

Enterprise Financial Risk Early Warning Based on Deep Neural Network

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Abstract: The occurrence of financial risk will have a great impact on the continuous operation of enterprises, which may lead to significant losses of enterprises and even cause bankruptcy of enterprises. With the increasing downward pressure on the domestic economy, economic transformation and upgrading, and the black swan event of the novel coronavirus epidemic, the operational pressure on listed companies has continued to increase, and the delisting risk of listed companies has gradually emerged. This paper mainly studies the enterprise financial risk early warning based on deep NN(NN). This paper first defines the concept of financial early warning and BP NN, and uses BP NN to construct the financial risk early warning model of listed companies. The model is trained and empirically analyzed. The results of empirical analysis show that the research of this paper is conducive to the development of indicators and methods for the prediction of financial risks of listed enterprises, which is conducive to the reference of regulators and investors.

1. Introduction

Due to the influence of various factors, an increasing number of listed companies have been treated with Special Treatment (referred to as ST) which refers to domestic listed companies receiving Special Treatment, that is, delisting risk warning [1]. ST listed companies will face huge difficulties, on the one hand, ST means there will be delisting risk, for investors will avoid these riskier stocks, CSRC supervision will be more severe, thus leading to narrow financing channels, making the company's operation worse. On the other hand, the legal rights and interests of its creditors will also be seriously affected. [2] The listed companies are in a very important position in the economic development of our country, so it is very important to supervise them and make risk prediction. On the one hand, for listed companies, risk prediction can be used to find out whether the company is currently in the ST state as soon as possible and adjust the problems in its operation

and management in time [3]. On the other hand, for investors, models can be used to help them make investment decisions to avoid losses. Therefore, it is very important to build a set of risk prediction model for listed companies in China, improve the risk prediction level, and play a very important role in the development of national economy, listed companies and investors. Today is the era of big data, with the continuous development of information technology and the strengthening of the ability of computers to process information, deep learning has become popular [4, 5]. By using deep learning, more data features can be learned automatically, replacing manually designed features, and it can process tensor data, that is, multidimensional data, and learn more information contained in data [6].

Since the 1930s, foreign scholars have made a lot of achievements in financial risk modeling and prediction. From the perspective of time axis, the research methods from univariate analysis to the introduction of Logistic regression to the current NN, support vector machine, decision tree and other data mining algorithms and combination models, corporate financial wind test prediction accuracy has been continuously improved [7]. In the 1990s, the domestic securities market began to develop gradually, and scholars began to study the risk prediction of listed enterprises. In the field of risk prediction of listed enterprises, there are still some differences and distances between the research objects and research methods and foreign countries. Further exploration and research in this field are needed in China [8]. With the deepening of research, researchers are no longer limited to the study of financial data, but pay more attention to financial texts and conduct text mining on financial texts [9]. Researchers generally focus on the research of financial text mining on corporate performance disclosure, audit reports and corporate annual reports [10].

In this paper, convolutional NN technology and natural language processing technology are applied to the risk prediction of listed enterprises in the securities market, in-depth mining of listed enterprises' financial statements and network comments text information, to establish the risk prediction model of listed enterprises and forecast the future risk status of listed enterprises. The prediction result can make the listed company operator detect the potential crisis signs as soon as possible, adjust the strategy in time, change the trend of the enterprise crisis, reduce or avoid the loss, also can make the investor insight into the development prospect of the listed company and make the right decision, also can make the creditor avoid the loan risk.

2. Financial Risk Early Warning Model based on BP NN

2.1. Definition of Relevant Concepts

(1) Financial warning

As an important subsystem of internal financial control of enterprises, financial risk early warning system can dynamically monitor potential financial risks of enterprises and issue emergency reports before financial risks are transformed into financial crises. In addition, the early warning system can help enterprises efficiently allocate their limited resources, remind them to correct in time when they find deviations in their business direction, and improve the correctness of their decisions [11].

Financial early warning has the following functions: information collection function, obtain accurate information is the premise of early warning preparation; Prediction function, through the analysis of information to find the factors that may harm the enterprise and timely issue a warning; Control function: When crisis occurs, find the root cause of financial crisis and formulate effective measures [12].

(2) BP NN

Artificial NN is a network model, whose operation principle is to operate by simulating the human brain's nerves, and distribute problems to each neuron in parallel [13]. In the process of

network training, problems are input as variables to continuously improve the setting of neuron nodes in each layer of the network, so that the accuracy of the model can reach the preset index value, and finally solve the problem of data classification learning [14, 15].

