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The Evaluation of Express Service Quality Based on BP Neural Network Algorithm

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Abstract. The rapid development of the express delivery industry has made it an important part of the modern service industry. The quality of express delivery services has become an important indicator of the competitiveness of express delivery companies. In order to optimize consumers' experience in the service industry, based on Python crawler technology, collected comments from Baidu's word-of-mouth STO, ZTO, YTO, and Yunda Express companies, and drew a word cloud diagram of comments, combined with the SERVQUAL scale and express service business processes, and integrate the quality and process of service results, established an evaluation index system for the quality of express delivery services. Based on this evaluation system, the BP neural network algorithm was used to construct the evaluation model, and the questionnaire survey data was used for empirical analysis. The results show that: 1) The express service quality evaluation index system and evaluation model based on dynamic website review data and service quality related theories are reasonable; 2) BP neural network improves the accuracy of service quality evaluation results. Providing theoretical support for the long-term development of express delivery companies and the express industry, and promoting the high-quality and steady development of the express industry.

Keywords: service quality, evaluation index system, Python, BP neural network

1. Introduction

In the development process of the e-commerce industry, the corresponding business flow, logistics, capital flow, etc. need to rely on the express industry to accelerate the operation of e-commerce. The rapid development of e-commerce continues to promote the update and iteration of the express industry, and the development of the express industry is changing with each passing day[1]. According to data from the State Post Bureau, after preliminary calculations, China's express delivery business volume will be 83 billion pieces in 2020, a year-on-year increase of 30.8%, and business revenue will reach 875 billion yuan, a year-on-year increase of 16.7%. Large-scale, high-profit, and broad-prospective labels have made the express delivery industry fiercely competitive. In the fierce competition, the express delivery industry, which belongs to the service industry, requires express delivery companies to improve their comprehensive service capabilities and face the increasing demand for services from consumers. Improving the service quality of the express delivery industry is a top priority[2-3].

Regarding the quality of service, different scholars have different understandings of service quality. Gronroos[4] proposes the concept of "customer knowledge service" in 1982, customer's expectations and actual experiences determine the quality of service. In 1983, Takeuchi[5] proposed service quality should be determined by the pre-service, service and service. In 1999, Zhu Gan et al. [6] made the specific connotation of service quality, and an empirical analysis of the medical industry. From the service quality definition study, the service quality evaluation system that is widely recognized and applied by scholars is the theoretical model of SERVQUAL and LSQ. In 2001, Mentzer et al. [7] proposed a more perfect LSQ model on the basis of previous research results. In 2016, Dang Wei et al. [8] added economic and security dimensions on the basis of SERVQUAL model's 5 dimensions, and s[1]plit LSQ model into 22 indicators. With the rapid development of the express delivery industry, the relevant research on the express delivery industry and express delivery enterprises at home and abroad gradually emerged. Dale[9] (1998)

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constructing the theoretical model of postal express service based on consumer satisfaction, and summarizes how to enhance service quality conclusions. Wang Daiyu et al.[10] (2008) uses factor analysis, and constructs score model of expressive enterprise competitiveness. Zou Jianping[11] (2010) studied the relationship between service quality and consumer loyalty, and constructs linear regression model based on BP neural network algorithm. Roslan et al.[12] (2015) added the service cost dimension on the basis of the five dimensions of SERVQUAL model to study the relationship between service quality of third-party logistics and customer satisfaction. Gong Yutong et al. [13] (2019) adopted data envelopment method (DEA) to establish a service quality measurement system for express delivery industry with two input indicators and three output indicators.

Through relevant research and analysis at home and abroad, it can be seen that the current literature mainly builds different evaluation systems based on the differences of research objects, or conducts targeted analysis of express service quality by constructing comprehensive evaluation models, and does not integrate consumer dynamic evaluation with express service quality. In this study, crawler technology was used to crawl the comments of online websites, and combined with consumers' evaluation of the service quality of various express delivery enterprises, an evaluation system of express service quality was constructed, which was dynamic and authentic. BP neural network algorithm is used to construct the evaluation model to avoid the influence of subjectivity and improve the accuracy and rigor of the evaluation results.

2. Construction of The Evaluation Index System of Express Service Quality Based On Data Mining

This research intends to refer to the related literature on service quality, use crawler technology to collect and sort out relevant comments under the four express companies on Baidu KouBei website, combine the high-frequency word attributes of the word cloud drawn by Python and the theoretical model of service quality to establish an express service quality evaluation index system. Provide a theoretical basis for the construction of the model later.

