

Research on Environmental Performance Evaluation of Metallurgical Listed Companies Based on Analytic Hierarchy Process

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Abstract: In recent years, the public has paid more and more attention to environmental issues, and building a resource-saving and environment-friendly society has become one of the important goals of China's economic construction. Therefore, metallurgical listed companies urgently need to build a reasonable and effective environmental performance evaluation index system to evaluate the environmental management effect of enterprises. Based on analytic hierarchy process, aiming at the lack of environmental performance evaluation research of metallurgical listed companies at this stage, this paper will design and build an environmental performance evaluation index system for metallurgical enterprises, and reasonably and scientifically evaluate the environmental situation of metallurgical listed companies from the perspective of economic input, environmental governance, and social concern, and draw the following conclusions: (1) metallurgical listed companies should put environmental governance at the top of the overall environment, We will invest more in environmental protection projects and project the concern of enterprises to the society. (2) The environmental protection of listed metallurgical companies is not only the macro goal of the company, but also needs to enable more stakeholders to actively participate in the process of environmental governance. (3) To build an environment-friendly society, we need not only government supervision, but also all kinds of enterprises to enhance their sense of social responsibility.

Keywords: Environmental performance, Evaluation index system, Analytic Hierarchy Process, Metallurgical listed companies.

1. Introduction

In the past decade, China's economy has always been at a stage of rapid development. However, with the development of economy, the worsening environmental problems have gradually become the focus of social attention. Listed companies have the obligation to regulate their own behavior and assume the responsibility of maintaining and creating the green water and green mountain ecological environment. This makes it very important to effectively evaluate the environmental management effect of enterprises and implement the environmental performance evaluation index system. Environmental performance mainly involves or aims at environmental status, environmental improvement trend, environmental efficiency, implementation of environmental policies, etc. Environmental performance evaluation can not only help enterprises find out the risks in environmental management and the focus of environmental management, and conduct qualitative and quantitative research on important indicators, but also provide a reliable basis for accounting the relevant costs and revenues of enterprise environmental activities and programs[1]. In addition, environmental performance evaluation can also urge enterprises to design incentive mechanisms to improve environmental performance, and propose effective measures to improve the environment.[2]

However, due to the late start of the research on environmental performance evaluation in China, the research on the construction of environmental performance evaluation index system is still in the exploratory stage, and a universal environmental performance evaluation system for metallurgical listed companies has not yet been formed, and there is also a lack of scientific and systematic evaluation

criteria and guidance. Based on analytic hierarchy process, aiming at the lack of environmental performance evaluation research of metallurgical listed companies at this stage, this paper will design and build an environmental performance evaluation index system[3], reasonably and scientifically evaluate the environmental situation of metallurgical listed companies from the perspective of economic input, environmental governance and social concern, and draw conclusions and relevant countermeasures.

2. Research Methods and Principles

2.1. Research principles

This paper will use AHP to analyze and evaluate the environmental performance of metallurgical listed companies. The analytic hierarchy process is more suitable for the decision making problems with the objective system of evaluation indicators with multi-level coupling relationship, and the objective value is difficult to describe quantitatively. The construction and application of AHP specifically include the following four steps.

2.2. Research methods

2.2.1. Establishment of hierarchical model

AHP divides the decision-making problem into three specific levels: the first level is the goal level, which represents the goal to be solved; The second level is the criterion level, which decomposes the target into related secondary indicators; The third layer is the indicator layer, which further refines the secondary indicators of the criteria layer into several representative indicators.

2.2.2. Construction of judgment matrix

According to the established hierarchical structure model, the judgment matrix is constructed using the 9-scale method. 1, 3, 5, 7, and 9 represent equally important, slightly important, obviously important, strongly important, and extremely important, respectively, to compare the relative

importance of each element in the hierarchy. Wherein, 2, 4, 6 and 8 are the median values of the above adjacent judgments; represents the result of the comparison between factor i and factor j, and the comparison between factor j and factor i is the reciprocal. Build four judgment matrices, as shown in Table 1-4.

