Construction of Comprehensive Evaluation Index System for Low-carbon Performance of Express Enterprises

Hailong Gao, Yao Hu* and Zeyi Jin
Wuhan University of Technology, Hubei, China

*Corresponding author e-mail: 501775147@qq.com

Abstract. Based on the research of the low-carbon performance factors of express delivery enterprises, the low-carbon performance comprehensive evaluation index system of express delivery enterprises is constructed from five aspects: packaging, storage, transportation, distribution and recycling. By using fuzzy comprehensive evaluation method, we can evaluate the low-carbon performance of enterprises, and finally improve the low-carbon performance of express delivery enterprises continuously through the PDCA cycle.

1. Introduction
After more than 30 years of development, China's express delivery industry has gradually become a rapidly growing and promising emerging strategic service industry [1]. However, the environmental pollution caused by it has become increasingly obvious. The existing researches mainly focus on the qualitative analysis of non-low-carbon links of express delivery enterprises, or only define the goals and contents of low-carbon logistics for express delivery enterprises. However, there is a lack of quantitative and systematic low-carbon performance indicators system. Therefore, it is urgent to construct a comprehensive evaluation system of low-carbon performance for express delivery enterprises.

2. The Choice and Description of Evaluation Index System
The index system can be divided into three levels: target level, criterion level and indicator level. As shown in Table 1, specific indicators of low-carbon performance evaluation are as follows:

(1) The Decomposition of Packaging Activity Index
In the courier business packaging process, the lack of environmental protection packaging materials, over-packaging, repeat packaging, "big package small goods" phenomenon can often be seen. Therefore, the low-carbon packaging performance indicators mainly include the degree of environmental protection of packaging materials, excessive packaging, the use of filler material and packaging standardization.

(2) The Decomposition of Storage Activity Index
In the storage process of goods, storage location is unreasonable. Low standardization of storage equipment and less use of new energy technologies will result in high costs in transportation and energy consumption. Therefore, the low-carbon storage performance indicators mainly cover the reasonableness of storage location, the degree of the standardization of storage equipment and new energy technology utilization.
(3) The Decomposition of Transport Activity Index
The transportation links of express enterprises are typical non-low-carbon links [2], mainly because of their high dependence on road and air transport which costs huge energy consumption and also because of backward and slow updating of transport vehicles and equipment. Therefore, the low-carbon performance indicators of transport mainly include the waste discharge of three wastes, the utilization rate of new energy vehicles, the level of information system construction and the quality of transport personnel.

(4) The Decomposition of Distribution Activity Index
In the course of distribution, items are not properly selected in distribution mode [3], communication between distribution centers and receiving party is not timely, distribution route is unreasonable and the concentration distribution rate is low, these will adversely affect low-carbon. Therefore, the distribution of low-carbon performance indicators mainly include the rationality of distribution mode, the level of distribution of information, delivery route rationality and centralized distribution.

(5) The Decomposition of Recycling Activities Index
The courier packaging recycling can both create a certain degree of economic benefits and also create good environmental benefits and in line with the concept of low-carbon environment [4]. Therefore, the level of packaging recovery, recycling and reverse logistics system is the main indicator of low carbon recovery performance.

3. The establishment of indicator weight
After the courier low-carbon performance evaluation index is established, pairwise comparison method is used to compare the indexes between the criterion level and the target level in turn. 1-9 scale value is used to indicate the importance of indicators and the importance is increasing as the value increases. The importance of indicators is mainly obtained through a questionnaire survey of experts. First, the judgment matrix is constructed, then the largest eigenvalue of the judgment matrix is calculated, and finally the consistency test is carried out. Calculating the arithmetic average of the data in the questionnaire that passed the consistency test to find the final judgment matrix. Using yapp software to calculate the relevant weight, the results obtained are shown in Table 1:

The CR of express value of low-carbon business performance evaluation matrix in the table is 0.0142 <0.1, passing the test in consistency. The CR of packaging, warehousing, transportation, distribution and recycling indexes are 0.0534,0.0176,0.0591,0.0490,0.0516, all less than 0.1, so the consistency tests are all qualified.

4. The Usage of Evaluation Index System
Although it is difficult to quantitatively describe the low-carbon performance of express enterprises at present, the fuzzy comprehensive evaluation method has great advantages in dealing with qualitative or uncertain problems [5]. Therefore, the research uses fuzzy comprehensive evaluation method to evaluate enterprises low carbon performance. The specific steps are as follows:

(1) To determine the set of indicators of evaluation $U_i$. It contains five guidelines, including packaging, storage, transportation, distribution, recycling, therefore $U_i = U_i (i = 1, 2, \ldots, 5)$. Each $U_i$ consists of the next level of indicators $U_{ij}$, namely $U = U_{ij}$.

