PREDICTING IRANIAN COMPANIES BANKRUPTCY BY THE USE OF ARTIFICIAL NEURAL NETWORK AND ART MAP FUZZY NEURAL NETWORK

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ABSTRACT

Investors, creditors and other users of financial information always cope with the risk of losing actual or potential financial resources in their decision makings, thus everything which could eliminate the above mentioned risk or even reduce it has high importance for them and it has a special place. One of the mechanisms that could help the investors and others in reducing the investment risk is paying attention to the accounting information and patterns of predicting bankruptcy. Therefore the current research studies the ability of two models of predicting bankruptcy in Iran Stock Market during t, t-1 and t-2 years. The t year is considered as the bankruptcy year for the bankrupt companies and it is considered as the year of being placed in the sample for the non-bankrupt companies. The current research sample includes 110 accepted companies in Stock Exchange which had the determined conditions. The sampling interval is from 2003 to 2006 and the required data extraction interval includes years 2001 to 2006. The research result shows that each of the two models have the skill of predicting the bankruptcy of companies that are members of Stock Exchange but the performance of ART MAP fuzzy neural network is better.

KEYWORDS: Predicting Bankruptcy, Investors, Users of Financial Information.

INTRODUCTION

Rapid progress of technology and the environmental changes of 20th century have increasingly accelerated the economy, and they bring about the increasing competition of businesses, and this limits the companies gaining benefit and financial resources, and this matter also increases the probability of bankruptcy for natural and legal persons (Odom & Sharda, 1990). Therefore the increase of knowledge of users of financial resources helps them to make logical decisions that
are appropriate for economy, and one of the ways for helping the investors and other users of financial statements is offering appropriate patterns for predicting bankruptcy, that after 1968 this concept experienced a main change in its main methodological and it directed its main method toward using several financial ratios (Altman, 1968). While up to 1968 bankruptcy was mainly predicted by one financial ratio (Altman, 1968). Using different ratios increased the ability of these models and it resulted in immediate detection of companies who were exposed to bankruptcy and help the investors to invest in a better place (Park & Han, 2002). Anyway, the models for predicting the bankruptcy could be divided to two groups (Min & Jeong, 2008). The first group includes the models based on the statistical methods, such as univariate and multivariate models. The second group includes that type of models for predicting bankruptcy which are based on the artificial intelligence systems. This type of models was created by extending the application of artificial intelligence in financial and accounting environment from 1990 onwards. Using artificial neural networks for predicting the bankruptcies was begun from 1990 by Odom and Sharda. From this year onwards several researchers have used the artificial neural networks for predicting bankruptcy including Dorota Witkowska which designed a neural network by the use of back-propagation learning algorithm in 1999 for predicting bankruptcy (Witkowska, 1999). Golinski is another researcher who conducted a successful research at the New York University in 1998 in creating an artificial neural network for predicting bankruptcy. Golinski used the progressive back-propagation learning model for designing the network and used the financial ratios of Altman’s multiple discriminant analyses as the network input. Golinski’s research result shows that the overall accuracy of designed model of Golinski is around 96% (Golinski, 1998). The artificial neural networks are not the only tools for predicting the bankruptcy; other researchers such as Slim in 2007 used the fuzzy logical technics for presenting a model for predicting bankruptcy which has a better performance compared to the other methods such as back propagation neural network and linear discriminant analysis in predicting bankruptcy. Slim used 17 financial ratios of 68 companies in years 2000-2005 in order to design his fuzzy model. His fuzzy neural network has 5 parts, and the number 1 index shows the fuzzy network form used in Slim’s research. This research result shows that the average accuracy of predicting bankruptcy in linear discriminant analysis model, the back propagation neural network and fuzzy neural network in the experimental sample were respectively 70.83%, 81.92%, and 97.92% and in the real test they were respectively 60%, 70%, and 90% (Slim, 2007). Hung Woo is another researcher in 2007 who compared the models of predicting bankruptcy and used the support vector machine (SVM) and genetic algorithms for designing a hybrid model and compared the accuracy of the designed model with the models of multiple discriminant analysis, Probit, Logit, artificial neural network, and simple SVM model (Hung Woo and et al, 2007).

