Research on Logistics Outsourcing E-Commerce Enterprise Performance Evaluation based on the Entropy Weight TOPSIS Model

Li Zhang 1,2, a, Xue Chen 2, b and Haimeng Fan2, c

1Tianjin Food Safety Management and Strategy Research Center, Tianjin 300222, China;
2School of Economics & Management, Tianjin University of Science &Technology, Tianjin 300222, China.

a jannyzl@163.com, b 1305436203@qq.com, c 1607862623@qq.com.

Abstract. According to the characteristics of e-commerce enterprises in logistics outsourcing, this paper builds 20 index level indexes of e-commerce enterprise performance which reflects logistics outsourcing based on 9 criteria. Using the entropy weight method from both subjective and objective in the face of various indicators of empowerment, taking four listed e-commerce enterprises logistics outsourcing as samples using TOPSIS model for the empirical study on enterprise performance, through layered evaluation and comprehensive evaluation of the results reveal the differences between corporate performance and the main factors affecting its performance, the real, the paper reveals the features of various e-commerce enterprises and existing problems, in order to provide decision basis for the development of the e-commerce enterprises.

Keywords: Logistics Outsourcing; E-commerce enterprises; Performance Evaluation; Entropy weight method; TOPSIS.

1. Introduction

As the economic market expands continuously and the social competition environment and consumers' demands change increasingly, e-commerce has become overwhelming throughout the whole world and is playing a more and more important role, while logistics has become an indispensable part of e-commerce supply chain. Studies have shown that perfect logistics operation will bring e-commerce enterprises with direct and positive effects and will become an important premise and guarantee of enhancing core competitions of e-commerce enterprises and improving performance [1]; It has been mentioned that logistics service is an important constituent of the integral of e-commerce enterprises and good sense for logistics service will positively and significantly affect customers' satisfaction (Bian Wenliang et al., 2011) [2]; It is expressed as improvement of the customer loyalty in terms of the vast e-commerce group [3]. Hence, e-commerce enterprises should intensify the logistics ability, establish scientific and valid performance evaluation system, keep optimizing resources and promote individual better development.

In recent years, a large quantity of local and overseas studies has been conducted for performance evaluation of enterprises. American scholars Kaplan and Norton originally put forward the concept of "balanced score card", which evaluates enterprise performance evaluation from four aspects of finance, internal operation, client and technical ability and learning and growth and organically integrates financial indicators and non-financial indicators to evaluate comprehensively and effectively enterprise performance [4]. Li Anyu and Zhang Zhao (2015) integrated data envelopment analysis model and the super-efficiency model and conducted empirical studies and analysis of management performance of 22 e-commerce enterprises from Shanghai and Shenzhen by virtue of software [5]. Hui Shupeng and Zheng Yubao (2016) introduced the balanced score card method and established system dynamics model relating to enterprises' strategic performance evaluation, applied simulated software to conduct simulation and prediction of the model and scientifically and effectively evaluate performance of enterprises [6].

Recently, local and overseas scholars after studies have established different performance evaluation indicator systems for different industries, involving different application theories and methods; most studies are qualitative, and there is a powerful lack of quantitative study results. This
paper will establish a corresponding performance evaluation indicator system based on the characteristics of logistics outsourcing e-commerce enterprises, overwhelming the performance evaluation method which only takes finance indicators into account, so it is reasonable and scientific. Wherein, quantization of quantitative indicators refers to assignment based on actual statistical data, and quantization of qualitative indicators refers to subjective assignment made by experts of relevant fields by virtue of Bipolar interval scale; Weights of evaluation indicators determined with entropy weight method and the TOPSIS model are used for calculation, sorting and analysis of performance of logistics outsourcing e-commerce enterprises.

2. Construction of the Performance Evaluation Indicator System of Logistics Outsourcing E-commerce Enterprises

Performance of e-commerce enterprises is evaluated using nine criterion indicators, including profitability A1, international operation ability A2, asset operation ability A3, client relationship management ability A4, solvency A5, outsourcing logistics service ability A6, development ability A7, learning and growth ability A8 and collaborative innovation ability A9 put forward based on relevant enterprise performance evaluation theories of local and overseas relevant study scholars such as Wang Xiaojuan et al. (2014) [7], Meng Zhihua (2017)[8], DQ Yang (2015)[9], Zhang Z (2017)[10] through studies of characteristics of logistics outsourcing e-commerce enterprises. The indicator system as shown in Figure 1 which can evaluate performance of logistics outsourcing e-commerce enterprises objective has been selected and determined preliminarily in principles of operability, scientificity and systemativeness for selecting indicators.

