

Analysis of Environmental Pollution Governance Service Projects Based on Grey Correlation Method

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Abstract. The comprehensive evaluation method of grey correlation was used to evaluate and analyze the four enterprises. A 26×4 correlation coefficient matrix was formed through the establishment of grey correlation models and calculation of correlation coefficients. After the correlation calculation based on indicator weights, such a conclusion was drawn that Enterprise B has the best operation service effect in the aspect of environmental pollution governance. This research provides a method to calculate the correlation coefficient in order to analyze the comprehensive ability of pollution control enterprises.

1.Introduction

As the iron and steel industry is the pillar industry of China's national economy and a main discharge source of pollutants, there is a long way to go as for its pollution control. Although the discharge of pollutants has decreased annually, it cannot offset the increase in the total amount of pollutants caused by the growth of iron and steel production. During the 13th Five-Year Plan period, controlling the dust and SO₂ emissions in sintering is also the focus of air pollution control in the iron and steel industry. As for the control of iron and steel sewage discharge, constructing integrated sewage treatment plants, reducing sewage discharge factors and increasing the reuse rate of water of productive use are important means to deal with the sewage discharged by iron and steel enterprises[1]. Therefore, it is necessary to improve the quality of pollutant control equipment through monitoring and evaluating the operation effects of key equipment and facilities including the iron & steel sintering flue gas desulfurization and dust removal device as well as comprehensive iron and steel sewage treatment apparatus. It is also required to improve the quality of third-party projects based on relevant standards, and thus fundamentally promote the healthy development of environmental protection industries that support the pollution control of the iron and steel industry. Therefore, while improving the operational effects of air pollutants and sewage control equipment in iron and steel enterprises, the introduction of the mechanism adopted by the third-party environmental protection companies in specialized operations of equipment and projects as well as market-oriented services, it is important in promoting the mutually beneficial cooperation of government, enterprises and third-party pollution control companies and realizing the efficient treatment of environmental pollution[2-3].

In order to promote the effective control of pollutants discharged in the iron and steel industry, polluters has gradually become a consensus to promote the pollution treatment by a third party to solve



the problems of discharge reduction and pollution control. The iron and steel industry of typical large polluter is chosen as the research object in order to improve the efficiency of pollution control, strengthen the effect of pollution control, develop technology advantage of pollution control enterprises, and promote the green, environmentally-friendly and healthy development of the iron and steel industry[4-5].

The research findings of this topic are the important technical support for the development of China's environmental protection industry. The introduction of professional pollution control technology and service can avoid the decentralization of pollution discharge enterprises, increase the technical level and pollution control efficiency, reduce the pollution control cost, and benefit the pollution discharge enterprises. Through adopting professional control technology to reduce the control cost, increase the up-to-standard discharge ratio, and decrease the numerous humans, material and financial resources invested in pollution control, the pollution discharge enterprises can focus on their own operation and development. Furthermore, it can promote the industrialization application of third-party environmental pollution control technology and service, provide the wide market space for environmental protection enterprises, and facilitate the rapid and healthy development of such enterprises[6]. The third-party environmental pollution control service will undoubtedly benefit the expansion of environmental protection industry market, especially the development of environmental protection enterprises in a type of comprehensive platform. And a well-developed environmental development industry market will also attract more social capital investment, which will promote the formation of a benign development pattern for the whole environmental protection industry.

Scoring and evaluating enterprise capabilities are not enough to measure the effect of environmental pollution governance operation service. As a result, it is necessary to take various indicators of the four enterprises into overall consideration and rank these enterprises by superiority through quantification. Therefore, a new evaluation method needs to be introduced to carry out comprehensive evaluation and analysis for environmental pollution governance projects of the four enterprises.

This paper adopts the method of grey correlation analysis, collecting data from multiple environmental pollution governance enterprises to determine evaluation indicators and assign values to them according to actual conditions of pollution governance service enterprises and expert suggestions as well as standard requirements based on the evaluation indicator system, and thus to build ideal objects.

2. Research method

The optimal value of each indicator for the four enterprises is taken as the indicator value of the ideal object. The optimal value is selected from enterprises participating in the evaluation. For different influencing factors, some indicators should be as high as possible, while some should be as low as possible. Ideal model data should be built based on the optimal value. On this basis, the indicator correlation coefficient and weight correlation were calculated, and the correlation order was established to determine the level of pollution governance service enterprises through evaluation and analysis.

