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Research on Credit Rating Evaluation based on BP Neural Network Model based on PSO Optimization

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Abstract

In recent years, with the increasing support of the state for micro and small businesses account for an increasing share of the banking business in the financial market. However, due to the complex situation of micro and small businesses,with the characteristics of information asymmetry, unstable operation, small enterprise scale, extremely high financing risk, and serious lack of collateral and guarantees, commercial banks can determine whether to lend to them and set the loan amount. inconvenience due to credit strategies such as, interest rates and tenors. In this paper, a certain number of enterprise-related indicators without credit records are used as the training samples of BP neural network, and a credit rating model based on BP neural network optimized by PSO algorithm is established. The evaluation serves as a reference.

Keywords

Credit Strategy; BP Neural Network; Particle Swarm Optimization; Commercial Bank Credit Rating.

1. Introduction

According to the "2021 China's Small and Medium Enterprise Financing Development Report" released by iResearch, as of 2021, small and micro enterprises will account for 96.5% of my country's market players, and China's small and micro enterprise loan balance has increased from 27.7 trillion yuan in 2016. By 2020, it will reach 43.2 trillion yuan, with a compound annual growth rate of 12.2%. However, in the context of the macroeconomic downturn and the shortage of liquidity in recent years, the problems of difficult and expensive financing for small and medium-sized enterprises are particularly prominent.

General commercial banks will provide loans to enterprises with strong strength and stable supply-demand relationship according to their own credit policies, transaction bill information of enterprises, and the influence of upstream and downstream enterprises, and can give preferential interest rates to enterprises with high reputation and low credit risk. Therefore, how to carry out effective credit risk assessment against small, medium and micro enterprises with weak risk capability is a challenge for commercial banks that play an important role in the financial market and take credit as their basic business.

In fact, the current credit evaluation system from domestic and abroad has been basically perfected, which can be roughly divided into three categories. The first type is mainly based on multivariate statistical analysis models based on corporate financial information as data sources, such as qualitative response model, Z-score model and ZETA credit risk model proposed by Altman; or based on market dynamic information, based on complex mathematics Models established by formulas, such as KMV model, CreditMetrics model, etc.; the second type is an expert evaluation method based on expert scores, such as using the Delphi method to discuss and summarize the opinions expressed by multiple experts anonymously, or adopt the brainstorming method to pass through multiple experts. The solvency and default probability of the enterprise are obtained after the expert group decision. The third category is the analytical technology models such as decision-making systems, neural networks and fuzzy analysis, which appear with the development of computers, artificial intelligence and data mining [1]. However, with the explosive growth of data scale today, there are many uncertain and volatile factors affecting corporate credit risk, such as changes in national policies, etc., and economic data often show non-linear relationships. The accuracy of traditional credit assessment methods The credit evaluation method of artificial intelligence can effectively solve the nonlinear phenomenon between data variables, so it is particularly important in the prediction of corporate credit risk today. Zhao Lingling uses K-Means cluster analysis to quantify the credit of small and medium-sized enterprises. Influence factors, so as to build a target optimization model, and propose corresponding credit strategies for enterprises of different levels [2], Ji Mengting extracted 16 characteristic indicators from the enterprise information data through time series, and then used the principal component analysis method to reduce the dimension to 5 Finally, the SVM classification prediction model is established, and the optimal parameters are obtained by cross-validation, and the reputation level of the unassessed record enterprise is predicted [3].

In this paper, the factors affecting credit evaluation are selected from the data set, and the BP neural network evaluation model optimized by particle swarm algorithm (PSO) is established to obtain the corporate credit rating, which provides optimization for commercial banks to make credit decisions for small and medium-sized enterprises.

2. Data Acquisition and Assumptions

The data of this article comes from the relevant invoice data of 123 companies with credit records and the relevant invoice data of 302 companies without credit records provided by the 2020 National Mathematical Modeling Competition for College Students. The data are processed, filtered and summarized using python and excel software Relevant invoice data. In order to facilitate the analysis of the problem in this paper, the research process and conclusions of this paper are based on the following assumptions: (1) When using excel and python to process data, there is no deviation from the original relevant data, and the transaction bills of the original enterprise The situation is an objective and true reflection; (2) It is assumed that the bank's investment preference is always greater than the total return brought by the credit enterprise it provides to its low-risk investment (similar to purchasing government bonds, etc.); (3) It is assumed that the credit model adopted by the bank is not limited to The traditional "tax loan" also accepts this newer form of "invoice loan"; (4) Suppose that the bank, in the process of evaluating and issuing corporate credit, will issue loans based on the results obtained from the final model, regardless of artificial factors that affect the credit limit, credit rate and credit term. (5) It is assumed that the enterprise has a certain ability to deal with emergencies, that is, the model established in this paper does not take other unexpected factors into account; (6) It is assumed that the relevant enterprises do not have misreported financial data of their operations,and all data are is true and reliable [4].

