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Performance Evaluation of Liaoning Province's Atmospheric Environment Governance Based on TOPSIS method*

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Abstract

As the core of the old industrial base in northeast of China, Liaoning Province has certain difficulties in pursuing economic development while maintaining efficient atmospheric environment governance due to its special industrial structure and its regional problems. Based on the TOPSIS method to evaluate the performance of atmospheric environment governance in Liaoning Province, it can be seen that the performance has achieved rapid growth in the short term between 2016 and 2017.The results of performance evaluation from the perspective of quasi target level, that is, the comparative analysis of 2013-2017 performance from three aspects of pressure dimension, status dimension and response dimension, found that there are performance differences under different quasi target dimensions, and the performance of atmospheric environment governance in Liaoning Province is greatly affected by environmental policies.

Keywords: Environment governance; Performance evaluation; TOPSIS method; Liaoning Province

TOPSIS method is also called "ideal solution method", and its main idea is to determine the ideal solution and negative ideal solution of the scheme. The ranking is performed by comparing the distance of an evaluation scheme which closes to the ideal solution (optimal solution) and keeps away from the negative ideal solution (the worst solution),that is, comparing the weighted Euclidean distance between the comparative evaluation scheme and the ideal scheme (optimal scheme) and the imperfect scheme (worst scheme), the evaluation schemes are ranked accordingly. If an evaluation scheme is closest to the ideal solution (optimal solution) and farthest away from the negative ideal solution (worst solution), then the evaluation scheme is an ideal scheme compared to other schemes. The TOPSIS method can combine different indicators to evaluate multiple indicators in the process of evaluation comparison. Therefore, it is a relatively comprehensive evaluation method. At the same time, because the TOPSIS method does not have strict requirements on the sample size, data distribution characteristics, and number of indicators. And it has the characteristics of wide application range, small calculation amount, intuitive geometric meaning, and small information distortion. Therefore, the TOPSIS method has been widely used in evaluation research in recent years.

1. Evaluation process

1.1 Firstly, based on the PSR model, the performance evaluation index system of atmospheric environment governance in Liaoning Province can be obtained as follows, and the calculation method of the index data and the attributes of the index are shown in Table 1.

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Tab.1 Performance evaluation indexes of atmospheric environment governance in Liaoning Province

First-level indexes	Secondary indexes	Tertiary indexes	Index properties	Calculation method
Pressure dimension	Resource consumption	Energy consumption in industrial production	Negative index	The proportion of industrial energy consumption in the total energy available for consumption in the region (%)
		Energy consumption of living	Negative index	The proportion of living energy consumption in the total energy available for consumption in the region(%)
	Exhaust emission	Sulfur dioxide (SO_2) emissions	Negative index	Sulfur dioxide emissions per unit of GDP (tons / billion yuan)
		NOx emissions	Negative index	Nitrogen oxide emissions per unit of GDP (tons / billion yuan)
		Smoke (powder) dust emissions	Negative index	Smoke (powder) dust emissions per unit of GDP (tons / billion yuan)
Status dimension	Pollution degree	Sulfur dioxide (SO_2) concentration	Negative index	Difference between annual average concentration and environmental quality secondary standard (μg / m3)
		Nitrogen dioxide (NO_2) concentration	Negative index	Difference between annual average concentration and environmental quality secondary standard (μg / m3)
		Carbon monoxide (CO) concentration	Negative index	Difference between annual average concentration and environmental quality secondary standard (mg / m3)
		Ozone (O_3) concentration	Negative index	Difference between annual average concentration and environmental quality secondary standard (mg / m3)
		Fine particulate matter (PM2.5) concentration	Negative index	Difference between annual average concentration and environmental quality secondary standard (μg / m3)
		The inhalable particles (PM10) concentration	Negative index	Difference between annual average concentration and environmental quality secondary standard (μg / m3)
	Pollution frequency	Days of moderate pollution	Negative index	The proportion of moderately polluted days in the total days of the year (%)
		Days of severe pollution	Negative index	The proportion of severely polluted days in the total days of the year (%)
		Days of serious pollution	Negative index	The proportion of seriously polluted days in the total days of the year (%)

The specific data mainly comes from China Statistical Yearbook (2013-2017), China Environmental Statistical Yearbook (2013-2016), Liaoning Statistical Yearbook (2013-2017), and Bulletin of the State of the Environment of Liaoning Province (2013-2017) and government website announcements.