Fig.1 Performance Evaluation Indicator System of Logistics Outsourcing E-commerce Enterprises
3. Weight Calculation of Performance Evaluation Indicator of Logistics Outsourcing E-commerce Enterprises Based on Entropy Weight TOPSIS Model

3.1 Fundamental of Entropy Weight Method

Entropy was originally introduced by C.E. Shannon into information theory and then was widely applied to social economy, engineering technology and other fields. Its fundamental is that the objective weight is determined based on degree of indicator variation [11]. In other words, smaller entropy means a larger deviation degree and more information, a greater role and a larger weight. On the contrary, larger entropy means a smaller deviation degree, less information, a smaller role in comprehensive evaluation and a smaller weight.

3.2 Model Construction based on Entropy Weight Method

Assumed that there are m logistics outsourcing e-commerce enterprises (m=1,2,3,⋯,m) and n enterprise performance evaluation indicators (n = 1,2,3,⋯,n), representing the i e-commerce enterprise corresponding to the j performance evaluation indicator, namely initial data forming a decision making matrix $A_{m \times n}$.

First, if there are differences among the quantity of indicators and dimensions in the decision making matrix, standardized processing is applied to initial data to form the standardized decision making matrix $A'_{m \times n}$.

Efficiency indicator: The larger value means the better evaluated contents;

$$X'_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \quad (1)$$

Cost indicator: The smaller value means the better evaluated contents;

$$X'_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \quad (2)$$

Second, specific gravity conversion is conducted for standardized decision making matrix to obtain the characteristic specific gravity ($Y_{ij}$):

$$Y_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}} \quad (3)$$

Third, calculate the entropy value ($e_{j}$) of evaluation indicator:

$$e_{j} = -k \sum_{i=1}^{m} (Y_{ij} \times \ln Y_{ij}) \quad (4)$$

$e_{j}$ Meaning the entropy value of the j evaluation indicator, the constant k is related to the number of samples $k = \frac{1}{\ln m}$.

Fourth, calculate the deviation degree ($d_{j}$)

$$d_{j} = 1 - e_{j} \quad (5)$$

Last, calculate the weight of evaluation indicators ($W_{j}$):

$$W_{j} = \frac{d_{j}}{\sum_{j=1}^{n} d_{j}} \quad (6)$$
Meaning the entropy weight of the j evaluation indicator.

### 3.3 Fundamental of TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method was put forward originally by C.L.Hwang and K.Yoon in 1981. As a priority selection technology related to similar sequence of ideal goals, it is an effective method for decision making of many goals [12]. Its fundamental is that sorting is made through calculating the gap between the evaluated object and the ideal solution and the negative ideal solution. It is optimal if the gap between the evaluated object and the ideal solution is the smallest and the largest and the negative ideal solution; otherwise, it is not the optimal. And indicator values of the optimal solution will reach the optimal value of the corresponding evaluation indicator; the indicator values of the worst solution will reach the worst value of the corresponding evaluation indicator.

### 3.4 Model TOPSIS Construction

First, constructing the weighting standardization decision making matrix V, the standardization decision making matrix without dimensions $A' = \{X'_{ij}\}_{m \times n}$ product of the weight vectors determined with the entropy weight method $W = (W_1, W_2, W_3, \ldots, W_n)$:

$$V = \{v_{ij}\}_{m \times n}$$ (7)

Second, calculate the ideal solution and the negative ideal solution to form the ideal vector $D^+$ and the negative ideal vector $D^-$. 

$$D^+_j = \{\max_i v_{ij}, j \in I_1 \}; \quad S^+_j = \{\min_i v_{ij}, j \in I_2 \}$$ (8)

$$D^-_j = \{\min_i v_{ij}, j \in I_1 \}; \quad S^-_j = \{\max_i v_{ij}, j \in I_2 \}$$ (9)

Wherein, $I_1$ represents efficiency indicator and $I_2$ represents the cost indicator.

