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Designing Bankruptcy Prediction System Using Artificial Neural Network Based on Evidence from Iranian Manufacturing Companies

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Abstract: Financial distress and bankruptcy result in a lot of costs. The costs will extend to different groups such as creditors, investors, managers, legal institutions and eventually capital owners. Bankruptcy prediction is a way that significantly can avoid financial distress. The purpose of the study is to design a system using artificial neural network to predict bankruptcy of companies listed in Tehran Stock Exchange before occurring bankruptcy, this system should be designed in a way that can predict the financial situation of company within the next three years. The research method is ex-post facto or survey and the statistical population of research including companies listed in Tehran Stock Exchange during 2001-2010. The data of 54 companies (30 bankrupt companies and 24 companies with Tobin Q above one) was tested by two parameters: 0.15 and 03% accuracy (optimism and pessimism).

Key words: Designing system, artificial neural network, bankruptcy prediction, Tehran Stock Exchange.

INTRODUCTION

Today, rapid advances of technology, vast changes in environment and economic globalization have accelerated economic growth and increasing competition of companies has restricted benefit access and increased the probability of bankruptcy. Company bankruptcy is usually determined by various and interrelated factors. Bankruptcy factors are generally including external and internal factors (Newton, 1998, 2009; Keats and Bracker, 1988). The subject of bankruptcy can be examined through observing direct impact of external and internal factors on the bankrupt company or analyzing financial ratios of bankrupt companies. Financial ratios reflect interactive effects of external and internal factors on company's poor financial position (Foster, 1986; Morris, 1997). Using financial ratios determine signals to show that company goes toward financial distress, before it declares its bankruptcy (Sandin and Porporato, 2008). Financial distress and bankruptcy result in a lot of costs. The costs will extend to different groups such as creditors, investors, managers, legal institutions and eventually capital owners and damage the world's economy considerably. Bankruptcy prediction is a way that significantly can avoid financial distress. Thus, firstly, by providing necessary warnings companies should be alerted to the occurrence of financial distress, so that they take preventive measures according to these warnings and secondly, investors can identify favorable investment opportunities from unfavorable investment opportunities to invest their resources at the best times. From a long period of time financial distress prediction of companies have been considered as the most important issues in financial field (Adnan and Dar, 2006). Recent studies in the field of Artificial Neural Networks (ANN) show that due to non-linear, non-parametric and adaptive learning characteristics of (ANN)'s, they are powerful tool for identifying and classifying prediction patterns (Lee *et al.* 1996). ANN Models have been used in many financial problems such as prediction of financial bankruptcy and they usage are rising. Most researchers who have used ANN to predict financial distress concluded that prediction accuracy using ANN significantly is higher than traditional statistical techniques (Atiya, 2001). The purpose of the study is to design a system using artificial neural network to predict financial situation of company within the next three years and in this way can help managers and investors in planning and right decision-making.

The importance and necessity of research: Since, the bankruptcy imposes huge social and economic costs on society, it should be taken into consideration from macroeconomics perspective because wasted resources in an economic unit being exposed to financial crisis could be allocated to other profitable opportunities. With

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respect to the content, all people and concerned authorities are interested to predict bankruptcy before it occurs (Leshno and Spector, 1996). Having outlook on companies' situation in different conditions was the main reason of this study so that how will be the future of company if everything is the best or if the condition of community or that industry is the worst?

Literature background

Bankruptcy: Bankruptcy is almost an ancient category. In one of the first academic studies on the theory of bankruptcy, it is defined as inability of company to make a profit that increases the potential inability to repay interest and origin of debt (Gordon, 1971). The definition of Dun and Bradstreetfrom the term of bankrupt companies is: business units that stop their operations due to assignment, bankruptcy, stop the current operation with losses by creditors (Newton, 1998). Whitaker (1999) defines bankruptcy as a situation in which the cash flows of the company is lower than total interest expense related to long-term debt (Wiegeraad and Kriens, 1997). Each network is trained by receiving examples. Training is a process that finally results in learning.