2.1. Acquisition and Processing of Comment Data

This study uses Python3 programming and selects Baidu KouBei comment data as the research object. A total of about 16,000 comments under the official Baidu KouBei of the four express companies of YTO, ZTO, STO and YunDa are crawled. The comment data is authentic and timely[14]. After obtaining the original comment data, this research uses MySQL database to process the express comment, strengthen the standardization of the data format, and obtain more standardized express service related comment data.

2.2. Analysis of Comment Data of Express Delivery Companies

This study uses Python3 to generate an online comment word cloud map of various express delivery companies, and combines the content displayed in the word[15] cloud map to analyse the service quality of each express delivery company, and establishes an express service quality evaluation index system based on the status quo of service quality research.

Fig. 1: Word cloud map of four express companies.

The above figure shows the high-frequency online reviews of the four express companies. The main keywords are summarized as shown in Table 1.

Table 1: Keywords Summary Results

Keywords	**Summary**
service, delivery, speed etc.	Overall evaluation
few days, two days, speed, too slow etc.	Timeliness evaluation
service, attitude, customer service etc.	Customer Service Evaluation
telephone, information tec.	Informatization evaluation
ship, sign, deliver etc.	Delivery Evaluation

I. Overall evaluation analysis

According to the content shown in the word cloud diagram, the high-frequency words that consumers generally evaluate the four express delivery companies mainly focus on the participles such as "service", "delivery", "speed", and overall. When consumers evaluate express delivery companies, they not only express their subjective feelings about express delivery companies, but also pay more attention to service quality. Service level has become an important indicator of the evaluation of express delivery companies. This change promotes the importance of express delivery companies to the improvement of service quality.

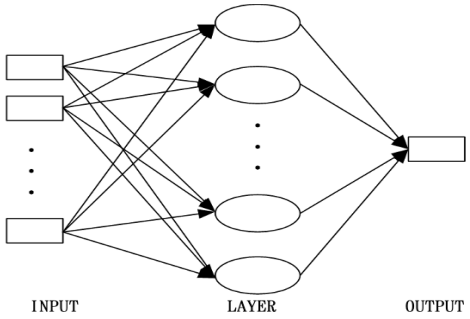

Fig. 2: Forecast model network structure.

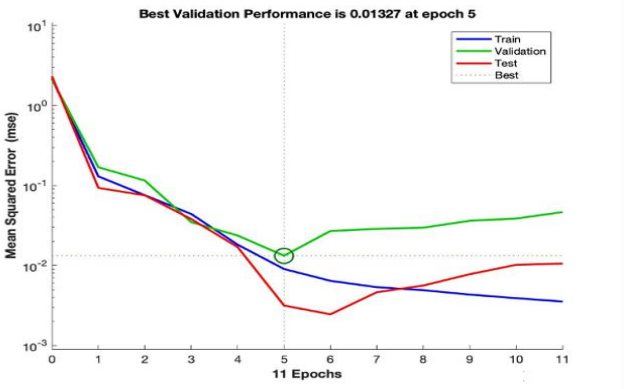

Fig. 3: Error curve of BP neural network.

II. Limitation requirements

Timeliness is the eternal benchmark for express delivery companies. With the continuous progress of the logistics industry, consumers are increasingly demanding timeliness for express delivery companies. In the word cloud picture shown in the figure above, the high-frequency words "few days", "two days", "speed", and "too slow" in consumer reviews are all related to the timeliness of express mail. Stable express delivery

timeliness attracts more consumers, and at the same time, the service experience of existing consumers has been improved, and the service quality of enterprises has been highly evaluated by consumers.

III. Customer service requirements

Customer service is a corporate behavior that is closer to consumers, and its quality can completely affect consumers' perception of the company. In the word cloud diagram shown in the figure above, the high-frequency words "service", "attitude", and "customer service" in consumer reviews are all related to the customer service of express companies. In today's networked age, consumers pay more attention to precision and personalized services, and the customer service of express companies must also be innovative, including personalized, intelligent and refined needs.

IV. Informatization requirements

Informatization is an important part of the core competitiveness of express logistics enterprises and social logistics systems. In the word cloud diagram, words such as "information" and "telephone" appear frequently, indicating that in most cases, consumers and courier companies mainly communicate by telephone, and the communication method is relatively simple. Increasing the degree of automation of express delivery companies through informatization can achieve the rational allocation of resources, the reduction of logistics costs, and the improvement of service levels.