Third, calculate the comprehensive Euclidean distance between the standardization vector of evaluation indicator and the positive ideal solution $S^+_i$ and the negative ideal solution $S^-_i$.

$$S^+_i = \sqrt{\sum_{i=1}^{m} (v_{ij} - D^+_j)^2}$$ (10)

$$S^-_i = \sqrt{\sum_{i=1}^{m} (v_{ij} - D^-_j)^2}$$ (11)

Last, calculate the relative closeness coefficient $C$ of indicators and the positive / negative ideal solution and the ranking.

$$C_i = \frac{S^-_i}{S^+_i + S^-_i}$$ (12)

### 4. Empirical Research

#### 4.1 Sample Selection and Data Resourcing

To enhance the comparability of evaluation object, but for insufficiency and lack of data, four listed logistics outsourcing e-commerce enterprises people are familiar with are selected, including Alibaba, Vipshop, JUMEI and Amazon. The initial data are shown as in Table 1. The data relate to quantitative indicators mentioned in the paper refer to 2015 financial data released by stock website enterprises. The quantization of qualitative indicators refers to the subjective assignment made by 6 relevant experts by virtue of 10-point scaling method of Bipolar interval scale.
| S/N | Criterion level                     | Index layer | Index property | Alibaba | Vipshop | JUME | Amazon |
|-----|-------------------------------------|-------------|----------------|---------|---------|------|--------|
|     |                                     |             |                | Quantitative | 31.9 | 3.8  | 1.8   | 0.56   |
| 1   | Profit-making capacity              | A1          | Net profit ratio of business (%) A11 | Quantitative | 55.0 | 51.8 | 29.14 | 1.47   |
|     |                                     | A12         | Cost-profit ratio (%) A12 | Quantitative | 6   | 51.8 | 29.14 | 1.47   |
|     |                                     |             | Information collecting ability A21 | Qualitative | 9   | 5   | 7     | 9      |
| 3   | Internal operation ability          | A2          | Situational handling ability A22 | Qualitative | 9   | 7   | 5     | 7      |
|     |                                     |             | Current assets turnover (times) A31 | Quantitative | 0.73 | 3.11 | 1.55 | 3.16   |
| 5   | Asset operation ability             | A3          | Turnover rate of accounts receivable (times) A32 | Quantitative | 114.08 | 200.63 | 139.26 | 17.78   |
| 6   |                                     |             | Customer satisfaction A41 | Qualitative | 7   | 9   | 7     | 9      |
| 7   | Client relationship management ability | A4     | Client retaining ability A42 | Qualitative | 9   | 7   | 7     | 7      |
| 8   |                                     |             | Current ratio A51 | Quantitative | 3.58 | 1   | 3.54 | 1.08   |
| 9   | Solvency A5                         |             | Property ratio (%) A52 | Quantitative | 0.67 | 4.64 | 0.37 | 3.89   |
| 10  |                                     |             | Liability-to-asset ratio (%) A53 | Quantitative | 38.1 | 82  | 27    | 79.3   |
| 11  | Outsourcing logistics service ability A6 |         | Cargo damage and shortage compensa | Qualitative | 7   | 7   | 7     | 9      |
| Indicator | Category | Weight 1 | Weight 2 | Weight 3 | Weight 4 |
|-----------|----------|----------|----------|----------|----------|
| A61       | Qualitative | 7        | 9        | 9        | 9        |
| A62       | Qualitative | 9        | 7        | 9        | 5        |
| A63       | Quantitative | 45.14    | 73.73    | 79.1     | 20.25    |
| A71       | Quantitative | 128.99   | 18.2     | 3.67     | 18.79    |
| A72       | Qualitative | 7        | 7        | 7        | 9        |
| A81       | Qualitative | 5        | 9        | 7        | 7        |
| A82       | Qualitative | 7        | 5        | 5        | 7        |
| A91       | Qualitative | 5        | 7        | 5        | 5        |

### 4.2 Performance Evaluation of Logistics Outsourcing E-Commerce Enterprises based on Entropy Weight TOPSIS Model

This paper selected four listed logistics outsourcing e-commerce enterprises and 20 indicators of 9 criterion layers to conduct ranking of enterprise performance (i.e. m=4, n=20). The calculation process is pretty long, so partial calculation steps are omitted.