Artificial neural networks: An artificial neural network is one of computational methods that by learning process and using processors called neuron to present a mapping between the input space (input layer) and favorable space (output layer) by recognizing inherent relationship among data. Hidden layer or layers, processes the data received from the input layer and convert it to the output layer. Learning network happens when link-weights between the layers are changed so that the difference between predicted and measured values is acceptable. By achieving this situation, learning process becomes true. These weights represent the memory and network knowledge. Trained neural network can be used to predict the outputs accordance with new set of data (Dayhoff, 1990). According to the neural network structure, its major features are high processing speed, learning model by presenting model, Generalization ability of knowledge after learning, flexibility against unintentional errors and lack of a significant disruption in case of difficulty in connections because of network weights distribution (Wiegeraad and Kriens, 1997).

Research background: The first study was conducted in the area of bankruptcy by Patrick in 1930 (Latinen and Kankaanpaa, 1999; Khanna, 1990) and then a lot of researches have been done to create bankruptcy prediction models known modeling method. These researches can be classified into two groups.

Statistical analysis: Studies attempting to predict by separate examining of every individual ratios. These studies have focused on analysis of financial ratios and their logic is that if there are significant differences between financial ratios of bankrupt and non-bankrupt firms, they can be used as bankruptcy predictor variables. Researches conducted by Tabachnick and Fidell (2001) Merwin (1942) and Beaver (1966) are classified in this category.

The second group of multiple diagnostic analyzing: Multivariate method that classifies the phenomena based on incompatible features. In other words, it is a statistical method used to classify observations into predefined groups (Altman, 1968; Latinen and Kankaanpaa, 1999). The purpose of multiple diagnostic analyzing is to predict the assignment of a specific item to a group or category among all groups and categories. The underlying assumption of multiple diagnostic analyzing is that a figure may be classified into one or more groups. In case of bankruptcy, bankrupt firms make up a group and non-bankrupt companies make up another one and each item is actually a company (Hossari, 2006). Researches conducted by Altman (1968, 2000), Deakin (1972), Booth (1983) and Altman *et al.* (1977) belong to this group (Altman, 1968, 2000; Altman *et al*., 1977; Booth, 1983; Deakin, 1972). The study is divided in two categories that each one has several subcategories and including parametric and non-parametric models. Discriminant analysis and conditional probabilities models are subdirectories of parametric model and neural network and recursive models are subdirectories of non-parametric model. Studies conducted by Martin (1977), Zavgren (1985) and Ohlson (1980) considered as parametric studies by Martin, (1977), Ohlson (1980), Zavgren (1985) and studies conducted by Frydman *et al.* (1985), Salchenberger *et al.* (1992), Tam and Kiang (1992) Charalambous *et al.* (2000), Charitou *et al.* (2004), Zhang *et al.* (1999), Coats and Fant (1991) and Wallace (2004) are examples of studies in the field of non-parametric models (artificial neural network and recursive model.

Most studies about bankruptcy belong to Altman (Odom and Sharda, 1990). Altman's multivariate discriminant analysis method was the milestone of discovery and identification of the financial crisis (Wiegeraad and Kriens, 1997). Altman suggested z-score model. This model later was revised by Altman, Haldman and Naryanan (Wiegeraad, 1999) and named ZETA credit

risk model. Altman presented the inverse model of ZETA credit risk model in 2000. He chose the multiple discriminant analysis as an appropriate statistical technique to classify observations into one of two target groups (bankrupt or non-bankrupt firms). Z-score model is a linear discriminant function composed of some criteria measured objectively, used as a basis to classify companies into two groups (bankrupt and non-bankrupt) companies. Ahelson presented a logarithmic model to predict bankruptcy. He has examined the main tetra factors that may result in bankruptcy. This tetra factors including the size of company, scales of company's financial pressure, performance standards and discrimination criteria of company. He used 9 financial ratios and analysis of multi-dimensional logit to create his model (Odom and Sharda, 1990).

