Research on the Factors Affecting the Quality of Fresh E-Commerce Logistics Services

Weimin Lin[1], Jining Yang[1], Chenghua Liu[1(✉)], and Mei Li[2]

[1] College of Logistics, Chengdu University of Information Engineering, Chengdu 610103, Sichuan, China
78943891@qq.com

[2] College of Logistics Management and Engineering, Nanning Normal University, Nanning 530001, Guangxi, China

Abstract. Based on the 4M1E management rule, the factors influencing the service quality of fresh produce e-commerce logistics are constructed from five dimensions: human, machine, material, law and environment, and the empirical analysis is conducted by combining intuitionistic fuzzy and DEMATEL methods. It is found that the three indicators of operation standardization, delivery time efficiency and logistics information platform are the key factors affecting its development. Based on this, the article proposes targeted solutions from the perspectives of strengthening logistics service awareness, enhancing the construction of intelligent logistics system and optimizing logistics distribution network, so as to improve the quality of fresh produce e-commerce logistics services.

Keywords: Fresh Produce E-Commerce · Logistics Service Quality · Influence Factors · Intuitionistic Fuzzy · DEMATEL Method

1 Introduction

With the rejuvenation of consumers and diversification of service demands, China's fresh food e-commerce ushers in significant development opportunities. According to the "2020 China Fresh Food E-Commerce Market Data Report", the size of China's e-commerce fresh food market will be 364.13 billion yuan in 2020. While consumer demand for e-commerce continues to rise, while the quality of logistics services remains low, there is an imbalance and mismatch between the two, and there is an insurmountable contradiction. According to the "2020 Annual Guided E-Commerce Consumer Complaint Data and Typical Cases Report": logistics, shipping, refunds and other issues are still the main problems of consumer complaints. The huge difference between consumer demand and service demand has made more and more e-commerce companies realize the importance of service quality in driving efficiency growth and sustainable development. To this end, in-depth analysis of the key factors of fresh e-commerce logistics service quality, clarify the relationship between the elements, on the one hand, to meet the new period of consumer demand for diversified and personalized services, on the other hand, to promote the high-quality development of China's fresh e-commerce enterprises.

N. Radojević et al. (Eds.): ICAID 2022, AHIS 7, pp. 1157–1165, 2023.
https://doi.org/10.2991/978-94-6463-010-7_119

2 The Fresh E-Commerce Logistics Service Quality Influence Factor Construction

Fresh e-commerce: it refers to the sale of fresh agricultural products on the Internet by means of e-commerce [2]. Fresh e-commerce logistics service quality refers to: the degree to which the fresh e-commerce logistics service provider provides can meet consumers' requirements for freshness, timeliness and comfort of products [3]. Based on the connotation characteristics of fresh e-commerce logistics service quality, combined with related literature, the 4M1E analysis method is used to construct the fresh e-commerce logistics service quality influence factors from five dimensions: human, machine, material, law and environment [5] (show in Table 1).

Table 1. Factors affecting the quality of fresh e-commerce logistics services

Target layer	Guideline layer	Indicator layer
Fresh e-commerce logistics service quality impact factors (A)	People (B_1)	Service Awareness (C_1)
		Service image (C_2)
		Operation normality (C_3)
	Machine (B_2)	Logistics information platform (C_4)
		Logistics low-temperature cold control equipment (C_5)
		Logistics monitoring and traceability system (C_6)
	Object (B_3)	Product quality and quality (C_7)
		Product temperature control compliance (C_8)
		Product packaging integrity (C_9)
		Product information completeness (C_{10})
	Law (B_4)	Distribution method (C_{11})
		Distribution time efficiency (C_{12})
		Process standardization (C_{13})
		Logistics service capacity (C_{14})
	Environment (B_5)	Logistics enterprise internal environment (C_{15})
		Fresh produce e-commerce logistics policy system (C_{16})

3 Description and Construction of the Research Model

DEMATEL, called decision making test and experimental evaluation method, mainly uses matrix calculations and graph theory concepts to describe the direct or indirect influence of each element with the rest of the elements in the constructed matrix data, and organizing the data leads to the ranking hierarchy of the elements in the system and the logical relationships between them [1, 6]. The specific steps are as follows.

