Research on the Evaluation of Fresh E-commerce Service Based on AHP-fuzzy Comprehensive Evaluation

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Abstract: *In recent years, China's e-commerce industry has developed rapidly in the past decade. Fresh enterprises represented by Freshippo, a famous Chinese fresh enterprises, are trying to meet a higher requirement of customer. In order to help the development of fresh e-commerce, this paper takes Freshippo as an example to evaluate the performance of fresh e-commerce services(FESs), constructs a set of performance evaluation index system of FESs by using analytic hierarchy process(AHP), and evaluates the service status of Freshippo by using fuzzy comprehensive evaluation method.Result shows that fresh e-commerce enterprises should always adhere to the concept of "product quality and service priority" in business process, and improve the cold chain logistics distribution system.*

Keywords: *Fresh food e-commerce; Analytic hierarchy process; Fuzzy comprehensive evaluation method*

1. Introduction

In June 2022, the number of Chinese netizens reached 1.051 billion, and the proportion of using mobile Internet reached 99.6%, ranking first in the world. Since the first year of China's fresh e-commerce in 2012, a large number of excellent fresh e-commerce enterprises and models have emerged in the past ten years. The emergence of the enterprises has made a significant change in the pattern of China's fresh retail market. Today, China's fresh e-commerce has basically formed a pattern of "two super, multi-strong, minority." As shown in figure 1, the proportion of fresh online retail has increased year by year and the growth rate has increased year by year. It is expected that the proportion of fresh online retail will exceed 20% in 2025.
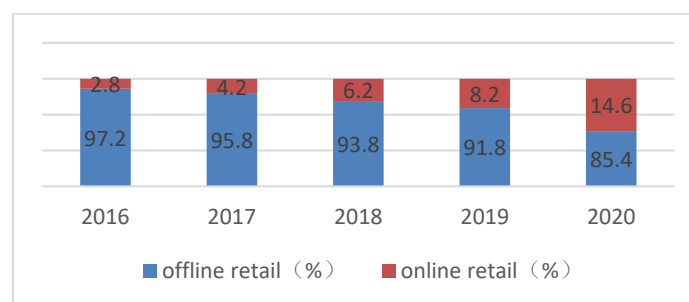

Figure 1: The scale structure of China's fresh e-commerce retail market from 2016 to 2020.

In order to maintain this good development trend, enterprise managers must grasp their own service levels in a changing market environment and regularly evaluate performance services. The level of performance directly reflects the management level of enterprises, and provides a realistic basis for enterprises to formulate development strategies and explore development models. From the perspective of research status, the current academic circles have a less evaluation of the overall performance of FESs. Therefore, based on the previous scholars ' research, on the basis of certain data conditions, this paper takes Freshippo as the empirical object based on analytic hierarchy process and fuzzy comprehensive evaluation, trying to explore a set of performance evaluation model of FESs, so as to help enterprises improve their management level[1].

2. Materials and Methods

2.1. Selection of index and construction of performance system

Combined with the characteristics of the index structure, this paper sets the evaluation index system into three levels: the target layer, the criterion layer and the index factor layer. The target layer is the overall service performance, and the criterion layer contains the product quality, cold chain distribution, technology platform and service flexibility, including 17 index factors[2]. The index system is shown in Table 1:

Table 1: FESs performance evaluation index system

Target layer	Criterion layer		Index factor layer	
	Index	Code	Index	Code
Overall service performance(A)	Product quality	B1	Product categories	C1
			Freshness	C2
			Price	C3
			Traceability degree	C4
	Cold chain distribution	B2	Integrity of products after delivery	C5
			Arrive on time	C6
			Quality of distribution personnel	C7
			Order response time	C8
			Delivery cost ratio	C9
	Technology platform	B3	Platform monthly activity	C10
			Customer conversion rate	C11
			Information protection	C12
			Convenience of APP operation	C13
	Service flexibility	B4	Employee service attitude	C14
			Emergency handling	C15
			After-sale service	C16
			Business hours	C17

2.2. Data

To better understand the factors affect the customer satisfaction, we first provide a brief overview both online and face to face with the customers and business experts. To make the evaluation results more comprehensive, the author sent questionnaires to 40 consumers of Freshippo and 10 practitioners of Freshippo, among which 50 were valid questionnaires.

