Research on BP neural network in enterprise credit rating management based on artificial intelligence era

Jingyi Ye¹, Xiao Han²
School of Management, Wuhan University of Technology, Wuhan Hubei, 430070, China
e-mail: yejingyi@whut.edu.cn

Abstract. BP neural network has been gradually applied in the field of economic management. It has many advantages that traditional methods can't achieve, but there are also disputes and problems. In this paper, the BP neural network model is established to analyze the credit risk indicators of listed companies, and the learning system of enterprise credit rating management is established to predict the future credit risk, so as to achieve the purpose of enterprise risk management, and the corresponding conclusions and suggestions are given to promote the development and innovation of enterprise management and artificial neural network.

1. Introduction
In the 21st century, artificial intelligence has gradually entered our field of vision, and the development of artificial intelligence technology has become ever more rapid. As an important branch of artificial intelligence, neural network has made excellent progress and gradually applied in various fields. In the part of enterprise credit rating management, when the credit rating agencies analyze and manage the enterprise credit rating, there may be many subjective factors affecting the management results in the ordinary management mode, and its indicators are too single and tend to be financial aspects, thus bringing irreparable consequences. With the arrival of artificial intelligence era, the learning ability of neural network is gradually understood by everyone, The analysis and management prediction of enterprise credit risk rating based on neural network can avoid the influence of subjective factors on the one hand, and improve work efficiency on the other hand, and can better manage enterprise credit risk on this basis.

Credit rating can solve the problem of adverse selection and moral hazard caused by information asymmetry between investors and operators. Credit rating not only opens up a channel for the information gap between financial institutions' capital supply and demand, which makes the investment of capital suppliers have investment objectives suitable for their own risks and preferences, but also strengthens the management efficiency of financial institutions, thus enhancing the overall efficiency of the capital market. Compared with the traditional credit rating method, BP neural network has better generalization ability to nonlinear relationship, and can carry out complex logic operation association according to given data, and learn and adjust according to the change of environment, which makes the result more accurate. Moreover, BP neural network has good fault tolerance, and when the data part is wrong, it can still get an effective model through training and get more accurate results. Therefore, BP neural network is more suitable for enterprise credit evaluation. Credit management is the lifeblood of an enterprise, and its core is credit rating. Applying BP neural network to enterprise credit rating management is an innovation of artificial neural network and a perfection of the enterprise management.
However, the selection of credit rating management indicators, the improvement of accuracy and the prediction of future enterprise risks have always been controversial issues.

In this paper, a three-layer BP neural network model is established to analyze the credit risk indicators of listed companies. According to the enterprise credit rating standards, quantitative analysis and qualitative analysis are adopted to extract 16 indicators from the perspective of evaluating enterprise credit risk. 40 enterprise credit rating information is selected to train and test the BP neural network, and the weights are adjusted by training to learn the data, and the learning results are tested by testing. Then the best credit risk rating index is obtained, and a nonlinear learning system for enterprise credit risk rating management is established, which can manage and predict the future enterprise credit risk. On the one hand, it can realize the application innovation of artificial neural network technology and apply it to the field of enterprise management, on the other hand, it also promotes the further development of artificial neural network theory.

2. Establishment and design of BP neural network model

BP neural network obtains the output value from the input layer to the final output layer of the hidden layer by signal forward propagation, compares it with the actual value and carries out error back propagation, so as to constantly adjust and correct the weights of the hierarchy, and finally achieves the purpose of generalization learning, and establishes a model for prediction.

2.1. BP neural network model

Common BP three-layer neural network is shown in the figure:

The three layers are input layer, hidden layer and output layer.

The input vector is \( x = (x_1, x_2, x_3 \ldots, x_n) \), when \( x = 1 \), the threshold of the input layer is obtained.

The output vector of the hidden layer is \( y = (y_1, y_2, y_3 \ldots, y_n) \), when \( y = 1 \), the threshold of the output layer is obtained.

Output variable of the output layer is \( o = (o_1, o_2, o_3 \ldots, o_l) \), and expected output vector is \( d = (d_1, d_2, d_3 \ldots, d_l) \).

The weight connection matrix between the input layer and the hidden layer is \( v = (v_1, v_2, v_3 \ldots, v_m) \); the weight connection matrix between the hidden layer and the output layer is \( w = (w_1, w_2, w_3 \ldots, w_l) \).

Their mathematical relationship is as follows:

\[
\text{Input layer: } n_i = \sum_{j=1}^{n} v_{ij} x_j, \quad y_j = f(u_j) \quad j = 1,2,3,\ldots,mn \tag{1}
\]

\[
\text{Output layer: } n_k = \sum_{j=1}^{m} w_{jk} y_j, \quad o_k = f(h_k) \quad k = 1,2,3,\ldots,ln \tag{2}
\]

The excitation function \( f(x) \) selects unipolar Sigmoid function because of its continuity and derivability, as follows:
\[ f(x) = \frac{1}{1+e^{-x}} \quad f'(x) = f(x)[1 - f(x)] \]  

Error is \( E = \frac{1}{2} (d - o)^2 \), bring the above formula in it to get the information below:

\[ E = \frac{1}{2} \sum_{k=1}^{l} \left( d_k - f(\sum_{i=1}^{m} w_{ik} f(\sum_{j=1}^{n} v_{ij} x_j)) \right)^2 \]  

The error function \( e \) is related to the weights \( v \) and \( w \), so the error can be reduced by adjusting the weights.

\[ M = \sqrt{n + l + \beta} \quad \beta = 1, 2, 3, ..., 10 \]

2.2. Input layer design: establish enterprise credit rating index system

According to the principles of importance, comprehensiveness, objectivity, effectiveness, scientificness and pertinence, the indicators of enterprise credit rating management are selected. On the basis of traditional financial indicators, plus the external market and the non-financial factors of the enterprise itself, a comprehensive investigation of enterprise credit risk rating is carried out comprehensively, and a total of 4 first-level indicators and 12 second-level indicators are selected, as shown in the figure.