Table 1. Judgment matrix of influencing factors of target layer A

| A | B1 | B2 | B3 | ω_i | $\lambda_{\max} = 3.0385$ CR = 0.0370 < 0.1 The judgment matrix has satisfactory consistency. |
|----|-----|-----|----|------------|---|
| B1 | 1 | 1/3 | 3 | 0.2583 | |
| B2 | 3 | 1 | 5 | 0.6370 | |
| B3 | 1/3 | 1/5 | 1 | 0.1047 | |

Table 2. Judgment matrix of influencing factors in criterion layer B1

| B1 | C1 | C2 | C3 | ω_i | $\lambda_{\max} = 3.0649$ CR = 0.0624 < 0.1 The judgment matrix has satisfactory consistency. |
|----|-----|----|-----|------------|---|
| C1 | 1 | 3 | 1/5 | 0.1884 | |
| C2 | 1/3 | 1 | 1/7 | 0.0810 | |
| C3 | 5 | 7 | 1 | 0.7306 | |

Table 3. Judgment matrix of influencing factors in criterion layer B2

| B2 | C4 | C5 | C6 | ω_i | $\lambda_{\max} = 3.0385$ CR = 0.0000 < 0.1 The judgment matrix has satisfactory consistency. |
|----|-----|----|-----|------------|---|
| C4 | 1 | 3 | 1/3 | 0.2583 | |
| C5 | 1/3 | 1 | 1/5 | 0.1047 | |
| C6 | 3 | 5 | 1 | 0.6370 | |

Table 4. Judgment matrix of influencing factors in criterion layer B3

| B3 | C7 | C8 | C9 | ω_i | $\lambda_{\max} = 3.0385$ CR = 0.0370 < 0.1 The judgment matrix has satisfactory consistency. |
|----|-----|-----|----|------------|---|
| C7 | 1 | 1/3 | 3 | 0.2583 | |
| C8 | 3 | 1 | 5 | 0.6370 | |
| C9 | 1/3 | 1/5 | 1 | 0.1047 | |

2.2.3. Consistency test of hierarchical single sorting

First, calculate the consistency index CI ($n > 1$ power matrix) of measurement matrix A [4]. The formula is:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (1)$$

When CI=0, it is called full consistency.

At the same time, the random consistency index RI is introduced. The random consistency index RI is the random mean value of the consistency index of the same order matrix, as shown in Table 5. Finally, the consistency ratio CR of the judgment matrix is used to check whether the judgment matrix A passes the consistency test. The formula is:

$$CR = \frac{CI}{RI} \quad (2)$$

Table 5. The value of RI

| Number of indicators | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|----------------------|---|---|------|-----|------|------|------|------|------|
| RI | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

When CR<0.1, the judgment matrix conforms to the consistency check standard of hierarchical single sorting; otherwise, it needs to be adjusted continuously, and the above steps are repeated to check the consistency of hierarchical single sorting.

2.2.4. Consistency test of hierarchical total ranking

The calculation steps for the consistency test of the total hierarchical sorting are as follows:

$$CI = \sum_{j=1}^m a_j CI_j \quad (3)$$

$$RI = \sum_{j=1}^m a_j RI_j \quad (4)$$

$$CR = \frac{CI}{RI} \quad (5)$$

When CR<0.1, the entire hierarchy passes the consistency check.

3. Result Analysis

3.1. Calculate index weight

In this paper, the target layer is the evaluation of environmental performance of metallurgical listed companies, and the criterion layer includes economic input (B1), environmental governance (B2) and social concern (B3). The corresponding indicator layer includes 9 detailed indicators.[5]

The indicator level corresponding to economic input (B1) includes three detailed indicators: waste disposal cost (C1), environmental protection project investment (C2) and

environmental pollution control cost (C3)[6]. The indicator layer corresponding to environmental governance (B2) includes three detailed indicators: concentration of discharged pollutants (C4), comprehensive utilization rate of waste (C5) and standard discharge rate of waste (C6). The indicator layer corresponding to social concern (B3) includes three detailed indicators: input rate of environmental protection technology innovation (C7), employee environmental protection education and training (C8) and stakeholder related satisfaction (C9)[7]. With the aid of YAAHP software, the schematic diagram of environmental performance evaluation indicator system of listed companies can be obtained according to the above indicator selection ideas, as shown in Figure 1.

innovation (C7), employee environmental protection education and training (C8) and stakeholder related satisfaction (C9)[7]. With the aid of YAAHP software, the schematic diagram of environmental performance evaluation indicator system of listed companies can be obtained according to the above indicator selection ideas, as shown in Figure 1.