2.3. Application process of AHP method

2.3.1. Determination of weight of evaluation system

In the process of determining the weight of performance evaluation, this paper selects an expert who has been engaged in research in related fields. In this paper, based on the scores of the expert to the indicators, the judgment matrix of the total target performance is calculated by *yaahp* software as follows:

$$A = \begin{Bmatrix} 1.0000 & 5.0000 & 7.0000 & 7.0000 \\ 0.2000 & 1.0000 & 6.0000 & 4.0000 \\ 0.1429 & 0.1667 & 1.0000 & 1.0000 \\ 0.1429 & 0.2500 & 1.0000 & 1.0000 \end{Bmatrix}$$

The maximum eigenvalue of A: λ_{max}=4.2187

The corresponding feature vector: W=(0.6391,0.2345,0.0609,0.0655). CR=0.0819<0.1, which passed the consistency test.

The same software is used to calculate the weight, and the available index layer corresponds to the weight of the criterion layer. Each evaluation matrix is shown as follows:

Product quality:

$$B1 = \begin{Bmatrix} 1.0000 & 0.2000 & 3.0000 & 0.2500 \\ 5.0000 & 1.0000 & 4.0000 & 1.0000 \\ 0.3333 & 0.2500 & 1.0000 & 0.2000 \\ 4.0000 & 1.0000 & 5.0000 & 1.0000 \end{Bmatrix}$$

The maximum eigenvalue of B1: λ_{max}=4.1680

The corresponding feature vector: W=(0.1238,0.4093,0.0704,0.3965). CR=0.0629<0.1, which passed the consistency test.

Cold chain distribution:

$$B2 = \begin{Bmatrix} 1.0000 & 7.0000 & 8.0000 & 8.0000 & 6.0000 \\ 0.1429 & 1.0000 & 1.0000 & 5.0000 & 4.0000 \\ 0.1250 & 1.0000 & 1.0000 & 1.0000 & 2.0000 \\ 0.1250 & 0.2000 & 1.0000 & 1.0000 & 0.5000 \\ 0.1667 & 0.2500 & 0.5000 & 2.0000 & 1.0000 \end{Bmatrix}$$

The maximum eigenvalue of B2:λ_{max}=5.4470

The corresponding feature vector: W=(0.6188,0.1631,0.0966,0.0540,0.0675). CR=0.0998<0.1, which passed the consistency test.

Technology platform:

$$B3 = \begin{Bmatrix} 1.0000 & 0.5000 & 0.1429 & 4.0000 \\ 2.0000 & 1.0000 & 0.2000 & 3.0000 \\ 7.0000 & 5.0000 & 1.0000 & 9.0000 \\ 0.2500 & 0.3333 & 0.1111 & 1.0000 \end{Bmatrix}$$

The maximum eigenvalue of B3: λ_{max}=4.1683

The corresponding feature vector: W=(0.1193,0.1648,0.6659,0.0501). CR=0.0609<0.1, which passed the consistency test.

Service flexibility:

$$B4 = \begin{Bmatrix} 1.0000 & 4.0000 & 1.0000 & 5.0000 \\ 0.2500 & 1.0000 & 0.2500 & 5.0000 \\ 1.0000 & 4.0000 & 1.0000 & 5.0000 \\ 0.2000 & 0.2000 & 0.2000 & 1.0000 \end{Bmatrix}$$

The maximum eigenvalue of B4: λ_{max}=4.2492

The corresponding feature vector: W=(0.3959,0.1502,0.3959,0.0580). CR=0.0933<0.1, which passed the consistency test.