1.2 Next, on the basis of data collection and collation, AHP method is used to determine the weight of each index, as shown in table 2.

Tab.2 Composite Weights of Indexes

Target layer	Quasi target layer	Criterion layer	Scheme layer
Atmospheric environment governance performance	Pressure 0.3392	Resource consumption 0.1987	Energy consumption in industrial production 0.1212
			Energy consumption of living0.0775
		Exhaust emission 0.1405	Sulfur dioxide (SO_2) emissions 0.0645
			NOx emissions 0.0422
			Smoke (powder) dust emissions 0.0338
	Status 0.442	Pollution degree 0.3472	Sulfur dioxide (SO_2) concentration 0.0728
			Nitrogen dioxide (NO_2) concentration 0.0529
			Carbon monoxide (CO) concentration 0.0398
			Ozone (O_3) concentration 0.0598
			Fine particulate matter (PM2.5) concentration 0.0686
			The inhalable particles (PM10) concentration 0.0533
		Pollution frequency 0.0948	Days of moderate pollution 0.0330
			Days of severe pollution 0.0371
			Days of serious pollution 0.0247
	Response 0.2188	Capital investment 0.0948	Investment in infrastructure construction 0.0441
			Investment in industrial waste gas treatment 0.0301
			Investment in forest greening 0.0206

	Industrial adjustment 0.0556	Industrial structure adjustment 0.0348
		Energy structure optimization 0.0207
	Policy action 0.0401	Eliminated vehicle 0.0107
		Demolition of coal-fired boiler 0.0138
		Investigate and deal with environmental violations of enterprises 0.0056
		Accountability officer 0.0050
		Accept environmental petition cases 0.0050
	Resident response 0.0284	Private car growth slows 0.0175
		Growth of domestic natural gas use 0.0110

1.3 The TOPSIS method is used for comprehensive evaluation. The specific performance evaluation steps are as follows.

The first step is to establish a matrix based on the original data. It is assumed that the evaluation objects are m and the evaluation indicators are n, then the matrix established is as follows:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (1.3.1)$$

The second step is to carry out index attribute assimilation in the original matrix, and the formula is:

$$x_{ij}^{'} = \begin{cases} \mathrm{x}_{ij} & (x_{ij} \text{ is Positive index}) \\ \frac{1}{x_{ij}} & (x_{ij} \text{ is Negative index}) \end{cases} \quad (1.3.2)$$

The third step is to normalize the data after the index assimilation and get the normalized matrix Z

$$Z = \begin{bmatrix} Z_{11} & Z_{12} & \cdots & Z_{1m} \\ Z_{21} & Z_{22} & \cdots & Z_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ Z_{n1} & Z_{n2} & \cdots & Z_{nm} \end{bmatrix} \quad (1.3.3)$$

In this formula Z_{ij}

$$Z_{ij} = \begin{cases} \frac{x_{ij}}{\sqrt{\sum_{\mathrm{i}=1}^{\mathrm{n}} x_{ij}^{2}}} & (x_{ij} \text{ in the original index is positive index}) \\ \frac{x_{ij}^{'}}{\sqrt{\sum_{\mathrm{i}=1}^{\mathrm{n}} (x_{ij}^{'})^{2}}} & (x_{ij} \text{ in the original index is negative index}) \end{cases} \quad (1.3.4)$$

The fourth step is to matrix Z and index weight W are weighted to get the weighted normalized matrix Z'

$$Z'=ZW=\begin{bmatrix} Z_{11}W_1 & Z_{12}W_2 & \dots & Z_{1n}W_n \\ Z_{21}W_2 & Z_{22}W_2 & \dots & Z_{2n}W_n \\ \dots & \dots & \dots & \dots \\ Z_{n1}W_1 & Z_{n2}W_2 & \dots & Z_{nm}W_n \end{bmatrix} \quad (1.3.5)$$

