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A comparison of artificial neural network and fuzzy neural network for prediction of financial distress of companies using bank facilities

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Abstract: One of the most important issues in the field of investment is the issue of financial distress and bankruptcy of companies. The phenomenon of bankruptcy affects financial institutions, employees, suppliers, investors and finally customers and sometimes causes irreparable loss. Banks are the institutions that are responsible for accumulating the excess liquidity of the country and directing it to the economic units which need liquidity. Therefore, the risk of non- repayment of facilities by customers is one of the important issues that influence their activities. Accordingly, banks seek to avoid the risk of capital loss by predicting bankruptcy. In recent decades, using artificial intelligence techniques which predict distress has been considered by institutions and experts. Due to the importance of this issue, the present study deals with the prediction of distress by comparing artificial neural and fuzzy neural methods. For this purpose, a sample of over 50 companies using the bank facilities was selected. Bankruptcy is predicted first by artificial neural network and then by fuzzy neural network. The results suggest that the fuzzy neural network shows a better predictive ability than the artificial neural network.

Key words: *Financial distress; Artificial neural network; Fuzzy neural network*

1. Introduction

The rapid advancement of technology and its impact on the business world along with considerable environmental changes have increasingly accelerated the economic growth which have limited the enterprises' competitive approach to gaining profit and increased probability of bankruptcy and financial risk of companies. In such an environment, compared to the past, more strategic decisions are needed in order for organizations to survive and maintain their competitive position. On the other hand, decision-making in financial issues is always risky, due to uncertainty. Therefore, one of the methods to take advantage of investment opportunities properly and avoid wasting investors' resources is the prediction of financial distress or bankruptcy. Achieving this requires providing prediction models regarding the overall prospect and the future position of the company. If these predictions are closer to reality, the decisions which are made based on such predictions will be more correct. This study attempts to predict financial distress of companies which use bank facilities in the form of fuzzy neural and artificial neural networks.

2. Financial distress of companies

Predicting financial distress, by designing indexes and appropriate models, can help companies become aware of the occurrence of financial distress and bankruptcy and adopt correct policies according to the warnings. Financial distress and bankruptcy of companies result in wasting resources and investment opportunities. On the other hand, those who are active in capital and money market need the information concerning the financial position and performance of current companies. However, one of the major risks faced by banks is the risk of repayment default or credit risk. In Iran's banking system, the main task of banks is still resource mobilization and its allocation in the form of financial facilities. The interest rate of facilities is used beyond economic policies in various economic sectors and the banks which provide facilities have been deprived of the chance of compensation of the risk of non- repayment of facilities by interest rate fluctuations.Therefore, if it is possible to predict the probability of occurrence of financial distress by measuring the model, the loss of wealth in the form of physical and human capital can be prevented. One of the methods through which we can benefit from investment opportunities and better allocation of resources is the prediction of the financial distress or bankruptcy of companies. This means that firstly, investors and creditors will be able to distinguish appropriate investment opportunities from inappropriate ones and invest their resources in appropriate investment opportunities (Mehrani et al., 2004). Secondly, by providing the necessary warnings, companies can become aware of the occurrence of financial distress and can take appropriate measures according to the warnings. Thus, the prediction of financial distress and bankruptcy of companies has always been one of the

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topics of interest to investors, creditors and governments. Identifying the companies that are on the verge of financial distress is very desirable since it prevents inappropriate and inefficient investment by marketers. In this regard, the present study aims to provide an appropriate model in order to predict the financial distress of companies which use bank facilities. Financial distress is a phenomenon that results in the bankruptcy of the business unit. Moreover, financial distress is defined as a situation in which a company is unable to meet its obligations and cannot consequently continue its business activities. Signs of financial distress are:

1. The output flows exceeding the input cash flows achieved from operations (according to historical or predicted financial statements)
2. Unfavorable main financial ratios
3. Default in payment
4. The lack of financial support of the government or creditors
5. The failure to provide the necessary financial resources in order to produce and supply new original product by making others necessary investments
6. Massive operational losses