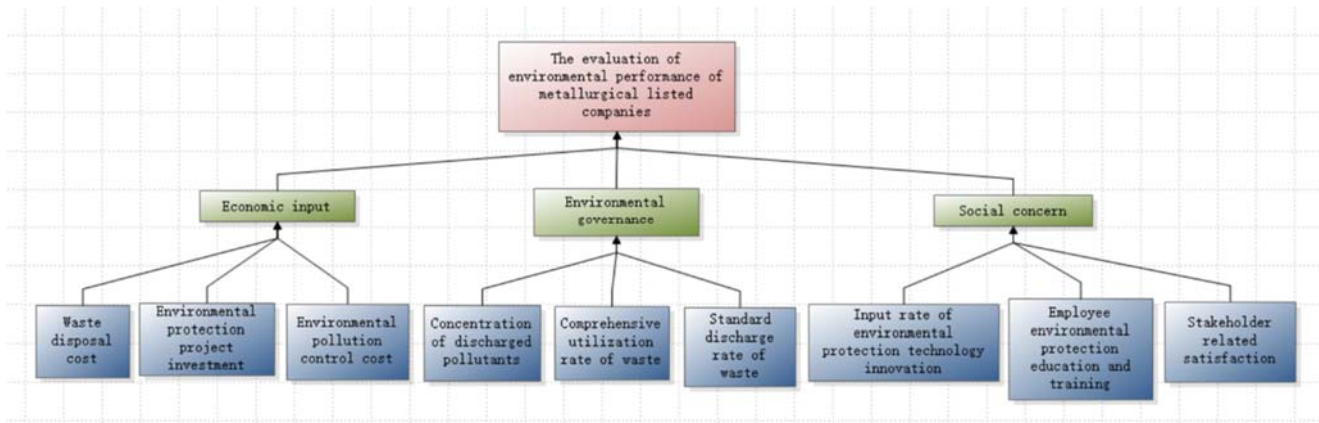


Figure 1. Environmental Performance Evaluation Index System of Metallurgical Listed Companies

In the survey, this paper used questionnaires to collect accurate data. On this basis, with the help of YAAHP software to process the collected data, the total weight value of each indicator in the environmental performance evaluation

indicator system of metallurgical listed companies is shown in Figure 2, and the weight value and its order are shown in Table 6.