Step 1: Digitize the information expressed by the indicators and construct a direct impact matrix.

The concept of intuitive ambiguity is as follows [7]. Definition 2.1: Let $F = (f_1, f_2, f_3, \cdots, f_n)$ be the set of options, and the decision maker compares n options between two and constructs a judgment matrix $A = [a_{ij}]_{n\times n}$, $a_{ij} = \left(u_{ij}, v_{ij}, \pi_{ij}\right)$, $i, j = 1, 2, 3, \cdots, n.$. Where, u_{ij} and v_{ij} denote the decision maker's degree of preference for options f_i and f_j, respectively. f_i and f_j when comparing them. π_{ij} denotes the degree of decision maker's hesitation for the two options, $\mu_{ij}, v_{ij} \in [0, 1]$, $\pi_{ij} = 1 - \mu_{ij} - v_{ij}$, at this time, the matrix A is called the intuitionistic fuzzy judgment matrix.

The risk preference factor $\eta \in [-1, 1]$ is imported in the calculation, and when $\eta < 0$, the decision maker is a risk averse. When $\eta = 0$, the decision maker is risk neutral; when $\eta > 0$, the decision maker is risk chaser.

Definition 2.2: Assuming the existence of an intuitionistic fuzzy number $\alpha = (\mu_\alpha, v_\alpha)$ and $\pi_\alpha = 1 - \mu_\alpha - v_\alpha$ as its hesitation, the accuracy function is [4].

$$h^\eta(\alpha) = \frac{\mu_\alpha + v_\alpha}{1 - \eta\pi_\alpha}$$

It is assumed that a single expert gives a fuzzy evaluation of the study indexes according to their risk preferences, and a two-by-two comparison is made between the indexes, and then the set of score functions becomes an intuitive fuzzy preference decision that transforms the fuzzy numbers into real numbers. At this stage, in order to meet the data requirements of the initial matrix of DEMATEL, the value of the diagonal of the matrix is taken as 0, and then after normalized deformation, the direct influence matrix S based on fuzzy information is obtained as follows.

$$A\left[a_{ij}\right]_{n\times n} = \begin{bmatrix} (\mu_{11}, v_{11}, \pi_{11}) & (\mu_{12}, v_{12}, \pi_{12}) & \ldots (\mu_{1n}, v_{1n}, \pi_{1n}) \\ (\mu_{21}, v_{21}, \pi_{21}) & (\mu_{22}, v_{22}, \pi_{22}) & \ldots (\mu_{2n}, v_{2n}, \pi_{2n}) \\ \vdots & \vdots & \ddots \vdots \\ (\mu_{n1}, v_{n1}, \pi_{n1}) & (\mu_{n2}, v_{n2}, \pi_{n2}) & \ldots (\mu_{nn}, v_{nn}, \pi_{nn}) \end{bmatrix}$$

$$\overset{h^\eta(a_{ij})}{\Rightarrow} H[h_{ij}]_{n\times n} = \begin{bmatrix} 0 & h_{12} & \ldots h_{1n} \\ h_{21} & 0 & \ldots h_{2n} \\ \vdots & \vdots & \ddots \vdots \\ h_{n1} & h_{n2} & \ldots 0 \end{bmatrix}$$

Assuming that there are m experts in the expert team, denoted as $G = (g_1, g_2, g_3, \cdots, g_m)$, the evaluation of the experts needs to be synthesized, and each expert is given the corresponding weight λ_k, $\lambda = (\lambda_1, \lambda_2, \lambda_3, \cdots, \lambda_m)$ is the set of

all decision experts $g_k(k = 1, 2, 3, \cdots, m)$ weights, and the integrated intuitionistic fuzzy preference decision matrix of the decision results of the expert team is obtained as follows.

$$Y[y_{ij}]_{n\times n} = \sum_{k=1}^{m} \lambda_k H^{(k)}$$

Where, $y_{ij} = \sum_{k=1}^{m} \lambda_k h_{ij}^{(k)}$, $i, j = 1, 2, 3, \cdots, n$

Step 2: Specification of the direct impact matrix *N*.

$$N = \left(\frac{y_{ij}}{\max\limits_{1\le i\le n}\left(\sum_j^n S_{ij}\right)} \right)_{n\times n}$$

Step 3: Calculate the integrated impact matrix *T*.

$$T = N(I - N)^{-1}$$

where

1) I is the unit matrix, i.e., the matrix with diagonal 1 and other values 0

2) $(I - N)^{-1}$ is the inverse matrix of $(I - N)$.

