Service quality evaluation of fresh agricultural products cold chain logistics based on principal component and neural network

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Abstract. With the rapid development of fresh e-commerce, the cold chain logistics service quality of fresh agricultural products has attracted the attention of businesses and customers. Starting from the connotation of cold chain logistics service quality, the evaluation index system of agricultural products cold chain logistics service quality with 13 influencing factors was established. Considering that too many dimensions of input data and strong correlation among indexes will affect the training of neural network, this paper proposes to build a service quality evaluation model of cold chain logistics of fresh agricultural products by combining principal component analysis with BP neural network. Through the actual data verification of an e-commerce logistics enterprise, the evaluation accuracy rate is significantly improved, which provides an effective method for the service quality evaluation of fresh agricultural products cold chain logistics.

1. Introduction
In the increasingly competitive e-commerce market of fresh agricultural products, the service quality of cold chain logistics is an important factor to improve customer satisfaction and competitiveness of e-commerce enterprises. For the evaluation of service quality of cold chain logistics of fresh agricultural products, BP neural network has gained great attention due to its good nonlinear approximation ability and operability [1-5]. However, when the correlation between the indexes in the input layer is high, the effect of the neural network will be affected. Therefore, the principal component analysis in the statistical method is used to reduce the correlation between the indexes, and the score of the principal component is taken as the input scalar of the BP neural network to construct a new BP neural network model.

2. Analysis on the evaluation index system of agricultural products cold chain logistics service quality

2.1. Evaluation index construction
Based on the service quality of fresh agricultural products cold chain logistics, the characteristics of cold chain logistics of agricultural products, SERVQUAL model and LSQ are analyzed. Taking quality, responsiveness, reliability and customer perception as the key control points to measure the service quality, the model uses expert judgment method and expert experience to comprehensively consider the characteristics of fresh agricultural products cold chain logistics and the principle of index selection, and selects the commodity operation quality, commodity integrity, order response time,
delivery punctuality and return and exchange time, complaint handling time, special case delay time, temperature control, distribution accuracy, distribution flexibility, information level, distribution personnel status and personalized service are 13 evaluation indicators. Therefore, the evaluation index system constructed is shown in Figure 1.

2.2. Construction of index data processing
The collection of index data is obtained by scoring. There are four grades: excellent, good, general and poor, corresponding to the data between 0-1. The specific corresponding table is shown in Table 1.

| Evaluation score | Evaluation level |
|------------------|------------------|
| (0.9,1]          | excellent        |
| (0.6,0.9]        | good             |
| (0.3,0.6]        | general          |
| (0.0,3]          | poor             |

3. Evaluation model of agricultural products cold chain logistics service quality based on Genetic Neural Network
Considering that there are too many indexes, if the correlation between indexes is strong, the training of BP neural network will be affected. Through the research literature, it is found that principal component analysis can effectively eliminate the correlation between variables, so the principal component and BP neural network are combined to construct the service quality evaluation model of fresh agricultural products cold chain logistics. The principal component analysis in statistical method is used to reduce the dimension of the original data, and then the BP neural network model is constructed for evaluation research. Based on PCA-BP Neural Network, this paper constructs the evaluation model of fresh agricultural products cold chain logistics service quality.

1) The principal component analysis is carried out on the original data, and the principal component score is taken as the input layer data of BP neural network.
2) Select the relevant parameters to build BP neural network and train the network.

3.1. Principal component analysis
Principal component analysis (PCA) is a statistical method that can effectively reduce the dimension of variables and save a large number of original data information. Principal component analysis is to transform the original variables with obvious correlation into new linear uncorrelated variables after orthogonal change processing. The new linear uncorrelated variables are principal components, so each principal component is composed of original variables by some linear combination. Generally, when the research object is more complex, we can extract the comprehensive variables smaller than the original variables according to the needs of the actual problems to reflect the information of the original variables as much as possible, which can simplify the research problems and improve the analysis efficiency.