CA-scoer: This model was established by scientists of Québec University in Canada and multivariate analysis method is used in this model. In this study 30 financial ratios of a sample of n = 173 of luxury plants that their annual sales were equal to 1-20 million dollars were used. In this model, when CA-score<0.3, companies will go bankrupt (Somers and Casal, 2008).

Dimitras *et al*. (1996): to improve the prediction of business crisis, they were conducted a comprehensive survey of literature on financial crisis. The 158 articles have been investigated and they were classified based on the country, industry, time, financial ratios and models. Although in the 1980s many approaches are presented to overcome the limitations of discriminant analysis but the findings showed that discriminant analysis technique is the most common system in financial crisis researches (Dimitras *et al*., 1996).

Wallace (2004) he designed a model using neural networks. In this model, the values of key financial ratios that in previous bankruptcy studies were reported as the best ratios were used. He used the ratios of working capital to total assets, cash flow to total assets, net profit to total assets, total liabilities to total assets, current ratio and quick ratio. Overall accuracy of his model was 94% (Wallace, 2004).

Raei and Falahpour in their study titled prediction of company's financial distress using artificial neural networks to predict financial distress in 80 production companies, they use Multivariate discriminant analysis model as a comparison model and according gather evidence conclude that in predicting financial distress, the prediction accuracy of artificial neural networks model significantly is higher than discriminant analysis model.

SoleimanieAmiri (2003), using multiple regression models and the data of 30 healthy and 30 bankrupt companies, he presents a model to predict the financial crisis in production companies and has tested this model three years before financial crisis. The results of this research suggest that mentioned model in one, two and three years before financial crisis has been classified respectively 95, 83 and 95% of total sample correctly (Gepp, 2005).

Purpose of research: This study is going to use the theoretical base of artificial neural networks and also on the basis of past empirical research and the use of financial ratios to design a system to predict bankruptcy of companies, this purpose is practical. The main objective of research is to design a system using artificial neural networks to predict bankruptcy of listed companies in Tehran Stock Exchange prior to bankruptcy.

Questions of research: The main question: How can a system be designed using artificial neural networks to predict bankruptcy of listed companies in Tehran Stock Exchange?

Sub-questions:

- How can a system be designed to predict bankruptcy?
- What kind of data should be selected to enter design system?
- How can a system be trained to act intelligently?
- How can system output be analyzed by two views (optimistic and pessimistic views)?

MATERIALS AND METHODS

The statistical population of research including companies listed in Tehran Stock Exchange during 2001-2010. To select a sample, primarily to train network, list of companies covered by Article 141 of the Commercial Code (financial distress), during 2001-2010, was prepared according to the following features:

- Financial period is ended up in 19 March
- The fiscal year is not changed during the study
- Not be a part of investment, leasing companies, insurance and bank
- Companyis financial statements should be available

Accordingly, 30 companies were selected. After that, in the same time the data of 24 companies were selected; these companies should have following conditions: Firstly, they have features mentioned above, secondly,