(2) To determine the set of reviews. The level set of low carbon performance evaluation of enterprises is set as $V = \{v_1, v_2, v_3, v_4, v_5\} = \{bad, relativelybad, normal, relativelygood, good\}$

(3) To determine the weight of each indicator. The corresponding weight is: $W_{ij} (i = 1, 2, \ldots, 5, j = 1, 2, 3, 4)$

(4) To find the fuzzy comprehensive evaluation set $B$ through the comprehensive evaluation matrix, that is $B = W \times R, R (i = 1, 2, \ldots, 5)$.
(5) To delete the fuzzy value. That is using fuzzy comprehensive evaluation set \( B \) and measurement scale \( S \) to calculate the evaluation object’s comprehensive evaluation score \( E \) : 
\[
E = B \times S.
\]
In the formula, \( s = \{\text{bad, relatively bad, normal, relatively good, good}\} = \{1,2,3,4,5\} \).

**Table 1.** The Hierarchical Structure of Indicators of Corporate Low-Carbon Performance

| Target level                                      | Level | Number weight | Consistency Rate(CR) | Indicator layer | Number | Relative weight | Absolute weight |
|--------------------------------------------------|-------|---------------|----------------------|-----------------|--------|----------------|-----------------|
| Express business low-carbon performance           |       |               |                      |                 |        |                |                 |
| (CR= 0.0142 <0.1)                                |       |               |                      |                 |        |                |                 |
| Package                                          | A     | 0.0557        | 0.0534               |                 | A1     | 0.1228         | 0.0068          |
|                                                  |       |               |                      | The degree of environmental protection of packaging materials | A2     | 0.3843         | 0.0214          |
|                                                  |       |               |                      | Excessive packaging | A3     | 0.3007         | 0.0168          |
|                                                  |       |               |                      | The degree of filling material usage | A4     | 0.1922         | 0.0107          |
|                                                  |       |               |                      | The standardization of packaging | B1     | 0.2098         | 0.0189          |
|                                                  |       |               |                      | The rationality of storage location | B2     | 0.2402         | 0.0217          |
|                                                  |       |               |                      | The standardization of storage equipment | B3     | 0.5499         | 0.0496          |
|                                                  |       |               |                      | The utilization of new energy technology | C1     | 0.0617         | 0.0207          |
|                                                  |       |               |                      | The emissions of three wastes | C2     | 0.1592         | 0.0535          |
|                                                  |       |               |                      | The utilization of new energy car | C3     | 0.3227         | 0.1085          |
|                                                  |       |               |                      | The level of information system construction | C4     | 0.4564         | 0.1535          |
|                                                  |       |               |                      | The quality of transport personnel | D1     | 0.0781         | 0.0156          |
|                                                  |       |               |                      | The rationality of distribution mode | D2     | 0.1537         | 0.0308          |
|                                                  |       |               |                      | The level of delivery information | D3     | 0.4735         | 0.0948          |
|                                                  |       |               |                      | The rationality of delivery route | D4     | 0.2947         | 0.0590          |
|                                                  |       |               |                      | Unified distribution | E1     | 0.5278         | 0.1676          |
|                                                  |       |               |                      | The level of package recycling | E2     | 0.3325         | 0.1056          |
|                                                  |       |               |                      | The level of usage recycling | E3     | 0.1396         | 0.0443          |
| Storage                                          | B     | 0.0902        | 0.0176               |                 |        |                |                 |
| Transportation                                   | C     | 0.3363        | 0.0591               |                 |        |                |                 |
| Distribution                                     | D     | 0.2003        | 0.0490               |                 |        |                |                 |
| Recycling                                        | E     | 0.3175        | 0.0516               |                 |        |                |                 |

Experts are now organized to rate a large express delivery company in Wuhan, rating scoring data shown in Table 2.

Using fuzzy comprehensive evaluation method for data processing, the expert satisfaction scores of packaging, warehousing, transportation, distribution and recycling indicators were 2.929, 3.445, 3.167, 3.411, and 2.606 respectively. The overall score of low carbon performance of the express delivery enterprises was 3.050. The comprehensive evaluation score is located in the "normal" and "better" interval of the evaluation set, indicating that the express delivery enterprise's low-carbon performance needs to be further improved.

