), the linear probability model by Myer and Pifer (1970), the logit model by Ohlson (1980), the probit model by Zmijewski (1984), and neural networks by Odom and Sharda (1990), have been much developed. Each of these models is discussed in the following sections.

2.1. Uni-variable analysis

An interest in bankruptcy prediction was first aroused by Beaver (1966), who utilized the uni-variable analysis technique for use in investigation. His utilization of the paired-sample approach and the use of a hold-out sample to validate the model has been a benchmark for later researchers. The uni-variable analysis is widely used because of its competitive advantage over simple calculation, its low-cost, easy explanations, and "not bad" performance. However, neither the contradictions nor the possible interactions among the variables are considered by such an approach, which limits its application, and so multi-variable techniques have been subsequently developed.

2.2 Multi-variate discriminant analysis

Altman (1968) tried to explore a bankruptcy prediction model with more financial statement variables taken into consideration, allowing the multi-variate discriminant function to be applied to his data. Even if several financial ratios are simultaneously regarded and the predicting power among the variables can be differentiated by the multi-variate discriminant analysis, the statistical requirement of the normal distribution assumptions is seldom held.

2.3 Regression function

The general regression function consists of a linear probability function, logit function, and probit function. Due to the shortcoming that the predicted probability of the linear probability function can possibly fall outside the (0, 1) range, logit and probit functions are to substitute for it. Ohlson was a pioneer in introducing logit function to bankruptcy prediction in 1980, and a follow-up study was conducted by Zmijewski, who first applied probit function in 1984. Up since then, there were contentions as to which regression model was most appropriate for which condition. Collins and Green (1982), Ingram and Frazier (1982), Harrell and Lee (1985), Gentry et al., 1985; 1987, and Gessner, Kamakura, Malhortra, and Zmijewski (1988) all have similar results in spirit, showing that the logit model is superior to the discriminant one. Further, Gessner et al. (1988) indicated that there is not much difference between logit and probit in nature. The decision as to when to use which specific technique depends on the characteristics of the data set in question. Eisenbeis (1977) and Press and Willson (1978) pointed out when the normal distribution assumptions for the discriminant function are not satisfied, the significance level of the hypothesis test and the estimate of the accuracy of classification will be biased. Ohlson (1980) also questioned the validity of the discriminant function analysis when the multi-normal distribution and equal covariance matrix between two population assumptions are violated. The linear probability model, with the advantage of not having to transform the original variables and user-friendly operations, makes itself more acceptable while its predicted probability may fall outside the (0, 1) range. Logit and probit do not encompass the normality assumption, nor does their predicted probability fall outside a binary range. However, they are criticized over a need to transform the original variables and the complicated computations involved.

2.4 Artificial neural network

The ANN is composed of richly interconnected non-linear nodes whereas communicate in parallel. The connection weights are modifiable, allowing ANN to learn directly from examples without requiring or providing an analytical solution to the problem. The most popular forms of learning are:

- ***Supervised learning*:** Patterns for which both their inputs and outputs are known are presented to the ANN. The task of the supervised learner is to predict the value of the function for any valid input object after having seen a number of training examples. ANN employing supervised learning has been widely utilized for the solution of function approximation and classification problems.

- ***Unsupervised learning*:** Patterns are presented to the ANN in the form of feature values. It is distinguished from supervised learning by the fact that there is no a priori output. ANN employing unsupervised learning has been non-bankruptcy employed for data mining and classification tasks. The self-organizing map (SOM) and adaptive resonance theory (ART) constitutes the most popular exemplar of this class.