2.3.2. Results of weight of evaluation system

Then the weight results are shown in Table 2

It can be seen from the above, in the criterion layer of FESs performance evaluation, the weight values from high to low are product quality, cold chain distribution, service flexibility and technology platform. The top 8 indicators in the second-level indicators are: freshness, traceability degree, integrity of products after delivery, product categories, price, information protection, arrive on time, and employee service attitude. It shows that product quality occupies the prominent position in FESs, and it should also be noted that cold chain logistics transportation has a greater impact on the performance of FESs.

Table 2: Weight table of evaluation indicators.

Criterion layer	Index factor layer	weight	Rank
B1 (W=0.6391)	C1 (W=0.1238)	0.0791	4
	C2 (W=0.4093)	0.2616	1
	C3 (W=0.0704)	0.0450	5
	C4 (W=0.3965)	0.2534	2
B2 (W=0.2345)	C5 (W=0.6188)	0.1451	3
	C6 (W=0.1631)	0.0383	7
	C7 (W=0.0966)	0.0227	10
	C8 (W=0.0540)	0.0127	12
	C9 (W=0.0675)	0.0158	11
B3 (W=0.0609)	C10 (W=0.1193)	0.0073	15
	C11 (W=0.1648)	0.0100	13
	C12 (W=0.6659)	0.0405	6
	C13 (W=0.0501)	0.0030	17
B4 (W=0.0655)	C14 (W=0.3959)	0.0259	8
	C15 (W=0.1502)	0.0098	14
	C16 (W=0.3959)	0.0259	9
	C17 (W=0.0580)	0.0038	16

2.4. Application of fuzzy comprehensive evaluation method

After the index weight of fresh e-commerce is established by AHP, the service performance evaluation of fresh e-commerce can be carried out by combining fuzzy comprehensive evaluation method. By collecting the data of the relevant personnel questionnaire, the fuzzy comprehensive evaluation of each index is carried out with excellent, good, general, poor and very poor evaluation grades, and the overall performance level is finally obtained[3].

2.4.1. Establishing fuzzy relation matrix

In order to construct the fuzzy relation matrix, it is necessary to understand the level of the index system subject to different evaluation levels. The specific steps are as follows: According to the evaluation set V given by the experts, the evaluation indexes are classified, and then the frequency N_{ij} of each statistical index belonging to each evaluation grade is added respectively. Then, according to the obtained frequency, the membership degree R_{ij} of the specific evaluation factor A in the evaluation grade V is calculated. Assuming that the number of experts is N, then R_{ij} is:

$$R_{ij} = \frac{N_{ij}}{N} \tag{1}$$

Next, the quantitative indicators are divided into two categories, positive indicators and negative indicators. This paper quantifies the relevant index data between [0,1] to prevent abnormal data affecting the overall evaluation results. The specific formulas are as follows:

The following formula is positive index:

$$R_{ij} = \begin{cases} 1 & x > b \\ \dfrac{x-a}{b-a} & a < x < b \\ 0 & x \le a \end{cases} \tag{2}$$

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The actual values of the positive and negative indexes in the above formula are expressed by x, and the lower and upper bounds of the same index correspond to [a, b]. In this round of fuzzy comprehensive evaluation, the author obtains the comprehensive evaluation data by means of

questionnaire survey score, and the final fuzzy relationship matrix established by the results obtained after sorting out the data is shown in Table 3:

Table 3: Fuzzy relationship matrix of Freshippo service performance evaluation.