Error Back Propagation Network (BP) is widely used in NN models, which is a kind of multi-layer feedforward NN. The transformation function of neurons is an S-shaped function, and the output of the model is a continuous quantity between 0 and L. It can realize nonlinear mapping from input to output [16, 17]. The middle layer and layer of the network are connected with each other, and the neurons communicate with each other through the same network weight. The forward three-layer NN can achieve a good simulation effect on the relationship between input and output, so it is widely used in the research of financial early warning [18].

The Algorithm of BP NN is based on the back-propagation Algorithm. The operation process is as follows: the input layer receives the data and transmits it to the output layer layer by layer, and the weight is constantly trained and adjusted. After the feedback is obtained, the neuron returns layer by layer with the path with the smallest error. Weight training is carried out again. It will stop automatically until the error drops to the minimum. The basic function of BP NN algorithm is Sigmoid function, which can automatically train its neurons after data input and output setting, so as to achieve the specified mapping results. Therefore, BP NN is widely used in pattern recognition, adaptive control, and in risk assessment and data stratification has a higher use of evaluation.

A simple sigmoid function is as follows:

$$f(x) = \frac{1}{1 + e^x} \quad (1)$$

BP NN has been widely used in military, medicine, artificial intelligence and other fields by scholars at home and abroad, laying a solid foundation for the technological development of various industries. Compared with other early warning methods, the advantages of BP NN are as follows:

First, the adaptability is strong and the sample is not limited. In the operation process, the weight of the network can be adjusted automatically according to the training error until the setting requirements are met.

Second, strong learning ability. In the training, the feedback parameters of neurons are received and adjusted continuously until the error decreases and the best fitting effect is achieved, which effectively avoids the appearance of non-objective factors such as artificial weighting in the traditional model.

Third, the accuracy is high and the error is smaller. BP NN has the property of convergence, and the system error can reach the required accuracy through continuous automatic training.

In view of the above aspects, this paper chooses BP NN as an analysis model, to give early warning of the financial risk of listed company in our country.

2.2. Financial Risk Early Warning Model Design

The learning process of BP network is mainly composed of two links, one of which is the forward calculation link, the other is the error back propagation link. In the forward calculation, the input layer makes corresponding input to the training sample, and the hidden layer(HL) expands the calculation, and finally sends the output value to the output layer. If the output layer cannot achieve the expected result, in the link of error back propagation, the wrong signal connection path will be transmitted back according to the original path, and the weight and threshold of each layer of the network will be adjusted layer by layer until it is conveyed to the input layer, and the operation will be repeated. The two processes are repeatedly performed in order, and at the same time, the weights and thresholds at each level are continuously adjusted accordingly. The learning process is not

completed until the network error reaches the minimum or meets the expected requirements.

(1) Input layer design. The number of metrics to be entered is the number of nodes in the input layer. If the number of input financial indicators is determined to be N , then the BP NN model designed in this paper arranges N nodes in the input layer.

Output layer design. For the output layer, the number of nodes in the output layer of NN represents the number of targets in the system. The design of output layer node mainly includes two aspects: data type and data size. When using the BP NN model to classify the problem, the normal processing means is to output the result matrix of all possible patterns first, and then the output value is processed by the method of rounding, which specifies that the larger than 0.5 belongs to the class "1", and the remaining situation belongs to the class "0". Since this paper divides the company's financial status into three states: financial health, annual loss and ST, the corresponding matrix is the 3D identity matrix. Let the identity matrix be:

$$t = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (2)$$

The form of financial health company is vector (1,0,0) the form of one-year loss company is vector (0,1,0) and the form of ST company is vector (0,0,1).

HL design. The number of HL nodes needs to be set to an appropriate value. On the one hand, although increasing the number of HL nodes can help improve the network accuracy, the training time of the model will also increase with the increase of the number of HL nodes. On the other hand, if the number of HL nodes is insufficient, the ability of the model to correct errors will be reduced. At present, it is usually determined according to the following formula:

$$l = \sqrt{n+m} + \alpha \quad (3)$$

(4) Transfer function selection. Based on the BP network has many types of transfer functions, we need to choose a scientific transfer function to maximize the efficiency of NN training. For the consideration of data type and accuracy, the Tansig function is selected in this paper. The input value of this function can be arbitrarily selected, and the output value range is [-1,1].

(5) Training function selection. The main training functions used by BP NN include TrainLM, TraingDX and TraingD. Based on the factors that the network system established in this paper belongs to the medium scale, the above three training functions are compared and analyzed. In order to make the efficiency of the algorithm relatively high, the TRAINLM function is finally selected.