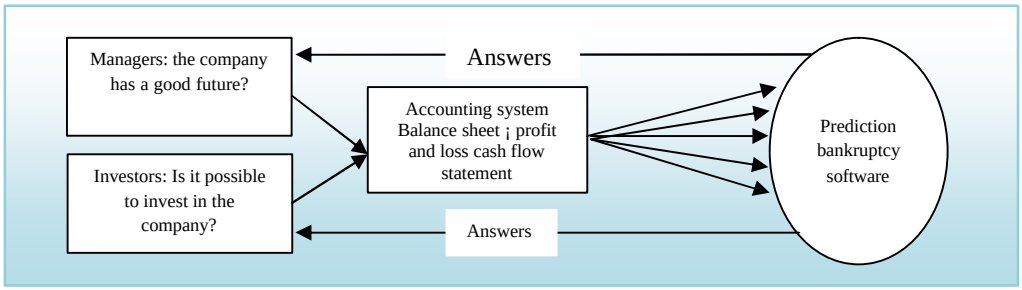

Fig. 1: The designed system based on decision support systems

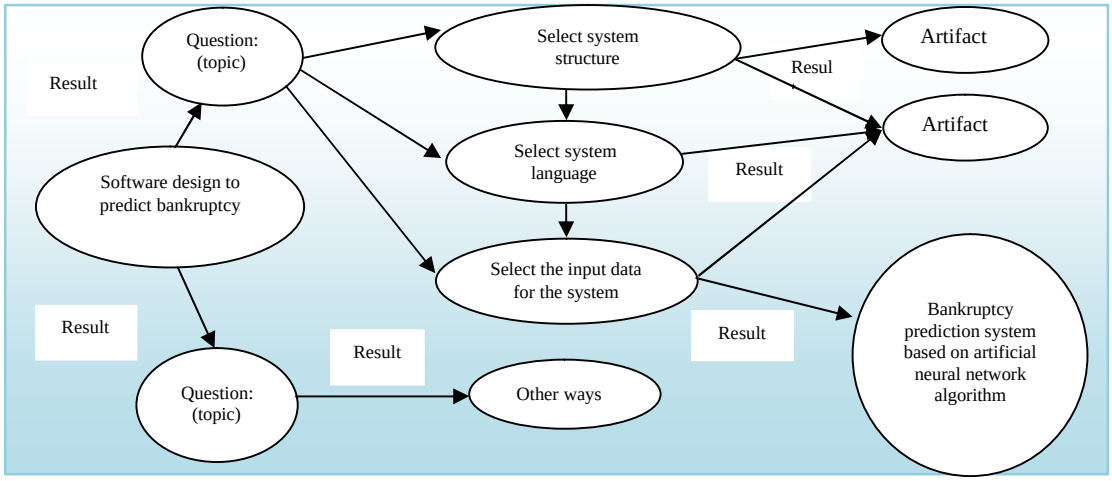

Fig. 2: System designing model to predict bankruptcy

their Q Tobin coefficient for 3 years (in mentioned timeframe) is more than one and thirdly, in the same 3 years, they are among the top 100 companies in Tehran Stock Exchange.

The first group enters data to the system and regarding as unsuccessful companies and the second group tests the accuracy of the system and regarding as successful group. To test the accuracy and reliability of the system a standard Tobin Q is used as the main criterion to select successful groups or non-bankrupt companies. When Tobin Q is above one, it indicates that there is an incentive to invest in companies. Successful companies are selected among those companies that their Tobin Q on three consecutive years is above one (Tan and Xiao, 2007; Tamari, 1966). The research method is Ex-Post Facto or Survey that have be done using audited financial statements of sample companies, In terms of inference method this research is descriptive.

The process of designing system in this study

The structure of designing system: In this research decision support systems was used to design the system (Fig. 1).

System designing model to predict bankruptcy in this study: To design a system model, the model (Potts and Bruns (1988) which has many applications in computer software design and most computer systems are designed based on this model was used with minor modifications as seen in Fig. 2 (Potts and Bruns, 1988; Wiegeraad and Kriens, 1997).

Algorithmused in the system design (bankruptcy prediction) in this study: Figure 2 shows the deigned model for the present study. In designed algorithm, two data categories in form of five selected financial ratios can be logged in.

Data collected prior to bankruptcy of companies experiencing financial distress in the next 3 years. The data stored in the system to improve system power and performance. Data belongs to the companies which we don't know their conditions and by arrival of the current financial ratios of those companies we are going to predict their future status.

