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STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

SCOPE FOR FURTHER RESEARCH

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APPENDIX/ANNEXURE

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BANKRUPTCY PREDICTION OF FIRMS USING THE DATA MINING METHOD

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ABSTRACT

The purpose of this paper is to anticipate financial bankruptcy of firms in Iranian Stock Exchange using the data mining technique. To that effect, required data were gathered from financial statements of 89 companies listed in Iranian Stock Exchange active in the business of Compact Disks, and the required data were estimated and extracted for a seven-year period (2003-2009). Statistical methods used in this paper include regression analysis, diagnostic analysis, and artificial neural network. The neural network used in this paper is a multilayer perceptron trained by error back propagation algorithm and include triple layer feed-forward neural network arranged as input, centric and output neurons. The sample of the study consists of two groups of bankrupted and solvent firms. The bankrupts group has been selected based on "Article 141" of Commerce Law during 2003 to 2009, and the solvent group has been chosen randomly and with respects to the industry of the bankrupted firm. Results reveal that data mining model with 53.78% accuracy in identifying bankrupted firms and 97.10% accuracy in identifying solvent firms, and artificial neural network model with 85% accuracy in identifying bankrupted firms and 95% accuracy in identifying solvent firms can predict bankruptcy of the firms.

KEYWORDS
bankruptcy prediction, data mining, artificial neural network model, diagnostic analysis.

INTRODUCTION

Bankruptcy of firms usually has an impact on stock exchanges' liquidity and economy development. In time of bankruptcy, banks normally make funds less available to bankrupted firms and, in order to recompense the extra-risk, ask for higher interests. Similarly, financial investment institutes, such as pension funds institutes and insurance companies, decrease buying shares and focus more on investments and bonds issued by banks or similar markets. All these would lead to lesser liquidity in capital market, increase in firms' capital cost and decrease in economical growth. With respects to adverse effects of bankruptcy on capital markets and economy, scholars and stakeholders decided to develop prediction models by using different approaches in order to reduce the disadvantages and damages due to those adverse effects. Usually, different and interrelated factors lead to bankruptcy of firms; hence, it is not a simple task to identify the exact cause or causes of bankruptcy and financial issues in each specific case. Generally, factors that lead to bankruptcy of organizations are whether internal or external to the organization. External factors are those that are not controllable by the firm, however, they may lead to financial problems for the firm. On the other hand, internal factors are due to managers' faults or their inability in taking appropriate actions with respects to managerial decisions; examples include providing and increasing customers' credit, excessive sales on credit, and inefficient management.[1] Bankruptcy prediction is a binary prediction in which the firm is either bankrupted or solvent and the model developed for such prediction should be capable of determining state of bankruptcy or non-bankruptcy of firms. Data mining methods include: 1- Artificial Neural Network; 2- Diagnostic Analysis; 3- Regression Analysis; 4- Neuro-fuzzy.

In a study titled "A Comparative Study of Bankruptcy Prediction using Altman, Logit and Artificial Neural Network Models", Garkaz and Barzegar Khandoozi (2010) analyzed this issue during the 2003-2009 period; financial ratios in neural network model include: 1- working capital to total assets; 2- retained earnings to total assets; 3- EBIT to total assets; 4- equity to debt ratio; 5- net sales to total assets. Accuracy of the models in the year of bankruptcy, one year and two years previous to that is 83.5%, 76.5% and 79.5%, for Altman model; 73.5%, 64.7% and 63.8% for logit model; and, 93.7%, 99.4% and 90% for Artificial Neural Network, respectively.

In a paper titled "Predicting Financial Exhaustion of Firms in Tehran Stock Exchange during 2006-2009 using Logit, Neuro-Fuzzy Network, and Neural Network", Moosavi and Ahangari (2012) used MAE (Mean Absolute Error) and RMSE (Root Mean Squared Error) to evaluate performance of these algorithms. According to findings, mean errors for neural, logit and neuro-fuzzy models were 31%, 39% and 41%, based on RMSE, and 23%, 32% and 34%, based on MAE, respectively.

Using neuro-fuzzy model, Zangane (2009) showed that both neuro-fuzzy and logistic regression can predict bankruptcy of firms; the period for that study was 1997-2008. Findings revealed an accuracy of 96.27% for neuro-fuzzy model and 80.21% for logistic regression model.

Sung Yin Chun (2009) compared logit, artificial neural network, combinatory multiple discriminant analysis, decision tree, support vector technique and combinatory neural network technique, and by using neural network learning, offered a hybrid model for predicting bankruptcy. The results showed an accuracy of 78.15% for combinatory multiple discriminant analysis model, 78.04% for logit model, 78.01% for artificial neural network model, 72.38% for decision tree, 78.0170% for support vector technique, and 78.92% for combinatory neural network model.

