Transactions on Quantitative Finance and Beyond

www.tqfb.reapress.com

Trans. Quant. Fin. Bey. Vol. 1, No. 2 (2024) 226–232.

Paper Type: Original Article

Predicting the Factors Affecting the Bankruptcy of Companies Using AHP-TOPSIS Technique and an Approach to Artificial Neural Networks

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Citation:

Received: 15 February 2024 *Revised: 07 April 2024* *Accepted: 17 September 2024*	Eskandari Nasab Siahkoohi, M. (2024). Predicting the factors affecting the bankruptcy of companies using AHP-TOPSIS technique and an approach to artificial neural networks. *Transactions on quantitative finance and beyond, 1*(2), 226–232.

Abstract

One of the biggest risks in the economies of countries is the bankruptcy of industries and companies. Predicting the bankruptcy of companies and industries provides the opportunity for the government, investors, and shareholders to take strategic actions to deal with crises and prevent potential losses. From an economic perspective, financial distress can be interpreted as the company being loss-making, in which case the company has failed to succeed. In fact, in this case, the company's rate of return is less than the cost of capital. Another form of financial distress occurs when the company fails to comply with one or more of the debt covenant terms, such as maintaining the current ratio or the special value ratio to total assets according to the contract. Therefore, there is no general agreement on the definition of financial distress, and the reasons that lead companies towards failure are very different. One possible reason for failure is the wrong direction of the company, which can be analyzed through the financial ratios of the companies. Since the 1960s, many studies have only examined financial ratios as indicators of failure. Therefore, the analysis is the basis for improving and developing failure prediction models. In this study, the influential variables in predicting bankruptcy were first selected using backgrounds. The most important factors were identified with the opinions of experts, and the weight of each criterion was obtained using the AHP technique. Then, these criteria were ranked using the TOPSIS technique to identify the most important factors. After completing these steps, by entering these variables into an artificial neural network of the multilayer perceptron type as input and using the backpropagation algorithm to train the network, the prediction accuracy increased, and accurate and reliable results were obtained.

Keywords: Financial distress, Bankruptcy, AHP-TOPSIS method, Backpropagation algorithm.

1 | Introduction

Today, the significant and rapid development of technology, along with extensive environmental changes, has given an accelerating pace to the field of economics; also, the increasing competition among institutions has limited profit margins and increased the likelihood of bankruptcy. Therefore, key stakeholders, managers, investors, and other commercial partners are interested in evaluating the financial position of a company and its tendency towards bankruptcy. Additionally, the financial distress of large international companies has made

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10.22105/tqfb.v1i2.39

the issue of financial distress or, in other words, bankruptcy, a very important concept in the field of economics and financial sciences. This is because, in the event of bankruptcy, high costs are imposed on companies and the government; on the other hand, the bankruptcy of companies affects market liquidity and economic development. Furthermore, financial distress and bankruptcy of companies lead to the waste of resources and failure to take advantage of investment opportunities. During bankruptcy, banks usually reduce lending to bankrupt companies and demand higher interest rates for the loans they provide to compensate for the additional risk. Similarly, investment institutions such as pension funds and insurance companies reduce stock purchases and tend more towards investing in bank loans or similar markets. All of these factors lead to a decrease in liquidity in capital markets, increased costs for companies, and a decrease in economic growth.

The bankruptcy of large companies and the financial scandals of some companies in recent years justify the increasing need for more extensive and in-depth research in the field of financial distress. Financial distress is a situation where a company does not have enough cash flow to meet its financial obligations. In the literature on asset pricing, the concept of financial distress has been discussed to explain abnormal patterns in stock returns. Since changes in a company's capital are considered a future indicator of company risk, investors pay great attention to this when making decisions about investing in securities [1]. Therefore, analyzing a company that is experiencing financial distress is essential. On the other hand, having sufficient knowledge in the field of risk management and understanding the difference between systematic and unsystematic sources of financial distress is important for choosing active and passive investment strategies in securities of distressed companies. Additionally, studying the risky behavior of financial distress and its impact on the stock returns of companies is useful for understanding the incompatible processes in distressed companies before bankruptcy. It can be used to improve crisis management in companies. This research can be of great interest to banks and financial institutions, as when a company applies for a loan, these institutions must assess the possibility of bankruptcy before responding to loan requests, as they will bear the highest costs in the event of bankruptcy. Financial scandals have led to a decrease of hundreds of billions of dollars in market value and loss of investor confidence in capital markets. Therefore, investors and creditors have a strong inclination to predict the financial distress of companies. On the other hand, this prediction can serve as a warning for shareholders and company managers, as it can influence their decision-making. From a management perspective, the tool of predicting the bankruptcy of companies provides the opportunity to take timely strategic actions to prevent the waste of resources and take advantage of suitable investment opportunities.

