Evaluation of the Competitiveness of Express Enterprises Based on Gray Relational Analysis and Entropy Weight

Xiaojin Li[a], Jinman Guo[b]

Civil Aviation University of China, Tianjin, China
[a]xiaojinli@vip.sina.com, [b]18829050179@163.com

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Abstract: In order to evaluate the competitiveness of China's express enterprises, this paper constructs a comprehensive index system from four aspects: market scale, service quality, guarantee ability and financial strength. Combining the gray relational analysis method and the entropy weight method to build the evaluation model, the six most representative express enterprises in China were selected for empirical analysis. The analysis results show that the competitiveness ranking of China's express enterprises in 2020 from strong to weak is: SF Express, ZTO Express, YTO Express, YUNDA Express, DEPPON Express and STO Express.

1. Introduction

With the popularization of Internet technology, electronic information and the rapid development of social economy, the express industry, as an important part of the logistics industry, has sprung up. According to the information released by China Federation of Logistics and Purchasing, the total revenue of China's logistics industry will be 10.5 trillion yuan in 2020, an increase of 2.2% over 2019. As an important part of the logistics industry, the express industry has become a sunrise industry with great potential. According to the 2020 postal industry operation released by the State Post Bureau, the cumulative business volume of China's express enterprises completed 83.358 billion pieces, an increase of 31.2% over the same period last year. China's express business revenue reached 879.54 billion yuan in 2020, an increase of 17.3% over the same period last year. [1]

However, the entry threshold of the express industry is low, resulting in more and more competitors of the same type, especially foreign express enterprises are also developing rapidly. Only a small number of express enterprises stand out in the fierce market competition, with the help of their advantages of low price and sensitive response to market demand, they quickly occupy the market. In such a complex environment with both opportunities and challenges, how to enhance the competitiveness of express enterprises is particularly critical.

Domestic and foreign scholars applied different methods to research the competitiveness of express enterprises. He Wei evaluated the competitiveness of express enterprises in China by using gray relational analysis method. [2] Zhou Peng-fei utilized the extension evaluation method to establish the correlation function, then calculated the correlation degree and the advantage degree, and the evaluation of the competitiveness of the express enterprises is made. [3] Han Song applied

neural network and statistical learning methods to evaluate the competitiveness of logistics enterprises in China.[4] Shan Xinyu built a competitiveness analysis model for private express enterprise basing on AHP/SWOT, and selected SF Express for empirical analysis.[5] Park evaluated the competitiveness of air cargo express enterprises in the Korean market. Their analysis showed that accuracy and promptness are the two most influential factors to competitiveness. [6]

Scholars have utilized different methods to evaluate competitiveness, but some of the methods are too subjective, and the human factor has too much influence. The indicator systems they constructed are not comprehensive enough. In addition, using a single evaluation method will result in inaccurate evaluation results. Based on previous researches, this paper takes into account the factors affecting the competitiveness of express enterprises, constructs a comprehensive evaluation index system, and the entropy weight method is applied to give weight to all indexes, then gray relational analysis method is applied to comprehensively evaluate the competitiveness of enterprises.

2. Construction of competitiveness evaluation index system

Competitiveness refers to the ability of an enterprise to compete in the market, which can be converted into a continuous and uninterrupted competitive advantage, and it is one of the necessary elements for an enterprise to ensure long-term development.

2.1 Influencing Factors

Constructing a reasonable index system needs to consider its scientificalness, comprehensiveness and accessibility. By reviewing a large amount of literature and combining the characteristics of express enterprises, the writers decided to construct the evaluation index system of the competitiveness of express enterprises from four aspects: market scale, service quality, guarantee capability and financial strength.

(1) Market scale

Market scale is an important indicator to evaluate the competitiveness of an enterprise and reflects the real strength of an enterprise. If the scale level of an enterprise is large, the economies of scale of the enterprise will also be improved. Therefore, four indicators were selected to reflect the service quality, such as operating income, express business volume, number of employees and net profit.