3. Artificial neural network

It is a network consisting of a number of interrelated elements called neurons which have some inputs and outputs .This network does a relatively simple task. Generally, neural networks receive their task during a training process. The task of brain and nerves, due to the millions of years of evolution, is the most complete and efficient model to identify our surrounding events. Researches and interest in artificial neural networks began since brain was known as a dynamical system with a parallel structure of processing quite contrary to conventional processors. Over the years, neurologists have been making an attempt to understand how the human brain works which resulted in the creation of artificial intelligence. The new approach to the brain function was the result of thoughts which were formed in the early twentieth century regarding structure of the brain as a collection of small computational components called neurons. The human brain contains a hundred billion neurons which are presumed to have 6×10^{14} relationships. This means that there is actually a very complex network which causes the human brain to act as a parallel processor. The most basic structural units of the nervous system are neurons. The tissues which are called nerve are a collection of neurons that transfer the information and messages from one part of body to another part. These messages are electrochemical messages. Although neurons have the same function, their size and shape depend on where they are located in the nervous system. Each natural neuron is comprised of four main components including cell body, dendrite, axon and synapse. Artificial neural network contains an input and output layer. The input layer consists of input variables such as $[x_1, x_2, \dots, x_n]$, where n is the number of variable. The output layer also contains a large number of output variables and each input x is connected to an output y. The signal p_j of input j is multiplied by the weight w_j. J is the number of input connection, an adder which adds the inputs of neuron with bias b-values. This activity is referred to as linear combination. A stimulus function is used to limit the output of neuron in an optimal range (Ghasemi, 2001).

4. Fuzzy neural network

Fuzzy Network is a network for taking measures under uncertain conditions which puts many of the inaccurate and ambiguous concepts, variables, and systems into a mathematical form and lays the groundwork for reasoning, inference, control, and decision making under uncertain conditions. It is also a kind of powerful combination tool of artificial intelligence that, according to the rules, from a number of ambiguous input variables, processes a value with certain values as the output of the system by fuzzy logic or making the inputs, weights and artificial neural network nodes fuzzy. In order to solve the problem by the fuzzy inference method, the inputs and outputs must first be identified. Afterwards, the following steps should be taken (Lee, 1990): step one: making the data (inputs) fuzzy, step two: utilizing fuzzy operators, step three: specifying the output according to fuzzy rules of Hough input , step four : summing all outputs , step five: non-fuzzy phase .

5. Research methodology and the studied variables

The variables used in this study are as follows:

1. Current assets to current liabilities ratio(X1)
2. Cash flow to current liabilities ratio(X2)
3. Operating cash flow to total liabilities ratio (X3)
4. Retained earnings to total assets ratio (X4)
5. Working capital to total assets ratio (X5)
6. Operating cash flow to total assets ratio (X6)
7. Total liabilities to total assets ratio(X7)
8. Total liabilities to total equity ratio(X8)
9. Earnings before interest and tax to profit before tax ratio (X9)
10. Operating profit to interest expense ratio (X10)
11. Profit before tax to average total assets ratio (X11)
12. Profit before interest and taxes to total assets ratio (X12)
13. Net sales to total assets ratio (X13)
14. Gross profit to sales ratio (X14)

Inputs

The data used in this study consists of 14 financial ratios which, through factor analysis method, is converted to 3 financial factors (liquidity, capital structure, the repayment of long-term debts

and profitability ratios). Artificial neural network has been designed using three derived financial ratios. One of the most widely used neural networks is Multi-Layer Perceptron Neural Network (MLP) that has been used in most studies. An error back propagation algorithm to train these multi-layer feed forward networks with differentiable driver functions can be used for prediction, identification and classification. During training MLP network by the learning algorithm BP, first, the calculation of the input of the network towards the output of the network is done and then the calculated error values is propagated in the previous layers. At first, the calculation of the output is done layer by layer and the output of each layer will be the input of the next layer.

After conducting the necessary studies and comparing various neural networks, Perceptron Neural Networks were finally used in the present study. In the designing neural networks, the number of hidden layers, hidden nodes and output nodes was determined after determining the network type and training method and the number of input nodes.

Choosing the number of inputs is of particular significance since each input model contains important information about the auto correlated and complex data structure. Most researchers have used trial and error method to obtain the number of input nodes. In this study, the number of input nodes is considered exactly equal to the number of network inputs namely 3 nodes. There is one output node and the number of nodes in the hidden layer is considered to be two. Different models have been tested to determine the appropriate topology of neural networks, and by varying the number of neurons in the hidden layer, the main prediction model was selected. In this study, the number of optimal neurons has been considered [1, 2, 3]. By applying the input to the network, the calculations of bask propagation were first done in order to obtain the output of the neural network model. Then, the output error and the desired value were calculated and propagated among the existing layers based on back propagation relations. After that, the weight matrices and bias vectors were modified. In this method, the number of frequency of the companies in the training group was 500. By increasing the number of frequencies, the number of errors decreased, and there was almost no improvement in the final frequencies. Afterwards, by using data from the test group, the accuracy of the designed artificial neural network was tested.