3) $T = [t_{ij}]_{n\times n}$ in t_{ij} indicates the degree of direct or indirect influence of indicator j by indicator i.

Step 4: Calculate the four "degree" values of the indicators.

1) Influence degree

The degree of influence is the comprehensive influence matrix of the corresponding indicators of each row on the rest of the indicators of the comprehensive impact value, counted as D, then $D = (D_1, D_2, D_3, \cdots, D_n)$, where $D_i = \sum_{j=1}^{n} t_{ij}$, $(i = 1, 2, 3, \cdots, n)$.

2) Influenced degree

The influenced degree is the combined influence value of each column in the composite influence matrix on the rest of the indicators, which is calculated as C, then $C = (C_1, C_2, C_3, \cdots, C_n)$, where $C_i = \sum_{j=1}^{n} t_{ji}$, $(i = 1, 2, 3, \cdots, n)$.

3) Centrality

The centrality reflects the importance of the indicator in the overall indicator and is calculated as $M_i = D_i + C_i$.

4) Reason degree

The reason degree reflects the degree of influence of the indicator on the rest of the indicators in the overall index, and is calculated as $R_i = D_i - C_i$.

Step 5: Identify the key elements affecting its development.

4 Empirical Analysis

4.1 Intuitionistic Fuzzy Evaluation

The set of indicators $F = (F_1, F_2, F_3, \cdots, F_{15})$, let 5 experts compare them pair by pair. Because the language effectiveness of the experts is uncertain, the weights of the experts

Table 2. Bias of expert teams towards risk indicators (1)

U	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}
C_1	0	0.25	0.05	0.75	0.50	0.50	0.25	0.05	0.05	0.50	0.25	0.05	0.25	0.25	0.75	0.75
C_2	0.75	0	0.05	0.75	0.75	0.50	0.25	0.25	0.25	0.50	0.50	0.05	0.25	0.50	0.95	0.95
C_3	0.95	0.95	0	0.95	0.95	0.75	0.25	0.25	0.25	0.50	0.75	0.25	0.05	0.25	0.95	0.95
C_4	0.25	0.25	0.05	0	0.25	0.25	0.05	0.05	0.05	0.25	0.75	0.05	0.25	0.50	0.75	0.75
C_5	0.50	0.25	0.05	0.75	0	0.50	0.25	0.25	0.25	0.50	0.50	0.05	0.25	0.50	0.95	0.95
C_6	0.50	0.50	0.25	0.75	0.50	0	0.05	0.25	0.05	0.50	0.75	0.25	0.05	0.25	0.75	0.75
C_7	0.75	0.75	0.75	0.95	0.75	0.95	0	0.50	0.50	0.50	0.75	0.05	0.25	0.50	0.95	0.95
C_8	0.95	0.75	0.75	0.95	0.75	0.75	0.50	0	0.50	0.75	0.75	0.25	0.05	0.50	0.75	0.75
C_9	0.95	0.75	0.75	0.95	0.75	0.95	0.50	0.50	0	0.75	0.75	0.05	0.25	0.50	0.95	0.95
C_{10}	0.50	0.50	0.50	0.75	0.50	0.50	0.50	0.25	0.25	0	0.75	0.05	0.05	0.50	0.75	0.75
C_{11}	0.25	0.50	0.25	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0	0.05	0.05	0.25	0.75	0.75
C_{12}	0.95	0.95	0.75	0.95	0.95	0.75	0.95	0.75	0.95	0.95	0.95	0	0.25	0.50	0.75	0.95
C_{13}	0.75	0.75	0.95	0.75	0.75	0.95	0.75	0.95	0.75	0.95	0.95	0.75	0	0.50	0.75	0.75
C_{14}	0.75	0.50	0.75	0.50	0.50	0.75	0.50	0.50	0.50	0.50	0.75	0.50	0.50	0	0.95	0.95
C_{15}	0.25	0.05	0.05	0.25	0.05	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25	0.05	0	0.95
C_{16}	0.25	0.05	0.05	0.25	0.05	0.25	0.05	0.25	0.05	0.25	0.25	0.05	0.25	0.05	0.05	0