The fifth step is to determine the ideal solution, namely the optimal solution (Z^+), and the negative ideal solution, namely the worst solution (Z^-).

$$Z^+ = (\max Z'_{i1}, \max Z'_{i2}, \dots, \max Z'_{im}) \quad (1.3.6)$$

$$Z^- = (\min Z'_{i1}, \min Z'_{i2}, \dots, \min Z'_{im}) \quad (1.3.7)$$

The sixth step is to calculate the ideal solution distance (D_i^+) between each evaluation scheme and the optimal scheme Z^+ and the negative ideal solution distance (D_i^-) between each evaluation scheme and the worst scheme Z^-.

$$D_i^+=\sqrt{\sum_{i=1}^{m}(maxZ'_{ij} - Z'_{ij})^2} \quad (1.3.8)$$

$$D_i^-=\sqrt{\sum_{i=1}^{m}(minZ'_{ij} - Z'_{ij})^2} \quad (1.3.9)$$

The seventh step is to calculate the degree of proximity between each evaluation scheme and the optimal scheme (Z^+), i.e., C_i.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (0 \leq C_i \leq 1) \quad (1.3.10)$$

In the eighth step, each evaluation scheme is ranked according to the $C_i$value of closeness degree. The larger the C_i value, the higher the ranking, indicating that the scheme is better.

According to the above steps, and calculate with Excel software, the final evaluation result is obtained (Table 3)

Tab.3 Ranking of Comprehensive Results of Assessment

Year	Ideal solution distanceD_i^+	Negative ideal solution distanceD_i^-	Closeness degreeC_i	Sort
2013	0.051492	0.039451	0.433799	5
2014	0.065629	0.053836	0.450645	4
2015	0.057532	0.047747	0.453525	3
2016	0.042851	0.049321	0.535097	2
2017	0.045841	0.062320	0.576179	1

The above ranking is the result of comprehensive evaluation through the indexes at the program level. In order to show the difference in the performance of Liaoning's atmospheric environment governance in the five years from 2013 to 2017, this article uses the TOPSIS method to sort and compare from the perspective of the quasi-target layer, that is, the three dimensions of pressure, status, and response. The following sorting results are obtained (see Table 4).

Tab.4 Ranking of evaluation results at Criterion layer

Year	Pressure dimension		Status dimension		Response dimension	
	Closeness degreeC_i	Sort	Closeness degreeC_i	Sort	Closeness degreeC_i	Sort
2013	0.419143	3	0.383209	5	0.623631	1
2014	0.419782	2	0.460402	4	0.399637	3
2015	0.411403	4	0.490726	3	0.345629	5
2016	0.386671	5	0.632082	1	0.386482	4
2017	0.614583	1	0.567850	2	0.529961	2

2. Evaluation result

By using the TOPSIS method to evaluate the performance of Liaoning Province 's atmospheric environment governance, the calculated value of the closeness C_i is finally used as a response to the comprehensive performance results. The larger the value, the better the overall result of performance, For the convenience of discussion, this article considers the value of C_i as a comprehensive performance index. From the final evaluation results, it can be seen that the performance of Liaoning Province 's atmospheric environment governance in the five years from 2013 to 2017 is generally on the rise, but there are still different degrees of fluctuation in horizontal and different dimensions in different years. Based on the evaluation of Liaoning Province's atmospheric environment governance performance, this paper will analyze the results of the evaluation from both comprehensive and horizontal perspectives and find out the problems.

Figure 1 reflects the results of the annual comprehensive assessment of the atmospheric environment governance performance of Liaoning Province from 2013 to 2017. It can be seen from the figure that the comprehensive performance indexes are 0.4161, 0.4388, 0.4397, 0.5546, and 0.5879, respectively. Looking at the overall performance index of atmospheric environment governance in Liaoning Province as a whole, it shows that the effect of atmospheric environment governance has gradually improved in the past five years.