Record the sequence of data for reference which should be determined first for correlation analysis as x_0 , generally expressed as:

$$x_0 = \{ x_0(1), x_0(2), x_0(3), \dots, x_0(n) \} \quad (1)$$

Record the sequence of numbers compared in correlation analysis as x_i , generally expressed as:

$$x_i = \{ x_i(1), x_i(2), x_i(3), \dots, x_i(n) \} \quad (2)$$

For a reference sequence of data x_0 , the compared sequence of numbers is x_i , and the following relational expression can be used to express the difference between each compared curve and reference curve at each data point, namely,

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \zeta \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \zeta \max_i \max_k |x_0(k) - x_i(k)|} \quad (3)$$

Wherein, $\xi_i(k)$ is the relative difference between the compared curve x_i and reference curve x_0 at the moment of k . The difference in this form is the correlation coefficient of x_i against x_0 at the moment of k . ζ is the identification coefficient between 0 and 1. In actual calculation, identification coefficient should be selected according to the correlation between sequences. Generally, ζ is not more than 0.5.

If

$$\begin{aligned}\Delta \min &= \min_i \min_k |x_0(k) - x_i(k)| \\ \Delta \max &= \max_i \max_k |x_0(k) - x_i(k)|\end{aligned}\quad (4)$$

$\Delta \min$ and $\Delta \max$ are respectively the minimum absolute difference and the maximum absolute difference of x_i and x_0 at any time. Thus, the following expression can be obtained:

$$\xi_i(k) = \frac{\Delta \min + \zeta \Delta \max}{|x_0(k) - x_i(k)| + \zeta \Delta \max} \quad (5)$$

The general expression of absolute correlation is:

$$r_i = \frac{1}{n} \sum_{k=1}^n \xi_i(k) \quad (6)$$

Overall, grey correlation analysis is quantitative comparative analysis of system states. Essentially, it is to compare the closeness of the sequence of curves consisting of several sequences of numbers to the curve geometry consisting of ideal (standard) sequences of numbers. The closer the geometric shapes are, the higher the correlation is. The correlation order reflects the closeness of each evaluated object to the ideal (standard) object, namely, the superiority rank of the evaluated object. The object with the highest grey correlation is the best. Therefore, the superiority of evaluated objects can be analysed and compared by grey correlation.

3. Grey comprehensive evaluation model based on grey correlation analysis

Comprehensive evaluation of environmental pollution governance projects aims to study the rank of multiple objects, namely, to eliminate the priority rank of evaluated objects and rate them correspondingly.

Grey comprehensive evaluation is mainly conducted based on the following model: $R = E \times W$

Wherein, $R = [r_1, r_2, \dots, r_m]^T$ refers to the comprehensive judgment result vector of No. m evaluated object. $W = [w_1, w_2, \dots, w_n]^T$ refers to the weight distribution vector of No. n evaluation indicator. The sum of all weights is 1.

4. Grey Correlation Analysis of the Third-party Environmental Pollution Governance Operation Service Projects

4.1 Selecting reference sequence

The optimal value of each indicator in the expert scoring sheet is selected as the best value among many plans. If a certain indicator should be as high as possible, the maximum of the indicator in each evaluated item is taken. Otherwise, the minimum, or the best value recognized by evaluators is taken.

After the optimal value is selected according to score given by experts, the following reference sequence V_0 can be built.

$V_0 = (8.5, 8.8, 9.2, 9.4, 9.0, 8.9, 9.1, 9.4, 9.3, 10, 10, 9.4, 9.2, 8.7, 9.2, 8.9, 9.2, 10, 9.2, 10, 9.7, 10, 10, 9.2, 9.5, 8.9)$

4.2 Correlation of a single level

Due to different degrees of indicators, correlation should be the product of the weight and correlation coefficient. The priority weight of each indicator at a certain level against objects of the previous level

is obtained according to the method used by experts. The calculation formula of correlation is as below:

$$R = W E^T \quad (7)$$

Indicator values should be normalized. After normalizing evaluation values of indicators in the scoring sheet, the minimum and maximum shall be obtained with the following expressions

$$\Delta \min = \min_i \min_k |x_0(k) - x_i(k)| = 0 \quad (8)$$

$$\Delta \max = \max_i \max_k |x_0(k) - x_i(k)| = 3.8 \quad (9)$$

Take $\zeta = 0.5$, and bring it into Expression $\xi_i(k)$

$$\xi_i(k) = \frac{0 + 0.5 * 3.8}{|x_0(k) - x_i(k)| + 0.5 * 3.8} \quad (10)$$

The 26×4 correlation coefficient matrix for each indicator and the optimal value in the reference sequence shall be obtained as Table 1.