are equally distributed. Learning from Yang Shuaifei's method, the expert's language {very dissatisfied (0.05, 0.95, 0.00), dissatisfied (0.25, 0.65, 0.10), general (0.50, 0.40, 0.10), satisfied (0.75, 0.15, 0.10), very Satisfactory (0.95, 0.05, 0.00)} Perform data fuzzification processing to get the intuitive fuzzy number [8] (show in Table 2).

4.2 Analysis of Factors Affecting the Quality of Fresh E-Commerce Logistics Services

According to the DEMATEL method, the centrality and cause degree of each indicator are calculated. The centrality reflects the importance of each indicator. According to the degree of centrality, the importance curve of logistics service quality of fresh food e-commerce is further drawn, as shown in Fig. 1.

Based on the content of Fig. 1, the centrality is ranked from the largest to the smallest: three indicators of operation standardization, delivery timeliness, and logistics information platform are the key factors affecting the quality of logistics services. The standardized operation of logistics and distribution personnel in the service process, the accuracy of delivery time efficiency, and the information interaction between personnel are the key factors that determine the quality of logistics services. The six indicators of product quality and quality, process standardization, service awareness, logistics low-temperature cold control equipment, product temperature control compliance, and logistics monitoring and traceability system are the core factors affecting logistics service quality. The service consciousness and operation standardization of logistics and distribution personnel are important conditions to ensure customer satisfaction, while

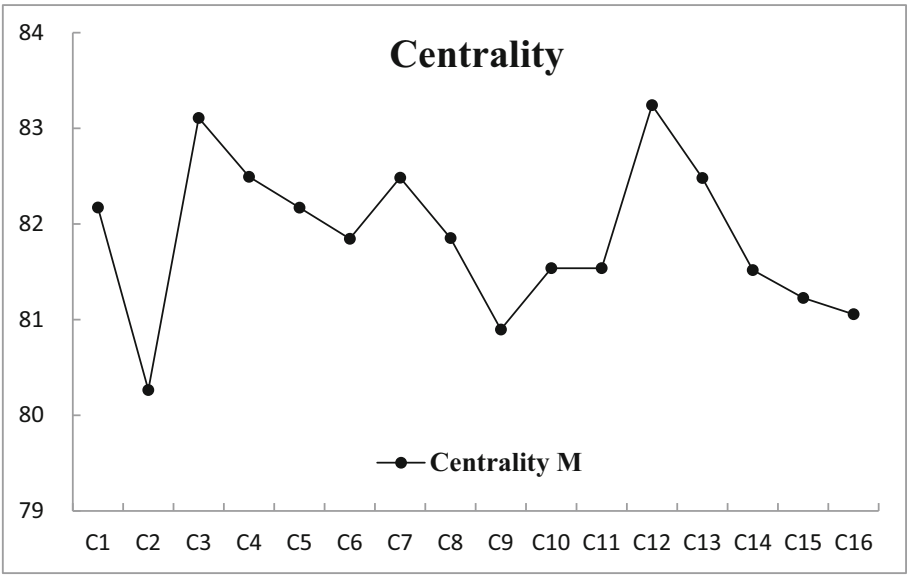

Fig. 1. Fresh produce e-commerce logistics service quality importance curve

the perfection of logistics facilities is the basic guarantee to maintain product quality and quality. The seven indicators of product information completeness, distribution method, logistics service capability, internal environment of logistics enterprises, fresh produce e-commerce logistics policy system, product packaging completeness and service image are the important factors affecting logistics service quality (Table 3).