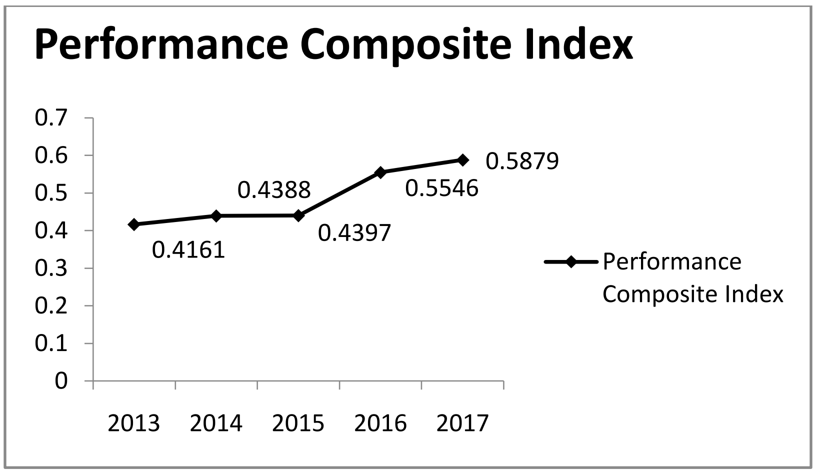
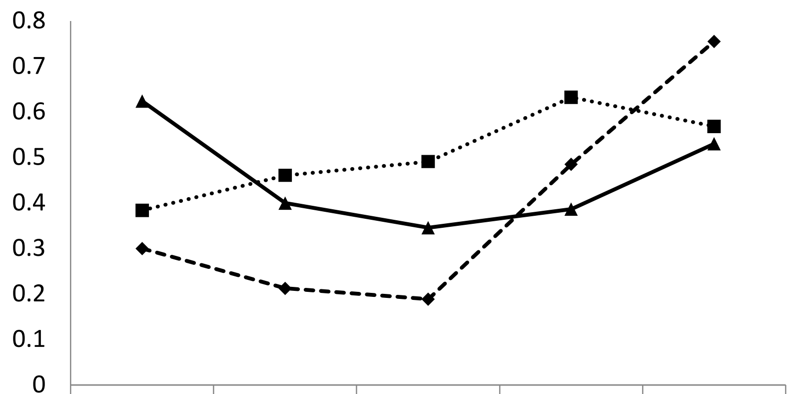


Fig.1 Annual comprehensive assessment results of atmospheric environment governance performance in Liaoning Province

In the five years of assessing Liaoning Province's atmospheric environment governance, there are two obvious time periods. The performance index from 2013 to 2015 is relatively stable, and its growth is relatively slow, but it achieved rapid growth in the short term between 2016 and 2017. In 2016, it increased by 26% compared with 2015. Under the condition of high performance index in 2016, it still increased by 0.03 in 2017.It shows that in the early years of the government's efforts to strengthen atmospheric governance, that is, the three years of 2013, 2014, and 2015, the governance effect was not very significant, but from 2016, the performance index showed a clear upward trend, which may be caused by the characteristics of the atmospheric environment itself. Due to the complexity of the atmospheric environment, pollution problems can be latent for a long time, not easy to be found in a short time, cover a wide range, and cause and effect chain is complex. Therefore, the governance cycle of the atmospheric environment is relatively long, and the governance results cannot be seen in a short time.

Figure 2 reflects the results of performance evaluation from the perspective of the quasi-target layer in the Liaoning Province 's atmospheric environment governance performance evaluation index system. That is, the performance comparison analysis from 2013 to 2017 from three aspects of the stress dimension, the status dimension, and the response dimension, in order to find the performance differences under different quasi-target dimensions, so as to make a more comprehensive supplement to the interpretation of comprehensive performance evaluation results.