(2) Service quality

Express industry as a service industry, its service quality is closely related to the future survival and development of express enterprises. Companies with good service consciousness and high standards can attract a wider customer base and thus meet the needs of various customers. After conducting a large number of surveys, four indicators were selected to reflect the service quality, such as types of value-added services, complaint rate.

(3) Guarantee ability

Guarantee ability can show the internal strength of express enterprises. It is very important to ensure that customers receive intact parcels on time. Therefore, five indicators were chosen to reflect the guarantee ability, such as number of transshipment centers, number of main line vehicles.

(4) Financial strength

Financial strength of a company is an important reflection of its economic strength. In this study, we decided to reflect the financial strength of each express enterprise by gearing ratio, total assets and market valuation.

2.2 Indicator System

The above four first level indicators contain sixteen secondary indicators as shown in the figure 1
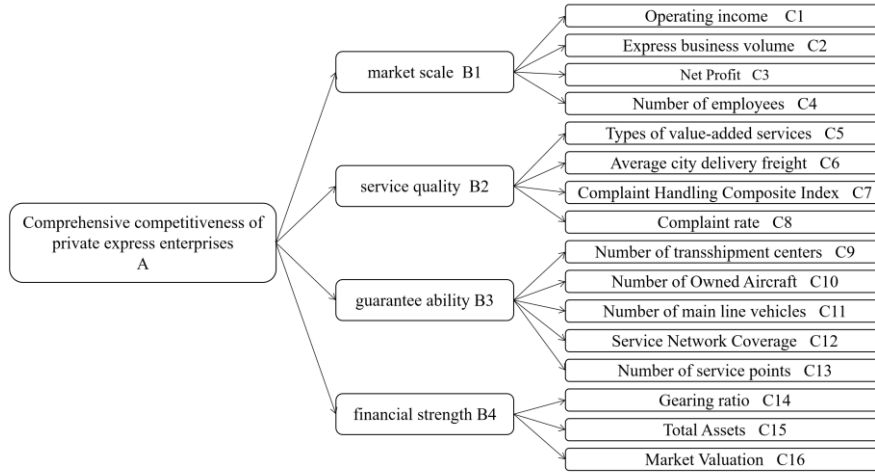
below.

Fig.1. Competitiveness Index System of Express Enterprises

3. Research Methodology

Generally speaking, the methods of indicator weighting can be divided into subjective method and objective method. The former mainly includes analytic hierarchy process and fuzzy evaluation method, However, the subjective method is greatly influenced by human factors. The latter includes entropy weight method and gray relational analysis method. It is more reasonable to apply objective method to weight index. The gray relational analysis method does not require a big sample, which is suitable for the case of small samples and little information. In this study, the gray relational analysis method with entropy weight is used to evaluate the competitiveness of express enterprises.

3.1 Calculation of weights by using entropy weight method

Entropy weight method is a method that quantifies the information of various indexes and obtains the weight coefficient of indexes by using the utility value of index information entropy. Generally speaking, if the information entropy of an indicator is smaller, it indicates that the more information the indicator can provide, and the indicator has a greater weight. [7] The entropy weight method is used to calculate the index weights. The specific steps are as follows:
- Construct the original data matrix

The original data matrix contains "n" samples and "m" indicators .it is constructed as follows:

$$X = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nm} \end{bmatrix} \quad (1)$$

- Standardize the index data

Positive indicators and negative indicators represent different meanings (higher values for positive indicators are better and lower values for negative indicators are better). Therefore, the indicators need to be standardized in different ways.

Positive indicators:

$$X'_{ij} = \frac{X_{ij} - min(X_{1j}, \cdots, X_{nj})}{max(X_{1j}, \cdots, X_{nj}) - min(X_{1j}, \cdots, X_{nj})} \quad (2)$$

Negative indicators:

$$X'_{ij} = \frac{max(X_{1j},\cdots,X_{nj})-X_{ij}}{max(X_{1j},\cdots,X_{nj})-min(X_{1j},\cdots,X_{nj})} \tag{3}$$