Figure 3 shows the algorithm used to design bankruptcy prediction system. User can monitor the

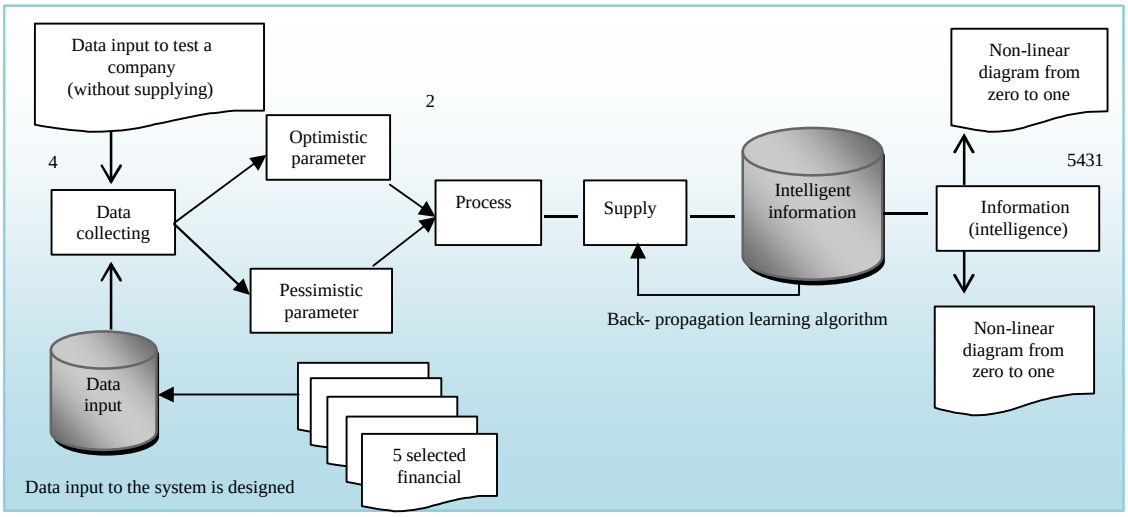

Fig. 3: System designing model to predict bankruptcy in the study

future situation of company using two parameters: Optimistic parameter (0/015) and pessimistic parameter (0/03). Coefficient of training system based on back-propagation algorithm is in range 0/01 to 0/09. The output is non-linear diagram arises from zero to one.

Variables and research pattern: This model is an artificial and mathematical model and its inputs including:

- X_1: Earnings before interest and taxes to total asset
- X_2: Earnings before interest and taxes to net sales
- X_3: Total equity to total liabilities
- X_4: Working capital to total assets
- X_5: Current Assets to current liabilities

After analyzing and special processing, these inputs are converted to one or more output variables. Inputs are independent variables and outputs are dependent variables. Thus, the research pattern was formulated as follows:

$$Y=f(X_1, X_2, X_3, X_4, X_5)$$

Information processing: This system is prepared in the form of software which runs on each computer system supported by Windows XP or Windows 7. This system is structured and programmed in the format of C# programming language. This system is formatted in a form of CD installed on a computer by running and installing its setup file. The prerequisite of CD installation is SQL SERVER 2008 software that should be installed on a computer before running setup file.

How to run a system and its data output: After installing the system, data can be logged in system by hand or machine. After entering data, the system can transform and process data into useful information in two ways.

Optimistic parameter (0.015): This parameter obtained by trial and error method optimistically examines and reports the situation of company in the next 3 year. Obviously, companies seen optimistically in the area of bankruptcy will be in the worst situation in the next three years and if in this case a company seenon the brink of bankruptcy, good condition is not predicted for it.

Pessimistic parameter (0/03): This parameter as well as the above parameter is obtained by trial and error method. In this case by entering the number of (0/03), system examines and reports the next status of company in the most possible pessimistic situation. Obviously, the future of companies seen in green area (pleasant area) in the most pessimistic situation will be the best and also the situation of companies seen in orange area (on the brink of bankruptcy) is predicted and reported not too bad.