Yeldiz and Akkoc (2010) conducted a research titled "Bankruptcy Prediction using Neuro Fuzzy: An Application in Turkish Banks". The sample of the study consisted of 55 banks that were divided to two groups as training and validation. The training group consisted of 11 bankrupted banks and 22 solvent banks. The validation group consisted of 8 bankrupted banks and 14 solvent banks. Independent variables consisted of the following six financial ratios: 1- capital ratios; 2- assets quality; 3- liquidity; 4- profitability; 5- income-expenditure structure; and 6- activity ratios. The results showed an accuracy of 90.91%.

RESEARCH DATA, HYPOTHESIS AND METHODOLOGY

In this research, which mainly aims at predicting firms' bankruptcy using the best predictor variables from previous studies, perceptron neural networks and diagnostic analysis are used alongside the following predictor variables. It should be mentioned that "Clause 141" of Commerce Law is the criteria for choosing a firm as bankrupted. According to "Clause 141" of Commerce Law, in the event of loss of at least half of the firm's assets, board of directors is obliged to bring together members of the general meeting of stakeholders as to decide for liquidation or survival of the firm.

Data include: 1- shareholders' equity to total liabilities and shareholders' equity ratio; 2- leverage ratios; 3- debt to equity ratio; 4- return on assets; 5- earning per share ratio; 6- return on equity ratio; 7- current ratio; 8- quick ratio; 9- current assets to total assets ratio; 10- cash flow to total debt ratio; 11- cash flow ratio; 12- inventories to total asset ratio; 13- inventories to sales ratio. Statistically, this research is a modeling study, and with respects to its methodology, it is a descriptive (semi-experimental) correlation study in which the relationship between variables is analyzed with regards to the research's objective.

Criteria for Sample Companies

They should be listed in Stock Exchange and their fiscal year should end by mid-March each year. They should not be financial intermediary firms and information about them should be available.

Hypotheses:

Hypothesis 1- Data mining model can predict firms' bankruptcy.

First, using data refinement methods, wild data were removed and then lost data were simulated using simulation method in data mining. Subsequently, we have examined factors influencing bankruptcy by using diagnostic analysis method. The results are shown in figure 1. Using Fisher statistic, we concluded that variables are significant and therefore predictable.

TABLE 1: SIGNIFICANT DIAGNOSTIC MODEL

P-value	F-value
0.000	***19.19***

19.19F=

TABLE 2: SIGNIFICANT COEFFICIENTS TEST

p-level	F-remove	Partial	Wilks'	
0.6621	0.1911	0.9997	0.6791	Equity ratio/assets
0.6375	0.2222	0.9996	0.6792	Equity Ratio
0.0904	2.8764	0.9950	0.6823	Debt/Equity
0.6958	0.1530	0.9997	0.6791	Profit before interest and taxes/ interest
0.0000	52.7839	0.9150	0.7420	Return on Assets
0.0849	2.9797	0.9948	0.6825	Earnings Per Share(EPS)
0.0725	3.2382	0.9943	0.6828	Return on equity
0.1811	1.7931	0.9969	0.6810	Currnt ratio
0.6336	0.2275	0.9996	0.6792	Acid-test raito
0.4970	0.4619	0.9992	0.6795	Currunt assets to total assets
0.0825	3.0247	0.9947	0.6825	Cash flow to totall debt ratio
0.0252	5.0376	0.9912	0.6849	Cash flow ratio
0.0079	7.1160	0.9876	0.6874	Inventory to total assets ratio
0.0000	27.4320	0.9539	0.7117	Inventory to sale ratio

According to figure 2, F function can be achieved through statistics of the similar test. From these statistics, it was revealed that what coefficients are significant and what are their values. In general, Return on Assets, Cash Flow ratio, Inventories to Total Assets ratio, and Inventories to Sales ratio are significant in the model; we used step-by-step diagnosis analysis technique to eliminate them. The results are shown in figure 3.

TABLE 3: SIGNIFICANT S ANALYSIS STEP-BY-STEP DIAGNOSIS TECHNIQUE

P-value	F-value
0.000	62.95

According to figure 3, it can be seen that the model is still statistically significant even after elimination of redundant variables. Now we examine the effect of significant variables of the model.