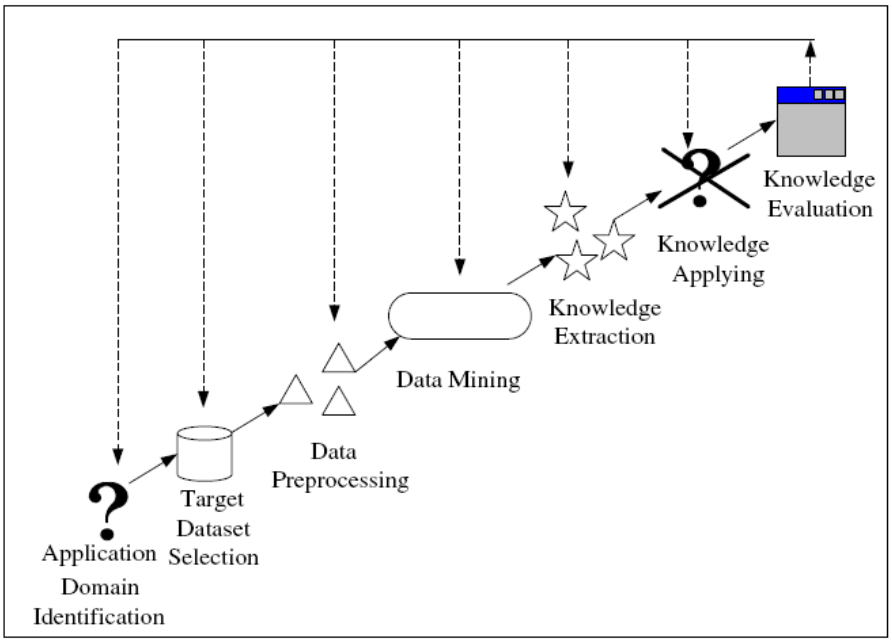
A back-propagation network (BPN) is a neural network, which uses a supervised learning method and feed-forward architecture. A BPN is one of the most frequently utilized neural network techniques for classification and prediction (Wu, Yang, & Liang, 2006). this is considered an advanced multiple regression analysis that can accommodate complex and non-linear data relationships (Jost, 1993). It was first described by Werbos (1974), and further developed by Ronald, Rumelhart, and Hinton (1986). The details for the back-propagation learning algorithm can be found in Medsker and Liebowitz (1994).

Regarding the above literatures, many researches employed the BPN techniques for many applications. However, a few of them used it to carry out empirical investigations of financial distress prediction related topics.

2.5 Data mining

Data mining (DM), also known as ‘‘knowledge discovery in databases” (KDD), is the process of discovering meaningful patterns in huge databases (Han & Kamber, 2001). In addition, it is also an application which can provide significant competitive advantages for making the right decision. (Huang, Chen, & Lee, 2007). DM is an explorative and complicated process involving multiple iterative steps. As Fig. 2 shows an overview of the data mining process (Han & Kamber, 2001), It is interactive and iterative, involving the following steps:

Figure 1
Data mining phases (Han & Kamber, 2001)



In the recent past, many research contributions have applied data mining techniques to many applications. DM has been non-bankruptcy applied to several financial problem domains. Recent examples are as follows:
Huang, Hsu, and Wang (2007) adopted the time-series mining approach to simulate human intelligence and discover financial database patterns automatically (Huang et al., 2007). Kirkos, Spathis, and Manolopoulos (2007) used classification mining to identify fraudulent financial statements (Kirkos et al., 2007). Chun and Park (2006) integrated the regression analysis and case-based reasoning for predicting the stock market index (Chun & Park, 2006). However, a few of these studies focused on the data clustering approach, and even fewer empirical investigations were made of financial distress prediction related topics.

3. RESEARCH METHODOLOGY

3.1. Method

This study is an explanatory, semi empirical and regression based research.

In summary, this research was carried out in two steps. In first phase, aligning the research hypothesis 1 and 2, the applicability of original Altman (1983) and Ohlson (1980) bankruptcy prediction models on Iranian listed companies for the post one, two and three years has been tested and compared, then the one with higher accuracy has been identified. In the second phase, by re-estimation of the models in Iran's environment, and the application of the identical regression techniques to Altman (1983) (i.e. Multiple Discriminant Analysis) and Ohlson (1980) (i.e. Logistic Regression), the accuracy of the new re-estimated models with the original variables has been appraised and compared.

Generally, the research has been carried out in the following turn and details:

1- By defining the bankruptcy regulatory threshold of Article 141 of Iran Commerce Law as the bankruptcy criteria, non-bankrupt and bankrupt companies of Iran stock exchange were identified in the period of 1998 to 2005.

2- Choosing the bankrupt companies sample from the population identified in the step one above, and choosing the non-bankrupt companies with the same number as the bankrupt samples.
3- Calculating the required financial ratios and other non financial data of the sample companies.
4- Entering the calculated financial ratios and data in the original models developed by Altman (1983) and Ohlson (1980) and comparing the results of bankruptcy prediction with the actual status of the sample companies.
5- The best model with the minimum prediction error was identified.
6- In the second phase, by utilizing Logit and MDA on the independent variables calculated in step 3 above, the best statistically significant models was developed.
7- The developed and spooled models from Logit and MDA were separately assessed for their bankruptcy prediction power and better technique was identified.

