Research on Early Warning Model of Financial Dilemma of Listed Enterprises on Small and Medium-sized Board

Shishi Sima
School of Foreign Languages, Central South University, Changsha 410083, China
767407098@qq.com

Abstract. Financial risk accompanies with the development of enterprises from start-up, maturity to recession. Under the new normal economic situation, China's economic growth slows down. Small and medium-sized board listed companies are facing greater financial risk than before. Financial early warning is a method to detect, diagnose and alarm the financial risks existing in the financial management activities of enterprises according to the changes of business conditions and financial indicators. This paper uses BP neural network to construct a financial early warning model for SME listed companies in China under the new normal background, and tests the accuracy of the model in the warning. Based on the test, it is assumed that the model achieves a good early warning effect. Finally, according to the characteristics of SME listed companies under the new normal situation, this paper puts forward some measures to deal with financial risks.

Keywords: Small and Medium Board Listed Companies; Financial Risk; Financial Early Warning; Economic Downturn Period.

1. Introduction

Financial risk is throughout the development of every enterprise, from start-up, maturity to recession. The operation of an enterprise is always accompanied by financial risk. If an enterprise maintains a high financial risk for a long time, it will not only increase the operating burden, but also lose the confidence of investors and then form a vicious circle, which will eventually lead to the rupture of the enterprise's capital chain and the outbreak of financial crisis. Therefore, it is necessary for enterprises to detect financial risks and deal with them reasonably.

Nowadays, the downturn period has become the current situation and trend of China's economic development. [China's economic growth slows down and enterprises are facing transformation and upgrading. This macro-environment may increase the financial risk of enterprises.] Small and medium-sized board listed companies are small-scale companies with circulating equity. Due to the limitation of their own scale and management level, the macro-impact of the downturn period is more pronounced. The above-mentioned problem is imperial for SMEs to solve for the healthy development. Therefore, a financial early warning model for the enterprises is established, sensitive and efficient to detect the financial crisis beforehand and take timely measures in the downturn period.

2. Concept Definition and Literature Review

2.1 The Meaning and Characteristics of Economic Downturn

The economic downturn period (the new normal) is a relatively stable state of China’s economy. The economic downturn period means that China's economy has entered a new stage different from the past three decades' high-speed growth period.

The main characteristics of China's economic downturn are as follows: firstly, from high-speed growth to medium-high-speed growth, the economic growth becomes more stable; secondly, the economic structure is constantly optimized and upgraded, the development is expected to be more stable, the consumption demand of the tertiary industry is gradually becoming the main body, the gap between urban and rural areas is gradually narrowing down, the proportion of residents' income is increasing, and the development results benefit the wider public; thirdly, the downturn period of China's economy reveals a new change in China's economic growth rate and reflects a new trend of future economic development.

2.2 The Meaning of Financial Early Warning

Financial early warning refers to the method of detecting, diagnosing and alarming the financial risks existing in the financial management activities of enterprises according to the changes of business conditions and financial indicators. Specifically, financial early warning can be defined either in a broad sense or in a narrow sense. Broad-sense financial early warning is to study all the factors that may lead to the financial risks of enterprises, as long as the potential risks of enterprises are found. The narrow sense of financial early warning is the enterprise financial crisis early warning. It is a financial distress early warning of adverse capital turnover, operating losses, and even bankruptcy. This paper uses the broad sense of financial early warning.

As a diagnostic tool for enterprise, financial early warning plays a preventive role. It can predict and diagnose the financial risks of enterprises as well as prevent potential financial risks from evolving into financial crises. Through financial early warning, we can understand the risk situation of enterprises and make reasonable investment decisions; creditors can use financial early warning to judge the risk situation of enterprises and formulate reasonable credit policies; government supervision departments can effectively supervise the risks of enterprises, so as to guide and control the market; other stakeholders, such as some affiliated parties of enterprises, can also use financial early warning to guide and control the risks of enterprises. In conclusion, an effective financial early warning model is of great significance to all stakeholders of an enterprise.

