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Study of Artificial Neural Network Accuracy Compared to Statistical Model of Logistic Regression for Prediction of Iranian Firms Bankruptcy

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ABSTRACT

The use of financial ratios for predicting companies' bankruptcy has always been considered by universities and economical institutions especially banks and other financial organizations. In such studies, statistical models like multiple distinctive analyses, logit Analysis, probit Analysis have usually been used. In this study, the prediction of accepted productive companies' bankruptcy in Tehran negotiable papers exchange has been paid by the use of artificial neural network model and we have also made a comprehensive review on the models of bankruptcy prediction. In this study, artificial neural network model with logistic regression statistical model that is a useful statistical model in bankruptcy prediction has been compared. Our findings from these models on the basis of 80 companies' data showed that artificial neural network model has more accuracy than logistic regression statistical model in bankruptcy prediction.
KEYWORDS: Artificial Neural Network (ANN), Bankruptcy prediction, financial ratios, Logistic Regression (LR).

INTRODUCTION

The rapid development of technology and its effect on the world of business along with extensive environmental changes have given growing momentum to economy, so that competitive approach of economical enterprises in the field of achievement to benefit has been limited and the possibility of bankruptcy and company's financial risk have been increased. On the other hand, decision making in financial issues is always accompanied with risk because of future uncertainties. So, one way of helping to investors is prediction patterns offer about overall perspective and company's future role. If these predictions be closer to reality, then decisions on the basis of such predictions will be more accurate.

One point that can help to the way of decision making process is the existence of suitable tools and models for evaluating financial relations and organization situation, because until then decision maker doesn't have a suitable evaluation from organization, his/her choice will not be optimal. A tool used to decision making about company is the models of bankruptcy prediction, so that it can help to suitable exploitation of investment opportunities and also prevention of wasting resources. Knowledge of bankruptcy prediction has vital importance for all users of financial statements and has an effect on the decisions of decision maker groups.

So first, we can make companies aware of bankruptcy occurrence by presentation of necessary warnings; so that, they can do necessary measures with respect to these warnings, secondly, investors can discriminate desirable opportunities of investment from undesirable opportunities and they can invest their resources in suitable opportunities. Closer prediction of bankruptcy makes it easy for users [1]. Bankruptcy is almost an ancient category and is basically a static system [2]. Bankruptcy means inadequacy of cash and inability to pay debts and current liabilities.

The purpose of this study is economical bankruptcy and with article 141 of the commercial law. Bankruptcy happens when at least half of company's capital has been wasted due to incurred damages. So, the company will be subject to article 141 of commercial law and will be introduced bankrupt [3]. At first, Beaver [4] used unavailable analysis for examination of financial ratios power in financial insolvency prediction. He used most from ratios that were related to cash details in this analysis. Altman [5] examined the effect of different combinations of financial ratios for predicting company's bankruptcy for the first time. Altman used multi distinctive analysis in this study. Shah and Murtaza [6] presented a model by the use of ANN for bankruptcy prediction. In this study, the information of 60 bankrupt companies and 54 solvent companies has been used in the years between 1992 to 1994. The prediction accuracy of this model was 73 percent. Yim and Mitchell [7] have examined and index of 100 companies that included 20 bankrupt companies during the years of 1995 to 1999 in Australia. Two combinatory models of ANN-Plogit and ANN-PDA have been selected as the best models for bankruptcy prediction and their correct classification percentage was 91 percent for sound and insolvent companies. Another study has been done by Yim and Mitchell for Japan. They divided their Japanese sample into two groups of banks and companies. The best combinatory model of neural networks was ANN-Logit-Plogit that could accurately classify 94% and 96% from the whole of insolvent and sound banks in this sample respectively and also 100% and 94.7 % from insolvent and sound companies out of this sample. Raei and Fallahpour [8] have presented a model for prediction of companies' bankruptcy by the use of artificial neural networks. This model compared with Multiple Distinctive Analysis (MDA) and its findings show that the percentage of bankruptcy prediction of neural networks model for the years of bankruptcy, one and two years before bankruptcy was 95.31% , 88.12% and 78.12% respectively and also 93.44%, 86.56% and 71.25% for Multiple Distinctive Analysis (MDA) model.

Hairong, Chan and Manger [9] have studied on Australian companies. Financial information of 46 companies has been used in this study in the years of 1988 to 1990. This included 23 financial insolvent companies and 23 sound companies. Artificial neural networks model has compared with logistic regression models and also step by step distinctive analysis with

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decision making tree model. The findings of this study show that the artificial neural networks model had better performance in comparison with other models. Multi layer perceptron network has been used in over 80 percent of these studies .Also, in few studies about bankruptcy prediction by Genetic Programming (GP), finding shows it's superiority to other statistical models [10]. With respect to mentioned cases of this study, the following assumption can be taken with the purpose of bankruptcy prediction of accepted companies in Tehran negotiable papers exchange by the use of artificial neural network.