Regarding the above methodology two things would be notified:

A. For step 1 to 5 above, aligning the objective of the research and as per the aforementioned hypothesis 1 and 2, no modifications have been made on the independent variables and their coefficients of the original models.
B. In Multiple Discriminant analysis, one of the fundamental suppositions of which is the normal distribution of the variables, the issue was confirmed by Kolmogorov-Smirnov test that as per the indicated errors of developed models in step 6 above, the distribution was normal.

3.2. Data

3.2.1. Sample

The sample is composed of 40 corporations with 20 firms in each of the two groups. The bankrupt group (group 1) are listed companies of Iran Stock Exchange that as per the Article No. 141 of Iran Commerce Law, their Retained Loss is more than twice of their capital. Since our criterion has been this Article of law, we've not scrutinized the effectiveness of this Article and have relied on that as a regulatory confinement being a bankruptcy signal for the company's stock holders. Recognizing that this group is not completely homogeneous (due to industry and size differences), we attempted to make a careful selection of non-bankrupt firms. The second group (group 2) consists of a paired sample of listed firms chosen on a stratified random basis from the same data base of Iran Stock Exchange.

The firms are stratified by the data dates and size of group 1, with the asset factor size [log (TA to GDP Index)] deviation of only 8% between groups 1 and 2 which was immaterial. In addition, the collected data are from quite same years as those compiled for the bankrupt firms. For the initial sample test, the data are derived from financial statements dated one, two and three annual reporting periods prior to bankruptcy. The data were derived from Iran-Tehran Stock Exchange database in the period of 1998 to 2005 and also from selected annual reports in that period. Due to the prediction of bankruptcy issue by three years before, the time span of the bankruptcy occurrence is falling in the period of 2001 to 2005, the data of which have been collected for the years 1998 to 2002.

3.2.2. Variable Selection

After the initial groups are defined and firms selected, balance sheet, income statement and cash flow data are collected. On the basis of the research predetermined hypothesis 1 and 2 of reviewing original Altman (1983)and

Ohlson (1980), the same independent variables were selected as the research variables separately for two models, and aggregately (taking 13 variables presented by Altman (1983) and Ohlson (1980)) for the 3rd hypothesis of the research. The ultimate initial variables were as identified in table 1 below.

TABLE 1
Research final independent variables list

Research Hypothesis	Row	Variable	Variable Definition	Abbreviation
One & Three	1	X1	Working Capital/Total Assets	WC/TA
	2	X2	Retained Earnings(Loss)/Total Assets	RE/TA
	3	X3	Earning Before Interest and Taxes/Total Assets	EBIT/TA
	4	X4	Book Value of Equity/Total Assets	BOE/TL
	5	X5	Sales/Total Assets	SALES/TA
Two & Three	6	X1	Working Capital/Total Assets	WC/TA
	7	X2	Total Liability/Total Assets	TL/TA
	8	X3	Log (Total Assets/GDP Index)	Size
	9	X4	Current Liability / Current Assets	CL/CA
	10	X5	One if total liabilities exceeds total assets, zero otherwise	OENEG
	11	X6	Net Income / Total Assets	NI/TA
	12	X7	Funds provided by operations divided by total liabilities.	FUTL
	13	X8	One if net income was negative for the last two years, zero otherwise	INTWO
	14	X9	Net Income for the most recent period minus net income of the last period divided by the sum of the absolute figures of nominator	CHIN

It would be notified that regarding the hypothesis 1 and 2. no modification has been made to the original variables and coefficients presented by Altman and Ohlson, whereas, since through the 3rd hypothesis, the original models have been re-estimated, no changes has been made on the variables but the coefficients have been changed as per the new models statistical significance.

3.2.3. Bankruptcy Definition Criteria

As considered above, the criteria of classifying the firms into group 1 (bankrupt companies) and group 2, has been article 141 of Iranian commerce law. According to this article, if the amount of the retained earnings (loss) doubles the amount of the registered capital of a company, whether public or private, that company is supposed to have become bankrupt and this issue must be delivered to the attention of the stockholders to make a decision to execute a capital injection or dissolve the existent of the unit. Of course as per the new regulation going to be approved, the company can not be easily dissolved and a committee would decide to restructure the unit and not immediately close the doors.