3. Model Training and Early Warning Experiment

3.1. Model Training

In this paper, 120 training samples (40 samples for each class) are used for training. In order to obtain better learning effects, the training times are set as 1500. The model was found to be stable after 1500 runs.

3.2. Early Warning Experiment

A company is A leading supplier of wireless network optimization equipment in China, committed to the research and development, production and sales of communication equipment.

Communication business is the company's traditional business. In the communication business section, the company mainly focuses on system integration, equipment production and sales and maintenance services.

In this paper, 19 financial early-warning indicators of company A in the last three years are input into the model and the results are output.

4. Analysis of Early Warning Experiment Results

4.1. Risk of Insolvency

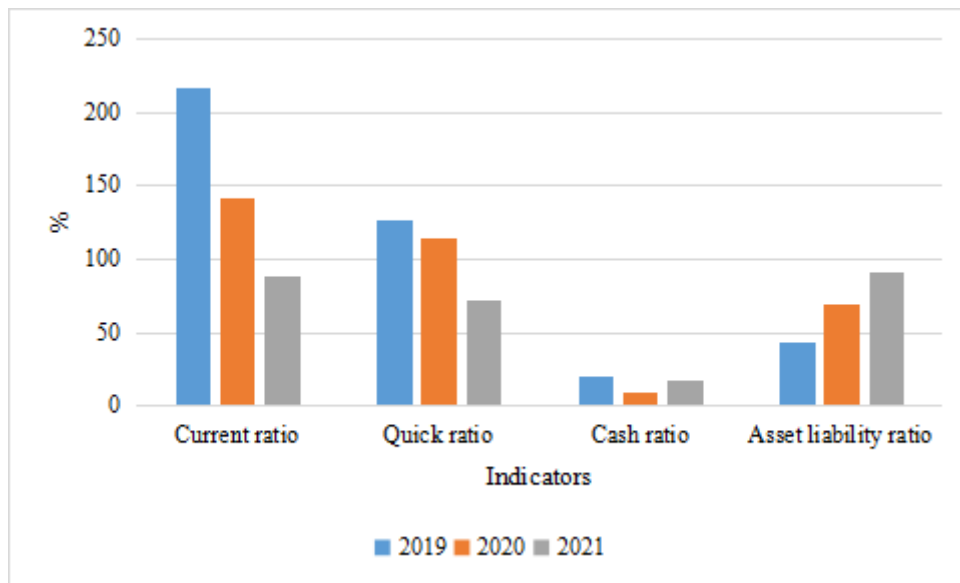


Figure 1. Analysis of debt paying risk of Company A

As shown in Figure 1, it is the result of A company's debt repayment risk analysis. Short-term solvency refers to the ability of an enterprise to repay short-term debt. If an enterprise cannot repay the maturing debt, there will be the possibility of debt crisis. Current ratio, quick ratio and cash ratio are important indicators to measure a company's short-term solvency.

4.2. Profit Risk

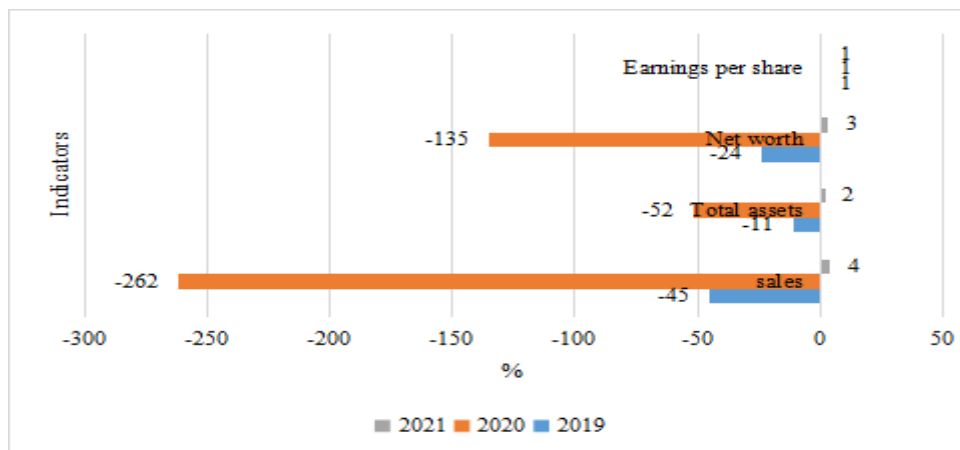


Figure 2. Profit risk analysis of Company A

As shown in FIG. 2, the earnings risk analysis results of Company A. Net profit margin on sales, net profit margin on total assets, return on equity and earnings per share are all important indicators to measure a company's profitability. By studying the profitability of Company A, we can understand the profit rate of the company itself. Sales profit rate reflects the profit level and operating efficiency of the enterprise.

