Establishment of Credit Evaluation Indicator System for Enterprise Environmental Behavior Based on Fuzzy ISODATA Clustering Analysis

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Abstract. Credit evaluation of enterprise environmental behavior is an important means to drive the healthy and sustainable development of China's construction industry. Based on the features of the construction industry and current enterprise environmental credit standards in China, the input-output indicator evaluation system for enterprise environmental behavior is established. The improved data envelopment analysis (DEA) model is applied to the credit evaluation of enterprise environmental behavior, which has solved the problem of prominent subjectivity in enterprise evaluation research at present and obtained the enterprise evaluation analysis method. On this basis, the environmental behavior data of a representative enterprise in 2010-2017 are evaluated and analyzed. The results suggest that the overall credit of its environmental behavior is excellent. However, given the credit fluctuations in odd and even years, its environmental behavior credit still requires further improvement.

Keywords: Fuzzy ISODATA Clustering Analysis Algorithm, Indicator System; Enterprise, Credit Evaluation, Environmental Credit

1. Introduction

With the rapid development of China's economy, the environmental pollution problem has become increasingly prominent. It has gradually become a bottleneck that restricts the sustainable development of China's economy [1-2]. The government work report of Premier Li Keqiang during the the National People's Congress and the Chinese Political Consultative Conference (NPC & CPPCC)in 2019 puts forward new requirements for enterprises to practice social responsibility and achieve sustainable development. The report points out that enterprises [3-4], as the main body of pollution prevention and control, must perform environmental protection responsibilities according to law. At the same time,
the report emphasized that pollution prevention, ecological construction and green development promotion were the government work priority in 2019 [5-6]. In the current situation of increasingly severe environmental pollution and the lack of perfect environmental management methods, how to accurately evaluate the environmental behavior credit of enterprises and then carry out scientific, environmental management of enterprises has become the core issue of effective environmental pollution control in China. At present, some related researches in our country have gradually established the enterprise environmental behavior evaluation system, but there is no research on specific enterprises in different industries. In recent years, through the investigation and research of experts, it is found that the industrial sector is the source of all kinds of major pollution emissions, where the pollution emissions of enterprises account for a large proportion of the total emissions. In this context, this paper uses data envelopment analysis (DEA) method to establish a credit evaluation model of enterprise environmental behavior, and selects the input-output situation of representative enterprises in this industry for empirical analysis, which is conducive to improving the evaluation system of enterprise environmental behavior in China, helping environmental supervision department supervise and manage the environmental behavior of various enterprises effectively. It has also provided a theoretical and practical basis for evaluating the environmental behavior credit of other enterprises.

From the existing literature, the research methods of enterprise environmental behavior evaluation are diverse, but most of them are qualitative analysis. The selection of indicators and the distribution of weight have high fuzziness and people-oriented, and the measurable indicators are not easy to be quantified. Based on the above research, this paper applies the improved fuzzy ISODATA clustering analysis algorithm, according to the features of the construction industry, constructs the enterprise environmental behavior credit evaluation indicator system, and makes an empirical analysis and summary based on the specific enterprise data. There are two innovations in this paper: first, the object of environmental behavior credit evaluation of enterprises is particular to the construction industry. Starting from the national standard, according to the features of enterprises, the relationship between input and output is studied, and the environmental behavior credit of different enterprises is evaluated; second, the subjective evaluation method is mainly used to determine the weight of various factors in the current enterprise environmental evaluation research in China, It is easy to be divorced from the actual production. To solve this problem, we used the improved DEA method in this paper to obtain the credit evaluation of enterprise environmental behavior by screening and quantifying the evaluation indicators. Subsequently, the evaluation results of specific enterprises are analyzed, which is of great significance in avoiding the influence of subjective factors, simplifying algorithms, reducing errors, etc.

2. Fuzzy ISODATA Clustering Algorithm
DEA is a new field of multi-disciplinary research, and it is also a method of relative credit evaluation. According to multi indicator input and multi indicator output, it evaluates the relative effectiveness or benefit of the same type of units or enterprises. C2R model is the most basic model in DEA. Because this paper evaluates the environmental behavior of enterprises, focusing on the environmental system evaluation of multi-input/output, it is of economic significance to judge whether DMU is effective
according to the dual programming of C2R model and the possible connection of production.

To construct the fuzzy ISODATA clustering analysis algorithm, it is necessary to assume that n comparable departments or units are decision units, and each decision unit has m types of input and s types of output that represent the effect of resource consumption (Table 1).