TABLE 4: SIGNIFICANT S ANALYSIS STEP-BY-STEP VALUES

p-level	F-remove	Partial	Wilks'	
0.000000	155.8338	0.787644	0.884333	Return on Assets
0.000000	32.9682	0.946039	0.736270	Inventory To Sale Ratio
0.003698	8.4958	0.985514	0.706778	Inventory To Total Assets ratio
0.020832	5.3702	0.990795	0.703012	Cash flow ratio

TABLE 5: VALUES OF SIGNIFICANT S ANALYSIS STEP-BY-STEP DIAGNOSIS TECHNIQUE

bankrupt	Non-bankrupt	
-1.30751	2.81911	Return on Assets
5.80543	3.77797	Inventory To Sale Ratio
-0.08599	-0.06060	Inventory To Total Assets ratio
0.00327	0.00163	Cash flow ratio
-2.48236	-1.33353	Fixed

According to figure 5, diagnosis function for solvent firms is as follows and the criterion for assuming a firm as solvent is 0.5918.

P=-1.33353+2.81911* Return on Assets +3.77797* INVENTORY TO SALE RATIO

-0.06060*INVENTORY TO TOTAL ASSETS ratio +0.00163* CASH FLOW RATIO

Diagnosis function for bankrupted firms is as follows and the criterion for assuming as bankrupted is 0.4082.

P=-2.4824+1.3075* Return on Assets +5.8054* INVENTORY TO SALE RATIO-0.08599* INVENTORY TO TOTAL ASSETS ratio +0.00327* CASH FLOW RATIO

After employing the above diagnosis function on samples, we can see that the model can describe about 79% of the firms.

TABLE 6: EXPLANATORY POWER OF DATA MINING

bankrupt	Non-bankrupt	Percent correct	
10	335	97.10	Non-bankrupt
128	110	53.78	bankrupt
138	445	79.42	Overall firms

Considering the probability value and comparing that value with the significance level, one can conclude that the "Data mining model can predict firms' bankruptcy".

Hypothesis 2- Artificial neural network model can predict firm's bankruptcy.

Similarly, to determine explanatory power of neural network model, data refining and simulation methods were used at first. Subsequently, using various models of neural networks, we tried to estimate the accuracy of neural networks in bankruptcy prediction. Neural function used in this study is perceptron. Based on a computing unit called perceptron, a type of neural network is generated. A perceptron takes a vector of inputs with real numbers and calculates a linear combination of these inputs. If the result exceeds a specific threshold, perceptron's output will be equal to 1, otherwise it will be equal to -1.

Perceptron's output is calculated based on the following equation:

$$O(x_1, x_2, \ldots, x_n) = \begin{cases} 1 & \text{if } w_0 + w_1x_1 + w_2x_2 + \ldots + w_nx_n > 0 \\ -1 & \text{otherwise} \end{cases}$$

We fed the network with the data for 5 times; the results are as follow: In figure 7 the accuracy of different neural networks are presented

TABLE 7: THE ACCURACY OF DIFFERENT NEURAL NETWORKS

Test perf.	Training perf.	neural network
90.51724	86.29550	MLP 14-12-2
89.65517	88.43683	MLP 14-9-2
88.79310	87.36617	MLP 14-4-2
90.51724	91.00642	MLP 14-7-2
88.79310	86.72377	MLP 14-***8***-2

According to figure 7, it is MLP 14-7-2 neural network model that has predicted a high percentage of the bankruptcies.

After employing mentioned neural networks, predicted bankruptcy of each network is shown in figure 8.

TABLE 8: PREDICTED BANKRUPTCY OF EACH NETWORK

bankrupt	Non-bankrupt		
187	280	**Overall firms**	MLP 14-12-2
133	270	accurate predictions	
54	10	Inaccurate predictions	
71	96	accurate predictability power	
28	3	inaccurate predictability power	
187	280	**Overall firms**	MLP 14-9-2
148	265	accurate predictions	
39	15	Inaccurate predictions	
79	94	accurate predictability power	
20	5	inaccurate predictability power	
187	280	**Overall firms**	MLP 14-4-2
150	258	accurate predictions	
37	22	Inaccurate predictions	
80	92	accurate predictability power	
19	7	inaccurate predictability power	
187	280	**Overall firms**	MLP 14-7-2
159	266	accurate predictions	
28	14	Inaccurate predictions	
85	95	accurate predictability power	
14	5	inaccurate predictability power	
187	280	**Overall firms**	MLP 14-***8***-2
134	271	accurate predictions	
53	9	Inaccurate predictions	
71	96	accurate predictability power	
28	3	inaccurate predictability power	

As mentioned, according to figure 8 the best neural network model is MLP 14-7-2 model that has the highest accurate predictability power. Overall, 280 bankrupted firms and 187 solvent firms were observed. Of these observations, 266 of solvent firms and 159 of bankrupted firms were accurately selected. Inaccurate predictions were 14 for solvent firms and 28 for bankrupted firms. The prediction accuracy percentage is 95 for solvent firms and 85 for bankrupted firms which shows better results than other models. Since neural networks predict the status of the firms accurately in 90 percent of times, it could be accepted that neural networks can predict bankruptcy of firms.