First, standardization processing is applied to initial data sample. Since 19 of 20 indicators in the paper are efficiency indicators, initial data are processed as per formula (1), and the "liability-to-asset ratio", as a cost indicator is processed as per formula (2) to finally form the standardization decision making matrix $A' = \{X'_{ij}\}_{m\times n}$.

Last, determine the performance evaluation indicators' weight with the entropy weight method.
Apply the entropy weight method formula (3) to calculate the standardization decision making matrix and then apply the formula (4), formula (5) and formula (6) to determine the entropy value $e_i$ and entropy weight of the evaluation indicator $w_j$. Results are shown as in Table 2.

Table 2. Entropy Values $e_i$ and Weights of Performance Evaluation Indicators $w_j$ of Logistics Outsourcing E-commerce Enterprises

| S/N | Criterion level                  | Index layer | $e_i$   | $w_j$   |
|-----|----------------------------------|-------------|---------|---------|
| 1   | Profit-making capacity A1        | A11         | 0.3172  | 0.0450  |
| 2   |                                  | A12         | 0.3203  | 0.0448  |
| 3   | Internal operation ability A2    | A21         | 0.2821  | 0.0474  |
| 4   |                                  | A22         | 0.5310  | 0.0309  |
| 5   | Asset operation ability A3       | A31         | 0.3126  | 0.0453  |
| 6   | Customer relationship A4         | A41         | 0.0664  | 0.0615  |
| 7   | Solvency A5                      | A51         | 0.1382  | 0.0568  |
| 8   | Logistics service quality A6     | A61         | 0.0997  | 0.0637  |
| 9   | Develop ability A7               | A71         | 0.0953  | 0.0596  |
| 10  | Learning and growth ability A8   | A81         | 0.0997  | 0.0594  |
| 11  | Collaborative innovation ability A9| A91     | 0.0664  | 0.0615  |

4.3 Calculate the Closeness Coefficient of Indicators of Enterprise Performance and Ranking with the TOPSIS Model

Based on the TOPSIS model, formula (7) is applied to multiply indicator weight $w_j$ determined by the standardization decision making matrix $A' = \{X'_{ij}\}_{m \times n}$ and the entropy weight method, and then formula (8) and formula (9) are applied to calculate the ideal value vector $D^+_j$ and the negative ideal value vector $D^-_j$. Results are shown as below:

$D^+ = (0.0450, 0.0448, 0.0474, 0.0309, 0.0453, 0.0349, 0.0615, 0.0594, 0.0568, 0.0467, 0.0473, 0.0594, 0.0637, 0.0473, 0.0596, 0.0388, 0.0594, 0.0309, 0.0615, 0.0594).$

$D^- = (0.0005, 0.0004, 0.0003, 0.0005, 0.0005, 0.0006, 0.0006, 0.0006, 0.0006, 0.0006, 0.0006, 0.0006, 0.0004, 0.0006, 0.0003, 0.0006, 0.0006).$

The comprehensive Euclidean distance between the standardization vector of each evaluation indicator and the positive ideal solution and the negative ideal solution is obtained with formula (10) and formula $D^+_j$ based on the ideal value vector, the negative ideal value vector $D^-_j$ and the weight standardization decision making matrix $V = \{v_{ij}\}_{m \times n}$. And then formula is applied to calculate the closeness, ranking and comprehensive closeness $S^+_i$, $S^-_i$ and the ranking of indicators at the criterion layer of e-commerce enterprises. Results are shown as in Table 3 and Table 4.
Table 3. Closeness and Ranking of Evaluation Indicators at the Criterion Layer of Logistics Outsourcing E-commerce Enterprises

| Sample  | A1 Ranking | A2 Ranking | A3 Ranking | A4 Ranking | A5 Ranking | A6 Ranking | A7 Ranking | A8 Ranking | A9 Ranking | A10 Ranking |
|---------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Alibaba | 100        | 1          | 100        | 1          | 0          | 4          | 6.38       | 2          | 11.11      | 9          | 3          | 1          | 0          | 4          | 100        | 1          |
| Vipshop | 51.99      | 2          | 0          | 4          | 100        | 1          | 6.76       | 3          | 51.77      | 2          | 90.96      | 3          | 41.36      | 2          | 6.38       | 2          |
| JUMEI   | 2          | 13.08      | 3          | 3          | 0          | 3          | 100        | 1          | 1.77       | 2          | 2.54       | 2          | 0.68       | 3          | 0          | 3          |
| Amazon  | 0          | 4          | 5.38       | 2          | 4          | 4.26       | 2          | 100        | 1          | 4          | 100        | 1          | 100        | 1          | 1          | 1          |