V. Delivery management requirements

Delivery management mainly refers to the basic requirements such as specialization that enterprises should have in the delivery process, and promote the standardization, standardization and scientific development of enterprises. In the figure above, words such as “delivery”, “sign” and “ship” show how consumers pay attention to the delivery links of logistics operations of express delivery companies. Express companies should also pay attention to the professionalization of each link. Standardize management and improve the service quality of enterprises.

By combing the related research on the quality of express delivery services at home and abroad, it can be seen that the SERVQUAL model focuses on the evaluation of process quality, and the LSQ model focuses on the quality of results. The current research on the dimensions of express service quality by domestic and foreign researchers is summarized in the Table 2.

TABLE 2: Research on the Dimensional Division of Express Services

Researcher	**The division of logistics service quality dimensions**
Wang Y，Zhang P L（2016）[16]	Refrigeration ability, operation ability, personnel communication ability and logistics information (cold chain logistics)
Wang HW, Song Y etc.（2017）[17]	Enterprise as a whole, price, timeliness, courier, informatization, security, customer service
Shan H M，Zhou Y etc.（2018）[18]	Guarantee, timeliness, tangibility, convenience, safety
Xu G Z（2019）[19]	Logistics service delivery quality, personnel service quality, information interaction quality, Emergency response quality (fresh food e-commerce logistics)
Huang X L，Hu Y S etc.（2020）[20]	Service product, service efficiency, service price, service content and service guarantee

It can be seen from the above table that the existing literature lacks the result quality and process quality in the service process of integrated express delivery companies, and a comprehensive measure of the quality of express delivery services. This study draws on the 5 dimensions of the SERVQUAL model and the corresponding 22 indicators[21] and the 9 dimensions of the LSQ model and the corresponding 25 indicators[22], combined with the characteristics of express service quality and the predecessor’s evaluation

system of express service quality The research results of the SERVQUAL model and the LSQ model are adjusted. This research is based on the above-mentioned keyword information extracted from the relevant online reviews of four express companies on Baidu Koubei, combined with the express delivery business process, with the express service process and service results as the touch point, and proposes a five-dimensional and nine-refined index The express service quality evaluation index system selects Tangibility, Timeliness, Responsiveness, Reliability, and Assurance as the five dimensions of the express service quality evaluation system. Combined with the current status of express service quality, the following 9 indicators are divided. The meanings and numbers of the corresponding indicators are as shown in the Table 3.

TABLE 3: Express Service Quality Evaluation Index

Dimension	Evaluation Index	Indicator Meaning	References	Number
Tangibility	Overall impression	The overall impression of express delivery companies in the minds of consumers	ALI F，DEY B L etc.（2015）[23]	X_1
Timeliness	Transportation speed	After the courier picks up the package, the speed at which the package arrives at the courier outlet	Zhuang D L，Li J etc.(2015)[24]	X_2
	Delivery speed	The speed at which consumers place orders to the courier to pick up and the courier to dispatch	Wang Y H，Sun G Y（2019）[25]	X_3
Responsiveness	Customer Service Attitude	Whether the customer service staff is serious and meticulous when answering consumer questions, and whether the tone is patient	Manzel（1999）[26]	X_4
	Complaint Processing efficiency	Whether the customer service personnel are timely and efficient in solving consumer complaints	G. Tan, J. Wang（2019）[27]	X_5
Reliability	Information -query convenience	Whether the track information of express delivery can be accurately, timely and conveniently obtained by consumers	W. Liang, Y. Wang（2015）[28]	X_6
	Timeliness of information update	Whether the track information and delivery status of the express are updated in time	X. Cao, L. Li（2015）[29]	X_7
Assurance	Intelligent terminal equipment	Whether the terminal equipment equipped by the courier is advanced and intelligent	B. Yu, H. Du（2013）[30]	X_8
	Courier service professionalization	Whether the courier provides professional services during the delivery process	L. He（2013）[31]	X_9

3. Construction of Service Quality Evaluation Model Based on BP Neural Network

After determining 9 indicators of express service quality evaluation, this study will build an evaluation model based on BP neural network based on the established service quality evaluation system, and conduct empirical analysis combined with questionnaire data to further verify the rationality and effectiveness of the model.

