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Original scientific paper

# An Entropy Weight-TOPSIS Based Method for e-Commerce Logistics Service Quality Evaluation

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**Abstract:** The problem of logistics service quality is the weakness that restricts the high-quality development of rural e-commerce. The paper combines SERVQUAL model and LSQ scale to build a rural e-commerce logistics evaluation system with five first-level indicators of reliability, timeliness, convenience, economy and empathy and 18 second-level indicators. On this basis, the service quality of five typical rural e-commerce logistics enterprises is comprehensively evaluated by using the entropy weight method and TOPSIS method through a questionnaire survey. The results show that the quality of logistics service should be improved from reliability and empathy. The service quality of Enterprise 4 is the highest, and that of Enterprise 5 is the worst.

**Keywords:** entropy weight-TOPSIS; rural e-commerce logistics; service quality

## 1 INTRODUCTION

In recent years, with the in-depth implementation of the rural revitalization strategy and the in-depth promotion of digital rural construction, China's rural e-commerce has developed rapidly. According to relevant data, China's rural online retail sales will reach 2.17 trillion yuan in 2022, up 3.6% year on year. Rural e-commerce has played a huge role in boosting economic development and employment. The development of rural e-commerce cannot be separated from the support of logistics, and the development of e-commerce also puts forward higher requirements for the service quality of logistics [1]. However, the service quality of rural e-commerce logistics, especially the logistics distribution, has a great impact on consumers' online shopping experience, and has become a weakness that restricts the development of rural e-commerce. Therefore, it is of great practical significance to deeply study the service quality of rural e-commerce, improve the service quality of relevant e-commerce logistics enterprises, and promote the development of rural e-commerce logistics.

## 2 LITERATURE REVIEW

There are many relevant studies on the evaluation of logistics service quality by domestic and foreign scholars. Perrault and Russ (1974) were the first to study this issue. The two scholars proposed the 7Rs theory based on time and place utility. The core of this theory is that enterprises can deliver goods to the right place at the right time with the right goods status and the right goods price accompanied by accurate goods information [2]. Parasuraman, Zenithal and Berry (PZB) (1988) put forward the famous SERVQUAL theory through the research on customer perceived quality. Through measuring the difference between customer's perception and service expectation in the service process, they established 22 indicators in five dimensions of reliability, empathy, responsiveness, assurance and tangibility [3], which were applied by many scholars at home and abroad to the evaluation of service quality in different industries. Meltzer, Flint and Keith (2001) established the LSQ scale with 9 dimensions and 25 indicators, including personnel communication quality and order process, based on the investigation and research of executives and a large number of front-line personnel of large logistics companies in the United States from the perspective of customers [4]. At present, many scholars build logistics service quality evaluation system based on SERVQUAL and LSQ scales and industry characteristics.

Many domestic scholars refer to SERVQUAL and LSQ scales to carry out research on logistics service evaluation. For example, based on the SERVQUAL and LSQ models, the literature [5] takes the rural terminal logistics distribution as the research object and combines the local logistics level to determine four first-level indicators and 18 second-level indicators of convenience, reliability, service attitude and timeliness. Literature [6] studies that in the context of new retail, the evaluation system of e-commerce service quality has been established by updating the local e-commerce logistics service quality control model. Literature [7] has constructed a crowdsourcing logistics service quality evaluation system with five dimensions and 21 indicators through questionnaire survey. On the basis of SERVQUAL and LSQ models, the literature [8] takes rural e-commerce logistics as the research object, selects 23 indicators from six dimensions of convenience, reliability, timeliness, care, economy and security, and constructs a rural e-commerce logistics service quality evaluation system.

## 3 CONSTRUCTION OF RURAL E-COMMERCE LOGISTICS SERVICE QUALITY EVALUATION INDEX SYSTEM

In constructing the evaluation index system of rural e-commerce logistics service quality, this paper refers to the relevant research of domestic and foreign scholars on the evaluation of logistics service quality, and combines the actual situation of rural e-commerce logistics service in China, and builds the index system from five dimensions of reliability, timeliness, convenience, empathy and economy based on the SERVQUAL model as shown in Fig. 1 and LSQ model as shown in Fig. 2. The corresponding secondary indicator system of each primary indicator system is shown in Tab. 1.