- Calculate the weights of the characteristics of the evaluation objects

$$P_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{n} X'_{ij}} \tag{4}$$

- Calculate entropy values

$$e_j = -k \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \tag{5}$$

$$k = \frac{1}{\ln(P_{ij})} \tag{6}$$

- Calculate the coefficients of variation

$$d_j = 1 - e_j \tag{7}$$

- Determine entropy weights

$$\omega_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{8}$$

3.2 Evaluation of competitiveness by using gray relational analysis method

The basic principle of gray relational analysis method is to determine whether there is a close connection between variables based on the degree of approximation of the geometry of the discrete series curves. If the comparison sequence and the reference sequence have a high degree of approximation of the curve geometry, then the relationship between the two series is closer and the gray correlation between them is larger; otherwise, the gray correlation between them is smaller. [8] In this study, after applying the entropy weight method to determine the weights of each index of the comprehensive competitiveness of enterprises, gray correlation analysis method is used to calculate the correlation degree, and the specific steps are shown as follows:

- Determine comparison sequence X_i and reference sequence X_0 .of which $X_i = (X_{i1}, X_{i2}, \cdots, X_{im})$,The reference sequence is the set of each of the optimal indicators, $X_0 = (X_{01}, X_{02}, \cdots, X_{0m})$ .The gray correlation space X is formed by X_i and X_0, $X = (X_1, X_2, \cdots, X_n, X_0)$.
- Normalize the gray correlation space to obtain the new gray correlation space $X' = (X'_1, X'_2, \cdots, X'_n, X'_0)$.
- Calculate the absolute difference between each comparison sequence index and reference sequence index.

$$\triangle_{ik} = |X'_{0k} - X'_{ik}| \tag{9}$$

- Calculate the correlation coefficient

$$\gamma_{oik} = \frac{\min_i \min_k |X'_{0k}-X'_{ik}| + \zeta \max_i \max_k |X'_{0k}-X'_{ik}|}{|X'_{0k}-X'_{ik}| + \zeta \max_i \max_k |X'_{0k}-X'_{ik}|} \tag{10}$$

$\zeta \in (0,1)$, Generally, this parameter is 0.5.
- Determine the degree of correlation

$$\gamma_{oi} = \sum_{j=1}^{m} \omega_j \times \gamma_{oik} \qquad (11)$$

$$\sum_{j=1}^{m} \omega_j = 1 \qquad (12)$$

- Ranking of enterprises according to their degree of correlation.

4. Empirical Analysis

4.1 Sample selection and data sources

- Sample selection

Up to now, among China's express enterprises, six express enterprises, SF Express, ZTO Express, YTO Express, STO Express, YUNDA Express and DEPPON Express, have occupied most of the market share. According to relevant data, ZTO Express occupied 23.4% of the market share in 2020, ranking first. The market shares of YUNDA Express, YTO Express, STO Express, SF Express and DEPPON Express were 17%, 15.1%, 10.6%, 9.8% and 0.67% respectively. The above six express enterprises can almost represent the current situation of express enterprises in China. Therefore, this paper takes the above listed express enterprises as the research object, and the listing of these express enterprises is shown in the following table 1:

Table 1. The listing of express enterprises

NO.	The listing of express enterprises		
	Listed exchange	*Stock Code*	*Enterprise*
1	SZSE [a]	002352	SF
2	NYSE [b]	ZTO	ZTO
3	SSE [c]	600233	YTO
4	SZSE	002468	STO
5	SZSE	002120	YUNDA
6	SSE	603056	DEPPON

[a.] Shenzhen Stock Exchange
[b.] The New York Stock Exchange
[C.] Shanghai Stock Exchange

- Data source

The data of operating revenue, net profit, number of employees and gearing ratio were obtained from the 2020 annual report of each express enterprise. The data of complaint rate and complaint handling composite index were obtained from the official website of the China Post Bureau. The data of number of main line vehicles, number of service points and types of value-added services were obtained from the official website of each express enterprise, and the average freight cost of urban delivery was used for ordinary type express delivery with a weight of 1 kg, which was delivered from Xi'an, Shaanxi Province to Civil Aviation University of China. The basic earnings per share was obtained from the financial statements of each enterprise in 2020, and this data was used to reflect the market valuation of the enterprise. The original data are shown in the following table 2:

Table 2. The original data

indicators	SF	ZTO	YTO	STO	YUNDA	DEPPON
C1(billion)[d]	153.99	25.21	34.91	21.57	33.50	27.50
C2(billion)	8.14	17.00	12.65	8.82	14.14	0.56
C3(billion)	7.33	4.33	2.20	0.05	1.42	0.56
C4	121925	22536	13490	9725	8646	79298
C5	25	7	4	7	11	16
C6	18	11	14	12	12	14
C7	93.45	90.03	94.19	93.96	94.65	95.90
C8	4.08	3.29	1.74	1.05	0.86	7.38
C9	196	94	75	68	67	71
C10	61	0	10	0	0	0
C11	45000	10100	5000	3500	4000	13490
C12(%)	97.07	92.00	97.33	87.00	96.40	93.50
C13	19000	30000	38375	25000	32624	30415
C14(%)	48.94	17.07	33.73	44.57	51.00	54.63
C15(billion)	111.16	59.21	26.43	15.95	29.50	10.19
C16	1.64	5.42	0.57	0.02	0.48	0.59

[d.] RMB

4.2 Data Processing

- Determine weights by using the entropy weight method

Used (2) and (3) to standardize the raw data, and then (4), (5), (6), (7) and (8) were used to determine the weight of each secondary indicator, and based on the principle of additivity of indicators at the same level, the weight of the primary indicator was the sum of the weights of the corresponding secondary indicators. The weights of the first-level indicator determined by the entropy weight method are shown in the following table 3:

Table 3. Weights of primary indicators

first level indicator		weight
market scale	B1	0.323
service quality	B2	0.074
guarantee ability	B3	0.390
financial strength	B4	0.213

The weights of the second-level indicator are shown in the following table 4:

Table 4. Weights of secondary indicators

second level indicator		weight
Operating income	C1	0.075
Express business volume	C2	0.041
Net Profit	C3	0.102
Number of employees	C4	0.105
Types of value-added services	C5	0.039
Average city delivery freight	C6	0.003
Complaint Handling Composite Index	C7	0.007
Complaint rate	C8	0.025
Number of transshipment centers	C9	0.022
Number of Owned Aircraft	C10	0.266
Number of main line vehicles	C11	0.101
Service Network Coverage	C12	0.001
Number of service points	C13	0.001
Gearing ratio	C14	0.001
Total Assets	C15	0.067
Market Valuation	C16	0.145

- Calculate the competitiveness correlation of each express enterprises.

First of all, the set of optimal terms of each index was selected as the reference sequence, and the original index data was standardized. Secondly, the correlation coefficient between each competitiveness index and the corresponding optimal competitiveness index of each express enterprise were obtained by (10). Thirdly, the correlation degree of each enterprise was calculated and ranked by (11). Correlation degree of an enterprise is directly proportional to its competitiveness, the greater the correlation, the stronger the competitiveness. Among the first-level indicators, the gray relational degree and ranking of market size and service quality of express enterprises are shown in the following table 5:

Table 5. Correlation degree of first level indicators (1)

Express companies	market scale		service quality	
	correlation degree	*rank*	*correlation degree*	*rank*
SF	0.872	1	0.762	3
ZTO	0.576	2	0.726	4
YTO	0.458	4	0.724	5
STO	0.391	6	0.805	2
YUNDA	0.468	3	0.837	1
DEPPON	0.415	5	0.673	6

The gray relational degree and ranking of guarantee ability and financial strength of express enterprises are shown in the following table 6:

Table 6. Correlation degree of first level indicators (2)

Express companies	Guarantee ability		financial strength	
	correlation degree	*rank*	*correlation degree*	*rank*
SF	0.939	1	0.799	1
ZTO	0.529	3	0.729	2
YTO	0.545	2	0.512	6
STO	0.486	6	0.536	5
YUNDA	0.525	5	0.580	3
DEPPON	0.528	4	0.544	4

The comprehensive competitiveness ranking results of express enterprises are shown in the following table 7