6. Financial distress prediction by fuzzy neural-network

The structure of fuzzy neural network is composed of artificial neural networks and fuzzy systems. In this structure, the advantages of both neural networks and fuzzy systems have been used .This means that both the trainable characteristic of neural network, due to weighted relations, and the characteristic of fuzzy systems, i.e. inaccurate modeling ability of inference that increases the accuracy and power of decision-making under uncertain conditions have been used in the structure of fuzzy neural network.

7. The design of fuzzy neural network

In order to design the fuzzy neural network, 72 companies including 36 distressed companies and 36 healthy companies were selected as training data and the remaining 22 companies were selected as test data. The difference between fuzzy neural network and artificial neural network is in the membership function that is allocated to input data in the fuzzy neural network. In designing the fuzzy neural network, two bell-shaped membership functions are allocated to each input of the network. The number of nodes and fuzzy relations of the designed network is 36 and 8, respectively. By using the companies in training group, the number of frequencies in training the network was considered 500 and by increasing the number of frequencies, the number of errors decreased. There was almost no improvement in the final frequencies. Afterwards, by using the test group, the trained fuzzy neural accuracy was tested. Finally, by using the test group, the accuracy of the trained fuzzy neural network was tested.

8. Test of independence

Although the methods used in this study have been nonparametric and classical statistical methods have not been used, the test of independence is used to ensure and verify the validity of the achieved results. In test of independent, the predicted and actual results are measured. It can be argued that there is a significant relationship between the predicted and the actual results when the independence between the actual and predicted is rejected.

Therefore, the statistical hypotheses were determined as follows:

H_0: the independence of the predicted and actual values
H_1: the dependence of the predicted and actual values

The test statistic is defined as follows:

$$x^2 = \sum_{i=1}^{r}\sum_{j=1}^{n}\frac{(O_{ij} - E_{ij})^2}{E_{ij}} \cong x^2(r-1)(n-1)$$

In order to conduct the test of independence of the fuzzy neural network model, the expected values of frequency probability were first calculated by using the following equation:

$\pi_{ij} = \pi_i \pi_j$
$\pi_{11} = \pi_1 \pi_1 = 0.5 \times 0.5 = 0.25$
$\pi_{12} = \pi_1 . \pi_2 = (0.5 \times 0.5) = 0.25$
$\pi_{21} = \pi_2 . \pi_1 = (0.4 \times 0.5) = 0.2$
$\pi_{22} = \pi_2 . \pi_2 = (0.4 \times 0.5) = 0.2$

The following equation is used in order to calculate the expected frequencies:

$E_{ij} = N\pi_{ij}$

$E_{11} = N\pi_{11} = 22 \times 0.25 = 5.5$

$E_{12} = N\pi_{12} = 22 \times 0.25 = 5.5$

$E_{21} = N\pi_{21} = 22 \times 0.2 = 4.4$

$E_{22} = N\pi\pi_{22} = 22 \times 0.2 = 4.4$

The degree of freedom is calculated as follows:

d.f =(2-1)(2-1)

$$x^2 = \sum_{i=1}^{r}\sum_{j=1}^{n} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \cong x^2(r-1)(n-1) = 7.5$$

By taking $\alpha = 0/05$ according the Chi-Square table, the following result is obtained:

$x^2_{0.05(1)} = 3.84146$

According to the results, the hypothesis H_0 regarding the independence of data was rejected at a significance level of 5%, and it can be argued that there is a relationship between actual and predicted results.

$$x^2 = \sum_{i=1}^{r}\sum_{j=1}^{n} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \cong x^2(r-1)(n-1) = 5.0705$$

$x^2_{0.05(1)} = 3.84146$

9. Conclusion

Research hypothesis: compared to ordinary neural network, the fuzzy neural network model is able to predict the financial distress of companies which use bank facilities with higher accuracy. In order to confirm or refute this hypothesis, artificial neural and fuzzy neural network models with three inputs were designed. Artificial neural and fuzzy neural network models were able to correctly classify 75 % and 80 % of companies into two groups including healthy and distressed companies in one year before the base year. According to the achieved results, the research hypothesis was confirmed. Since proper training of neural network requires a massive amount of data, the inadequacy of accurate and relevant information that was collected from the Stock Exchange Organization is one of the reasons of the low accuracy of models. In the present study, fuzzy neural network model, due to the fact that it can complement the artificial neural network and improve its performance and also due to the lack of financial information, shows a better performance than artificial neural network with little difference.

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