3.1. BP Neural Network

When applying the BP neural network model, a supervised learning mode is generally adopted, that is, according to a given input data set x_i and the corresponding known output d_i (also called expected output), the weight w and bias b of the training network, minimize the error between the actual output y_k generated under the network conditions and the corresponding expected output d_k, that is, the purpose of the learning and training of the neural network is to determine the two parameters corresponding to the network: Connect the weight w and the bias b of each neuron. The learning of neural network can be divided into two processes, namely forward calculation and backward propagation calculation.

3.2. Model Construction

When building a model using BP neural network, firstly, it is necessary to determine the structure mode of the network, that is, the level of the network, the number of input nodes n_1, the number of hidden layers n_2, and the number of output nodes n_3. The specific network design of this research is as follows [32]:

I. Input and output layer design

In this study, the number of indicators in the constructed evaluation indicator system is used as the input of the neural network, so the number of nodes in the input layer is n_1 =9. The output of the model is the customer's evaluation of the express service quality, so the number of output nodes n_3=1.

II. Hidden layer design

In the BP neural network model, the number of hidden layer nodes is generally determined based on experience or experiment. In this research, an empirical formula about hidden layer nodes [33] is introduced:

$$(n_1 + n_2)^{1/2} + a, (a=2\sim10) \quad (1)$$

In the formula, a is an empirical constant. Taking the estimation formula of (1) as the lower limit, the number of hidden nodes in the model n_2=10. The specific structure of this research model is shown in Fig.2.

4. Empirical Analysis

4.1. Data Collection and Processing

This study designed a questionnaire on the quality of express delivery services based on the above-built indicator system, and randomly distributed questionnaires with express company users as the subjects of the survey. This study combines the status quo of service quality and industry characteristics, divides the express service level into 5 grades and assigns corresponding scores, and scores each indicator.

In this survey, a total of 300 questionnaires were issued and 232 questionnaires were retrieved. The valid questionnaires were 224, and the questionnaire validity rate was 95.6%. Using SPSS software for reliability analysis, the Cronbach's Alpha coefficient was calculated to be 0.911, and the reliability of the questionnaire reached the requirements, so in-depth analysis can be carried out.

After the data is collected, the collected data needs to be standardized. The normalization processing is selected in this study, which can improve the convergence speed and calculation accuracy of the model, and ensure the stability and reliability of the experimental results [34]. This study uses the Min-max normalization method, and the conversion function is as follows:

$$x^*=(x-min)/(max-min) \quad (2)$$

In the formula, min represents the minimum value of the sample data, and max represents the maximum value of the sample data. This research uses Python to process the data, and the process is concise and clear.

4.2. BP Neural Network Training and Result Analysis

I. Model training

This research uses MATLAB software [35] for modeling, takes 194 questionnaire data as the training set, and the remaining 30 data as the test samples. Inputs the trained network for testing, and compares the output results with the actual values to test the nerves. The correctness of network prediction results. In this study, purelin is selected as the model output function, tansig is the hidden layer function of the model, and the MATLAB neural network toolbox is used to randomly select 70% of the data samples, 15% of the verification samples, and 15% of the test samples, using the traininglm function and LM algorithm for training the internet.

The above-built model is trained through the neural network toolbox of MATLAB R2017b, and 194 questionnaire data are used as the training set. After 11 iterations, the training is completed. The training result is shown in Fig.3. When the number of training iterations reaches 5, the training error reaches 10^{-2}, the training result meets the error accuracy requirement, and the model training ends.

The regression coefficients in the training process of each data set are shown in TABLE 4. It shows the regression relationship between the target output of the training set, the test set, and the validation set and the output value of the neural network. When the regression coefficient is larger, the correlation is stronger. In

TABLE 4, the data regression coefficient of the training part is 0.9950, the data regression coefficient of the verification part is 0.9324, and the data regression coefficient of the test part is 0.9982, which further shows that the BP neural network model in this study has a high degree of fit.

TABLE 4: Data set Sample Regression Relationship

Data set sample	Regression
Training set	0.9950
Validation set	0.9324
Test set	0.9982

II. Analysis of simulation results

In order to further verify the applicability and accuracy of the evaluation model, this study uses the remaining 30 data samples as a test. After using Python to denormalize the prediction results, the corresponding results are shown in TABLE 5. According to the table, it can be found that the error between the actual output value of the evaluation model and the expected value is small, and the average absolute error percentage is 0.582%. Therefore, the evaluation effect of the model is good, and the model has credibility and validity.