The cause degree can be divided into cause and effect factors according to the positive and negative degree of cause. According to the cause degree, the cause and effect diagram of fresh produce e-commerce logistics service quality can be further drawn (see Fig. 2).

Based on the content of Fig. 2, the positive reason degrees are ranked in descending order: product packaging completeness, service image, delivery time efficiency, service awareness, logistics information platform, logistics monitoring and traceability system, product information completeness, delivery method, product temperature control compliance, and process standardization 10 indicators, indicating that in the whole index system, these factors positively accelerate or advance the fresh produce e-commerce logistics service quality improvement. The negative cause degree is ranked in order from largest to smallest: fresh e-commerce logistics policy system, logistics enterprise internal environment, logistics service capability, logistics low-temperature cold control equipment, product quality and quality, and operation standardization 6 indicators, indicating that these factors are first influenced by the above factors, and then in the impact on fresh e-commerce logistics service quality. The cause factor is a direct factor of service quality improvement, which can not only promote the improvement of logistics service quality from the positive side, but also influence the improvement of service system from the side. Therefore, the later development should pay more attention to

Table 3. Bias of expert teams towards risk indicators (2)

V	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}
C_1	0	0.65	0.95	0.15	0.40	0.40	0.65	0.95	0.95	0.40	0.65	0.95	0.65	0.65	0.15	0.15
C_2	0.15	0	0.95	0.15	0.15	0.40	0.65	0.65	0.65	0.40	0.40	0.95	0.65	0.40	0.05	0.05
C_3	0.05	0.05	0	0.05	0.05	0.15	0.65	0.65	0.65	0.40	0.15	0.65	0.95	0.65	0.05	0.05
C_4	0.65	0.65	0.95	0	0.65	0.65	0.95	0.95	0.95	0.65	0.15	0.95	0.65	0.40	0.15	0.15
C_5	0.40	0.65	0.95	0.15	0	0.40	0.65	0.65	0.65	0.40	0.40	0.95	0.65	0.40	0.05	0.05
C_6	0.40	0.40	0.65	0.15	0.40	0	0.95	0.65	0.95	0.40	0.15	0.65	0.95	0.65	0.15	0.15
C_7	0.15	0.15	0.15	0.05	0.15	0.05	0	0.40	0.40	0.40	0.15	0.95	0.65	0.40	0.05	0.05
C_8	0.05	0.15	0.15	0.05	0.15	0.15	0.40	0	0.40	0.15	0.15	0.65	0.95	0.40	0.15	0.15
C_9	0.05	0.15	0.15	0.05	0.15	0.05	0.40	0.40	0	0.15	0.15	0.95	0.65	0.40	0.05	0.05
C_{10}	0.40	0.40	0.40	0.15	0.40	0.40	0.40	0.65	0.65	0	0.15	0.95	0.95	0.40	0.15	0.15
C_{11}	0.65	0.40	0.65	0.65	0.40	0.65	0.65	0.65	0.65	0.65	0	0.95	0.95	0.65	0.15	0.15
C_{12}	0.05	0.05	0.15	0.05	0.05	0.15	0.05	0.15	0.05	0.05	0.05	0	0.65	0.40	0.15	0.05
C_{13}	0.15	0.15	0.05	0.15	0.15	0.05	0.15	0.05	0.15	0.05	0.05	0.15	0	0.40	0.15	0.15
C_{14}	0.15	0.40	0.15	0.40	0.40	0.15	0.40	0.40	0.40	0.40	0.15	0.40	0.40	0	0.05	0.05
C_{15}	0.65	0.40	0.95	0.65	0.95	0.65	0.95	0.65	0.40	0.65	0.65	0.65	0.65	0.95	0	0.05
C_{16}	0.65	0.40	0.95	0.65	0.95	0.65	0.95	0.65	0.40	0.65	0.65	0.65	0.65	0.95	0.95	0