Hypothesis 3- The level of the first type error is equal for data mining and neural networks bankruptcy prediction models. (First type error means that the firm is solvent but the model has selected it as bankrupted.)

Since the bankruptcy predictability power of neural network model and diagnosis analysis technique is identified, it would be adequate to compare inaccuracy of the two models in determining bankruptcies; then, the following hypotheses are proposed:

H0: The level of the first type error is the same for data mining and neural networks bankruptcy prediction models.

H1: The level of the first type error is not the same for data mining and neural networks bankruptcy prediction models.

The statistical representation of this hypothesis is as follows:

H0: $\alpha 1 = \alpha 2$

H1: $\alpha 1 \neq \alpha 2$

Where α1 and α2 are first type errors of diagnosis analysis and neural networks models, respectively.

TABLE 9: THE LEVEL OF THE FIRST TYPE ERROR IS THE SAME FOR DATA MINING AND NEURAL NETWORKS BANKRUPTCY

Inaccurate predictions for solvent	The prediction accurate solvent	first type error	
10	335	2.90	data mining
14	266	5.00	neural networks

TABLE 10: TABLE OF TEST RATIO

P-value	Z-value
0.1849	1.3258

With regards to the probability value and comparing that value with the significance level, one can conclude that the null hypothesis or the hypothesis stating "the level of the first type error is the same for data mining and neural networks bankruptcy prediction models" is not rejected in 95% confidence level. As the values for errors are too close, it cannot be generalized, and so they are assumed as equal.

Hypothesis 4- The level of the second type error is the same for data mining and neural networks bankruptcy prediction models. (First type error means that the firm is bankrupted but the model has selected it as bankrupted.)

It is adequate to compare inaccuracy of the two models in determining non-bankruptcies; then, the following hypotheses are proposed:

H0: The level of the second type error is the same for data mining and neural networks bankruptcy prediction models.

H1: The level of the second type error is not the same for data mining and neural networks bankruptcy prediction models.

H0: $\beta 1=\beta 2$

H1: $\beta 1 \neq \beta 2$

Where β1 and β2 are the second type errors of diagnosis analysis and neural networks models, respectively. According to diagnosis analysis and neural networks models:

TABLE 11: THE LEVEL OF THE SECOND TYPE ERROR IS THE SAME FOR DATA MINING AND NEURAL NETWORKS BANKRUPTCY

inaccurate predictions in bankrupt	accurate predictions in bankrupt	second type error	
110	128	46%	data mining
28	159	15%	neural networks

TABLE 13: TABLE OF TEST RATIO

P-value	Z-value
0.0000	7.5225

With regards to the probability value and comparing that value with the significance level, one can conclude that the null hypothesis or the hypothesis stating "the level of the first type error is the same for data mining and neural networks bankruptcy prediction models" is not rejected in 95% confidence level. As the difference is high, the result can be generalized.

RESULTS AND FINDINGS

In order to perform statistical analysis required for predicting firms' bankruptcy using data mining method, 89 companies listed in Iranian Stock Exchange were chosen as samples for this study and the required data were estimated and extracted for a seven-year period (2003-2009). To determine the accuracy of the proposed hypotheses using the designed tests, information's averages were analyzed. Based on the first hypothesis of the research, data mining method can predict bankruptcies. Accuracy of this model was shown to be 53.78% for bankrupted firms and 97.10% for solvent firms. Based on the second hypothesis of the research, neural network model can predict bankruptcies. Accuracy of this model was shown to be 85% for bankrupted firms and 95% for solvent firms. Based on the third hypothesis of the research, the level of the first type error is equal for data mining and neural networks bankruptcy prediction models. Therefore, Stock Exchange can use these models for ranking of the firms and provide investors and other financial users with important information. Meanwhile, by timely disclosing of information, it could be possible to help firms' managers and economical policy makers of the country finding timely and appropriate solutions. Since by using neural network model it would be possible to analyze the bankruptcy of firms, with 95% accuracy in identifying solvent firms and 85% accuracy in identifying bankrupting firms, before bankruptcy, we suggest creditors, investors and users of financial information to determine the possibilities of bankruptcy of the subject firms using the above-mentioned model. This way, in addition to decreasing the investment risk, they could make wiser decisions. We suggest auditors to use this model in situations where they are supposed to give their opinions about continuity or bankruptcy of firms subject to auditing. Bankruptcy prediction of firms is one of the major issues in financial decision making, and, with respects to the consequences of this phenomenon on macro and micro levels of societies, considerable tools and models, each employing different methods or predictor variables, are developed globally.

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Sd/-

Co-ordinator

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