After processing information by system, the result will present non-linear diagram as seen in following figure in the output part of function F. This diagram takes a number between 0-1 and considers the situation of company in the next three years. The maximum point of function is number one which is the sign of highest probability of bankruptcy for a company to be tested. (Red diagram). If output number of function is a number between 0.50-0.70, it means that the company is on the

Table 1: Results of designed system test for two groups of companies (successful and unsuccessful)

	Successful (Q_{tobin}>1)				Unsuccessful (bankrupt)			
	Pessimism (0.3%)		Optimism (0.15%)		Pessimism (0.3%)		Optimism (0.15%)	
Group companies prediction	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Pleasant	83.7	20	100	24	0.0	0	3.40	1
Brink of bankruptcy	16.3	4	0	0	13.3	4	16.60	5
Bankruptcy	0.0	0	0	0	86.7	26	80.00	24

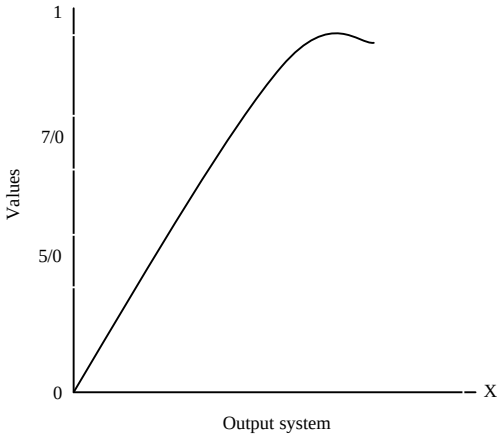

Fig. 4: data outputsystem

brink of bankruptcy (Orange diagram) and if output number of function is in the area less than 05.0 or much more tends to zero, is a sign that company is far away from bankruptcy (Green diagram). In the output part a menu is designed as the level of accuracy that can be assigned it a number from 0-1. If input number is much closer to zero, the system will examine the situation of company more optimistically and if it is much closer to one, it will report the situation to the user more pessimistically (Fig. 4).

The structure of neural network in this study

Neurons: Networks formed three layers of input, hidden and output are common types of artificial neural networks in decision-making (Dimitras *et al*., 1996). So the network used in this study is Multi-Layer Perceptron (MLP). The number ofneurons in the input layers is equal to the number of predictor variables it means equal to 5 and the number of neurons in the output layers regarding to the network output was selected 1. Determining the number of network hidden layers was not easy but after many tests so that the overall network performance was improved and by using trial and error method, 7 neurons were selected for hidden layers. Figure 4 shows an overview of designed network. To train a network of back-propagation learning algorithm is used (Fig. 5).

Conversion function: conversion function used in this study is sigmoid function that always produces values

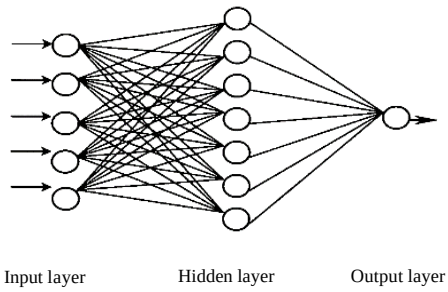

Fig. 5: An overview of designed neural network

between 0-1. One of the most important benefits of this function is that it is not in the status of threshold:

$$F(Z) = \frac{1}{1+e^{-z}}$$

Programming language in designing system: The design is done using MLP Model in neural network and system programming language is C-shop (The importance and the main difference of this system designing with previous one is in the type of selected programming language for this study) C-shop language is a high level language with high level of flexibility and adaptability. Most of the previous designs are based on language issue and the most important objection is the lack of dynamism and applications for different modes. In data processing section to find the correct weight of data and training network engine and form plat as the following model is use (Fig. 6).

Designed system test: To test the designed system two groups of companies with two parameters (optimism and pessimism) have been tested. In Table 1, the tests results are declared.