Reliability refers to the characteristic that a company can generate trust among consumers through certain services. Timeliness refers to the ability of e-commerce and logistics enterprises to provide corresponding services

to rural e-commerce consumers in the first time. Convenience reflects the demand of rural consumers for access to convenient services. Empathy reflects the professional ability and attitude of e-commerce and logistics enterprise staff in providing services to rural consumers. Economy is due to the relatively low-income level of rural residents. Logistics enterprises need to integrate local logistics resources and reduce their own logistics costs in order to provide lower prices for local e-commerce consumers, fully considering economic factors.

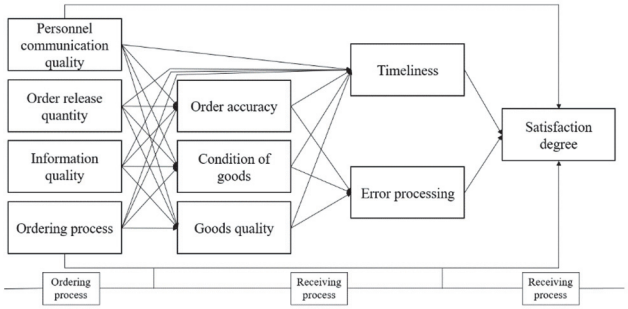


**Figure 1** SERVQUAL model

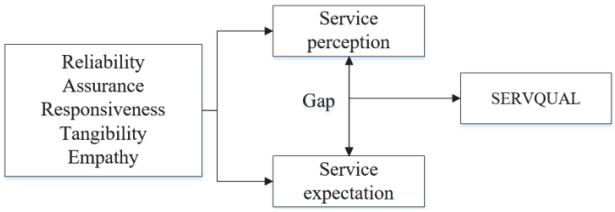


**Figure 2** LSQ model

**Table 1** Evaluation indicators of rural e-commerce logistics service quality

| Target layer | First-level indicators | Two-level indicators |
|---|---|---|
| Rural e-commerce logistics service quality | Reliability A | The arrival is consistent with the order A1 |
| | | The goods are in good condition A2 |
| | | Logistics distribution information is accurate A3 |
| | Timeliness B | Timely order response B1 |
| | | Timely customer service response B2 |
| | | Timely update of logistics information B3 |
| | | Timely handling of abnormal goods B4 |
| | | Timely handling of return and replacement B5 |
| | Convenience C | Convenient pickup by customers C1 |
| | | Convenient for customers to return and exchange goods C2 |
| | | Comprehensive network coverage of logistics enterprises C3 |
| | | Convenient payment terms C4 |
| | Empathy D | Staff with good attitude D1 |
| | | Staff with professional proficiency D2 |
| | | Prompt for pickup by phone or SMS D3 |
| | Economy E | Logistics cost economy in rural areas E1 |
| | | Economic cost of return and exchange E2 |
| | | Economic cost of value-added service E3 |

## 4 RESEARCH METHODOLOGY

### 4.1 Index Weight Calculated by Entropy Weight Method

Entropy weight method is an objective weighting method, which determines the weight of indicators according to the impact of the relative change of indicators on the overall system by calculating the information entropy of indicators. This method has been widely used in various fields such as statistics and has strong research value [9].

Entropy can be used to judge the randomness and disorder of an event, as well as the dispersion of indicators. The smaller the entropy value, the greater the degree of dispersion of the index, which means the greater the impact of the index on the comprehensive evaluation (i.e. weight) [9]. For example, if the sample data are equal under a certain indicator, the impact of the indicator on the overall evaluation is 0, and the weight value is 0.