**Table 1. Input and output data of the decision unit.**

| Input weight | Investment | Decision unit | Produce | Output weight |
|--------------|------------|---------------|---------|---------------|
| $v_1$        | 1          | $x_{11}, x_{12}, \ldots, x_{1j}, \ldots, x_{1n}$ |         |               |
| $v_2$        | 2          | $x_{21}, x_{22}, \ldots, x_{2j}, \ldots, x_{2n}$ |         |               |
| $\ldots$     | $\ldots$  | $\ldots$      |         |               |
| $v_r$        | $r$        | $x_{r1}, x_{r2}, \ldots, x_{rj}, \ldots, x_{rn}$ |         |               |
|              |            | $y_{11}, y_{12}, \ldots, y_{1j}, \ldots, y_{1n}$ |         | $\mu_1$       |
|              |            | $y_{21}, y_{22}, \ldots, y_{2j}, \ldots, y_{2n}$ |         | $\mu_2$       |
|              |            | $\ldots$      |         | $\ldots$      |
|              |            | $y_{r1}, y_{r2}, \ldots, y_{rj}, \ldots, y_{rn}$ |         | $\mu_s$       |

Table 1 $x_{ij}, y_{ij}$ for known input and output data, $v_i$ and $\mu_i$ weight value corresponding to input and output, $v = (v_1, v_2, \ldots, v_r)^T \geq 0, v \neq 0, \mu = (\mu_1, \mu_2, \ldots, \mu_s)^T \geq 0, \mu \neq 0, x_0 = x_{j_0}, y_0 = y_{j_0}$ the input-output value of the corresponding target, $x_j = (x_{ij}, x_{2j}, \ldots, x_{nj})^T, y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})^T$ is the vector of input and output.

The comprehensive credit evaluation indicator of unit J is defined as follows:

$$h_j = \frac{\mu_j^T y_j}{v_j^T x_j} = \sum_{i=1}^{s} \frac{u_i y_{ij}}{\sum_{i=1}^{n} v_i x_{ij}}, j = 1, 2, \ldots, n$$

(1)

Where $x_j > 0, \mu \geq 0, v \neq 0, v^T x_j > 0$.

Now evaluate the performance of the decision-making unit to form the following C2R:

$$\begin{cases} \max h_{j_0} = \frac{\mu_{j_0}^T y_{j_0}}{v_{j_0}^T x_{j_0}} \\ s.t. \frac{\mu_j^T y_j}{v_j^T x_j} \leq 1 \\ \mu \geq 0, v \geq 0 \end{cases}$$

(2)

The Charnes Cooper transform is used for the equivalent linear programming:
Where \( t = \frac{1}{v'x_0} \), \( \omega = tv, u = t\mu \), and equation (2) can be converted into equation (3):

\[
\begin{align*}
\max & \quad u^T y_0, \\
\omega^T x_j - \mu^T y_j & \geq 0, \\
\omega^T x_0 & = 1, \\
\omega & \geq 0, \mu \geq 0, \omega, \mu \neq 0
\end{align*}
\]

(3)

The dual programming model is as follows:

\[
\begin{align*}
\min & \quad \theta, \\
\lambda_j x_j & \leq \theta x_0, \\
\sum_{j=1}^n \lambda_j y_j & \geq y_0, \\
\lambda_j & \geq 0, j = 1, 2, 3, \ldots, n
\end{align*}
\]

(4)

3. Analysis of Credit Evaluation Indicator System for Enterprise Environmental Behavior

The optimal solution of the hypothesis (7) is \( \lambda^*, S^{-}, S^{''-}, \theta^* \). Based on the following theorem, the effectiveness of DEA can be determined.