2.3 Financial Early Warning Model

Financial early warning began in 1932 with Fitzpartrick' s research on single-variable bankruptcy early warning. Since then, Altman (1968) has used multiple linear judgement to carry out financial risk early warning and established Z-Score model. This model has a high accuracy in financial risk judgement. So far, it still has reference significance. However, multivariate linear judgement model requires that the independent variables of bankruptcy and non-bankruptcy enterprises should obey normal distribution and their variance and covariance should be consistent with each other. In order to overcome these limitations, Ohlson (1980) applied the multiple logistic regression model to the field of financial early warning. The conditional probability was used to judge the financial risk of enterprises. With the development of information technology, artificial neural network was gradually applied to the financial early warning of enterprises. Odom et al. (1990) used neural network to predict the bankruptcy of enterprises. The results showed that when the neural network was used to construct the model, the financial early warning model has better prediction ability. Artificial neural network model overcomes the limitations of statistical methods with strong fault tolerance and error correction ability, so its significance is well recognized by many scholars.

As the capital market started late, China has a shorter research history of financial early warning. Most of the research methods are based on foreign research. Zhou Shouhua et al. (1996) first improved Altman's Z-score model and established F-score model. Since then, some scholars have used Z-score model to study financial early warning in different industries in China. [Zhu Hongting (2019)] Wang Zong Sheng et al. (2019) separately used Logistic model to carry out financial early warning research on listed manufacturing companies in China, which had better prediction effect. [Huang Xiaoyuan et al. (1995) was the establisher of a neural network early warning system in China. The research results show that the early warning system based on neural network is simple in structure and easy to apply, indicating a broad application prospect.] Afterwards, some scholars began to apply BP neural network and therefore the application has achieved high accuracy in financial early warning of Listed Companies in different industries in China.

In summary, the domestic and foreign research on financial early warning has made considerable achievements, and with the continuous development and improvement of the securities market, the research on financial early warning has attracted more and more attention from domestic and foreign scholars. They generally divide the research objects into ST companies and non-ST companies in the study of financial early warning but simply dividing enterprises into these two categories to indicate the financial health will be slightly rough and may affect the result of early warning. In this research, the financial risk of small and medium-sized board enterprises is defined as the research object and

their financial situation under the background of economic downturn is forewarned by using the model based on BP neural network.

3. Overview of BP Neural Network

According to the previous research results, the use of BP neural network for financial early warning has better early warning effect, which does not require samples to obey a specific distribution, but overcomes the statistical limitations, has strong fault tolerance and error correction ability, and has a higher accuracy in predicting the financial situation of enterprises. Therefore, this paper uses BP neural network for financial early warning.

BP neural network, one of the most widely used neural network models at present, is a multi-layer feedforward network trained by error back propagation algorithm. It consists of two processes: forward propagation of information and backward propagation of error. BP neural network includes input layer, middle layer and output layer. Neurons in input layer are responsible for receiving input information from outside and transmitting it to middle layer and negative middle layer. The information of the last hidden layer in the middle layer is further processed and transmitted to the output layer to complete a forward transmission of information. The output layer outputs the information processing results to the outside world. When the actual output value does not match the expected output, it enters the reverse propagation stage of error. Errors are corrected through the output layer by decreasing the error gradient. The weights of layers, which propagate back and forth to the middle layer and input layer by layer, are the process of learning and training of neural networks. By learning, the weights of each layer are adjusted continuously until the error of network output is reduced to an acceptable level, or until the number of times of learning is set in advance. The network model is shown in Figure 1.

4. Empirical Study

4.1 Sample Selection and Classification

4.1.1 Samples Selection

The significance of financial risk early warning lies in forecasting the future financial risk of the company. Therefore, the choice of early warning data should be forward-looking and ensure the accuracy of forecasting. In view of this, this paper uses the financial indicators of 2016 and 2017 to forecast the financial situation of listed companies on SME board in 2018, respectively.

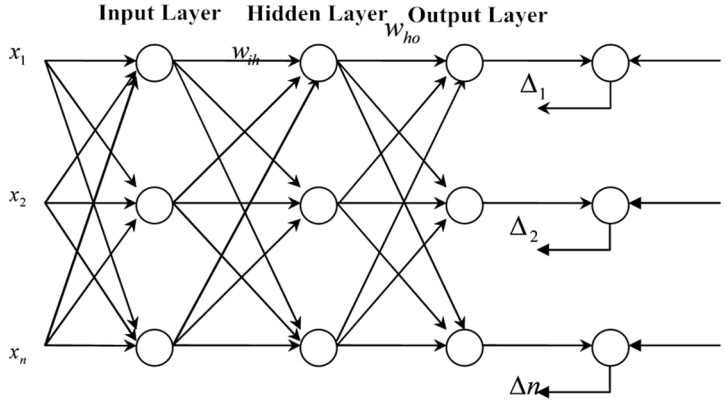

Fig. 1 BP neural network model

The object of this study is listed companies on SME board. As of December 31, 2018, there are 732 companies listed on SME board in Shenzhen Stock Exchange. In view of the data of 2016 and 2017, 701 companies listed on and before December 31, 2016 are selected to construct the model, excluding financial industry (3) and companies with incomplete data. In this paper, 695 SMEs listed on the SME board are selected as research samples.