3.2. Construction of neural network model
Compared with other algorithms, the biggest advantage of BP neural network is that it can deal with nonlinear computing problems. The network structure of three or more layers can make BP neural network approach a nonlinear function with arbitrary precision. Its strong nonlinear mapping ability makes it has unique advantages in the analysis of nonlinear problems. The service quality evaluation of fresh agricultural products cold chain logistics is a complex problem, which has many influencing factors, and each factor is not a simple linear combination relationship. When the neural network model is used to evaluate the quality of service, a three-layer network structure is established.
The first layer is the normalized structure layer. Since there are 13 nodes in the bottom layer, a total of 13 nodes are taken as the input layer, which are commodity operation quality (B1), commodity integrity (B2), order response time (B3), delivery punctuality (B4), return and replacement processing time (B5), complaint handling time (B6), special case delay time (B7), temperature control (B8), and distribution Delivery accuracy (B9), distribution flexibility (B10), informatization (B11), distribution personnel status (B12), personalized service (B13).

The second layer is the hidden network layer, using trial and error implicit function: R is the number of input layers, S1 is the number of hidden layers, S2 is the number of output. Set the number of hidden layers S1 equal to 3, and the activation function is the tangent function Tan sig() of S type.

The third layer is the final output network layer, and the setting is a node. This stage represents the final quality of service evaluation results, and the activation function is purtline().

4. Case analysis

The simulation program is programmed on MATLAB 2017A. The basic parameters of neural network algorithm are: the training number of neural network is set to 2500 steps, the training function is set to trainlm function, and the training error is set to 0.005. Using the constructed network structure to train the data obtained by principal component analysis, the network meeting the training requirements is saved. The principal component score of the test sample is taken as the input of the network, and the principal component score of the test sample is predicted with the network trained and saved before.

The basic data needed in this paper comes from the service data of a logistics enterprise. After screening, 22 sample data are sorted out, as shown in Table 2. Among them, the first 20 samples are used as research data samples, and sample data No. 21 and 22 are used to verify the experimental effect.

| Id | B1  | B2  | B3  | B4  | B5  | B6  | B7  | B8  | B9  | B10 | B11 | B12 | B13 | Result |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 01 | 0.85| 0.59| 0.47| 0.61| 0.65| 0.62| 0.60| 0.75| 0.85| 0.71| 0.62| 0.52| 0.56| 0.7234 |
| 02 | 0.75| 0.53| 0.65| 0.80| 0.68| 0.52| 0.45| 0.80| 0.88| 0.66| 0.72| 0.47| 0.47| 0.6578 |
| 03 | 0.75| 0.54| 0.80| 0.61| 0.50| 0.41| 0.70| 0.64| 0.86| 0.58| 0.71| 0.81| 0.80| 0.6589 |
| 04 | 0.56| 0.43| 0.80| 0.71| 0.83| 0.61| 0.80| 0.37| 0.71| 0.94| 0.67| 0.91| 0.90| 0.6156 |
| 05 | 0.42| 0.81| 0.90| 0.72| 0.81| 0.72| 0.80| 0.86| 0.66| 0.31| 0.81| 0.73| 0.72| 0.6348 |
| 06 | 0.84| 0.35| 0.40| 0.61| 0.48| 0.82| 0.70| 0.83| 0.53| 0.60| 0.83| 0.61| 0.61| 0.6378 |
| 07 | 0.73| 0.62| 0.71| 0.66| 0.72| 0.51| 0.88| 0.65| 0.80| 0.73| 0.59| 0.59| 0.7415 |
| 08 | 0.43| 0.33| 0.43| 0.31| 0.26| 0.36| 0.81| 0.82| 0.63| 0.91| 0.37| 0.26| 0.26| 0.4289 |
| 09 | 0.90| 0.81| 0.76| 0.61| 0.81| 0.73| 0.51| 0.66| 0.81| 0.70| 0.81| 0.91| 0.91| 0.7815 |
| 10 | 0.89| 0.89| 0.85| 0.71| 0.81| 0.85| 0.76| 0.85| 0.92| 0.80| 0.83| 0.91| 0.90| 0.8890 |
| 11 | 0.90| 0.91| 0.65| 0.81| 0.78| 0.95| 0.88| 0.93| 0.85| 0.92| 0.75| 0.83| 0.83| 0.8498 |
| 12 | 0.88| 0.92| 0.73| 0.71| 0.80| 0.65| 0.81| 0.72| 0.87| 0.80| 0.90| 0.81| 0.81| 0.8478 |
| 13 | 0.85| 0.95| 0.81| 0.82| 0.77| 0.80| 0.76| 0.63| 0.81| 0.91| 0.86| 0.81| 0.81| 0.8085 |
| 14 | 0.91| 0.86| 0.81| 0.75| 0.84| 0.75| 0.81| 0.87| 0.67| 0.91| 0.92| 0.90| 0.90| 0.8289 |
| 15 | 0.89| 0.94| 0.92| 0.97| 0.91| 0.95| 0.91| 0.95| 0.91| 0.92| 0.94| 0.96| 0.96| 0.9120 |
| 16 | 0.72| 0.72| 0.83| 0.63| 0.77| 0.85| 0.80| 0.93| 0.84| 0.81| 0.75| 0.80| 0.82| 0.7299 |
| 17 | 0.80| 0.64| 0.80| 0.81| 0.71| 0.73| 0.89| 0.81| 0.81| 0.61| 0.81| 0.71| 0.71| 0.7068 |
| 18 | 0.67| 0.80| 0.70| 0.61| 0.80| 0.81| 0.83| 0.85| 0.85| 0.75| 0.87| 0.93| 0.93| 0.7511 |
| 19 | 0.64| 0.82| 0.70| 0.81| 0.72| 0.83| 0.77| 0.67| 0.63| 0.81| 0.95| 0.81| 0.81| 0.7677 |
| 20 | 0.88| 0.94| 0.80| 0.81| 0.83| 0.93| 0.94| 0.77| 0.83| 0.87| 0.88| 0.94| 0.94| 0.8434 |
| 21 | 0.75| 0.70| 0.80| 0.67| 0.76| 0.82| 0.83| 0.86| 0.83| 0.75| 0.80| 0.84| 0.84| 0.7333 |
| 22 | 0.94| 0.92| 0.80| 0.83| 0.82| 0.93| 0.92| 0.81| 0.83| 0.85| 0.88| 0.94| 0.94| 0.8457 |

