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Evaluation Model and Index System for Enterprise Strategic Management Capability Based on Neural Network Algorithms

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In recent years, China's economy has developed at a high speed, in which small and medium-sized enterprises have played a mainstay role. In the rapid development of small and medium-sized enterprises, their strategic management ability is related to the speed of expansion of the enterprises and the attraction of investors. This paper briefly introduces the strategic management capability of enterprises and subdivides it into eight indicators. Moreover the evaluation index system of strategic management capability is developed, and the evaluation model of strategic management capability based on Back-Propagation (BP) neural network algorithm is introduced. Then the strategic management capability of nine enterprises was simulated. The results showed that the precision of the evaluation model increased with the increase of training time and this was stable after 400 cycles of training, and the mean square error was smaller than 10^{-5} after 550 cycles of training. Compared with the traditional multiple regression equation, the scores and qualitative evaluation results of the management ability of enterprise A, B and C are more accurate and closer to the standard results of expert comprehensive evaluation.

Keywords: Back-Propagation neural network, strategic management ability, evaluation model, index system

1. INTRODUCTION

With the help of the basic policy of reform and opening-up, small and medium-sized private enterprises in China have constantly adapted to the changes of the market economy in the new era and eventually become another major pillar of the economic development of China [1]. Compared with large state-owned enterprises, small and medium-sized private enterprises are more flexible in management and have more advantages in meeting customer needs [2]. The existence of private enterprises has enriched and stabilized China's economic system. Moreover, with the development of the economy, the rules of financial markets have become more and more mature, and surplus capital in the market has begun to flow to small and medium-sized private enterprises. For investors who have capital and intend to invest in private enterprises, they prefer enterprises with higher growth [3]. Higher growth means faster development speed and increased profitability, so investors need growth ability evaluation indicators for reference. Small and medium-sized enterprises need evaluation indicators to improve their growth ability to attract investment. The evaluation of growth ability has many aspects [4], including marketing ability, human resource allocation ability and technological innovation ability. The evaluation methods of the above aspects include qualitative evaluation relying on experts'analysis in many aspects and quantitative evaluation based on measurable data in the development of enterprises. Yang et al. [5] put forward a fuzzy clustering evaluation method of enterprise

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Table 1 Evaluation indices of enterprise strategic management capability.

Number	Index	Unit
X_1	Management Quality	\
X_2	Employee motivation	\
X_3	Rationality of Enterprise System	\
X_4	Strategic implementation capacity	\
X_5	Human Resource Allocation Ability of Enterprises	\
X_6	Technological Innovation Ability	\
X_7	Marketing cost	Ten thousand yuan/year
X_8	Operating income	Ten thousand yuan/year

technological innovation based on self-organizing neural network to improve the rationality and scientific aspect of the evaluation of enterprise technological innovation ability and verified the effectiveness of the proposed method through case studies. Chen et al. [6] improved the learning ability of the Radial Basis Function (RBF) neural network through the use of the self-organizing map neural network. The simulation results showed that the learning ability of the algorithm was better than other algorithms, and it could accurately evaluate the cost demand information and reduce the inventory cost in the enterprise resource planning system. Geng et al. [7] used data mining technology and neural networks to collect data of 107 companies based on 31 financial indicators and three time windows and established a financial crisis early warning model. The experimental results showed that this method was more accurate than decision tree and vector machine prediction. This paper briefly introduced the strategic management capability of enterprises, divided the capability into eight indicators, established the evaluation index system of strategic management capability and introduced the evaluation model of strategic management capability based on Back-Propagation (BP) neural network algorithm, and simulated the strategic management capability of nine enterprises.

2. EVALUATION INDEX OF ENTERPRISE MANAGEMENT ABILITY

For an enterprise, its healthy development cannot be separated from the correct strategic management. The evaluation indices of an enterprise's strategic management ability [8] are shown in Table 1.

In order to facilitate the study and analysis of the strategic management capabilities of enterprises, this paper refers to the analytic hierarchy process (AHP) [9]. Using AHP, the strategic management capabilities is divided into eight small evaluation indicators to evaluate the strategic management capabilities of enterprises comprehensively. For an enterprise, in addition to being able to cope with the external environment, reasonable and benign internal management is the cornerstone of enterprise development.

The above eight indicators can be linked with the strategic management capability of enterprises through the multiple regression equation [10]:

$$H = a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8 + b, \quad (1)$$

where H stands for strategic management capability, X_i refers to evaluation index, a_i is the corresponding coefficient of index, which shows the degree of the index's influence on management ability, and b is a constant term. Theoretically, the multiple regression equation can be directly applied to the evaluation and calculation of the strategic management capability of an enterprise. But in practical application, the various indicators are not independent of each other, but have different correlations, which directly leads to multiple collinearity problems in the calculation results and seriously reduces the accuracy of the calculation results.