3. Credit Rating Evaluation Model of BP Neural Network based on PSO Optimization

3.1. Theory Preparation

An artificial neural network (ANN) is a computer system formed by a number of very simple processing units connected to each other in some way, which aims to simulate the structure and function of the human brain. Dynamic responses to process information. Among them, the neuron model is designed to simulate the structure of biological neurons. Neurons are composed of cells and their many synapses. Several protrusions as input signals are called "dendrites", while only one protrusion as an output terminal is called "dendrites". for "axon". The BP neural network used in this paper is a multi-layer feedforward neural network which is back-propagated by error. The basic idea is the gradient descent method, which uses the gradient search technology to minimize the error mean square error between the actual output value and the expected output value of the network. Its topology includes an input layer, a hide layer, and an output layer, as shown in Figure 1.

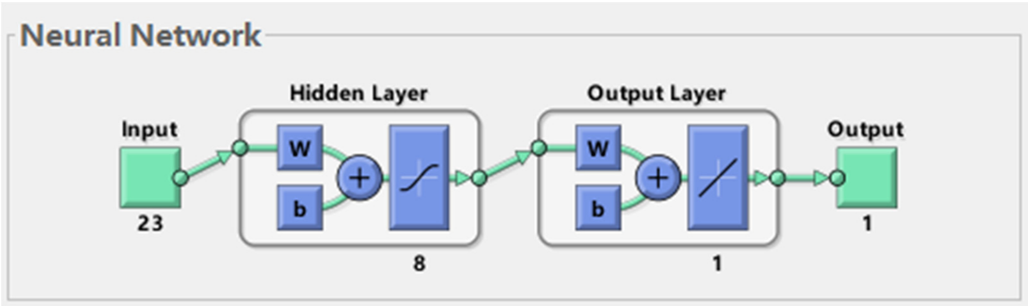

Figure 1. BP neural network topology diagram.

The basic process of BP neural network is divided into two processes: signal forward propagation and error reverse propagation. Firstly, the output signal acts on the output node through the hidden layer. After nonlinear transformation, the output signal is generated. If the actual output is not consistent with the expected output, the error generated by the output is transmitted back to the output layer through the hidden layer, and the error is distributed to all units of each layer. The error signal obtained by each layer is used as the basis for adjusting the weight of each unit. By adjusting the input, the weights and thresholds between nodes at each layer are adjusted to make the error decrease along the gradient direction. After several iterations, the parameters corresponding to the minimum error are determined, and the successful model of neural network fitting is obtained.

3.2. Model Establishment

3.2.1. Data Cleaning

Each enterprise data has a credit rating assessed by the bank, which is divided into four grades: A, B, C and D. Among them, an enterprise with a credit rating of D is directly considered by the bank to be in breach of contract and will not provide loans for it. , you can directly delete the data of such enterprises, and then quantify the remaining enterprises as "A"-3, "B"-2, "C"-1 according to the credit rating; quantify whether the default is "with default record"-1 , "No default record" -0; this paper uses 23 evaluation indicators as input, namely credit rating, default, number of input invoices, number of valid input invoices, number of invalid input invoices, number of negative input invoices, valid input amount, input Valid tax amount, invalid input amount, valid input price tax, number of output invoices, number of valid sales invoices, number of invalid output invoices, number of negative sales invoices, valid sales amount, valid output tax, invalid output amount, Output effective value tax, total revenue, input invoice billing stability, output invoice billing stability, voided invoice rate, negative invoice rate.

3.2.2. The Establishment Steps of BP Neural Network

The activation function selected in this model is the Sigmoid function, and the function formula is:

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

The notation convention is:ω_{jk}^{l}represents the connection weight of the kth neuron in the $(l-1)$th layer to the jth neuron in the lth layer, and θ_j^l represents the bias of the jth neuron in the lth layer.

The expression of net activation quantity:

$$net_i = \sum_{j=1}^{n} w_{ij}\, x_j - \theta_i \tag{2}$$

In order to design a BP neural network with a reasonable structure, it is also necessary to determine the structure of the hidden layer for design. Although the number of layers is too deep, the ability to fit the function will be enhanced in theory, but in practice, it will cause over-fitting problems, and it will also increase the difficulty of training, making it difficult for the model to converge. Therefore, this paper adopts three-layer BP neural network for sample training, focusing on adjusting the number of neurons in the hidden layer. By the Komogorov theorem there is a reference formula as follows:

$$n_l = \sqrt{n+m} + a \tag{3}$$

Among them, n is the number of nodes in the input layer, m is the number of nodes in the output layer, a is a constant between 1 and 10, and n_l is the number of neurons in the layer[5]. The range of n_1 can be obtained by calculation as 5-14, and its value is 5.