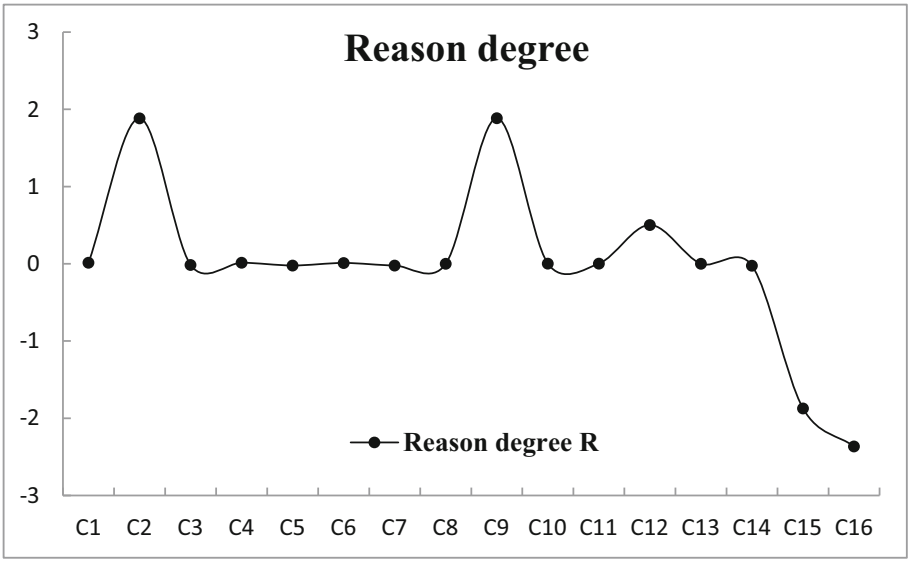

Fig. 2. Fresh e-commerce logistics service quality cause and effect diagram

the cause factor, and influence the result factor by improving the cause factor, and then promote the improvement of the overall logistics service quality.

5 Research Conclusions and Research Shortcomings

5.1 Research Conclusion

Based on the 4M1E management rule, using the literature research method and Delphi method, the fresh produce e-commerce logistics service quality evaluation index system is constructed, and the combination of intuitionistic fuzzy and DEMATE method is used to conduct in-depth analysis of the influencing factors. The conclusion of this study is as follows: from the central degree: three indicators of operation standardization, delivery time efficiency and logistics information platform are the fundamental factors affecting its development. From the cause degree: three indicators of product packaging integrity, service image, and delivery time efficiency play an important role in the improvement of logistics service quality.

5.2 Research Shortcomings

Although the method adopted in this study can identify the key factors affecting the quality of fresh produce e-commerce logistics services to a certain extent, its research scope is limited to the scope of 4M1E, which makes the accuracy of the research results need to be further verified and improved.

Acknowledgments. This paper was supported by a project of Guangxi Natural Science Foundation. Project name: Research on several intuitionistic fuzzy multi-attribute decision models: using decision maker preferences as an analytical perspective. Project Task No: 2018GXNSFBA281102. Project Application No: 2018JJB180015.

References

1. Baruah S, Raj S, Ray A et al (2012) Analysis of influencing factors for costs on substation siting based on DEMATEL method. Procedia Eng 38:2564–2571
2. Tianli D, Li Yufeng X (2021) Analysis of factors influencing the development of fresh produce e-commerce in China based on ISM-MICMAC model. North Hortic 20:155–163
3. Han Shuguang W, Jing CQ (2016) Research on the evaluation index system of fresh e-commerce logistics service quality. J Zhejiang Univ Technol (Soc Sci Edn) 36(02):138–143
4. Li M (2017) Research on intuitionistic fuzzy multi-attribute decision making method based on decision maker's preference perspective. Beijing University of Technology Press, Beijing
5. Liu MF, Chen W (2020) Research on the risk influencing factors of fresh cold chain front-end warehouse logistics service quality based on integrated DEMATEL-ISM. Saf Environ Eng 27(01):118–125
6. Tsai WH, Hsu W (2010) A novel hybrid model based on DEMATEL and ANP for selecting cost of quality model development. Total Qual Manag 21(4):439–456

7. Xu Z (2013) Compatibility analysis of intuitionistic fuzzy preference relations in group decision making. Group Decis Negot 22(3):463–482
8. Yang S (2020) Research on the selection of cross-border e-commerce logistics service providers. Hangzhou University of Electron Science and Technology