	2013	2014	2015	2016	2017
Pressure dimension	0.2995	0.2119	0.1882	0.4848	0.7550
Status dimension	0.3832	0.4604	0.4907	0.6321	0.5679
Response dimension	0.6236	0.3996	0.3456	0.3865	0.5300

Fig.2 Assessment results from different dimensions

From the perspective of the pressure dimension, its performance index gradually declined between 2013 and 2015, but achieved rapid growth in 2016 and 2017. It increased 1.6 times in 2016 compared to 2015, and increased 55% in 2017 compared to 2016. This shows that since 2016, the pressure on the environment has been significantly reduced compared to previous years, and it has continued to weaken. From the perspective of the status dimension, the performance index in 2013-2017 showed an overall upward trend. Except for a slight decline in 2017, other years have achieved steady improvement, which indicates that the status of the atmospheric environment has continued to improve in recent years. From the perspective of response dimension, the overall trend of its performance was u-shaped, and 2013 was the highest point of its performance level, indicating that the response of human activities to atmospheric environmental problems was the highest in 2013, and then gradually declined until 2016, when it began to recover. On the whole, the performance indexes of both the pressure dimension and the status dimension showed an upward trend, while the response dimension showed a downward trend and then an upward trend. During this period, there were two special time points, namely 2013 and 2016. The performance index in 2013 is at a relatively high level in each dimension, and even in the status dimension, its value is not much different from that in 2014. In 2016, the performance index showed a high level of growth in all dimensions, especially in the response dimension, this year was the turning point in which the performance index changed from falling to rising. 2013 was the first year of comprehensive implementation of atmospheric environment governance, and the first year of the introduction of major measures by the Liaoning Provincial Government on atmospheric environment governance. In 2016, the newly revised "Air Pollution Control Law" came into effect, at the same time, the central government's control over the implementation of local governments' environmental responsibilities is also increasing. It can be seen that the performance of atmospheric environment governance in Liaoning Province is greatly affected by environmental policies.

3. Discussion

It can be seen from the results of the assessment of the performance of atmospheric environment governance in Liaoning Province that governance performance is greatly affected by environmental policies, and the effect of policy intervention is very significant. However, Liaoning Province is the core of the old industrial base in Northeast China. Due to its own industrial structure, its economic development relies heavily on natural resources such as coal and iron and steel, so that the pressure for industrial structure adjustment in a short period of time is greater, and the financial capital investment for atmospheric environment governance is also relatively tight, so the cost of its policy intervention is relatively high. This higher cost will cause the government to not always adopt the form of policy intervention to promote the process of governance of the atmospheric environment, so it is less sustainable.

References

Bulletin of the State of the Environment of Liaoning Province (2013-2017). Liaoning: Environmental Protection Department of Liaoning Province.

China Statistical Yearbook (2013-2017). Beijing: National Bureau of Statistics of China.

China Environmental Statistics Yearbook(2013-2016). Beijing: National Bureau of statistics and Ministry of environmental protection.

He Sisi.(2010). *Research on Chang-Zhu-Tan Two-Type Social Evaluation Based on Improved TOPSIS Model*. Changsha: Central South University.

Liaoning Statistical Yearbook (2013-2017). Liaoning: Liaoning Provincial Bureau of Statistics.

Liaoning Provincial People's Government. *Implementation Plan of Liaoning Province's Action Plan for Prevention and Control of Air Pollution*.
[EB/OL].(2014-04-28)[2018-4
http://www.chinalawedu.com/falvfagui/22598/ca2014042811362367794612.shtml

Law of the People's Republic of China on Air Pollution Control.(2015).Beijing: China Environmental Protection Industry.

Poist.,& Xiao Mingzheng.(2005).*Performance Evaluation of Public and Non-profit Organizations: Methods and Applications*. Beijing: Renmin University of China Press.

Sun Jianjun,&Cheng Ying.(2005). *Quantitative analysis methods*. Nanjing: Nanjing University Press.

State Council. *Notice of the State Council on Printing and Distributing Action Plan for Air Pollution Control*.[EB / OL].(2013-09-13) [2019-02-20].

http://www.gov.cn/zhengce/content/2013-09/13/content_4561.htm

Xue Wei. (2011).*Statistical Analysis and Application of SPSS*. Beijing: Renmin University of China Press.

Zade, L.A. (1984).*Fuzzy Sets, Linguistic Variables and Fuzzy Logic*. Beijing: Science Press.