Criterion layer	Index factor layer		Excellent	Good	General	Poor	Very poor
B1 (W=0.6391)	C1	W=0.1238	0.24	0.44	0.08	0.12	0.12
	C2	W=0.4093	0.20	0.42	0.16	0.12	0.10
	C3	W=0.0704	0.40	0.22	0.14	0.08	0.16
	C4	W=0.3965	0.28	0.38	0.08	0.10	0.16
B2 (W=0.2345)	C5	W=0.6188	0.26	0.32	0.18	0.12	0.12
	C6	W=0.1631	0.36	0.28	0.12	0.12	0.12
	C7	W=0.0966	0.34	0.24	0.18	0.08	0.16
	C8	W=0.0540	0.26	0.36	0.14	0.12	0.12
	C9	W=0.0675	0.30	0.34	0.10	0.12	0.14
B3 (W=0.0609)	C10	W=0.1193	0.42	0.20	0.12	0.18	0.08
	C11	W=0.1648	0.28	0.36	0.16	0.10	0.10
	C12	W=0.6659	0.18	0.42	0.14	0.14	0.12
	C13	W=0.0501	0.28	0.42	0.04	0.10	0.16
B4 (W=0.0655)	C14	W=0.3959	0.42	0.24	0.08	0.14	0.12
	C15	W=0.1502	0.28	0.34	0.18	0.10	0.10
	C16	W=0.3959	0.44	0.16	0.12	0.16	0.12
	C17	W=0.0580	0.22	0.40	0.18	0.14	0.06

2.4.2. Index performance evaluation of Index factor layer

The fuzzy relationship matrix for the evaluation set of the four measures of product quality in Freshippo service is as follows:

$$R1 = \begin{Bmatrix} 0.24 & 0.44 & 0.08 & 0.12 & 0.12 \\ 0.20 & 0.42 & 0.16 & 0.12 & 0.10 \\ 0.40 & 0.22 & 0.14 & 0.08 & 0.16 \\ 0.28 & 0.38 & 0.08 & 0.10 & 0.16 \end{Bmatrix}$$

The fuzzy relationship matrix for the evaluation set of the five measures of cold chain distribution in Freshippo service is as follows:

$$R2 = \begin{Bmatrix} 0.26 & 0.32 & 0.18 & 0.12 & 0.12 \\ 0.36 & 0.28 & 0.12 & 0.12 & 0.12 \\ 0.34 & 0.24 & 0.18 & 0.08 & 0.16 \\ 0.26 & 0.36 & 0.14 & 0.12 & 0.12 \\ 0.30 & 0.34 & 0.10 & 0.12 & 0.14 \end{Bmatrix}$$

The fuzzy relationship matrix for the evaluation set of the four measurement indicators of the technology platform in Freshippo service is as follows:

$$R3 = \begin{Bmatrix} 0.42 & 0.20 & 0.12 & 0.18 & 0.08 \\ 0.28 & 0.36 & 0.16 & 0.10 & 0.10 \\ 0.18 & 0.42 & 0.14 & 0.14 & 0.12 \\ 0.28 & 0.42 & 0.04 & 0.10 & 0.16 \end{Bmatrix}$$

The fuzzy relationship matrix for the evaluation set of the four measurement indicators of service flexibility in Freshippo service is as follows:

$$R4 = \begin{Bmatrix} 0.42 & 0.24 & 0.08 & 0.14 & 0.12 \\ 0.28 & 0.34 & 0.18 & 0.10 & 0.10 \\ 0.44 & 0.16 & 0.12 & 0.16 & 0.12 \\ 0.22 & 0.40 & 0.18 & 0.14 & 0.06 \end{Bmatrix}$$

Therefore, the single-factor evaluation based on product quality is as follows:

D1=W1 $\odot$ R1=[0.1238,0.4093,0.0704,0.3965] $\odot$

R1=V(0.1238∧0.24)V(0.4093∧0.20)V(0.0704∧0.40)V(0.3965∧0.28),V(0.1238∧0.44)V(0.4093∧0.42)V(0.0704∧0.22)V(0.3965∧0.38),V(0.1238∧0.08)V(0.4093∧0.16)V(0.0704∧0.14)V(0.3965∧0.08),V(0.1238∧0.12)V(0.4093∧0.12)V(0.0704∧0.08)V(0.3965∧0.10),V(0.1238∧0.12)V(0.4093∧0.10)V(0.0704∧0.16)V(0.3965∧0.16)=[0.25,0.39,0.12,0.11,0.13]

Similarly to the calculation, it can be obtained

Single-factor evaluation based on cold chain transportation is:

D2=[0.29,0.31,0.16,0.12,0.12]

The single-factor evaluation based on the technology platform is as follows:

D3=[0.23,0.38,0.14,0.14,0.11]

Single-factor evaluation based on service flexibility is as follows:

D4=[0.40,0.23,0.12,0.14,0.11]

2.4.3. Index performance evaluation of Criterion layer

The fuzzy relationship matrix of the four measurement indicators for the total performance target of a Freshippo service set is as follows:

$$R = \begin{cases} 0.25 & 0.39 & 0.12 & 0.11 & 0.13 \\ 0.29 & 0.31 & 0.16 & 0.12 & 0.12 \\ 0.23 & 0.38 & 0.14 & 0.14 & 0.11 \\ 0.40 & 0.23 & 0.12 & 0.14 & 0.11 \end{cases}$$

The single-factor evaluation based on the total objective performance is:

D=[0.27,0.36,0.13,0.12,0.12]

In conclusion, it can be evaluated according to the calculation results

$$G = D*V^T = [0.27,0.36,0.13,0.12,0.12] \begin{bmatrix} 5 \\ 4 \\ 3 \\ 2 \\ 1 \end{bmatrix} = 3.54$$

$$G1 = D1*V^T = [0.25,0.39,0.12,0.11,0.13] \begin{bmatrix} 5 \\ 4 \\ 3 \\ 2 \\ 1 \end{bmatrix} = 3.52$$

$$G2 = D2*V^T = [0.29,0.31,0.16,0.12,0.12] \begin{bmatrix} 5 \\ 4 \\ 3 \\ 2 \\ 1 \end{bmatrix} = 3.53$$

$$G3 = D3*V^T = [0.23,0.38,0.14,0.14,0.11] \begin{bmatrix} 5 \\ 4 \\ 3 \\ 2 \\ 1 \end{bmatrix} = 3.48$$

$$G4 = D4*V^T = [0.40, 0.23, 0.12, 0.14, 0.11] \begin{bmatrix} 5 \\ 4 \\ 3 \\ 2 \\ 1 \end{bmatrix} = 3.67$$

In summary, regarding the performance evaluation results of Freshippo, the performance of Criterion is shown in Table 4:

Table 4: Comprehensive performance evaluation results of Freshippo service

Performance level	Index
Excellent	—
Good	—
General	D1,D2,D3,D4
Poor	—
Very poor	—

From the results, the four indicators of Freshippo were evaluated as general. However, it needs to be clear that although the comprehensive evaluation is general, this evaluation adopts the five-level evaluation, so its evaluation score will be slightly lower than the four-level evaluation standard. From the data point of view, Freshippo tends to good in product quality, cold chain distribution and technology platform.

3. Discussion

In terms of product quality, the weight result is 0.6391, ranking first among the four indicators. However, the evaluation result is 3.52 points, which actually ranks third among the four indicators.

From the perspective of specific indicators, Freshippo is more prominent in price. According to the survey, among the user groups with a monthly income of more than 10,000, Freshippo seems more popular than other platforms obviously. Not only that, most of the consumers are in the first-tier and new first-tier cities, and the proportion of groups with a master's degree above is more. The high TGI (Target Group Index) reflects the preference of this group for Freshippo.

However, there is still much room for improvement in product freshness. From the perspective of AHP, the proportion of product freshness weight is the highest in product quality indicators, but the praise ratio (excellent + good) is the lowest among the four indicators. Although Freshippo guarantees that, the product is sold directly on the shelf, and it will be destroyed if not sold out. However, in recent years, there have been many negative news about the freshness. Since January 2020, the market supervision department has informed that more than 20 batches of low-quality food products involving vegetables, pork and seafood have been sold in Shandong, Jiangsu, Shanghai, Hubei, Sichuan and other provinces. Facts have proved that the Freshippo is still insufficient in product quality assurance.