2 | Research Method

The main goal of the present research is to understand better the factors affecting the bankruptcy of companies and to investigate and predict the bankruptcy point of companies based on their financial statements. Also, implementing these factors in artificial neural networks for more accurate prediction [2]. This research is applied in terms of goal, descriptive in terms of method, correlational in terms of research method, and modeling in terms of statistics [3]. In the present research, after library studies, variables for prediction were considered based on the best ratios in the results of previous research, such as the ratio of pre-interest and tax profit to total assets, current ratio (Current assets to current liabilities), the ratio of accumulated profit and loss to total assets, the ratio of shareholders' equity to total liabilities, and the ratio of total liabilities to total assets. The required data for this research was obtained by referring to the software archive of the Tehran Stock Exchange, the website of the Research and Islamic Studies Management of the Stock Exchange, and the Codal website and downloading all the financial statements of the companies listed on the stock exchange [4]. The population studied in this research consists of textile manufacturing companies listed on the stock exchange between the years 2011 and 2018. The sample used consisted of 21 textile companies whose information was available and were selected as follows:

First, a list of companies that had been subject to article 141 of the commercial law based on the company's legal inspector's report between the years 2011 and 2018 was prepared. Among them, 21 companies with

available financial information were selected [5]. Then, based on the financial ratios that were selected using the backgrounds and the expert opinion matrix to find the weight of each, the Analytic Hierarchy Process (AHP) technique was used. After the options and indicators were determined, pairwise comparisons were made between the indicators. In this research, a questionnaire was prepared at this stage to measure pairwise comparisons between the criteria, and experts and accounting professors were used for this purpose. They were asked to rate the questionnaire with a numerical selection between one and nine based on the importance of the criteria.

2.1|AHP Algorithm Stages

The steps are as follows [6]:

I. In the first step, we multiply the pairwise comparison matrix of the criteria by the vector of relative weights obtained from it.

II. In the second step, we divide the result by the vector of relative weights of the criteria to obtain the compatibility vector.

III. In the third step, we calculate the arithmetic mean of the elements of this vector, which is called λ.

IV. In the fourth step, we calculate the inconsistency index as follows:

$$\Pi = \frac{\lambda - n}{n - 1}.$$

In the fifth step, the IRI index is extracted based on n (number of indices) from the following random matrix incompatibility index table, and the Incompatibility Rate (IR) is calculated from the following equation.

$$IR = \frac{\Pi}{IRI}.$$

Using the pairwise comparison matrix, the weights of the criteria were determined, and then the criteria were ranked using the TOSIS technique and Excel software.

2.2|TOPSIS Algorithm

I. Quantifying and scaling the decision matrix N.

II. Obtaining the weighted non-dimensional matrix $V = N * W_{n*n}$.

III. Determining the positive ideal solution and negative ideal solution.

vj ideal positive solution + = {vector of best eigenvalues}.

vj ideal negative solution -={vector of worst eigenvalues}.

"The best values" for positive indicators are the largest values. For $d_j^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}$ negative indicators, the smallest values and "The worst" for positive indicators are the smallest values, and for negative indicators, the largest values.

IV. Calculating the distance of each option to the positive and negative ideal.

$$d_j^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}.$$

$$d_j^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2}.$$

V. Determining the relative proximity of each option to the idealso lution.

$$cI_i = \frac{d_i^-}{d_j^- + d_i^+}.$$

VI. Ranking options: the larger the cl of an option, the better it is [7].

Ultimately, in order to input data into the artificial neural network, the same number of bankrupt companies, a healthy company, should be selected as the second group [8]. The criteria for selecting healthy companies are as follows:

I. They should preferably be in the same industry.

II. Their information should be available for the years 2011-2018.

III. They should be within a certain size range.

The second group is selected using a random sampling method. It is necessary to determine the effective factors in the performance of the neural network, including the number of hidden layers, the number of neurons in each layer, the learning algorithm, the activation function, the learning rate, the number of iterations, normalizing the data, and the size of the training and testing sets, in order to design a neural network in MATLAB software [9].

2.3 | Findings

Dependent variable: this research is only about bankruptcy [10]. Independent variables: quantitative variables or financial ratios extracted from financial statements. The variables used in the study are variables that have been selected using previous research. These are financial ratios that more researchers have used. These variables are listed in the table below.

Table 1. Predictive Predecessor Variables of Bankruptcy.

Variables
Return on assets before interest and taxes to total assets.
Current ratio (Current assets to current liabilities).
Equity ratio (Shareholders' equity to total liabilities).
Total liabilities to total assets.
Accumulated profit and loss ratio to total assets.

3 | Input Variables

3.1 | Research Resulets

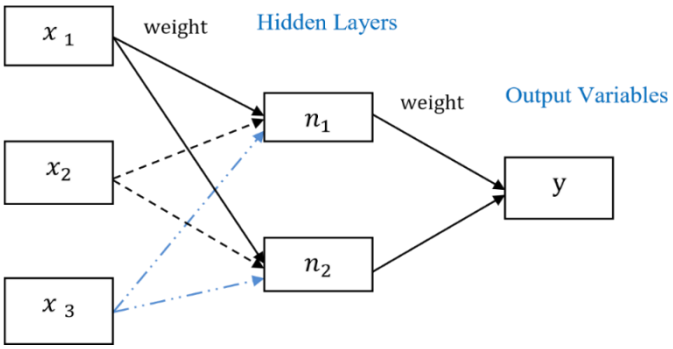

Fig. 1. Conceptual model of research for artificial neural network [11].