After the previous calculation, the actual output can be obtained, and $\delta_o(k)$ can be calculated using the actual output and the expected value:

$$\delta_o(k) = \frac{\partial \mathrm{e}}{\partial y_{io}} = \frac{\partial\left\{\frac{1}{2}\sum_{i=1}^{q}[d_i(k) - y_{oi}(k)]^2\right\}}{\partial y_{oi}} = -[d_i(k) - y_{oi}(k)]y_{oi}(k) \tag{4}$$

$$\frac{\partial \mathrm{e}}{\partial w_{ho}} = \frac{\partial \mathrm{e}}{\partial y_{io}(k)} \cdot \frac{\partial y_{io}(k)}{\partial w_{ho}}, \frac{\partial y_{io}(k)}{\partial w_{ho}} = \frac{\partial\left(\sum_{h=1}^{p} w_{ho} h_{oh}(k) - \theta_o\right)}{\partial w_{ho}} \tag{5}$$

Finally, the global error E is calculated:

$$E = \frac{1}{2m}\sum_{k=1}^{m}\sum_{i=1}^{q}[d_i(k) - y_o(k)]^2 \tag{6}$$

Use the back-propagation algorithm to repeatedly adjust the weights and biases of the network to make the output vector as close as possible to the expected vector. When the sum of squared errors of the network output layer is less than the specified error, the training is completed[6], save The weights and biases of the network.

3.2.3. BP Neural Network based on PSO Optimization

If the optimization is carried out according to the traditional gradient descent method, this method often has a slow convergence speed and is prone to fall into a local optimum. This paper adopts the method of combining PSO optimization method with BP neural network to improve the above model. The connection weights and thresholds of the BP neural network are regarded as the elements of the position vector X of the particles in the particle swarm, and then the particle swarm optimization method is used to replace the gradient descent method of the BP network to realize the optimization of the network connection weights and thresholds. Suppose that the number of nodes in the input layer, hidden layer and output layer of the BP neural network are n_i, n_h, and n_o, respectively,and the information of each particle is represented by d-dimensional vector,then $d = n_o n_h + n_h n_i + n_o + n_h$. In this paper, the update of particle position is combined with the gradient descent method of BP neural network.From this,a new weight updating method is derived.

$V_{im}(t)$ represents the initial position of the ith particle, H_{j1} is regarded as the output of the hidden layer node j_1, and I_h outputs the data from the input layer node h; α and β are the particle learning rates; r_1 and r_2 is two random values, generally between 0 ∽ 1; t is the current number of training iterations; [ ] represents the rounding function.

First initialize the BP neural network, including setting the input layer of the network, the hidden layer, the number of neurons in the output layer, and the input and output of the training samples. Reinitialize the particle swarm, including the particle size N, the position vector and velocity vector of each particle, the individual extreme value and global optimal value of each particle, the iterative error accuracy ε, constant coefficients c1 and c2, and the maximum inertia weight. η_{max}, minimum inertia weight η_{min}, maximum speed v_{max} and maximum number of iterations, etc.

During the training process, the speed of each particle is continuously updated, and it is judged whether the updated speed is greater than the maximum speed $\mathrm{v_{max}}$. If it is greater than the maximum speed $\mathrm{v_{max}}$, the updated speed will be the maximum speed $\mathrm{v_{max}}$,otherwise, remain unchanged. Also update the position of each particle.

Calculate the global minimum fitness value of the particle swarm $\mathrm{f_g = min\{f_1, f_2, \dots, f_N\}}$; if the current iteration number reaches the maximum iteration number or $\mathrm{f_g < \varepsilon}$, the iteration stops; otherwise, calculate each The particle's individual extreme value $\mathrm{P_i}$and global extreme value $\mathrm{P_g}$ position, continue to update the particle's speed and position. Finally, the network weights and thresholds determined by the position of the global extreme value $\mathrm{P_g}$ are output[7].

3.2.4. Model Solving

In this paper,123 small, medium and micro enterprises are divided into training data, verification data and test data according to the ratio of 8:1:1, that is, 99 groups of training data, 12 groups of verification data, and 12 groups of test data.

Now the trained BP neural network model can only output normalized data. In order to get the real data, the function mapminmax can be used. The formula is as follows:

$$y = \frac{(y_{max}-y_{min})(x-x_{min})}{x_{max}-x_{min}} \tag{7}$$

Then get the final training result. After several iterations, the mean square error is the smallest, MSE=5.0839e-08, and the best performance verification graph is obtained, as shown in Figure 2.

After multiple iterations of training, verification and testing of the neural network, the neural network finally converges to the best performance verification state. Fig.3 below shows the correlation coefficients of the neural network training, verification, testing and final total training results respectively. The figure shows that the total correlation coefficient of neural network training, verification, testing and the final graph are all about 0.9999, indicating that the neural network has an ideal fitting effect. The credit rating evaluation of 302 companies with no credit rating records can be predicted using this neural network.