(1) Data standardization

Assume that the evaluation index system includes n indicators, a total of m samples, and the initial data matrix can be formed:

$$x=\begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}; x=\left\{x_{ij}\right\}_{m\times n}\left(1\le i\le m,\ 0\le j\le n\right) \quad (1)$$

In the formula, $x_{ij}$ is the value of the $j$-th evaluation index of the $i$-th sample.

Standardize matrix $X$ by converting it to the same scale for better comparison and analysis:

$$r_{ij}=\frac{x_{ij}-\min\left(x_i\right)}{\max\left(x_i\right)-\min\left(x_i\right)} \quad (2)$$

In the formula, $r_{ij}$ is the value of the $j$-th evaluation index of the ith sample.

(2) Calculate the proportion y of the index value of the $i$-th object under the $j$-th index $y_{ij}$.

$$y_{ij}=\frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}\left(0\le y_{ij}\le 1\right) \quad (3)$$

(3) Calculate the index information entropy value $e$ and information utility value $d$:

① The formula for calculating the information entropy of index j is as follows:

$$e_j=-k\sum_{i=1}^{m} y_{ij}\ln y_{ij} \quad (4)$$

$k$ is constant, $k = 1/\ln m$.

②The utility value of information is proportional to the weight. The greater the utility value of information, the more weight. The calculation formula is as follows:

$$d_j=1-e_j \quad (5)$$

(4) Calculate the weight of evaluation indicators.

The entropy method is used to estimate the weight of each index. The greater the weight, the greater the contribution to the evaluation results. The weight of the jth index:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{6}$$

### 4.2 Topsis Method Comprehensively Ranks the Service Quality of Logistics Enterprises

TOPSIS method is a sequential optimization technology of ideal target similarity, especially suitable for multi-objective decision analysis [10]. TOPSIS can fully utilize data information and avoid subjectivity of data [11]. The main idea of TOPSIS method is to first calculate the optimal solution and the worst solution, and then judge the distance from the evaluation object to the optimal solution and the worst solution. If the distance from the evaluation object to the optimal solution is larger and the distance from the worst solution is smaller, the higher the ranking of the evaluation object is, and the highest ranking is the best.

(1) Data standardization, see Eq. (1)

(2) Data normalization, see Eq. (2)

(3) The weighted decision matrix is constructed according to the weight of each evaluation index obtained by the entropy weight method:

$$z_{ij} = w_j \cdot r_{ij} \left(1 \le i \le m,\ 0 \le j \le n\right) \tag{7}$$

(4) Determine the positive ideal solution and negative ideal solution of each evaluation index:

$$S_j^+ = \max\left\{z_{ij}\right\}\left(1 \le i \le m,\ 0 \le j \le n\right) \tag{8}$$

$$S_j^- = \min\left\{z_{ij}\right\}\left(1 \le i \le m,\ 0 \le j \le n\right) \tag{9}$$

(5) The Euclidean distance is used to calculate the distance between the evaluation object and the positive and negative ideal solution:

$$H_i^+ = \sqrt{\sum_{j=1}^{n}\left(S_j^+ - z_{ij}\right)^2} \tag{10}$$

$$H_i^- = \sqrt{\sum_{j=1}^{n}\left(S_j^- - z_{ij}\right)^2} \tag{11}$$

(7) Rank according to the service quality. The larger the $\eta_i$ is, the closer the service quality is to the optimal level. On the contrary, it means that the service quality is closer to the worst level.

## 5 CASE ANALYSIS

Based on the evaluation index system of rural e-commerce logistics service quality and the basic situation of five representative e-commerce logistics enterprises, a questionnaire survey was conducted to investigate e-commerce consumers, village level service station staff, and e-commerce enterprise leaders in rural areas to obtain their evaluation data of logistics service quality in rural areas. The questionnaire was prepared using Likert's five-level scale, with 1 point representing "complete nonconformity" and 5 points representing "complete conformity". A total of 310 copies were distributed, and 288 valid samples were recovered. According to the questionnaire, the evaluation index scores of five logistics enterprises are counted, and the average value is taken as the original data of the evaluation index.