In terms of cold chain distribution, the weight result is 0.2345, ranking second among the four indicators. The evaluation result is 3.53 points, which is actually ranked second among the four indicators. From the specific indicators, the best performance indicator is "arrive on time". Concerning business model, Freshippo adopts to "store consumption+online shopping+ instant delivery"; Operators can use smart devices to operate from the arrival of goods to the store, through the shelves, sorting, packaging and distribution processes. This work is simple and effective, and the error rate is very low. The whole system completes the sorting and packaging work within 10 minutes from the user's order, and realizes the distribution within 3 kilometers within 20 minutes, so as to achieve the integration of warehouse and store, so there is a higher score in this aspect. From the perspective of AHP, although Integrity of product takes the highest weight, the rate of praise is still in the bottom of the four indicators. On the one hand, due to perishable and fragile characteristics, the distribution of fresh products in the logistics industry still is a major problem; On the other hand, in addition to the local orders, Freshippo will also receive online orders from other places, so Freshippo will use third-party logistics for orders beyond the scope of distribution, and it will not be able to guarantee the quality of fresh food delivery.

In terms of technology platform, the weight result is 0.0609, ranking fourth among the four indicators. The evaluation result is 3.48 points, which is actually ranked fourth among the four

indicators. Freshippo has a good performance in platform monthly activity, customer conversion rate and convenience of APP operation. This is due to Alibaba's rich e-commerce experience and strong technical support over the years. In 2021, the e-commerce industry reported that Freshippo's e-commerce activity is at the forefront of the industry and has entered the echelon of tens of millions. However, Freshippo has incurred much criticism in the operation of the App. Its APP has a low score in the application market. The main reasons for poor evaluation are:' location information is chaotic ', ' membership code checkout is inconvenient ', ' frequent payment anomalies ', ' mandatory download APP payment ' and so on. It has added entertainment projects which are similar to 'Ant Forest' to the module of ' Hema Town '. Such function often interferes with online operations during users use and affect the users' sense of experience. Although the proportion of weight in the technical platform is not the highest, the construction of fresh e-commerce cannot be ignored. Compared with the other indicators, the score of the technology platform is more backward. Therefore, Freshippo needs to optimize the technology platform currently, especially the APP. On the one hand, some redundant functions need to be reduced, so as to improve practicability and reliability; on the other hand, measures should also be taken to allow consumers to simplify payment methods and less mandatory operations[4].

In terms of service flexibility, the weight result is 0.0655, ranking third among the four indicators. The evaluation result is 3.67 points, which is actually ranked first among the four indicators. The most noteworthy indicators are employee service attitude and after-sales service. The service attitude is ranked in the top two of the four index factors, and the index weight ratio is also the top two, but at the same time, the poor evaluation rate is also the top two. On the one hand, managers know that their target group is relatively highly educated and high-income young people, so they pay attention to improving the service experience, which is why a considerable number of people can be satisfied with the service of Freshippo. On the other hand, due to the expansion of the stores and the decrease of the cost input, the lack of training for the service quality of the staff leads to the lack of business processing ability. At present, Freshippo has mixed opinions on after-sales service on the internet, and has even been repeatedly exposed to the scandal of moral kidnapping consumers. Although the weight of service flexibility level is not the highest, it also plays an important role in the business process. If Freshippo wants to maintain the leading position in the fresh retail distribution industry, it should actively adjust its marketing strategy and turn the service focus back to improving services. Secondly, we should strengthen staff training, improve staff service attitude and staff business processing ability; finally, it is necessary to combine the improvement measures of the previous indicators to improve the level of after-sales service.

4. Conclusion

Performance evaluation plays an important role in real enterprise management. Using analytic hierarchy process can effectively help enterprise managers or researchers to carry out performance evaluation. This paper establishes a FESs performance evaluation index system contains four criterion layer indicators of product quality, cold chain distribution, technology platform and service flexibility and 17 index factor layer indicators. At the same time, this paper uses the evaluation system with Freshippo as the empirical object based on the fuzzy comprehensive evaluation method and comes out some inspirations. The impact of FESs performance results from a combination of various factors. Managers need to be both focused and nuanced in the decision-making process. Only by constantly grasping the balance between the two in the dynamic can we achieve satisfactory performance results.

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