3. EVALUATION MODEL OF MANAGEMENT ABILITY BASED ON BP NEURAL NETWORK

The basic structure of BP neural network is divided into input layer, hidden layer and output layer. The hidden layer can be single layer or multi-layer. As shown in Figure 1, the BP neural network model has three layers. $x_1, x_2, \cdots, x_n$ is the input vector X, which is the evaluation value of an index in this paper. i, j, k are the dimensions of the input layer, hidden layer and output layer respectively. ω_{ij} is the weight of the input layer to the hidden layer. ω_{jk} is the weight of the hidden layer to the output layer. Output vector H is the strategic management score of an enterprise. The algorithm used in the BP neural network is the error back propagation algorithm, and its steps are as follows:

(1) Initialization: The weights between the input layer, hidden layer and output layer of the neural network in the evaluation model are initialized. They were initialized to zero during model training and to the post-training weights during use.

(2) Standardization: Input the original data of each index evaluation and management ability actual score of training samples in the training model. Qualitative indicators are scored by experts to obtain specific values. Quantitative indicators are directly processed by standardized data. The processing formula [12] is as follows:

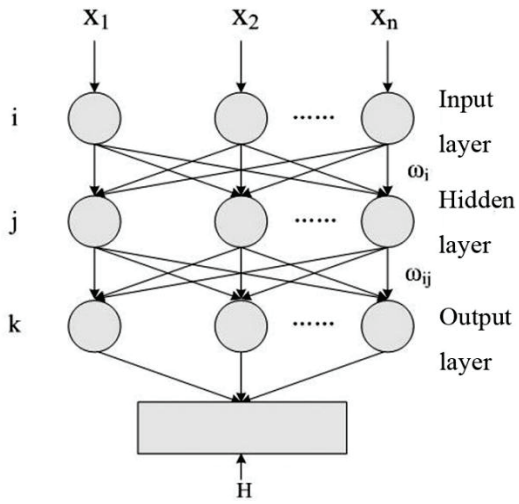

Figure 1 The structure of BP neural network model.

$$F_j = \begin{cases} \frac{X_j - X_{j\min}}{X_{j\max} - X_{j\min}} & \text{the evaluation is proportional to the score} \\ 1 - \frac{X_j - X_{j\min}}{X_{j\max} - X_{j\min}} & \text{the evaluation is inversely proportional to the score} \end{cases}, \quad (2)$$

where F_j is the standard value of the j-th index, X_j is the original value of the j-th index, $X_{j\min}$ is the minimum value of the j-th index, which is preset, and $X_{j\max}$ is the maximum value of the j-th index, which is preset.

(3) Forward propagation calculation [13]: The calculation is done layer by layer according to the forward propagation direction of the network, and the calculation formula is:

$$o = f\left(\sum_{i=1}^{n} \omega x_i - \alpha\right), \quad (3)$$

where o is The output value of each layer, α is the adjustment item of each layer, and $f(\bullet)$ is the activation function of the current node layer, which can be linear or non-linear.

(4) Error back-propagation calculation [14]: After the calculation, the management ability score is obtained and compared with the set actual management score. The calculation formula of error between them is:

$$E = \frac{(d_k - y_k)^2}{2}, \quad (4)$$

where E is the error between the calculated management ability score and the actual management score. If the error is within the specified range, the result will be output directly; if not, the weight of the hidden layer and output layer is reversely adjusted. The formula of weight adjustment is:

$$\omega(t+1) = \omega(t) + \eta(1 - y_k)o, \quad (5)$$

where η is the learning rate of adjusting weight.

(5) Repeated training: After the weight adjustment, the error between the calculated management ability score and actual management score is recalculated. Steps (3) and (4) are repeated until the error reaches the specified range.

(6) Qualitative evaluation: After getting the management ability score, a qualitative evaluation is made on the strategic management ability of enterprises according to the evaluation set: $H \in [0.9, 1]$ indicated good qualitative evaluation, $H \in [0.7, 0.9)$ indicated relatively good qualitative evaluation, $H \in [0.5, 0.7)$ indicated average qualitative evaluation, $H \in [0.3, 0.5)$ indicated relatively poor qualitative evaluation, and $H \in [0, 0.3)$ indicated poor qualitative evaluation.

4. SIMULATION ANALYSIS

4.1 Experimental Environment

In this paper, the BP neural network model algorithm in MATLAB [15] was utilized, and the qualitative evaluation index was quantified by expert scoring method. The experiment was carried out on the laboratory server with configuration of Windows 7 system, I7 processor and 16G memory.

4.2 Experimental Data

As shown in Table 2, strategic management capability indicators of nine enterprises were selected and standardized as experimental data. Among them, the evaluation data of No. 1 to No. 6 enterprises were used as training samples, A, B, C as experimental samples, and their actual management scores were obtained by comprehensive evaluation of experts, which was the regarded as the accurate evaluation in this paper.

Table 2 Evaluation indicators of enterprise management capability after standardization.

