Enterprise Environmental Performance Evaluation Based on Super Efficiency SBM

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Abstract: Based on the existing research results, this paper constructs an enterprise environmental performance evaluation index system. Based on the Data Envelopment Analysis, this paper selects the data of 27 representative listed enterprises in Chengdu-Chongqing economic circle from 2017 to 2021 by using the super-efficiency SBM model considering the non-expected output, and conducts static environmental performance. The result shows that the static environmental performance level of enterprises in Chengdu-Chongqing economic circle is low. It is suggested that enterprises should improve their green management ability and take the initiative to assume social responsibilities.

Keywords: corporate environmental performance; Data envelopment analysis

1. The introduction

Enterprise is the direct manufacturer of environmental pollution. For the reason of sustainable development, enterprises, governments and researchers must pay attention to the study of environmental performance of enterprises. It is of great value to study the environmental performance of enterprises in the Chengdu-Chongqing economic circle, which is the core driving force of the development of the western part of the country, for realizing the long-term sustainable development of enterprises and promoting the regional high-quality development.

2. Construction of environmental performance evaluation model for enterprises

2.1 Selection principles of evaluation indicators

The index is an important presentation way to reflect the current situation of the subject. The quality of the selected index determines the quality of environmental performance evaluation. The construction process of index system is a process of selecting scientific and objective indicators and re-screening based on different perspectives and certain principles. To build a scientific, fair and reasonable environmental performance evaluation index system, it is necessary to follow the principles of scientificity, feasibility and comparability [1-3]. Decision making Unit (DMU) is the evaluation object of the data envelopment model, and this paper refers to every enterprise in Chengdu-Chongqing economic circle. The selection of DMU should meet the basic quantity requirements. There are three opinions about the quantity of DMU through literature review: (1) First, the quantity of DMU should not be less than twice the sum of the number of input and output indicators; (2) Second, the number of DMU should meet the principle of thumb, that is, $n \geq max\{pq, 3(p+q)\}$, where n represents the number of decision making units, p represents the number of input indicators, and q represents the number of output indicators. (3) The number of DMU is greater than or equal to the sum of 3 times the number of input-output indicators [4]. In this paper, 27 listed enterprises in the Chengdu-Chongqing economic circle from 2017 to 2021 are selected as research objects, with a total of 135 samples, including 2 input indicators and 2 output indicators (including expected output and non-expected output). Based on any of the above quantitative principles, the number of decision making units and the number of indicators in this paper meet the requirements of DEA.

2.2 Evaluation index system design

Considering the availability and processing of data, this paper selects indicators from the two input perspectives of capital and labor, and the two output perspectives of economy and pollution. Capital

investment measure for the net value of fixed assets and labor input indicators for the staff, the comprehensive pollution index choice enterprise emissions of sulfur dioxide, nitrogen oxides emissions, emissions, ammonia nitrogen and chemical oxygen demand (COD) emissions of smoke dust particulates emissions these five kinds of pollutant emissions, using the entropy weight method integrated into one comprehensive pollution index as the expected output index. Economic output is operating income.

2.3 Environmental performance evaluation model -- super efficiency SBM model

In the super-efficiency SBM[5] model, it is assumed that there are n decision units, and DMUj (j=1... , n), according to each decision making unit m items for expected output and the expected output, vector $x \in R^m$, $y^d \in R^{s_1}$, $y^u \in R^{s_2}$; X、Y^d and Y^u are matrices greater than 0, $X = [x_1 \cdots x_n] \in R^{m \times n}$, $Y^d = [y_1^d \cdots y_n^d] \in R^{s_1 \times n}$, $Y^u = [y_1^u \cdots y_n^u] \in R^{s_2 \times n}$. The super efficiency SBM model constructed with non-radial, non-oriented and non-expected output is as follows:

$$min \, \rho = \frac{1 + \frac{1}{m \sum_{i=1}^{m}\left(\frac{s_i^-}{x_{ik}}\right)}}{1 - \frac{1}{(s_1 + s_2)\left(\frac{\sum_{p=1}^{s_1} s_P^{d+}}{y_{pk}^d} + \frac{\sum_{q=1}^{s_2} s_q^{u-}}{y_{qk}^u}\right)}}$$