![Figure 2. Enterprise credit rating index](image)

2.3. The number of hidden nodes

In general, the complexity of the three-layer BP neural network model is proportional to the number of layer nodes. However, when the number of layer nodes is too large, the amount of calculation will increase, and it will take a lot of time. At the same time, "over-fitting" may occur. At the same time, when the number of layer nodes is too small, the overall performance of BP neural network model will be reduced. We can refer to the empirical formula of scholars to deduce the number of hidden layer nodes. This paper selects 7: (where \( M \) represents the number of hidden layer nodes, \( N \) represents the number of input layer nodes, and \( L \) represents the number of output layer nodes.)

\[ M = \sqrt{n + l + \beta} \quad \beta = 1, 2, 3, ..., 10 \]
2.4. Quantification of data
The range of the selected activation function is [0,1]. Therefore, the output value should be normalized, so we define the enterprise credit rating as AAA, AA, A, BBB, BB, B, CCC, CC, C, and so on. Finally, the output value corresponding to grade C is 0.1-0.2. The following table:

| Grading standards | Credit rating/standing | Credit rating |
|-------------------|------------------------|--------------|
| 0.9-1.0           | AAA                    | Excellent    |
| 0.8-0.9           | AA                     | Excellent    |
| 0.7-0.8           | A                      | Good         |
| 0.6-0.7           | BBB                    | Better       |
| 0.5-0.6           | BB                     | Tolerableness|
| 0.4-0.5           | B                      | Common       |
| 0.3-0.4           | CCC                    | Discrepancy  |
| 0.2-0.3           | CC                     | Be poor      |
| 0.1-0.2           | C                      | Very poor    |

3. Training and testing of BP neural network model
The credit rating information of 40 listed enterprises in the same industry in 2020 is selected as samples. According to the idea of cross-validation, it is divided into 30 training samples to train the adjustment weights for data learning and generalization, and 10 test samples are used to test the accuracy of learning. A three-layer BP neural network model is constructed, the topological structure is 12-7-1, the input vector x is composed of the established credit rating management indicators, the samples are brought in for training, the weights are constantly trained and adjusted, and the neural network toolbox of Matlab is used for network training operation, the learning rate is 0.01, the maximum training times are 1000, and the learning accuracy is 0.01, the first 30 training samples are taken to train the neural network, and after the neural network is trained, the input is made.

| Sample No. | Expected output | Credit rating | Actual output | Forecast rating |
|------------|-----------------|---------------|---------------|----------------|
| 31         | 0.66            | BBB           | 0.62          | BBB            |
| 32         | 0.79            | A             | 0.75          | A              |
| 33         | 0.82            | AA            | 0.86          | AA             |
| 34         | 0.54            | BB            | 0.36          | CCC            |
| 35         | 0.66            | BBB           | 0.62          | BBB            |
| 36         | 0.58            | BB            | 0.59          | BB             |
| 37         | 0.54            | BB            | 0.46          | BB             |
| 38         | 0.74            | A             | 0.74          | A              |
| 39         | 0.91            | AAA           | 0.93          | AAA            |
| 40         | 0.69            | BBB           | 0.67          | BBB            |
Figure 3. Line chart of credit rating error of test sample enterprises (Yellow line means “error”)

As can be seen from the above chart, by comparing the actual output: the predicted credit score and the expected output value of BP neural network learning: the real credit score is available, from the perspective of prediction rating, there is only one error, and the accuracy rate reaches 90%. From the perspective of analysis error, the error value keeps two decimal places, the maximum error is 33%, and the minimum error value is close to 0%. The real value of some samples is basically consistent with the predicted value, assuming the tolerance is 10%, then this paper

4. Conclusions and recommendations
The test samples are highly consistent with the actual credit rating. The predicted values of samples 36, 38 and 39 are basically consistent with the expected values, and the predicted values of samples 34 and 37 are quite different from the expected values. Judging from the forecast rating, the correct rate has reached 90%.

BP neural network is suitable for the evaluation and management of enterprise credit risk and the prediction of enterprise future credit rating. It can be generalized by learning. Compared with the traditional credit rating management mode, BP neural network has better effect, higher accuracy, objectivity, comprehensiveness and fault tolerance.

Enterprise credit risk is not static, when the corresponding indicators of enterprises change, the corresponding credit rating management will also change accordingly. Using BP neural network can manage and predict enterprise credit risk more quickly and efficiently, so that users can make the most reasonable countermeasures and policies in the shortest time.

The index selection using BP neural network includes not only financial data, but also many non-financial factors in enterprise credit risk management, which should be considered in the model, so as to improve the accuracy and provide innovation and development of technology application for enterprise credit risk management in the future.

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