4. Statistical Analysis

4.1. reviewing bankruptcy prediction power of original Altman (1983) and Ohlson (1980), research hypothesis 1 and 2

4.1.2. Altman (1983), research hypothesis 1

In this section without any modifications made on Altman (1983) bankruptcy prediction model, presented in equation 1 below, the accuracy of the model has been tested on Iran listed companies dataset for the years 1998 to 2005.

$$z' = 0.717\,x_1 + 0.847\,x_2 + 3.107\,x_3 + 0.420\,x_4 + 0.998\,x_5 \qquad \text{(Equation 1)}$$

The independents variables definition has been presented in table 1 above. In this model; if by entering the calculated variables of the research, Z score figure is greater than 2.9, the company is classified as non bankrupt, less than 1.23, it's bankrupt and between these two thresholds, is the grey area or critical zone which requires more investigation for the classification.

Summary of examination of Altman bankruptcy prediction model for 1, 2 and 3 years before has been presented in table 2 below:

TABLE 2
Classification results - Altman (1983) bankruptcy model, 1, 2 and 3 years before

Year	Actual			Predicted			Accuracy	
	Group 1	Group 2	Total	Group 1 (Bankrupt)	Group 2 (Non-Bankrupt)	Gray Zone (Critical)	Number correct	Percent correct
One year before	20	20	40	13	6	20	**19**	**47.5**
Two year before	20	20	40	8	7	23	**15**	**37.5**
Three year before	20	20	40	6	7	27	**13**	**32.5**
Total	**60**	**60**	**120**	**27**	**20**	**70**		

As it can be observed in above table, the accuracy of the model has been solely based on the number of the correct classified companies as bankrupt or non-bankrupt. Due to lack of sufficient information and low correlation between the substance of article 141 of Iran commerce law and the actual closure of the bankrupt companies (i.e. the companies filed for the article are not discontinued nor laid off from the Stock Exchange Board), the gray (critical) area has not been further analyzed into group 1 and 2.

4.1.3. Ohlson (1980), research hypothesis 2

In this section also without any modifications made on Ohlson (1980) bankruptcy prediction model, presented in equation 2 below, the accuracy of the model has been examined on Iran listed companies dataset for the years 1998 to 2005.

$$z_i = -1.32 - 0.407x_1 + 6.03x_2 - 1.43x_3 + 0.0757x_4 - 2.37x_5 - 1.83x_6 + 0.285x_7 - 1.72x_8 - 0.521x_9 \quad \text{(Equation 2)}$$

The independents variables definition has been presented in table 1 above, row 6 to 14. In this model if by entering the calculated variables of a specific company, the conditional probability of the calculated Z value as per equation 3 below, is greater than 0.5, the company is classified as non bankrupt, less than 0.5, it's bankrupt and the point of 0.5 in this threshold, is the grey area or critical zone which requires more investigation for the classification.

$$P(Z) = 1/(1+e^{-z}) \quad \text{(Equation 3)}$$

Summary of examination of Ohlson bankruptcy prediction model for the post 1, 2 and 3 years has been presented in table 3 below:

TABLE 3
Classification results - Ohlson (1980) bankruptcy model, 1, 2 and 3 years before

Year	Actual			Predicted			Accuracy	
	Group 1	Group 2	Total	Group 1 (Bankrupt)	Group 2 (Non-Bankrupt)	Gray Zone (Critical)	Number correct	Percent correct
One year before	20	20	40	0	13	0	**13**	**32.5**
Two year before	20	20	40	2	15	0	**17**	**42.5**
Three year before	20	20	40	3	12	0	**15**	**37.5**
Total	**60**	**60**	**120**	**5**	**40**	**0**		

As shown above, none of the predictions has fallen in the grey area

4.2. Developing a bankruptcy prediction model using MDA and Logit techniques

4.2.1 Multiple discriminant analysis

The objective of this part is to develop a model for predicting bankruptcy issue in one, two and three years before, by the application of multiple discriminant analysis (MDA) and Iranian listed companies' dataset for the years 1998 to 2005. This test was carried out in the stepwise method of discriminant analysis. The following null and alternative hypotheses of H_0 and H_1 were defined as follows:

H_0 : The derived model is not significant

H_1 : The derived model is significant

In MDA technique, how much the Wilks' Lambda statistic is smaller for the extracted and observed model, the significance of that model is higher, and H_0 can so be refuted with the reliance span of 95% and the opposite H_1 then would be accepted.