The results of the test indicate that with optimism parameter (015.%), among 30 unsuccessful companies, system can predict the situation of 24 companies correctly, it means that in the most optimistic case system predicts that these 24 companies will go bankrupt in the next 3 year. System also predicts that in the most optimistic case the situation of 5 companies will be on the brink of bankruptcy. In this test only one company is in

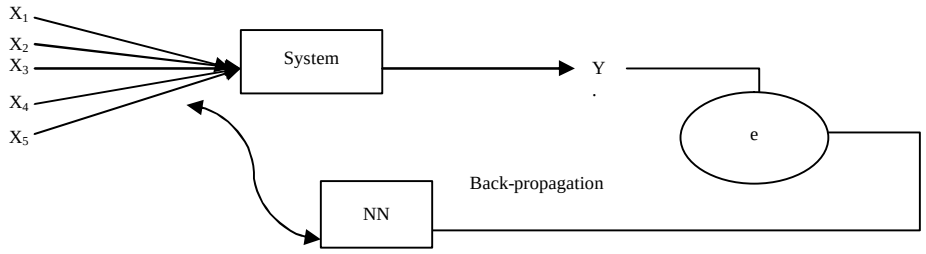

Fig. 6: The design is using MLP Model

the good condition that detected as the error of system. The results of the test indicate that with pessimism parameter (0.03), among 30 tested companies, system can predict the situation of 26 companies correctly. It means that system predicts that these 26 companies will go bankrupt in the next 3 years. System also predicts that in the most pessimistic case the situation of 4 companies will be on the brink of bankruptcy. It means that financial situation of such companies will not show the pleasant situation or clear vision. The results of system test for successful companies by using optimism parameter (0.015) indicate that system (100%) predicts their future correctly. The system indicates pleasant future for those companies that are part of the Exchange's top companies.

Note: It should be noted that if green condition is attributed to companies that use optimism parameter (0.015), it does not mean that those companies have pleasant future or good outlook but a tested company should be examined by using both optimism and pessimism parameters in order to comment about the future of company. As seen in the table, by using pessimism parameter (0.03%), 20 companies are in green condition (pleasant), it means that the system is able to predict the situation of 20 companies correctly. The 4 companies are in orange condition. Regarding that these 4 companies are in green condition as optimism parameter (0.015) is used and in orange condition as pessimism parameter (0.03) is used, it can be concluded that the company have normal condition.

Companies in green zone in terms of using both two parameters of optimism (0.015) and pessimism (0.03): If Companies are in green zone in terms of using both two parameters of optimism (0.015) and pessimism (0.03), it can be concluded with high confidence that the company will be successful in future. In these circumstances, by getting output information of system, the user can look at the future of company positively. In these companies usually the ratio of shareholder's equity to debt is above one (or near one).

Companies in green zone in term of using optimistic parameter (0.015) and in orange zone in terms of using pessimistic (0.03): In this case system reports that the future of company is normal (not too good and not too bad). In this condition, people who use the output information of system can predict balanced future for company.

Companies in green zone in term of using optimistic parameter (0.015) and in red zone in terms of using pessimistic (0.03): Information content of such kind of output could be evidence that the situation of company is very fragile in future, it means that if the situation is not changed and everything remains as usual, the company may not go bankrupt, but if something distasteful is happened and prevents improvement of company like reduced profitability or loss of customer (even small amount), it will cause crisis in future. Such companies may be able to survive financially in future and maybe even by meeting a little unpleasant event they will go bankrupt and experience financial crisis. In fact, this situation is an alert for the uncertain future state of company.

Companies in orange zone in terms of using both two parameters of optimism (0.015) and pessimism (0.03): The system reports predict unpleasant situations for such companies. The amount of returns on sales and returns on assets in such companies are usually low but the ratio of shareholder's equity to debt is far away from danger zone (There is a low debt in the capital structure of such companies) usually financial problems (sales and profit problems) in these companies result in risk of financial crisis in future (the amount of debt in the capital structure of such companies is gradually increased and they cannot afford it). In this situation, there is a negative information content for users to predict the future state of the company.

Companies in orange zone in term of using optimistic parameter (0.015) and in red zone in terms of using pessimistic (0.03): This situation is a sign of beginning

crisis for companies. If these companies can modify conditions (improve the condition) by modifying returns on sales and profitability and using specific features in the corporate governance framework, they can improve their future and the future of company, otherwise experiencing financial distress and cannot continue their activities.