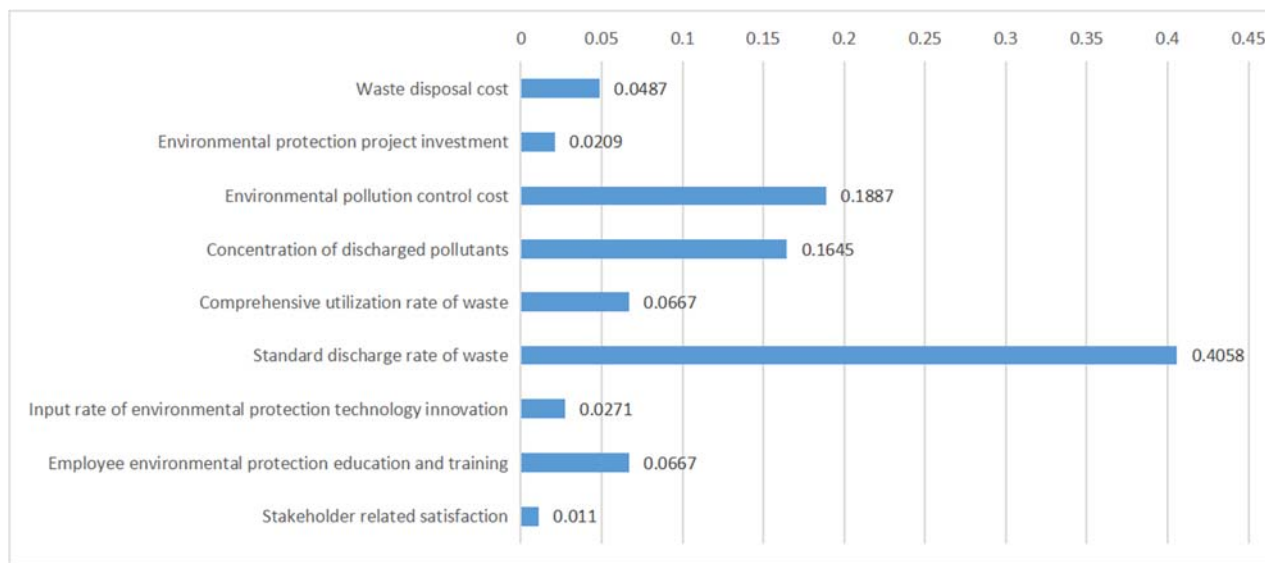


Figure 2. Total weight value of each indicator in the environmental performance evaluation indicator system of listed metallurgical companies

3.2. Result analysis

Combined with relevant data, Table 6 shows that in the environmental performance evaluation indicator system of listed metallurgical companies, among the three secondary indicators, the maximum weight of environmental governance (B2) is 0.6370, and the minimum weight of social concern (B3) is 0.1047. Among the nine third level indicators, the weights of the up to standard waste discharge rate (C6) and the environmental pollution control cost (C3) rank first and second, and their corresponding weight values are 0.4058 and 0.1887 respectively. The weights of stakeholder

satisfaction (C9) and environmental protection project investment (C2) rank first and second from the bottom, respectively, with their corresponding weights of 0.0110 and 0.0209. By comparison, it can be seen that the weight ranking of secondary indicators is highly consistent with that of tertiary indicators.

It can be seen from Table 6 that among the environmental performance evaluation indicators of listed metallurgical companies, environmental governance is the most important criterion layer, and the corresponding waste discharge rate is an important basis for direct evaluation of environmental performance, which needs to be paid more attention.

Table 6. Weighting table of each indicator in the environmental performance evaluation indicator system of listed metallurgical companies

| Target layer | Criterion layer | Indicator layer | Total weight value | Sequence |
|---|--|--|--------------------|----------|
| Environmental Performance Evaluation of Metallurgical Listed Companies A | Economic input B1 0.2583 | Waste disposal cost C1 | 0.0487 | 6 |
| | | Environmental protection project investment C2 | 0.0209 | 8 |
| | | Environmental pollution control cost C3 | 0.1887 | 2 |
| | Environmental governance B2 0.6370 | Concentration of discharged pollutants C4 | 0.1645 | 3 |
| | | Comprehensive utilization rate of waste C5 | 0.0667 | 4 |
| | | Standard discharge rate of waste C6 | 0.4058 | 1 |
| | Social concern B3 0.1047 | Input rate of environmental protection technology innovation C7 | 0.0271 | 7 |
| | | Employee environmental protection education and training C8 | 0.0667 | 4 |
| | | Stakeholder related satisfaction C9 | 0.0110 | 9 |

4. Conclusion

This paper evaluates the environmental performance of listed metallurgical companies based on analytic hierarchy process. Through data analysis, the following conclusions are drawn:

(1) Metallurgical listed companies should put environmental governance at the top of the overall environment. First, they should introspect whether they meet the discharge standards of various wastes required by the state, and whether they can effectively use resources comprehensively. Then, they should invest more in environmental protection projects, project their concern to the society, and serve the society, so that all stakeholders can benefit from the good environment.

(2) Environmental protection of listed metallurgical companies is not only the company's macro goal, but also needs to be implemented in every detail. For example, through employee training and education, we will strengthen employees' awareness and participation in environmental protection, make the concept of environmental protection deeply rooted in people's hearts, and enable more stakeholders to actively participate in the process of environmental governance.

(3) Environmental performance evaluation, as an effective means to measure the environmental protection of listed metallurgical companies, needs to be constantly strengthened. On the one hand, the government needs to introduce corresponding policies for supervision. On the other hand, the listing of metallurgical industry itself should have more sense of social responsibility, take the lead, become an environment-friendly enterprise, and contribute to the blueprint of "green water and green mountains".

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