General accuracy of artificial neural networks model in company's bankruptcy prediction is more than logistic regression model. For testability acceptance this research hypothesis has been changed into three statistical hypotheses for years of t, t-1 and t-2. The t year for bankrupt companies is the year that company has been subjected to Article 141 [4] of the commercial law and for solvent companies is the basis year of information gathering. It is necessary to mention that the test of this hypothesis will be done in a meaningful level of 0.05%.

1. THEORETICAL BASES

2.1 Artificial Neural Network and Logistic Regression

Artificial neural network is a type of information process pattern that inspired from inherent or natural neural systems. Artificial neural networks are dynamic systems that can transfer hidden rules and knowledge of data into network structure through experimental data processing. So, this is called intelligent system [11].

Neural networks are composed of a series of layers that include simple parts of processor called neuron and they can act in parallel. Each input layer is related to one or more middle layer and also middle layers are connected to output layer [12]. Since many factors like hidden layers, the number of hidden layers neurons, data normalization and learning algorithm, have an effect on neural networks function, so, the best architecture of neural network will be obtained through experiment and try and error. Error Back Propagation network (BP) that is a type of feed forward network has been used [13]. Transformation function used in this study, is a sigmoid function that its formula is quall to: $f(net) = (1 + e^{-net})^{-1}$. Net means: the total weight of input variable from previous layer. By this function, the output variable amount will be between zero and one. Performance function for network training is considered as the mean sum of squared errors (MSE) that is: $F = MSE = \frac{1}{n}\sum_{i=1}^{n}(e_i)^2$. The other information related to artificial neural network are: the number of hidden layer = 1, the number of hidden layer neurons = 10, learning rate = 0.5 The iteration number depends on learning rate related to performance function. So, with 0.5 learning rate, the number of iterations in neural network 1 to 4 in the year t will be 132, 185, 135 and 156 respectively.

In this study, bankrupt companies are introduced as number zero and solvent companies as number one. So, output result of this network should be like this. Since network output is a number between zero and one through Sigmoid transformation function, so, if numerical output be less than 0.5, it will be classified as a bankrupt company and if numerical output be more or equal to 0.5,it will be classified as a solvent company.

Logistic regression is a robust statistical model that is like normal regression, but with this difference, method to estimate the coefficients is not similar. In logistic regression, instead of minimizing squared errors (that will be done in normal regression), the probability of an event happening will be maximized.

A concept called odds ratio (ratio of $\frac{P_i}{1-P_i}$ that is ratio of event happening probability to no event happening probability) has been used in logistic regression. Odds ratio logarithm will be calculated on the basis of $\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_i x_i$, this model called logic model [14].

2. METHODOLOGY

Research method was descriptive with the approach of post-eventual. Historical information of companies has comparatively been studied for research hypothesis test. Two different statistical populations have been studied in this research; the first one is accepted productive companies in Tehran negotiable paper exchange market that have been bankrupt (companies subject to Article 141 of the commercial law).

This population includes 44 companies that of course there wasn't complete access to the information of 4 companies, and the sample of bankrupt companies has been chosen from it. The second statistical population includes accepted solvent companies in Tehran negotiable papers exchange market. This population includes 332 companies, so that the sample of solvent companies has been chosen from it. Furthermore, the examination of research literature shows that coupling sampling has been used in most previous studies and for this reason we have used such method in this research.

So, the sample used in this research includes 40 bankrupt companies (chosen from bankrupt companies population) so that all bankrupt companies are available and also 40 solvent companies (chosen from solvent companies population with respect to selected samples of bankrupt companies population) that have been chosen randomly and simply from it's population. Data gathering has been done through referring to three-year old financial statements available in the library of Tehran negotiable papers exchange.

In this study, the original sample has been divided into four parts of 20's. There are 10 bankrupt companies and 10 sound or solvent companies in each of them. Then, four subsamples have been formed by the use of this 20's samples, so that, in each subsample, we have used 60 samples for network training (in the case of LR, model drawing) and 20 samples for network testing (in the case of LR, model testing). So, we have replaced 20 samples of training set with 20 samples of tentative set in each subsample.

Table1. Result of average equality test about variables used in the year t

Variables	The average in Non-Bankrupt companies	The average in Bankrupt companies	t	Sig.
Ratio of Earnings before Interest and Tax to Total Assets (EBIT_TA)	0/1571	- 0/0488	- 10/043	0/000
Ratio of Earnings before Interest and Tax to Net Sales (EBIT_NS)	0/7397	- 0/0797	- 1/460	0/014
Ratio of Total Equity to total Liabilities (TE_TD)	0/6423	0/0562	- 4/990	0/000
Ratio of Working capital to total assets (WC_TA)	0/0978	- 0/1317	- 4/763	0/000
Ratio of Current Assets to Current Liabilities (CA_CL)	1/2271	0/8616	- 5/015	0/000

All variables used in research literature have been examined to determine independent variables. So, first we calculate statistics of each variable in each two groups and also equality test of averages has been done. In this stage, final decision for choosing five original variables has been done. Table 1 shows the results of equality test of averages for applied variables. To summarize data, we have first calculated ratios by the use of gathered data for all companies and for each years of t, t-1 and t-2. All actions related to summarization have been done by MS Excel software. After data summarization, we have first considered to statistical model, i.e. logistic regression (LR) .This model has been obtained by the use of logistic regression available in SPSS software. In the next step, bankruptcy prediction will be done by the use of Artificial Neural Networks through MATLAB software and by Toolbox Neural Network.