According to the features of the construction industry and the measures for enterprise environmental credit evaluation (Trial) issued by the State Environmental Protection Administration, this paper constructs the enterprise environmental behavior credit evaluation indicator system as shown in Table 2:

| Table 2. Input-output indicator system |
|--------------------------------------|
| **Input indicators**                |
| Raw material                         | Comprehensive energy consumption of cement |
| energy                               | Coal, electricity, natural gas |
| water resource                       | Freshwater consumption per unit output value |
| capital                              | Investment in environmental protection funds |
| **Output indicator**                 |
| waste gas                            | Chemical oxygen demand emissions, sulfur dioxide emissions |
| solid waste                          | NOx emission |
| Other                                | Sludge, hazardous solid waste, free solid |

4. Empirical Analysis

4.1 Company Profile and Data Source

China Building Materials Group Co., Ltd. With total assets of nearly 600 billion yuan, 250,000 employees and annual operating revenue of more than 300 billion yuan, it is a representative large-scale enterprise in the construction industry.
4.2. Model Solution

In this paper, it is assumed that the environmental situation disclosed in the corporate responsibility report is a decision-making unit, which is solved by lingo software. Where γ is the effective value of the decision-making unit, and the combination proportion is j = 1,2,3,4, S+, S- is the relaxation variable S+(S1, S2, S3, S4, S5, S6), S- (S1p, S2p, S3p, S4p, S5p), taking ε= 0.000001. The environmental information data of China Building Materials Group Co., Ltd. in 2013 are taken as an example, and the input-output effectiveness evaluation model is as follows:

| Table 3. Model calculation results. |
|------------------------------------|
| Particular year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| 0   | 1.000000 | 1.000000 | 0.952287 | 1.000000 | 0.894726 | 1.000000 | 0.970376 | 1.000000 |
| S1  | 0.000000 | 0.000000 | 32.41989 | 0.000000 | 8.099574 | 0.000000 | 18.20326 | 0.000000 |
| S2  | 0.000000 | 0.750000 | 150.0643 | 0.000000 | 265.2873 | 0.000000 | 0.000091 | 0.000000 |
| S3  | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 3.996722 | 0.000000 | 3.32087 | 0.000000 |
| S4  | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 7.427893 | 0.000000 | 0.280327 | 0.000000 |
| S5  | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| S6  | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| S1p | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.121269 | 0.000000 | 0.000180 | 0.000000 |
| S2p | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| S3p | 0.000000 | 0.000000 | 0.632392 | 0.000000 | 0.749569 | 0.000000 | 0.000004 | 0.000000 |
| S4p | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| S5p | 0.000000 | 5.759960 | 0.376233 | 0.000000 | 0.000000 | 0.000000 | 0.008759 | 0.000000 |

Table 3 shows that in 2010, 2013, 2015 and 2017, θ=1, S+, S- is 0, and the sum of these years is DEA effective, which shows that the environmental behavior of the enterprise is optimal, that is to say, under the condition of reducing resource cost as much as possible, the emission of waste is also greatly reduced; in 2011, θ=1, S-, S+ is not 0, and the DMU of this year is weak DEA effective, That is to say, DMU can get the same output by reducing the existing input. In the environmental behavior credit evaluation, it indicates that the environmental behavior is not optimal, there may be a waste or the waste discharge is not up to the standard due to the enterprise management is not in place; in 2012, 2014 and 2016, θ<1, the DMU in these years is DEA invalid, which indicates that in the environmental behavior evaluation, The environmental credit of enterprises is the lowest, the input resources are not fully utilized, the waste gas and wastewater are not reasonably discharged. Hence, the relevant systems should be developed and appropriate measures should be taken to improve the environmental behavior credit.

5. Conclusions

Through the study of enterprise environmental credit evaluation standards, an environmental credit evaluation system that reflects enterprise environmental behavior objectively is established preliminarily in this paper. China Building Materials Group Co., Ltd., an representative enterprise in this industry, is selected to perform an empirical test on its environmental behavior based on the enterprise input-output situation and DEA method. The following conclusions are drawn: Overall, the environmental behavior credit of the enterprise was staggered over the years. The environmental
behavior credit in odd years was relatively high. In contrast, the environmental behavior credit in even years was not ideal. This suggests that when the enterprise environmental behavior credit is good, it tends to neglect the internal management, loosen the application of environmental protection technology, and the improvement of production credit. Hence, the problems such as inconsistent supervision, neglecting environmental management in production scale expansion, failure to consider both economic benefits, and environmental responsibility are present in the enterprise, resulting in the fluctuation of environmental behavior credit.

In general, the environmental behavior credit of the enterprise is good. It has paid attention to the management of its environmental behavior while improving the production scale. However, in some years, the evaluation results of its environmental behavior is still weak, which should be improved on the original basis for synchronous improvement of enterprise benefit and social responsibility. This study has provided a theoretical and practical basis for the credit evaluation of enterprise environmental behavior, which is conducive to improving the establishment of enterprise environmental behavior evaluation systems in China.

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