$$s.t. \sum_{j=1,\neq k}^{n} x_{ij} \lambda_j - s_i^- \leq x_{ik} \qquad i = 1, \cdots, m$$

$$\sum_{j=1,\neq k}^{n} y_{pj}^d \lambda_j + s_p^{d+} \geq y_{pk}^d \qquad p = 1, \cdots, s_1$$

$$\sum_{j=1,\neq k}^{n} y_{qj}^u \lambda_j - s_q^{u-} \leq y_{qk}^u \qquad q = 1, \cdots, s_2$$

$$1 - \frac{1}{(s_1+s_2)\left(\frac{\sum_{p=1}^{s_1} s_P^{d+}}{y_{pk}^d} + \frac{\sum_{q=1}^{s_2} s_q^{u-}}{y_{qk}^u}\right)} > 0$$

$$\lambda_j \geqslant 0 \; ; j = 1, \cdots, n; s^{d+} \geq 0; s^{u-} \geq 0; s^- \geq 0$$

3. Environmental performance evaluation of enterprises

This paper selects 27 heavily polluting A-share listed enterprises in Shanghai and Shenzhen in Chengdu-Chongqing economic circle from 2017 to 2021 as research objects. All the data are from the corporate official website annual report and social responsibility report. The efficiency value obtained based on the constant returns to scale (CRS) is called the comprehensive efficiency value. If the efficiency value is greater than 1, it indicates that the enterprise achieves DEA efficiency. Comprehensive efficiency (TE) is the technical efficiency value without the exclusion of scale effect, indicating the enterprise's ability to maximize output under the premise of given input, or to minimize input under the condition of given output.   Comprehensively reflecting the enterprise's management and technology level, resource allocation ability, scale efficiency, etc. The calculated data are shown in

As you can see from Table 1, the average comprehensive efficiency of enterprises in the Chengdu-Chongqing economic circle from 2017 to 2021 is 0.361, and the maximum comprehensive efficiency value (1.672) and the minimum comprehensive efficiency value (0.082) are far different (1.590), indicating that the environmental performance level of the sample enterprises is very different and the environmental management situation is not optimistic. Among the 27 enterprises, the average comprehensive efficiency of 8 enterprises is higher than the overall average of the sample, which are as follows: Wuliangye, its comprehensive efficiency value is 1.431; Luzhou Laojiao, its comprehensive efficiency value is 1.155; Tianyuan Shares ,its comprehensive efficiency value is 1.018; Guoguang Shares, comprehensive efficiency value is 0.769; Swellfun square, its comprehensive efficiency value is 0.547; Tongwei Shares , its comprehensive efficiency value is 0.537;Chongqing Beer , its comprehensive efficiency value is 0.476; Tianqi Lithium, its comprehensive efficiency value is 0.399.The enterprises that do not reach the average level of comprehensive efficiency reach 70.37%. There are only 3 enterprises with effective DEA, namely Wuliangye (1.431), Luzhou Laojiao (1.156) and Tianyuan Shares(1.018), which only account for 11.11% of the sample enterprises, indicating that

the sample enterprises have huge potential for improvement of green management, and it is urgent to strengthen and improve resource utilization efficiency and carry out pollution remediation and other work.