Index No.1: Fuzzy Neural Network
In 2009 Hung and Chen conducted a research similar to Hung Woo and et al; these two researchers used the decision tree algorithm, BPN and SVM models for predicting the probability of companies’ bankruptcy and they concluded that the decision tree model and BPN have the accuracy which equals 70% and 72.37% and the SVM model has the accuracy which equals 70.89%. The current research has been conducted in 2013 and it wants to use two models of back-propagation neural network and ARTMAP fuzzy neural network for predicting bankruptcy of Iranian companies being accepted in Tehran Stock Exchange and compares the accuracy of these two models. Thus the main hypotheses of this research could be formulated as followed:

1) Artificial neural network model has the ability to predict the bankruptcy of existing companies in Iran Stock Exchange.
   - $H_0$: There is no positive significant correlation between detecting the artificial neural network and actual situation of bankrupt and non-bankrupt companies.
   - $H_1$: There is a positive significant correlation between detecting the artificial neural network and actual situation of bankrupt and non-bankrupt companies.

2) Fuzzy neural network model is able to predict the bankruptcy of existing companies in Iran Stock Exchange.
   - $H_0$: There is no positive significant correlation between detecting the fuzzy neural network model and the actual situation of bankrupt and non-bankrupt companies.
   - $H_1$: There is positive significant correlation between detecting the fuzzy neural network model and the actual situation of bankrupt and non-bankrupt companies.

And for conducting such research 5 financial ratios are used, and these ratios include:

1. The ratio of working capital to total assets
2. The ratio of retained earnings to total assets
3. The ratio of earnings before interest and taxes to total assets
4. The ratio of equity to total liabilities
5. The ratio of net sales to total assets

**METHODOLOGY**
The current research seeks to find the answer to this question that whether the fuzzy neural network model and the artificial neural network model are able to predict the bankruptcy or not? And moreover it wants to introduce the most accurate model. For this firstly the appropriate sample must be chosen from the leading population. This is done by the systematic elimination method and random sampling, in a way that at first the industries are chosen and then in each of the industries two groups of bankrupt and non-bankrupt companies are chosen. The result of this operation was choosing 110 companies among 300 companies that are members of Tehran Stock Exchange, and these 110 companies include 55 bankrupt companies and 55 non-bankrupt companies. In the next step one group is chosen from the sample members as the experimental sample and designing network and providing appropriate weights to the inputs are conducted through them. Then both networks are designed and the steps of designing neural and fuzzy networks are provided below, and ultimately after designing the models the experiment begins, then by the use of two statistical methods of U-Mann Whitney and ANOVA the achieved results are analyzed and compared to each other.

Steps of designing artificial neural network:

The artificial neural network is a software program or a semiconductor chip which could act the same as human’s brain (Menhaj, 2005). When the network receives the inputs in this research which are the financial ratios according to the experimental sample and the type of optional learning by the researcher begins to weight each of the inputs and in the current research the network learning is back-propagation algorithm. The back-propagation method is created by generalizing the training rules of Widrow-Hoff in multilayered network that has decision making derivative function. In this method the input, network output and desirable output are used for network learning and the network which has output come closer to the desirable output (Jamshidi and et al, 2007, page 219). Thus generally it could be said that back-propagation algorithm begins with randomly giving initial value to network weights and then after each weight giving it surveys the model input and estimates the error. This error along the network is called feedback and it causes some changes in the weights of nodes in their way. The algorithm is repeated in this manner until the producing outputs for the experimental data reach an acceptable level of accuracy and the errors be minimized as much as possible (Ben Coppin, 2006: page 333). Each of the neural networks has 4 parts including inputs, weights, transfer function and network output. And the transfer function of current research artificial neural model is called sigmoid function which is achieved through the below formula:

$$f(NET) = \left[ 1 + e^{-NET} \right]^{-1}$$

And by NET we mean total weight of input variables from the previous layer. By the use of this function the amount of output variable will be a number between 0-1. Mainly in artificial neural
networks, regulating is used for preventing maintaining network. In fact in this method the performance function which is usually MSE or SSE is modified. The MSE function includes:

\[ F = \text{MSE} = \frac{1}{N} \sum_{i=1}^{N} (e_i)^2 \]

In regulating method for improving the capability of network generalizing one phrase is added to the performance function which includes the mean sum of squares of weights and neural network biases. This performance function in MATLAB software is known as MSEREG.

\[ \text{MSEREG} = \gamma \text{MSE} + (1 + \gamma) \text{MSW} \]

And \( Y \) is the performance ratio and a number between 0 and 1.

\[ \text{MSW} = \frac{1}{n} \sum_{i=1}^{n} W_j \]

Using this performance function causes to have smaller network weights and smaller biases, and this by itself forces the network to provide smoother responses. By using this performance function the final results were very favorable. The results of neural network training and method of reducing error are shown in index No. 2.