Table 1. Overall Rank and Weights of Evaluation Indicators for the Third-party Environmental Pollution Governance Operation Service.

Correlation Coefficient Values	A	B	C	D
Number of Staff	0.613	0.487	1.000	0.576
Enterprise Scale	0.679	0.543	1.000	0.731
Market Investment and Financing Capacity	0.413	1.000	0.333	0.594
Social Credit	0.905	1.000	0.864	0.864
Financial Position	0.905	0.792	0.633	1.000
Proportion of Professionals	1.000	0.514	0.731	0.576
Enterprise Technical Innovation Capability	1.000	0.679	0.731	0.396
Facility Energy Consumption	0.905	1.000	0.864	0.792
Facility Water Consumption	0.905	1.000	0.655	0.404
Equipment Availability	1.000	1.000	1.000	1.000
Equipment Operation Rate	1.000	1.000	1.000	1.000
Facility Service Life	0.905	1.000	1.000	0.864
Pollutant Treatment Cost	0.731	0.633	0.864	1.000
Annual Maintenance Cost	0.864	0.826	1.000	0.760
Annual Labor Cost	0.792	1.000	0.655	0.731
Floor Area	0.543	1.000	0.655	0.760
By-product Utilization	1.000	0.559	0.826	0.864
Discharge Compliance	1.000	1.000	1.000	1.000
Improvement of Surrounding Environment	0.792	0.864	1.000	0.950
Removal Rate of Pollutants	1.000	1.000	1.000	1.000
Safe Operation Rules and Regulations	0.792	0.905	0.792	1.000
Automatic Online Monitoring	1.000	1.000	1.000	1.000
Secondary Pollution Control Measures	1.000	1.000	1.000	1.000
Service Timeliness	1.000	0.905	0.792	0.528
Service Quality and Normalization	1.000	0.731	0.576	0.543
Service Buyer Satisfaction	0.905	1.000	0.704	0.760

4.3 Ultimate correlation of multi-level evaluation system

In this study, a three-level evaluation indicator system for environmental pollution governance operation service shall be established to integrate correlation coefficients of all indicators at No. k level, and obtain the correlation of indicators at the previous level respectively. Then the correlation of this level shall be taken as the original data to obtain the correlation of indicators at the level before previous one until the correlation of indicators of the highest level is obtained.

According to the weights of indicators calculated before, the correlation r of the four enterprises can be obtained through the formula of correlation x weight, shown as Table 2.

Table 2. Correlation Calculation.

Enterprise A	Enterprise B	Enterprise C	Enterprise D
0.90312	0.935873	0.895529	0.893382

4.4 Ultimate correlation of multi-level evaluation system

The enterprises should be ranked by correlation r . Correlation rank is the rank of projects or enterprises obtaining goods results from environmental pollution governance service evaluation. Therefore, $r_B > r_A > r_C > r_D$ is obtained, and Enterprise B has the best effect of environmental pollution governance operation service.

5. Conclusions

The third-party environmental pollution governance evaluation can increase the pollution governance level of enterprises, promote the application of relevant technologies in pollution treatment projects, and stimulate enterprises with high service level to stand out from market competition, thus to achieve the survival of the fittest, and improve pollution prevention and control capability and governance efficiency. In this paper, the grey correlation comprehensive evaluation method was used to evaluate and analyze the four enterprises. A 26×4 correlation coefficient matrix was formed through the establishment of grey correlation models and calculation of correlation coefficients. After the correlation calculation based on indicator weights, it's concluded that Enterprise B has the best operation service effect in the aspect of environmental pollution governance. The research method in this paper can be used to solve problems such as unclear responsibility, unsound mode, nonstandard service and unreasonable assessment during the third-party environmental pollution governance, thus to make clear major bases and guidelines of both parties' responsibilities, promote implementation and application of environmental performance contract management, increase pollution treatment cost efficiency, regulate market orders, create a unified, open, fair and orderly competition environment, and contribute to healthy and rapid development of environmental protection equipment and environmental protection service industries.

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