4.1.2 Samples Classification

In previous studies on financial early warning, researchers usually classified the research objects into two categories, that is, according to whether the company is specially treated or not. This classification means that the financial situation of the enterprise is only in two states: health and crisis. In fact, the change of the financial risk of the enterprise is a gradual process. Based on this, this paper does not divide the sample enterprises into two types. ST company and non-ST company are two kinds of classification methods. Instead, cluster analysis method is used to process the sample data and divide the financial situation of enterprises into five grades, from health to heavy warning.

According to the data of financial indicators of SME listed companies in 2018, two-step cluster analysis is carried out by SPSS software. The number of clusters is divided into five categories. The statistical results are shown in Table 1.

Table 1. Statistical statement of corporate financial status

Cluster Results	Company Status	Number of Companies
1	V	20
2	I	41
3	II	267
4	III	18
5	IV	349
Total		695

This paper divides the financial situation of listed companies on SMEs board into five levels, namely, health, good, general, light and heavy warning levels, in which “health” and “good” imply the financial risks that the companies are faced with are relatively small and need to be maintained; under “general” category, the companies may have potential risks, to which appropriate attention should be paid; under the light warning level, the companies have certain financial risks, and the companies should pay attention to them. Companies in a state of serious alert may be facing financial crisis, the company should take immediate measures to deal with it. To be vigilant, it is important to identify problems in time and take appropriate measures.

4.2 Index Determination

The indicators which are selected as variables in the early warning model has a great influence on the prediction efficiency and accuracy of the model. This paper chooses the financial indicators in the early warning system from the four aspects, namely, the solvency, operating ability, profitability and development ability of enterprises to constructs the financial early warning indicator system, as detailed in Table 2.

Table 2. Financial early warning index system

Indicator type	Indicator name	Calculation formula
Solvency indicator	Current ratio	Current assets / current liabilities
	Quick ratio	Quick Assets / Current Liabilities
	Cash flow ratio	Net cash flow from operating activities / current liabilities
	Assets and liabilities	Total liabilities / total assets
	Cash flow interest coverage multiple	Net cash flow from operating activities / interest expense
Operating capacity indicator	Accounts receivable turnover	Sales revenue / average balance of accounts receivable
	Inventory turnover	Cost of sales / average inventory balance
	Total asset turnover	Sales revenue / average balance of total assets
Profitability indicator	Return on assets	Profit before interest and taxes / average total assets
	Total net asset interest rate	Net profit / average balance of total assets
	Net interest rate	Net profit / shareholder equity
	Operating profit margin	Operating profit / operating income
	Operating net profit margin	Net profit / sales income
	Net income of operating income	Net cash flow from operating activities / operating income
Development capability indicator	Capital preservation and appreciation rate	Owner's equity at the end of the period / owner's equity
	Capital accumulation rate	(Owner's equity at the end of the period - the owner's equity at the beginning of the period) / owner's equity at the end of the previous year
	Total asset growth rate	Total assets growth this year / total assets
	Operating income growth rate	Operating income growth this year / operating income in previous years
	Sustainable growth rate	[Equity Net Interest Rate × (1 - Dividend Payment Rate)] (/ 1-Molecule)

4.3 Parameter Determination

The parameters of BP neural network affect the operation efficiency and prediction error of the network, and the applicable functions of different samples are also different. [Based on the theoretical experience of the relevant design of the neural network and the continuous revision of the actual operation, the following parameters are selected to construct the neural network model for financial early warning of listed companies on SME boards.] The parameters of BP neural network are set up in this paper as shown in Table 3.