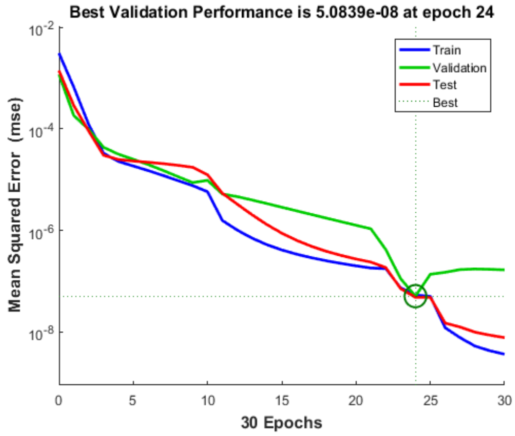

Figure 2. Best performance verification graph.

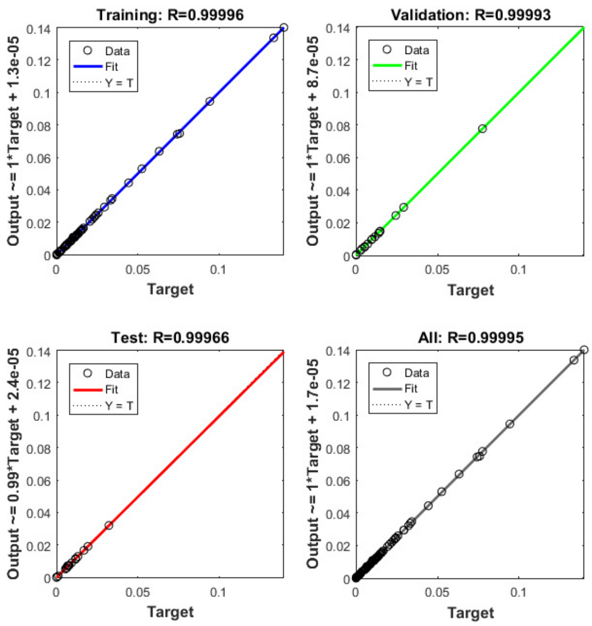

Figure 3. Linear Regression Plot

In the figure, R is the correlation coefficient, and the calculation formula of R^2 is:

$$R^2 \equiv 1 - \frac{SS_{res}}{SS_{tot}} \tag{8}$$

SS_{res} is the sum of squares of the difference between the true value and the predicted value, and SS_{tot} is the total sum of squares.

Based on the prediction results of the neural network, the cluster analysis of Mahalanobis distance is used to classify enterprises at all levels. The Mahalanobis distance formula is:

$$D(X_i, X_j) = \sqrt{(X_i - X_j)\Sigma^{-1}(X_i - X_j)^T} \tag{9}$$

Among them, X_i and X_j both represent the estimated value of the mean vector of the prediction result. In cluster analysis, Euclidean distance is usually used as the distance measure between two data, and Euclidean distance is used in practical problems because it ignores the data feature unit. And the influence of different attributes is difficult to meet the actual requirements, while the Mahalanobis distance is based on a modification of the Euclidean distance, which takes into account the connection between various characteristics, eliminates the influence of dimensions, and can also exclude variables. correlation interference.

Using MATLAB to establish a relevant clustering analysis model and evaluating the results of 302 enterprises based on neural network, the credit risk of 302 enterprises can be obtained. Among the 302 companies, 72 were rated A, 72 were rated B, 133 were rated C, and the rest were rated D.Banks will also deny loans to companies with the highest risk levels.

4. Conclusion

Aiming at the difficulty of commercial banks in assessing the credit risk of small, medium and micro enterprises, this paper analyzes the factors that affect corporate reputation from the invoices of these small and medium enterprises, and constructs a neural network that can quantitatively predict the credit rating of small, medium and micro enterprises. Finally, based on the results predicted by the above neural network, these small, medium and micro enterprises can be divided into 4 risk levels through cluster analysis. Through the above quantitative results, commercial banks can choose to first lend to the enterprises with the highest credit rating and the best risk level among the above-mentioned enterprises, and can choose to appropriately lower the loan interest rate to these enterprises to attract these enterprises, and in order to maximize profits, they can The maximum loan amount is given to these businesses. For some companies with a B-level credit rating and a better risk level, the credit strategy can be adjusted appropriately to pursue the stability of income. For some B-level risk levels above the risk level, you can choose to increase the loan interest rate and amount to screen out the enterprises with strong anti-risk ability and better management ability to lend. For commercial banks to formulate lending strategies, the remaining loan amount can be selected from C-level enterprises, and all D-level enterprises and enterprises at higher risk levels will not choose to lend.

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