Neural-Fuzzy Network Designing Steps
The theory of fuzzy sets was firstly used by Mamdani in 1975 exactly one decade after introducing the theory of fuzzy sets. The biggest and most important capability of fuzzy systems is their ability in implementing and running the conceptual models and the humanistic approaches, which means that one fuzzy system has the ability to use the same method which an expert uses for decision making or modeling and implement it under complete accuracy. Fuzzification, inference engine, knowledge base and Defuzzification are four main parts of each fuzzy system. Methods of communication and formation of these four parts are shown in index No. 3.

Index 3: The overall Structure of One Fuzzy System

One of the most important issues in designing each fuzzy system is the issue related to the inputs, type and amount of inputs, membership functions and their amount, and the amplitude of the input signals and all of them are known as fuzzification. One of the most practical membership functions is Gaussian membership function and its overall form is as below:

\[ f(x) = e^{-\left(\frac{x-m}{\sigma}\right)^2} \]

And \( m \) is the sign for the center of fuzzy set and \( \sigma \) is the sign of variance. Another member of this function is knowledge base which includes a series of fuzzy rules of if-then and it is mentioned below:

\[
R_1: \text{If } x_1 \text{ is } A_{1}^i \text{ and } x_2 \text{ is } A_{2}^i \text{ and } \ldots \text{ and } x_n \text{ is } A_{n}^i \text{ then } y \text{ is } B_1 \\
R_2: \text{If } x_1 \text{ is } A_{1}^j \text{ and } x_2 \text{ is } A_{2}^j \text{ and } \ldots \text{ and } x_n \text{ is } A_{n}^j \text{ then } y \text{ is } B_2 \\
\vdots \\
R_N: \text{If } x_1 \text{ is } A_{1}^N \text{ and } x_2 \text{ is } A_{2}^N \text{ and } \ldots \text{ and } x_n \text{ is } A_{n}^N \text{ then } y \text{ is } B_N
\]

Which within \( X^T = [x_1, x_2, \ldots, x_n] \) is the input variables vector, \( y \) is a vector and \( N \) is the number of rules in the knowledge rule. \( A_{i}^j, i = 1, \ldots, N \text{ and } B_{j}, j = 1, \ldots, N \) are the membership
functions for the input and output variables. In order to eliminate the weakness of spending too much time for regulating the membership functions in fuzzy systems efforts have been made to use the neural network learning technics. The fuzzy-neural systems which are called TSK systems consist of a series of if-then rules as the following figure:

\[
R_1: \text{If } x_1 \text{ is } A^1_1, \text{ and } x_2 \text{ is } A^1_2, \text{ and } \ldots, \text{ and } x_n \text{ is } A^1_n \text{ then } y_1 = \sum_{k=1}^{n} a^1_k \mu^1_k(x_k) + b_1
\]

\[
R_2: \text{If } x_1 \text{ is } A^2_1, \text{ and } x_2 \text{ is } A^2_2, \text{ and } \ldots, \text{ and } x_n \text{ is } A^2_n \text{ then } y_2 = \sum_{k=1}^{n} a^2_k \mu^2_k(x_k) + b_2
\]

RESULTS:

The current research results show that both models have the capability to predict bankruptcy of accepted companies in Tehran Stock Exchange, but the ARTMAP fuzzy neural network has higher abilities., in a way that the accuracy of artificial neural network model in bankrupt group for years t, t-1, and t-2 were respectively 100%, 100% and 94% while in the very same group for years t, t-1 and t-2 the designed fuzzy neural model had the accuracy of 100%, 99%, and 96%, of course the same exists in the non-bankrupt group and the accuracy of artificial neural network for years t, t-1 and t-2 is respectively 87%, 98% and 86% while the results of bankruptcy prediction of neural-fuzzy model for years t, t-1 and t-2 are respectively 99%, 96% and 95%. The achieved results are also predictable in advance, because the neural-fuzzy model has two fuzzy and neural logics and it has more capability of learning and deducting and it could predict the future better. The results of both models are shown below:

<table>
<thead>
<tr>
<th>Model</th>
<th>Performance accuracy in group</th>
<th>For year t</th>
<th>For year t-1</th>
<th>For year t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial neural network model</td>
<td>Bankrupt</td>
<td>100%</td>
<td>100%</td>
<td>94%</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>87.5%</td>
<td>98.7%</td>
<td>86.3%</td>
</tr>
<tr>
<td>Neural-fuzzy network model</td>
<td>Bankrupt</td>
<td>100%</td>
<td>99%</td>
<td>96.5%</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>99%</td>
<td>96%</td>
<td>95.5%</td>
</tr>
</tbody>
</table>
The hypothesis test also shows that both models have the capability of predicting bankruptcy of companies that are members of Tehran Stock Exchange and as it is reflected in the below table the results of studying the correlation between reality and assessment of the model show the existence of a significant correlation.

Results of Artificial Neural Network Model with Back-Propagation Algorithm

<table>
<thead>
<tr>
<th>For year</th>
<th>Studying the correlation between reality and assessment of the model</th>
<th>Correlation coefficient</th>
<th>Sig</th>
<th>Status</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td></td>
<td>0.889</td>
<td>0.000</td>
<td>Inside critical region</td>
<td>Existence of a positive significant correlation between assessment of the model and reality</td>
</tr>
<tr>
<td>t-1</td>
<td></td>
<td>0.962</td>
<td>0.000</td>
<td>Inside critical region</td>
<td>1st hypothesis accepted</td>
</tr>
<tr>
<td>t-2</td>
<td></td>
<td>0.844</td>
<td>0.000</td>
<td>Inside critical region</td>
<td></td>
</tr>
</tbody>
</table>

Significance level is 0.05 but in significance level 0.001 this correlation exists as well

<table>
<thead>
<tr>
<th>For year</th>
<th>U-Mann Whitney test for studying the significant differences between group means</th>
<th>Z</th>
<th>Sig</th>
<th>Test interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td></td>
<td>-1.07</td>
<td>0.28</td>
<td>If sig &gt; 0.05 then no significant difference exists between the means</td>
</tr>
<tr>
<td>t-1</td>
<td></td>
<td>-1.59</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>t-2</td>
<td></td>
<td>-1.59</td>
<td>0.11</td>
<td></td>
</tr>
</tbody>
</table>

After studying the existence of a significant correlation between the results of each model and the actual (real) status of companies that are members of the sample, it was time for this question that is there equality between the mean of results of both neural and neural-fuzzy model or not? And for answering this question the U-Mann Whitney test was used. And as it is observable in the table, the results of both models are not equal and the neural-fuzzy model has more capabilities.
Results of ARTMAP Fuzzy Artificial Neural Network Model

<table>
<thead>
<tr>
<th>For year</th>
<th>Studying the correlation between reality and assessment of the fuzzy model</th>
<th>Correlation coefficient</th>
<th>Sig</th>
<th>Status</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td></td>
<td>0.986</td>
<td>0.000</td>
<td>Inside critical region</td>
<td>Existence of a positive significant correlation between assessment of the model and reality</td>
</tr>
<tr>
<td>t-1</td>
<td></td>
<td>0.962</td>
<td>0.000</td>
<td>Inside critical region</td>
<td></td>
</tr>
<tr>
<td>t-2</td>
<td></td>
<td>0.921</td>
<td>0.000</td>
<td>Inside critical region</td>
<td></td>
</tr>
</tbody>
</table>

For year U-Mann Whitney test for studying the significant differences between group means

<table>
<thead>
<tr>
<th>For year</th>
<th>U-Mann Whitney test for studying the significant differences between group means</th>
<th>Z</th>
<th>Sig</th>
<th>Test interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td></td>
<td>-1.01</td>
<td>0.22</td>
<td>If sig &gt; 0.05 then no significant difference exists between the means</td>
</tr>
<tr>
<td>t-1</td>
<td></td>
<td>-1.54</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>t-2</td>
<td></td>
<td>-1.54</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>

Acknowledgement

This article was extracted from a research project supported by the Islamic Azad University, Aliabad katoul Branch. The authors of this Research acknowledgement of research sector specially research assistant of Islamic Azad University, Aliabad katoul Branch from for their cooperation

REFERENCES