Table 4. Comprehensive Closeness and Ranking of Performance of Logistics Outsourcing E-commerce Enterprises

| Sample  | Comprehensive | Ranking |
|---------|---------------|---------|
| Alibaba | 44.5772       | 3       |
| Vipshop | 49.8769       | 2       |
| JUMEI   | 40.4350       | 4       |
| Amazon  | 50.0554       | 1       |

4.4 Analysis of the Empirical Study Results

Based on analysis of Table 2 Entropy Values $e_i$ and Weights $w_i$ of Performance Evaluation Indicators of Logistics Outsourcing E-commerce Enterprises, the weight of profitability $A_1$ is 0.0885, that of internal operation ability $A_2$ is 0.0772, that of asset operation ability $A_3$ is 0.0791, that of customer relationship management ability $A_4$ is 0.1192, that of solvency $A_5$ is 0.1487, that of outsourcing logistics service ability $A_6$ is 0.1820, that of development ability $A_7$ is 0.0971, that of learning and growth ability $A_8$ is 0.0890 and that of collaborative innovation ability is 0.1192. It shows that the primary factors of affecting performance of logistics outsourcing e-commerce enterprises include the customer relationship management ability, solvency ability, outsourcing logistics service ability and the collaborative innovation ability. Weights of these four criterion indicators account for 56.91% of the total weight value; And weight proportion of the outsourcing logistics service ability is the largest, especially that the indicator of scheduled and accurate delivery ability $A_62$ accounts for the most of the 20 indicators, from which it can be easily found that logistics outsourcing service ability plays an important role. So as for logistics outsourcing e-commerce enterprises, good logistics operation can significantly improve the performance of an enterprise; the solvency ability has the second largest weight proportion, and the client relationship management ability and the collaborative innovation ability have the same weight. They all play a large role for e-commerce enterprises and will significantly affect their performance.

It can be found from Table 3 Closeness and Ranking of Evaluation Indicators at the Criterion Layer of Logistics Outsourcing E-commerce Enterprises and Table 4 Comprehensive Closeness and Ranking that the closeness of Alibaba is the lowest in terms of asset operation ability, outsourcing logistics service ability and the learning and growth ability and it is at the bottom of ranking, especially the outsourcing logistic service ability which is vital to e-commerce enterprises. Since the lowest three indicators, Alibaba is ahead of the four enterprises. Although its comprehensive ranking is at the third place, its other abilities are ahead of those of other three enterprises almost. So it should make improvement at these three aspects to improve its comprehensive strength. From general summary of the closeness of indicators of Vipshop, its abilities except the bad internal operation ability are above the average and superior to other enterprises, so its comprehensive ranking is at the second place. JUMEI's customer relationship management ability and collaborative innovation ability are at the bottom of the ranking and other abilities below the average are not comparable with other three enterprises. Its comprehensive closeness is relatively worse and ranks the fourth place. As for Amazon, its profitability, solvency and development ability are disadvantaged and other abilities are advantaged relatively, especially the outsourcing logistics service ability far ahead of other three enterprises. Its comprehensive closeness score is the highest and ranks the first place.
5. Conclusion

Fast inflation of the global economy makes the e-commerce industry develop vigorously and the market competition becomes fiercer accordingly. Advanced logistics mode and scientific management method especially vital to e-commerce enterprises can not only improve the logistics efficiency but also enhance the competitiveness of the e-commerce platform. And logistics outsourcing is one of the most commonly used modes. This paper carries out a deep study of performance of four listed logistics outsourcing e-commerce enterprises by virtue of the entropy weight method and the TOPSIS model through establishing the logistics outsourcing e-commerce enterprise performance evaluation indicator system, truly revealing differences of e-commerce enterprises' performance, influential factors and existing problems. This study not only helps e-commerce enterprises formulate development strategies but also points out the direction of further development of the e-commerce industry. In future studies, effects of informationization logistics services on e-commerce platform can be discussed further to realize the collaborative development of modern logistics and e-commerce industry.

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