Table 7. Comprehensive Competitiveness Ranking

Express companies	Overall Competitiveness	
	correlation degree	*rank*
SF	0.880	1
ZTO	0.525	2
YTO	0.407	3
STO	0.377	6
YUNDA	0.402	4
DEPPON	0.399	5

4.3 Results analysis

- Overall Competitiveness analysis

From the calculation results, the ranking of comprehensive competitiveness from strong to weak is: SF >ZTO >YTO >YUNDA >DEPPON>STO. And then SF Express (0.881) far surpasses other companies, which shows the strength of SF Express in China's express industry, ranking 61st in the

2019 "China Brand Development Index" 100 list issued by People's Daily. The second-ranked ZTO Express (0.525) also obtains good results.

- Market scale analysis

In terms of market size, the ranking of competitiveness from strong to weak is SF>ZTO>YUNDA>YTO> DEPPON>STO. From the perspective of the secondary index weight, the largest proportion is the number of employees, followed by the net profit. SF Express has great advantages in both aspects.

- Service quality analysis

In terms of quality of service, the ranking of competitiveness from strong to weak is: YUNDA>STO>SF>ZTO>YTO>DEPPON. It can be seen that YUNDA Express performs better than other express enterprises. In terms of the weights of the secondary indicators, the biggest influence on service quality is the types of value-added services and the complaint rate. SF Express can provide the most kinds of value-added services, but it has a higher complaint rate, thus pulling down the ranking. YUNDA Express has the lowest complaint rate and provides more value-added services. Therefore, it performs well in service quality.

- Guarantee ability analysis

In terms of guarantee ability, the ranking of competitiveness from strong to weak is: SF>YTO>ZTO>DEPPON>YUNDA>STO. SF Express and YTO Express have its own cargo aircrafts, which other express enterprises do not have at present, so these two enterprises perform well in guarantee ability. Especially, SF Express has 61 self-owned all-cargo aircrafts (14 leased) and 1.67 million tons of air shipments, accounting for 34% of the total domestic cargo and mail transportation. From the weight of secondary indicators, the number of main line vehicles is also an important factor, and SF Express also has the largest number of main line vehicles, reaching 45,000.

- Financial strength analysis

In terms of financial strength, the ranking of competitiveness from strong to weak is: SF>ZTO>YUNDA>DEPPON>STO>YTO. From the weight of secondary indicators, the indicator with the greatest impact on financial strength is market valuation, which is reflected by basic earnings per share in this study, with ZTO Express being the largest at 5.42 yuan per share, followed by SF Express at 1.64 yuan per share. And the total assets of SF Express reached 111.160 billion yuan, an increase of 20.13% over the same period last year, far more than other enterprises. SF Express maintains a healthy debt level, and its financial position is sound and optimistic.

5. Conclusion

This study has constructed a comprehensive evaluation index system of express enterprises' competitiveness from four aspects: market scale, service quality, guarantee ability and financial strength, and combined the entropy weight method and the gray relational analysis method to construct the evaluation model, and then we selected six most representative express enterprises in China as samples for empirical analysis. The results of the study show that the ranking of comprehensive competitiveness for express enterprises from strong to weak is: SF Express (0.880), ZTO Express (0.525), YTO Express (0.407), YUNDA Express (0.402), DEPPON Express (0.399) and STO Express (0.377). It can be seen that SF Express is in the leading position in China's express industry, followed by ZTO Express.

At present, China's express industry is in a golden era with rapid development and fierce competition. In order to survive in the brutal competitive environment, express enterprises must strive to improve their competitive advantages. This evaluation model proposed in study can well reflects the competitive level of express enterprises, it has very important practical significance, which can help express enterprises to make a detailed analysis of their own strength, to find the

competition strategy matching their position, and enhance their competitive strength.

Due to the limited level of the writers, whether the index system established in this study is universal and scientific remains to be studied. In addition, we only counted the data of one year in 2020, which may not accurately reflect the actual situation of express enterprises, and these aspects can be studied in depth in the future.

Acknowledgement

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