4.3. Operational Risk

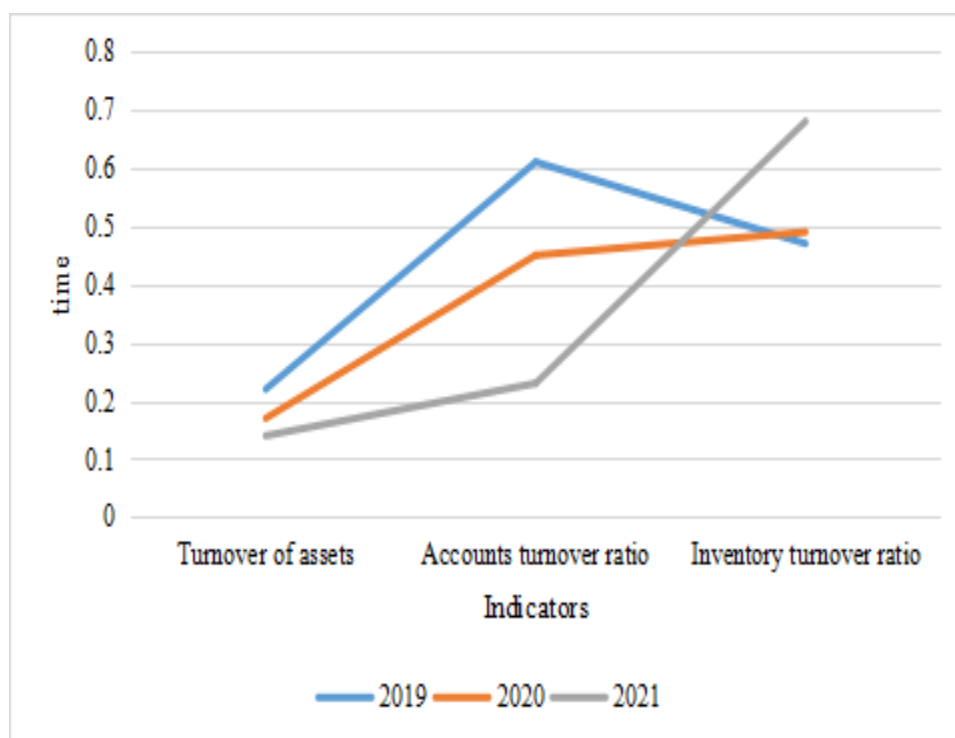


Figure 3. Operation risk analysis of Company A

As shown in Figure 3, it is the result of operation risk analysis of Company A. Operation ability reflects the efficiency and benefit of capital operation of enterprises using different assets. Usually, the turnover efficiency of different types of assets is used to determine the operation level of enterprises. Total assets turnover rate measures the utilization efficiency of total assets of an enterprise.

4.4. Growing Risk

Table 1. A company growth risk analysis

	Growth rate of revenue	Growth rate of net assets	Growth rate of total assets
(2019)	-17	-21	-31
(2020)	-43	-66	-37
(2021)	-62	-54	-8

As shown in Table 1, are the growth risk analysis results of Company A. Year-over-year growth rate of operating income, growth rate of net assets per share and growth rate of total assets are important indicators to measure a company's growth ability.

4.5. R&D Risks

Table 2. Research and development risk analysis of Company A

	Research and development as a percentage of revenue	Proportion of capitalized R&D	Ratio of capital personnel
(2019)	11	29	18
(2020)	9	26	13
(2021)	13	21	7

As shown in Table 2, the research and development risk analysis results of Company A are presented. The ratio of R&D investment to operating revenue, the ratio of capitalized R&D investment to R&D investment, and the ratio of R&D personnel reflect the company's emphasis on R&D activities.

5. Conclusion

This paper takes listed enterprises as the research object, and studies the financial risk early warning of listed enterprises. First of all, the present situation and existing problems of financial risk of listed enterprises are analyzed. Secondly, the financial risk early warning model of listed enterprises is constructed based on BP NN, and the financial indicators are selected as the financial early warning index system from different aspects of the enterprise's debt paying ability, profitability, operation ability, growth ability and research and development ability. The final results show that the BP NN model designed in this paper can predict the financial risk of listed companies stably and effectively. Meanwhile, the accuracy of prediction also proves the feasibility of early warning index system. Therefore, the cause of financial risk can also be studied scientifically and effectively through the analysis of early warning indicators.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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