Companies in red zone in terms of using both two parameters of optimism (0.015) and pessimism (0.03): These companies are in incubation period of bankruptcy and likely they will experience bankruptcy in the next one to 3 year and they cannot afford the debt and face with sharp drop of shares in Stock Exchange Market.

RESULTS AND DISCUSSION

Status of operating profit ratio to sales and operating profit to assets in incubation period before bankruptcy: Returns on sales and returns of assets of often companies in the three years before bankruptcy are greatly reduced. The average of operating profit ratio to assets in 1-3 years before bankruptcy is as follows: (-0.01 and 0.038 and 0.057). Also the average of operating profit ratio to sales is respectively: (0.061, 0.041 and -0.04). The results indicate returns on sales and assets of most companies before bankruptcy is less than 10%.

Status of capital structure in incubation period before bankruptcy: If among 30 failure companies surveyed in this study a simple arithmetic mean of shareholder's equity to debt ratio is calculated, the result respectively are: 33, 25 and 21%. But the point that should be carefully considered is the variance of averages that is a big number (0.05, 0.038 and 0.02).due to some unexpected circumstances or reasons such as corporate governance, financial situation of some companies suddenly is changed, by deleting these companies from arithmetic mean list (4 companies from 30 surveyed companies) including Malayer industrial company, Tabriz making compressor, Jahan vegetable oil, Pars appliances, variance is changed and new variance is obtained: 0.02, 0.026, 0.02. Now the average ratio of shareholder' s equity to debt will be respectively: 15, 125 and 11%. About 3 years before bankruptcy, 85% of capital structure of these companies was drowning in debt and one year before bankruptcy, 90% of capital structure of these companies was drowning in debt. If the amount of debt in capital structure of a company increases, company's risk of bankruptcy will be increased. As a result, the company should be able to increase the status of probability and returns on assets. Otherwise, increasing debt in the capital structure is a risk for company.

Status of working capital in incubation period before bankruptcy: To survey Company's working capital than current assets, current liabilities should be considered. Arithmetic mean of the ratio for the 30 failed companies of this study respectively three and one year before bankruptcy are: 1.26, 1.16 and -1.04. Again, in the same order the variance of the mean is: 0.15, 0.08 and 0.03, to reduce the variance, 4 companies mentioned above is deleted from list; new variance (0.08, 0.017 and 0.03) of these ratios is reduced to: 1.04, 0.936 and 0.9 that it is a sign that the beginning of incubation period of bankruptcy is the beginning of decreasing working capital. By decreasing current assets and increasing current liabilities, it can be concluded that the borderline of number one for this ratio is the boundary between the onsets of the crisis, it this ratio reaches number one; it can be an alarm for company.

The importance of weights in selected financial ratios: The most important ratio among 5 important ratios is the ratio of operating profit to assets and then the ratio of working profit to sales that if it is high, it can compensate the weakness of other ratios and then the ratio of current assets to current liabilities and working capital to total assets are important. The ratio of shareholders' equity to debt is the least important ratio among selected ratios of study.

CONCLUSION

The results of the designed system test indicate that in terms of pessimism parameter, the system prediction accuracy for unsuccessful companies is 96.6% and for successful ones is 100% and in terms of optimism parameter, the system prediction accuracy for unsuccessful companies is 86.7% and for successful ones is 83.7%.

LIMITATIONS

The main limitation of this study was the lack of access and connection with board of directors of companies surveyed in this study. Due to time limitation, it is not possible to test the system comprehensively.

SUGGESTIONS

It is suggested that this system is available to all users of financial information of companies listed on Tehran Stock Exchange to provide beneficiaries with genuine signs of surveyed company's situation. To improve the quality of information reporting of this

system, all users should collect data of any new company before its bankruptcy and add it to the system, in this way it will be promoted automatically.

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