SPSS statistical software was used to analyze the samples, and the following path was used in the menu interface of the software: analysis dimension reduction factor analysis, and then the variable parameters and related parameters of principal component analysis were set. The number of extracted principal components is 7, so the 7 principal components can retain most of the information of the original data. As shown in Table 3.

| Id | B1  | B2  | B3  | B4  | B5  | B6  | B7  |
|----|-----|-----|-----|-----|-----|-----|-----|
| 01 | 0.55| 0.39| 0.39| 0.24| 0.33| 0.42| 0.62|
14 indexes have been transformed into 7 comprehensive indexes by principal component analysis, and the principal component scores of samples are taken as BP neural network training and detection samples. Therefore, the input variable is the score of seven principal components obtained by principal component analysis, and the output variable remains unchanged. We input the first 20 processed sample data into the neural network model to verify the data No.21 and No.22, and the results are shown in Table 4. Obviously, the results of three groups of service quality evaluation based on principal component neural network are all satisfactory, and the relative error is within ± 0.004.

| Number of experiments | \( t_{k1}=0.7333 \) | \( t_{k2}=0.8457 \) | \( e_{k1} \) | \( e_{k2} \) |
|-----------------------|----------------|----------------|--------|--------|
| 1                     | 0.7339         | 0.8489         | 0.0006 | 0.0032 |
| 2                     | 0.7348         | 0.8428         | 0.0015 | -0.0029|
| 3                     | 0.7306         | 0.8495         | -0.0027| 0.0038 |

Comparing the new evaluation results with the results without PCA dimension reduction, it is found that the PCA neural network can not only achieve faster convergence speed, but also reduce the average relative error and improve the accuracy of the evaluation results.

5. Conclusion
When BP neural network model is used to evaluate the service quality of fresh agricultural products cold chain logistics, when the index dimensions of input data are too many and the correlation is high, the principal component analysis should be applied to the original data to achieve the effect of dimension reduction, and then the effect of evaluation will be better.

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