Table 1: Comprehensive efficiency of enterprise environment from 2017 to 2021

Number	Name of Enterprise	2017	2018	2019	2020	2021	Mean	Rank
1	Fu 'an Pharmaceutical Company	0.141	0.150	0.177	0.222	0.177	0.173	18
2	Boteng Shares	0.084	0.082	0.094	0.172	0.159	0.118	27
3	Tongwei Shares	1.016	0.430	0.435	0.390	0.413	0.537	6
4	Sichuan Golden Top	0.116	0.235	0.191	0.244	0.222	0.202	11
5	Biology of harmony	0.138	0.155	0.137	0.176	0.311	0.183	15
6	New Gold Road	0.130	0.131	0.163	0.220	0.250	0.179	16
7	Luzhou Laojiao	1.352	1.220	1.275	0.761	1.169	1.155	2
8	Guocheng Mining	0.167	0.125	0.103	0.159	0.227	0.156	24
9	Sichuan Meifeng	0.127	0.118	0.133	0.220	0.292	0.178	17
10	Wuliangye	1.290	1.364	1.410	1.478	1.612	1.431	1
11	Shuangma, Sichuan	0.188	0.280	0.239	0.454	0.364	0.305	9
12	Huabang Health	0.200	0.170	0.145	0.204	0.200	0.184	14
13	Beihua Holdings	0.134	0.119	0.139	0.196	0.199	0.157	22
14	Leer chemistry	0.148	0.118	0.131	0.206	0.213	0.163	20
15	Tianyuan Shares	1.081	1.028	1.068	1.109	0.803	1.018	3
16	Collon Pharmaceutical	0.129	0.185	0.163	0.193	0.179	0.170	19
17	Tianqi Lithium	0.538	0.453	0.239	0.208	0.557	0.399	8
18	Fuling Zhacai	0.132	0.126	0.127	0.196	0.173	0.151	25
19	Yuntu Holdings	0.169	0.141	0.159	0.232	0.296	0.199	13
20	San Sheng Shares	0.128	0.136	0.147	0.195	0.180	0.157	23
21	Guoguang Shares	1.672	1.530	0.160	0.242	0.240	0.769	4
22	Kanghong Pharmaceutical	0.308	0.240	0.209	0.228	0.205	0.238	10
23	Deo Household	0.174	0.165	0.208	0.256	0.204	0.201	12
24	Huasen Pharmaceutical	0.212	0.194	0.132	0.140	0.113	0.158	21
25	Chongqing Beer	0.189	0.618	0.464	0.730	0.377	0.476	7
26	Swellfun square	0.328	0.320	0.430	0.579	1.080	0.547	5
27	Qianhe flavor industry	0.124	0.108	0.111	0.184	0.178	0.141	26
	Mean	0.368	0.311	0.355	0.385	0.361	/	/

4. Conclusions and Recommendations

4.1 Main Conclusions

Based on the panel data of 27 enterprises in Chengdu-Chongqing economic circle, this paper calculates the environmental performance of the sample enterprises from 2017 to 2021 by using the super-efficiency SBM model containing unexpected output. The average efficiency during the calculation period is 0.361, and the average value of each year ranges from 0.311 to 0.386, reaching a peak of 0.385 in 2021. Most enterprises' efficiency value is lower than the average level, and the overall efficiency fluctuates slightly and is at a relatively low level.

There were 5, 4, 3, 2 and 2 enterprises that realized DEA effectiveness each year, respectively. From the average of 5 years, only Wuliangye, Luzhou Laojiao and Tianyuan Stock Company achieved comprehensive efficiency and effectiveness.

4.2 Suggestions

The empirical research results show that there are many sample enterprises with environmental efficiency of more than 1 (such as Wuliangye, whose average comprehensive efficiency is 1.431 during 2017-2021, which is an effective production unit, indicating that enterprises can achieve coordination between economic growth and environmental protection. Corporate environmental performance is a part of corporate performance. Promoting the improvement of corporate environmental performance will not hinder the growth of corporate benefits, but contribute to the healthy, long-term and sustainable development of enterprises. Therefore, enterprises should constantly improve the level of green management to maximize corporate value.

First of all, form the consciousness of green thinking. Enterprises should not only pursue the maximization of economic benefits, but should pursue the harmonious coexistence of enterprises and the environment. They should not blindly sacrifice the environment in exchange for economic benefits, and should realize the long-term, healthy and stable green development of enterprises. It should not only focus on solving the current development problems faced by the enterprise and the need to greatly improve economic benefits, but also focus on the enterprise's future development and the realization of long-term interests of the enterprise.

Second, implement green management measures. Create a green cultural atmosphere and carry out environmental protection education within the enterprise. At the same time, the establishment of internal environmental performance monitoring mechanism to regularly monitor the enterprise's resource conservation. It is necessary to conduct investigation and evaluation in every link of production and operation activities such as procurement, production and sales. It is also important to eliminate the source of pollutants and waste resources and standardize the process. In terms of production management, we should actively choose clean energy, learn green technology, firmly grasp the production quality of green products, and pursue green development.

Then, we should take active social responsibilities. Enterprises should establish a relationship between their own development and that of the country and regions. At the same time, enterprises should take the concept of green development to lead enterprises to take the road of green and sustainable development and increase the investment in environmental protection. In addition, enterprises should strive to reduce the level of corporate pollutant emissions, while continuously improving the level of corporate environmental performance.

Acknowledgement

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