TABLE 5: Error analysis of model test

Test sample number	Expected output value	Actual output value	Relative error absolute value (%)	Test sample number	Expected output value	Actual output value	Relative error absolute value (%)
1	3	2.94193362	1.935	16	3	2.97283418	0.905
2	4	3.98029078	0.494	17	3	2.96393249	1.202
3	4	4.00009547	0.002	18	3	2.98803762	0.398
4	4	3.99115775	0.221	19	3	2.9866642	0.444
5	3	2.97940074	0.686	20	3	2.9638718	1.204
6	3	2.97779799	0.740	21	3	2.9822569	0.591
7	4	3.96231964	0.942	22	4	3.99419623	0.145
8	4	3.98621114	0.344	23	4	3.98368509	0.407
9	3	2.96122647	1.292	24	3	3.01613731	0.537
10	3	2.97977427	0.674	25	3	2.96678219	1.107
11	3	3.00052095	0.0173	26	4	3.97236919	0.690
12	3	2.98874575	0.375	27	4	3.97427376	0.643
13	3	2.98691829	0.436	28	4	4.00231423	0.057
14	4	3.98183644	-0.454	29	4	3.98318617	0.420
15	4	3.97133247	0.716	30	4	3.98123422	0.469

At the same time, the fitting coefficient R2 obtained in this test is 0.99615, which is close to 1, indicating that the model has a strong fitting ability and can be used as an application model for evaluation index analysis. Effectiveness and reliability.

Based on the above empirical analysis results, the express service quality evaluation model based on data mining proposed in this study is consistent with the results of the express service quality satisfaction questionnaire, and has good applicability.

Compared with other research, the difference is: 1) This study first uses reptile technology to climb online website, and construct the express service quality evaluation system with consumers, with dynamic, authenticity; 2) This study combines self-organizing, self-learning, and self-adaptive characteristics of BP neural network, studying the specific relationship between express service quality and evaluation indicators, avoiding subjective impact. The express delivery service quality evaluation results output by the evaluation model proposed in this study more intuitively show the differences in the overall service quality of various

express companies, and provide a basis for express companies to improve service quality and formulate targeted service quality improvement strategies.

5. Conclusion

This research aims at the problem of how to effectively improve the service quality of express companies, combined with the theoretical system of service quality, constructs a service quality evaluation model based on the BP neural network algorithm, and draws the main conclusions: 1) This research uses data mining technology, combined with the high-frequency word attributes and service quality theoretical models of the four express company commentary word clouds drawn, and establishes an express service quality evaluation index system, which dynamically reflects consumers' concerns about service quality, and reflects express companies' timeliness, informatization and other indicators. The pros and cons provide a reference for express delivery companies to improve their service quality in a targeted manner. 2) This study uses the established evaluation indicators as the input of the model, eliminates the influence of subjective factors, and combines the autonomous learning ability of the BP neural network algorithm to further avoid the randomness in the traditional comprehensive evaluation process, the subjective assumptions of the evaluation subject, and its cognitive ambiguity can improve the accuracy and rigor of express service quality evaluation results, and provide methodological references for related research on express service quality evaluation. 3) This study combined the questionnaire survey data and used MATLAB software to conduct empirical analysis of the model, and further verified the rationality and effectiveness of the evaluation model. It has certain applicability to the evaluation and research of express service quality, and it is reasonable for consumers to choose express delivery. Enterprises provide guidance for delivery services, which provides a new research entry point for the study of express service quality.

Based on the consumer's perspective, this research uses data mining technology to establish evaluation indicators, which truly and dynamically reflect the focus of consumers when evaluating the service quality of various express companies; build a service quality evaluation model based on BP neural network algorithm , made a certain supplement to the relevant research on the quality of express delivery services, provided theoretical support to various express delivery companies on how to improve service quality, and helped expand the decision-making direction of express delivery companies, thereby optimizing development strategies. In addition, considering that there are temporarily unsolvable problems in the BP neural network, such as the uncertainty of the network structure, the randomness of the initial weights and thresholds, etc., it is easy to lead to poor stability of the evaluation results. Therefore, in the follow-up in-depth research, consider BP neural network and genetic algorithm are combined to make up for the shortcomings of BP neural network when applied alone, enhance the stability of the evaluation model, and improve the accuracy of the evaluation results.

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