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Table 2. The summary of expert rating data

| The guidelines layer | Indicator factors | bad | Relatively bad | Normal | Good | Relatively good |
|----------------------|-------------------|-----|----------------|--------|------|----------------|
| Package              | The degree of environmental protection of packaging materials | 7   | 8              | 10     | 3    | 2              |
|                      | Excessive packaging | 4   | 7              | 9      | 7    | 3              |
|                      | The degree of filling material usage | 6   | 7              | 9      | 5    | 3              |
|                      | The standardization of packaging | 2   | 3              | 10     | 8    | 7              |
|                      | The rationality of storage location | 2   | 3              | 8      | 10   | 7              |
|                      | The standardization of storage equipment | 3   | 4              | 9      | 7    | 7              |
| Storage              | The utilization of new energy technology | 2   | 5              | 8      | 8    | 7              |
|                      | The emissions of three wastes | 7   | 6              | 11     | 4    | 2              |
|                      | The utilization of new energy car | 7   | 7              | 9      | 5    | 2              |
|                      | The level of information system construction | 4   | 3              | 8      | 8    | 7              |
|                      | The quality of transport personnel | 3   | 4              | 9      | 9    | 5              |
|                      | The rationality of distribution mode | 4   | 3              | 7      | 8    | 8              |
|                      | The level of delivery information | 3   | 4              | 8      | 8    | 7              |
|                      | The rationality of delivery route | 3   | 3              | 8      | 8    | 8              |
|                      | Unified distribution | 3   | 5              | 10     | 5    | 7              |
|                      | The level of package recycling | 7   | 7              | 9      | 4    | 3              |
| Transportation       | The utilization of new energy technology | 2   | 5              | 8      | 8    | 7              |
|                      | The emissions of three wastes | 7   | 6              | 11     | 4    | 2              |
|                      | The utilization of new energy car | 7   | 7              | 9      | 5    | 2              |
|                      | The level of information system construction | 4   | 3              | 8      | 8    | 7              |
|                      | The quality of transport personnel | 3   | 4              | 9      | 9    | 5              |
|                      | The rationality of distribution mode | 4   | 3              | 7      | 8    | 8              |
|                      | The level of delivery information | 3   | 4              | 8      | 8    | 7              |
|                      | The rationality of delivery route | 3   | 3              | 8      | 8    | 8              |
|                      | Unified distribution | 3   | 5              | 10     | 5    | 7              |
|                      | The level of package recycling | 7   | 7              | 9      | 4    | 3              |
|                      | The level of usage recycling | 8   | 7              | 8      | 4    | 3              |
|                      | The level of reverse logistics system | 8   | 6              | 9      | 4    | 3              |

5. Company's Low Carbon Performance Management Based on PDCA Cycle

Constructing an index system of comprehensive evaluation of low-carbon performance for express delivery enterprises and using fuzzy comprehensive evaluation method to evaluate its low-carbon performance in order to improve the low-carbon performance of express delivery enterprises, is a process which fully reflects the planning and implementation, inspection, disposal of the cycle of low-carbon management methods of the research- PDCA cycle management.

The PDCA cycle [6] also known as a mass ring. It can improve the quality of a managed object. PDCA is the first letter of the English words Plan, Do, Check, and Act. The research uses the PDCA quality circle of express enterprises' low-carbon performance to manage the whole process of the low-carbon performance of express enterprises. The process can be shown in Figure 1.

After the completion of the first round of recycling, and then continue to loop from the source, through the above PDCA cycle, each cycle will have an impact on the discovery and solution of low-carbon business performance issues and the formation of a rise in business and improve the express delivery business low Carbon Performance, and finally steady the operation of Low Carbon Streams.
6. Conclusion
On the basis of field investigation, we conduct a systematic analysis based on the combination of qualitative analysis and builds a set of comprehensive low-carbon performance evaluation index system for express delivery enterprises. Using fuzzy comprehensive evaluation method, we can draw a low-carbon performance score of a company, and then make the links that affect the low-carbon performance of the express delivery company clear. Using the PDCA cycle to improve it, so as to continuously improve the low carbon performance of the express delivery company. The feasibility of the comprehensive evaluation index system is demonstrated by examples, which can provide reference for the evaluation of low carbon performance of express enterprises. At the same time, the index of the evaluation system has the characteristics of being dynamic, and there are still some problems such as the special and scientific selection. This is also an important direction that the index system can do in-depth study in the future.

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