Number	1	2	3	4	5	6	A	B	C
X_1	0.578	0.533	0.647	0.498	0.603	0.558	0.613	0.502	0.548
X_2	0.609	0.581	0.638	0.589	0.611	0.562	0.628	0.574	0.581
X_3	0.611	0.592	0.615	0.553	0.598	0.556	0.588	0.654	0.602
X_4	0.594	0.644	0.542	0.588	0.574	0.643	0.532	0.584	0.614
X_5	0.541	0.421	0.784	0.654	0.784	0.658	0.447	0.478	0.484
X_6	0.544	0.564	0.687	0.664	0.741	0.584	0.568	0.546	0.557
X_7	0.645	0.754	0.648	0.584	0.674	0.669	0.458	0.548	0.657
X_8	0.747	0.678	0.548	0.698	0.548	0.556	0.458	0.658	0.573
Actual management score	0.678	0.745	0.679	0.0596	0.762	0.485	0.952	0.697	0.456

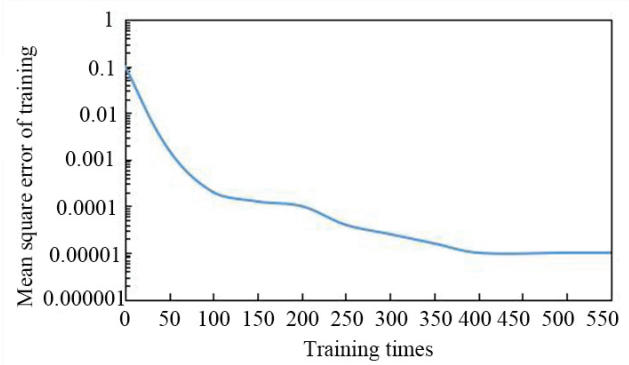

Figure 2 Variation curve of mean square error during.

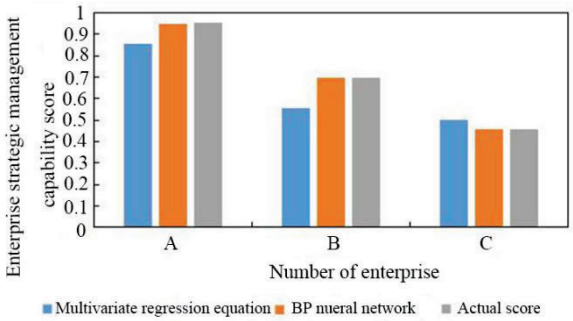

Figure 3 Scoring results of strategic management ability of enterprise A, B and C.

4.3 Experimental Results

As shown in Fig.2, with the increase of training times, the training mean square error of the enterprise strategic management capability evaluation model based on BP neural network algorithm decreased continuously until it stabilized at about 10^{-5} after 400 cycles of training; after 550 cycles of training, the mean square error of the model was basically within the range of 10^{-5}, and the training completed. The mean square error refers to the expected value of the square of the difference between the estimated value and the true value of the parameter, which can effectively reflect the accuracy of a model.

As shown in Fig.3, in order to prove the accuracy of the evaluation model based on BP neural network, the results obtained by using the multivariate regression equation were compared with the standard results obtained by expert comprehensive evaluation. The three results of enterprise A, B and C obtained by using multivariate regression equation were 0.855, 0.555 and 0.501 respectively. The results of enterprise A, B and C obtained by using BP neural network evaluation model were 0.951, 0.699 and 0.458 respectively. The standard results of enterprise A, B and C obtained by expert comprehensive evaluation were 0.952, 0.697 and 0.456 respectively. It was found from Fig. 3 that the evaluation results of multivariate regression equation on enterprise strategic management ability had large errors when compared with the standard scores, while the score obtained by the evaluation model based on BP neural network was basically the same as that obtained with the standard score. The qualitative evaluation results obtained by the multivariate regression equation were relatively good for A, common for B and relatively poor for C. The qualitative evaluation result obtained by the BP neural network based evaluation

model was good for A, average for B and relatively poor for C. The qualitative evaluation results obtained by the expert comprehensive evaluation were good for A, average for B and relatively poor for C. It could be seen that the evaluation model based on BP neural network was more accurate in qualitative evaluation.

5. CONCLUSION

This paper briefly introduced the strategic management capability of enterprises, subdivided the capability into eight indicators, established the evaluation index system of strategic management capability, introduced the evaluation model of strategic management capability based on BP neural network algorithm, and simulated the strategic management capability of nine enterprises. The evaluation data of six enterprises were used as training samples, and the evaluation data of three enterprises were used as evaluation data. In the training process of the evaluation model, with the increase of training times, the mean square error of the model became smaller and smaller; after 400 cycles of training, the mean square error of the model was stable at about 10^{-5}; after 550 cycles of training, the mean square error of the model was within the range of 10^{-5}, which met the use standard, and the training completed. The experimental samples of three enterprises were evaluated by the trained evaluation model, and the obtained results were compared with the results of multivariate regression equation and expert comprehensive evaluation. It was found that the model proposed in this study was more accurate than the traditional multivariate regression equation score and qualitative evaluation.

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