Using experts' opinions and the necessary information from financial statements, the results have been summarized in the following tables using AHP and TOPSIS techniques.

Table 2. The main predictive factors of financial distress are according to experts' opinions.

Variable Name	Number
Return on equity	1
Net profit margin	2
Capital	3
Assets	4
Operating profit	5
Capital turnover ratio	6
instantaneous ratio	7
Cash ratio	8
Asset turnover	9
Current ratio	10

Table 3. Results of AHP analysis.

Weight Obtained From the AHP Technique	Independent Variable	Rank
0. 206	Operating profit	1
0.157	Current ratio (Liquidity)	2
0.020	Quick ratio	3
0.263	Asset turnover ratio	4
0.173	Net profit margin	5

Table 4. Ranking of predictive variables using the TOPSIS technique.

CL	$d-$	$d+$	Independent Variables	Rank
0.647	0.066	0.036	Current ratio	1
0.611	0.055	0.035	Operating profit	2
0.586	0.051	0.036	Quick ratio	3
0.573	0.047	0.035	Asset turnover ratio	4
0.366	0.034	0.059	Net profit margin	5

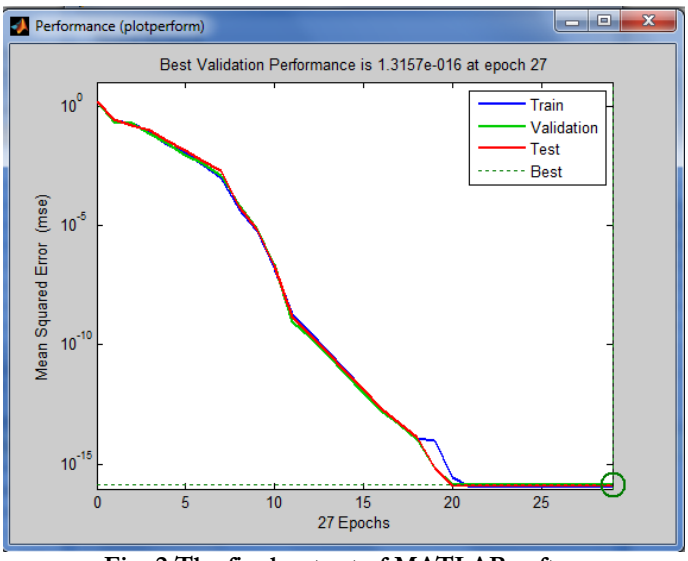

Fig. 2.The final output of MATLAB software.

4 | Conclusion

Financial distress is a condition in which a company or individual cannot generate sufficient income, leading to the inability to fulfill or pay their financial obligations. Financial distress in a company often does not occur; however, when it does, the company's stock market value drops. Therefore, an early warning of imminent bankruptcy is necessary for accurate and prompt prediction to deal with the company's bankruptcy [12]. The main goal of the present research is to understand better the factors affecting financial distress in some stock companies and to examine and predict the point of financial distress in companies based on their financial statements. This research was conducted using the AHP-TOPSIS method and artificial neural networks [13]. Therefore, in the present study, in the first stage, the identification of factors causing financial distress in steel industry companies was carried out, followed by the selection of stock indicators, and then the ranking of indicators was done using a combination of AHP/TOPSIS methods.

Bankruptcy of companies can create major crises for shareholders, managers, and the country's economy, causing them to incur significant losses [14]. Therefore, researching to examine the financial bankruptcy of companies, identify its causes and factors, and be able to address company issues with problem-solving methods to prevent the loss of national wealth in the form of physical and human capital and its consequences becomes increasingly important. One of the important issues in the field of financial decision-making for any company is predicting its financial bankruptcy. From a management perspective, the tool for predicting financial bankruptcy provides the possibility to take timely strategic actions and avoid bankruptcy. Therefore, finding a model to predict the bankruptcy of companies is essential. The results obtained in this research show that, based on the prioritization that was done, among the five important selected factors, the current ratio has a higher priority compared to other factors, and by entering variables into an artificial neural network, the predictability capability can be increased [15]. The accuracy and precision of prediction can be improved to prevent financial crises and irreparable losses in unfavorable conditions with appropriate decisions.

Author Contribution

Mohammad Eskandari Nasab Siahkoohi developed a systematic methodology for evaluating and ranking these factors to assist organizations, investors, and policymakers in reducing bankruptcy risks.

Funding

This research did not receive support from any particular grant offered by public, commercial, or non-profit funding organizations.

Data Availability

The data used in this study to evaluate the sustainability of suppliers are proprietary and cannot be disclosed to the public. Nevertheless, summarized information and methodological details may be provided upon reasonable request to the corresponding author.

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