3. RESULT AND DISCUSSION

4.1 Results

In this section, we will present research findings and their analysis in the order of scenario. Table 2 shows prediction total results of four subsamples of artificial neural network model (ANN) along with logistic regression model (LR) for the year t.

Table2. Prediction results for the year t

(t)		Artificial Neural Network				Logistic Regression			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Total	Bankrupt	37	39	39	39	37	36	37	37
		% 92/50	% 97/50	% 97/50	% 97/50	% 92/50	% 90	% 92/50	% 92/50
	Non-bankrupt	39	39	39	38	37	38	37	38
		% 97/50	% 97/50	% 97/50	% 95	% 92/50	% 95	% 92/50	% 95
	Total	76	78	78	77	74	74	74	75
		% 95	% 97/50	% 97/50	% 96/25	% 92/50	% 92/50	% 92/50	% 93/75

These results show that prediction accuracy of ANN is more than LR in all four subsamples. The difference of these two models in subsample (1), (2), (3) and (4) is equal to 2.5%, 5%, 5% and 2.5% respectively. The results of coupling comparison test for the year t have shown in table 3.

Table3. The results of coupling comparison test for the year t

n		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ANN - LR	3.75000	1.44338	.72169	1.45327	6.04673	5.196	3	.014

Table 4 shows the prediction total results of four subsamples of ANN model along with LR model for the year t-1. These findings show that prediction accuracy of ANN is more than LR in all four subsamples. The difference of these two models in subsamples 1 to 4 is equal to 6.25%, 7.50%, 3.75% and 5% respectively. The results of coupling comparison test for the year t-1 have shown in table 5.

Table4. Prediction results for the year t-1

(t-1)		Artificial Neural Network				Logistic Regression			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Total	Bankrupt	35	36	35	35	34	34	34	34
		% 87/50	% 90	% 87/50	% 87/50	% 85	% 85	% 85	% 85
	Non-bankrupt	35	36	34	36	31	32	32	33
		% 87/50	% 90	% 85	% 90	% 77/50	% 80	% 80	% 82/50
	Total	70	72	69	71	65	66	66	67
		% 87/50	% 90	% 86/25	% 88/75	% 81/25	% 82/50	% 82/50	% 83/75

Table5. The results of coupling comparison test for the year t-1

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ANN - LR	5.62500	1.61374	.80687	3.05717	8.19283	6.971	3	.006

Table 6 shows the prediction total results of four subsamples of ANN model along with LR model for the year t-2. These findings show that prediction accuracy of ANN is more than LR in all four subsamples. The difference of these two models in subsamples 1 to 4 is equal to 7.50%, 10%, 7.50% and 10% respectively. The results of coupling comparison test for the year t-2 have shown in table 7.

Table6. Prediction results for the year t-2

(t-2)		Artificial Neural Network				Logistic Regression			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Total	Bankrupt	30	36	32	34	30	31	32	32
		% 75	% 90	% 80	% 85	% 75	% 77/50	% 80	% 80
	Non-bankrupt	37	33	35	35	31	30	29	29
		% 92/50	% 82/50	% 87/50	% 87/50	% 77/50	% 75	% 72/50	% 72/50
	Total	67	69	67	69	61	61	61	61
		% 83/75	% 86/25	% 83/75	% 86/25	% 76/25	% 76/25	% 76/25	% 76/25

Table7. The results of coupling comparison test for the year t-2

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ANN - LR	8.75000	1.44338	.72169	6.45327	11.04673	12.124	3	.001

Our findings show that artificial neural network model (ANN) has a good power in prediction of company's bankruptcy. We can say this with high certainty. It is natural that the power of model prediction will be decreased by becoming farther from the year of bankruptcy happening. We can say that prediction total accuracy of artificial neural network model in bankruptcy prediction is meaningfully more than logistic regression model. So, the main research hypothesis of this study is accepted.

4.2 DISCUSSION

Findings about bankruptcy prediction through artificial neural network by MATLAB software and Neural Network Toolbox available show that prediction percentage in classifying companies for four subsamples in the year t are respectively 95%, 97.50%, 97.50%, and 96.25% and for the year t-1 are respectively 87.50%, 90%, 86.25%, and 88.75%, and also for the year t-2 are respectively 83.75%, 86.25%, 83.75%, and 86.25%. This model in the meaningful level of 5% has more power in company's bankruptcy prediction in comparison with logistic regression model. Shah and murtaza, raei and fallahpour and also Edward et.al have shown in previous studies, we can use artificial neural network with high certainly compared with statistical models.

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