### 5.1 Calculate the Weight of Each Evaluation Index by Entropy Weight Method

In order to ensure the reliability of the weight of each evaluation index obtained, the weight calculation data is taken from 288 samples of the questionnaire survey, and calculated according to the Eq (1) to Eq. (6). The entropy weight value of each index weight is shown in the following Tab. 2.

### 5.2 Close Value Analysis of Quality Evaluation Indicators Based on TOPSIS Method

Combined with the weight of each index calculated by entropy weight method and according to Eq. (7) to Eq. (12), the comprehensive evaluation results of five logistics enterprises are obtained, as shown in Tab. 3.

**Table 2** Entropy weight value of logistics service index evaluation

| First-level indicators | Entropy weight | Rank | Two-level indicators | Entropy weight | Rank |
|---|---|---|---|---|---|
| A | 0.255 | 1 | A1 | 0.125 | 1 |
| | | | A2 | 0.096 | 3 |
| | | | A3 | 0.034 | 13 |
| B | 0.196 | 4 | B1 | 0.023 | 16 |
| | | | B2 | 0.047 | 9 |
| | | | B3 | 0.051 | 8 |
| | | | B4 | 0.045 | 11 |
| | | | B5 | 0.030 | 14 |
| C | 0.197 | 3 | C1 | 0.026 | 15 |
| | | | C2 | 0.017 | 18 |
| | | | C3 | 0.062 | 7 |
| | | | C4 | 0.093 | 4 |
| D | 0.230 | 2 | D1 | 0.045 | 10 |
| | | | D2 | 0.067 | 5 |
| | | | D3 | 0.118 | 2 |
| E | 0.122 | 5 | E1 | 0.036 | 12 |
| | | | E2 | 0.019 | 17 |
| | | | E3 | 0.067 | 6 |

**Table 3** Comprehensive results of service quality evaluation of e-commerce logistics enterprises

| Enterprise | Positive ideal solution distance $H_i^+$ | Negative ideal solution distance $H_i^-$ | Relative closeness $\eta_i$ | Rank |
|---|---|---|---|---|
| Enterprise I | 0.113 | 0.084 | 0.425 | 3 |
| Enterprise II | 0.110 | 0.083 | 0.430 | 2 |
| Enterprise III | 0.114 | 0.080 | 0.414 | 4 |
| Enterprise IV | 0.076 | 0.083 | 0.522 | 1 |
| Enterprise V | 0.173 | 0.083 | 0.324 | 5 |

### 5.3 Results

According to the calculation results of entropy weight method, among the five first-level indicators, reliability accounts for the largest weight, followed by empathy. Explain that the improvement and improvement of rural e-commerce logistics service quality should focus on reliability and empathy. It is urgent to improve the standardization of distribution business, improve the attitude of service personnel, and ensure the integrity of goods packaging and distribution. According to the ranking of the proximity of five logistics enterprises calculated by TOPSIS method, the relative proximity of enterprise 4 is the highest, ranking the first, the logistics service quality is the highest, the relative proximity of enterprise 2, 3 and 4 is similar, the ranking of enterprise 5 is the lowest, and the logistics service quality is poor.

## 6 CONCLUSION

By summarizing the previous research on logistics service quality evaluation and combining SERVQUAL model and LSQ scale, this paper constructs a rural e-commerce logistics service quality evaluation index system consisting of five first-level indicators and 18 second-level indicators, and comprehensively uses entropy weight and TOPSIS method to evaluate the logistics service quality of five typical e-commerce logistics enterprises. The following optimization suggestions are put forward: (1) Pay attention to the reliability of goods transportation and distribution to avoid packaging damage, goods loss and other problems. (2) Strengthen staff training, improve the professional level and service attitude of service personnel, so as to enhance customer satisfaction and improve service quality. (3) The low coverage of logistics outlets in rural areas leads to low distribution efficiency. We should strengthen infrastructure construction and improve the construction of terminal distribution networks.

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