The final independent variables and derived coefficients in the MDA technique on Iranian listed companies dataset for 1, 2 and 3 years prior to bankruptcy and entering the initial independent variables as shown in table 1 above in the MDA modelling, has been demonstrated in table 4 below:

TABLE 4
Independent variables and coefficients derived in MDA technique

Row	Independent variable	Coefficients		
		1 year before	2 year before	3 year before
1	Earning Before Interest and Taxes/Total Assets (EBIT/TA)	1.76	1.256	2.169
2	Working Capital/Total Assets (WC/TA)	-3.215	-5.387	-6.137
3	One if total liabilities exceeds total assets, zero otherwise (OENEG)	1.994	--	--
4	Net Income / Total Assets (NI/TA)	7.317	8.235	5.287
5	Intercept	-1.565	-1.416	-1.206
6	Group Centroids (Z score Domain)	-1.56<Z<1.56	-1.612<Z<1.612	-1.565<Z<1.565

Wilks' Lambda and Canonical Correlation for the resulted figures of table 4 above has been shown in table 5 below:

TABLE 5
Wilks' Lambda and Canonical Coefficients of the derived models in MDA technique

Year prior to bankruptcy	Wilks' Lambda	Canonical Correlation
One year before	0.281	0.848
Two years before	0.268	0.856
Three years before	0.279	0.849

On the basis of the models derived as shown in table 4 above, the following model prediction accuracy was resulted as shown in table 6 below. it's noted that, the same as the analytical procedures carried out on hypothesis 1, due to the lack of sufficient information and low correlation between the substance of article 141 of Iran commerce law and the actual collapse of the bankrupt companies (i.e. the companies filed for the article are not discontinued nor laid off from the exchange board), the gray (critical) area has not been further analyzed into group 1 and 2.

TABLE 6
Classification results – MDA prediction technique for 1, 2 and 3 years before

Year	Actual			Predicted			Accuracy	
	Group 1	Group 2	Total	Group 1 (Bankrupt)	Group 2 (Non-Bankrupt)	Gray Zone (Critical)	Number correct	Percent correct
One year before	20	20	40	10	13	17	**23**	**57.5**
Two year before	20	20	40	8	10	22	**18**	**45**
Three year before	20	20	40	8	10	22	**18**	**45**

4.2.2 Multiple discriminant analysis

The objective of this part is to develop a model for predicting bankruptcy issue in one, two and three years before, by the application of Logistic regression technique and Iranian listed companies' dataset for the years 1998 to 2005.

This test was carried out in the stepwise backward method and by the definition of H_0 and H_1 as follows, the significance of the derived models have been proved by differentiating statistics of Wald, Cox and Snell R Square, -2 Log Likelihood, Chi-square and the significance of the sole variables derived from each step(less than 10%).

H_0 : The derived model is not significant

H_1 : The derived model is significant

The final independent variables and derived coefficients in the this technique on Iranian listed companies dataset for 1, 2 and 3 years prior to bankruptcy and entering the initial independent variables as shown in table 1 above in the Logit modelling, has been demonstrated in table 7 below:

TABLE 7
Independent variables and coefficients derived in Logit technique

Row	Independent variable	Coefficients		
		1 year before	2 year before	3 year before
1	Size [Log(TA/GDP Index)	7.287	--	--
2	Working Capital/Total Assets (WC/TA)	-18.518	-627.172	-26.087
4	Net Income / Total Assets (NI/TA)	43.701	798.9028	--
3	One if total liabilities exceeds total assets, zero otherwise (OENEG)	--	-55.808	--
1	Earning Before Interest and Taxes/Total Assets (EBIT/TA)	--	--	10.127
5	Intercept	-25.183	--	--

If upon entering the independent variables of a specific company into above models, the conditional probability of the resulted Z value as per the equation 3 above, is greater than 0.5, the company is classified as non bankrupt, less than 0.5, it's bankrupt and the point of 0.5 in this threshold, is the grey area or critical zone which requires more investigation for the classification.
The relevant statistics of the derived models in the table 7 above, demonstrating the quality of the models are shown in table 8 below:

TABLE 8
Wilks' Lambda and Canonical Coefficients of the derived models in MDA technique

Year prior to bankruptcy	Chi-square	Cox & Snell R Square	-2 Log Likelihood
One year before	43.719	0.665	11.733
Two years before	55.542	0.750	--
Three years before	40.539	0.637	14.913

5. Conclusions

Considering the hypothesis provided in the research, the following results were achived through this research:

A. Original Altman (1983) bankruptcy prediction model, without any modification made in the independent variables and coefficients, can predict bankruptcy issue of Iranian listed companies with the accuracy of 47.5%, 37.5% and 32.5% respectively for one, two and three years before.

B. Original Ohlson (1980) bankruptcy prediction model, without any modification made in the independent variables and coefficients, can predict bankruptcy issue of Iranian listed companies with the accuracy of 47.5%, 37.5% and 32.5% respectively for one, two and three years before.

Above conclusions have been summarized in the table 9 below

TABLE 9
Comparison of original Altman (1983) and Ohlson (1980) models

Year prior to bankruptcy	Prediction Accuracy Percent		Accuracy Difference- Altman to Ohlson
	Altman	Ohlson	Percent
One year before	**47.5**	**32.5**	**15**
Two years before	**37.5**	**42.5**	**(5)**
Three years before	**32.5**	**37.5**	**(5)**

Then we can conclude that;

For one year before bankruptcy;	Altman prediction accuracy>Ohlson prediction accuracy
For two year before bankruptcy;	Altman prediction accuracy<Ohlson prediction accuracy
For three year before bankruptcy;	Altman prediction accuracy<Ohlson prediction accuracy

So, on the basis of the above conclusion; since original Ohlson model could predict the bankruptcy in more frequently, it's generally concluded that original Ohlson bankruptcy prediction model could predict the bankruptcy of Iranian listed companies more accurately than original Altman (1983) bankruptcy model.

C. Regarding the third hypothesis, by utilizing MDA and Logistic regression prediction technique, the researcher tried to develop a suitable model for predicting bankruptcy of Iranian listed companies in one, two and three years prior to bankruptcy, he concluded that the model resulted from MDA method could predict the bankruptcy issue of Iranian listed companies with the accuracy of 57.5%, 45% and 45%, respectively in one, two and three years prior to bankruptcy; meanwhile, Logistic regression technique resulted in the accuracy of 95%, 100% and 90% respectively for one, two and three years before bankruptcy on the same dataset.

Upon the above conclusion, the following summary in table 10 has been provided on the third hypothesis of the research:

TABLE 10
Comparison of MDA and Logistic regression techniques on research samples

Year prior to bankruptcy	Prediction Accuracy Percent		Accuracy Difference- Altman to Ohlson
	Altman	Ohlson	Percent
One year before	**57.5**	**95**	**(37.5)**
Two years before	**45**	**100**	**(55)**
Three years before	**45**	**90**	**(45)**

Then we can conclude that;

For one year before bankruptcy;	Logistic regression accuracy>MDA regression accuracy
For two year before bankruptcy;	Logistic regression accuracy>MDA regression accuracy
For three year before bankruptcy;	Logistic regression accuracy>MDA regression accuracy

Considering the above-demonstrated conclusions; since Logistic regression prediction technique has resulted in more accurate predictions than MDA technique, it's generally concluded that Logistic regression technique would predict the bankruptcy issue of Iranian listed companies more accurately than MDA technique.
Reviewing the research's hypothesis, and concluded results, the following summary in table 11 below has been provided, supporting the refusal or acceptance of the research hypothesis:

TABLE 11
Summary of the research's hypotheses

Hypothesis	Hypothesis description	Hypothesis status	
		Reject	Accept
Hypothesis one	Original Altman (1983) bankruptcy prediction model has more power in prediction bankruptcy issue on Iranian listed companies.	**Rejected**	
Hypothesis two	Original Ohlson (1980) bankruptcy prediction model has more power in prediction bankruptcy issue on Iranian listed companies.		**Accepted**
Hypothesis three	Multiple Discriminant analysis technique has significantly more power than Logistic regression (Logit analysis) in prediction the bankruptcy issue of Iranian listed companies.	**Rejected**	

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