Table 3. Parameter Setting of BP Neural Network

Parameter	Value	Parameter	Value
Number of layers (layer)	3	Transfer function (output layer)	purelin
Number of input layer nodes (a)	19	Training function	Trainlm
Number of hidden layer nodes (a)	10	Learning rate	0.05
Number of output layer nodes (a)	5	Number of training	100
Transfer function (hidden layer)	tansig	Target error	0.00000001

4.4 Model Training and Testing

In this paper, the above BP neural network is trained and tested by SPSS software. 695 samples in each prediction year are divided into learning samples and testing samples. Among them, 100 samples are randomly selected as testing samples by the program, and the remaining 595 samples are trained.

Because of the characteristics of the neural network toolbox, each initialization of the network is random, the weights and thresholds are different when the training is completed, and the errors of the network will be different, so that the results of each operation of the network will be different. In order to avoid the contingency of the network operation results, this paper divides the program of 2016 and 2017 into two prediction years. Twenty times were run separately, and the accuracy of each prediction was counted. The statistical results are shown in tables 4 and 5.

According to the statistics of the operation results of the neural network model provided in Tables 4 and 5, using the financial indicators of 2016, the accuracy of the sample test basically fluctuates between 64% and 75%, and the average test accuracy of 20 times is 69.15%. In terms of the financial indicators of 2017, the accuracy of the forecast of the financial situation of the test sample is 75%. The average test accuracy of 20 operations is 78.2%. It shows that the BP neural network constructed in this paper has a high accuracy in predicting the company's financial situation, and the prediction accuracy of 2017 financial indicators for the company's financial situation in 2018 is higher than that of 2016 financial indicators.

Comparing the forecasting results of the two models, the forecasting accuracy of the financial indicators in 2017 is higher than that in 2016. When forecasting the company's financial situation, the financial data in the year (t-1) can be more accurate than the financial data in the year (t-2). When forecasting the company's financial situation with the model in practice, it can be separately used. Using the financial indicators of the first year and the first two years of the forecast year to predict the financial situation of the company, that is, two years in advance can be used to predict the financial situation of the company after two years. If the potential risk is forecasted, it can be paid attention to early. Then, one year in advance, the forecasting model of (t-1) year is used to revise the company's early warning and make a more accurate judgment of the company's financial situation. The combination of models can achieve better early warning effect.

Table 4. Statistics of BP Neural Network Operating Results of Data Samples in 2016

Operation times	Number of test samples	Misjudged number	Accuracy rate (%)
1	100	32	68
2	100	36	64
3	100	28	72
4	100	29	71
5	100	28	72
6	100	29	71
7	100	33	67
8	100	31	69
9	100	30	70
10	100	27	73
11	100	30	70
12	100	33	67
13	100	34	66
14	100	25	75
15	100	29	71
16	100	33	67
17	100	36	64
18	100	35	65
19	100	28	72
20	100	31	69
Total	2 000	617	69.15

Table 5. Statistical table of BP neural network operation results of data samples in 2017

Operation times	Number of test samples	Misjudged number	Accuracy rate(%)
1	100	21	79
2	100	18	82
3	100	23	77
4	100	19	81
5	100	24	76
6	100	23	77
7	100	20	80
8	100	24	76
9	100	24	76
10	100	21	79
11	100	23	77
12	100	22	78
13	100	18	82
14	100	25	75
15	100	19	81
16	100	24	76
17	100	24	76
18	100	24	76
19	100	19	81
20	100	21	79
Total	2 000	436	78.2

5. Conclusion

In this paper, BP neural network is used to predict the financial situation of SMEs listed on the board of our country. It shows that this prediction model has a good prediction effect on SMEs listed on the board. The model has certain prediction ability. Although the accuracy of each operation is different, the fluctuation degree of the accuracy of the results is basically maintained within an acceptable range. Therefore, the forecasting model has certain stability. In conclusion, the financial early warning model constructed in this paper has certain reference significance for managers, investors and other stakeholders of enterprises.

Under the economic downturn, SMEs in China are facing more opportunities and challenges. Managers should take precautions against financial risks from the following aspects according to the results of financial early warning: Firstly, they should adapt to the characteristics of economic downturn, attach importance to the innovative ability of enterprises, and gradually realize transformation and upgrading; Secondly, regard the early warning of financial risks as a part of financial management of enterprises and normalize activities to improve the financial management level of SMEs; Third, improve the governance structure of SMEs listed companies, try to avoid family holding and ensure the scientific decision-making; Fourth, improve the risk awareness of managers to identify potential risks of enterprises as soon as possible, and take timely measures to prevent them.

To sum up, financial risk is the only way to achieve healthy and sustainable development in the context of the economic downturn.

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