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Research on the Efficiency Assessment and Its Key Influencing Factors Analysis of the Investment in the Environment Governance of 15 Sub-Provincial Cities in China

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Abstract: Continued the environmental pollution restricts the city's sustainable and healthy development in the future. The public goods characteristics of urban environment need a lot of funds for environmental governance from local finance, so improving the efficiency of fiscal expenditure of environmental governance is an important way to solve the current lack of financial investment. This paper evaluates the fiscal expenditure efficiency of environmental governance in local cities in China and empirically examines the environmental variables that affect the efficiency of fiscal expenditure. Based on this, it puts forward some policy recommendations to further improve the efficiency of fiscal expenditure in environmental governance. This paper focuses on 15 sub-Provincial cities, which includes cities named Chengdu, Dalian, Guangzhou, Harbin, Hangzhou, Jinan, Nanjing, Ningbo, Qingdao, Xiamen, Shenzhen Shenyang Wuhan Xi'an and Changchun.

The innovation of this paper systematically summarizes the investment efficiency of environmental governance, based on the principle of building evaluation index system, taking the total investment in environmental governance as input index and the performance of environmental governance investment in water, gas and solid control as output, establishing 15 sub-Provincial cities of China environmental governance investment efficiency evaluation index system, based on the DEA method of 15 sub-Provincial cities of China environmental governance investment efficiency evaluation model, and then the environmental governance investment efficiency as the mother factor, the evaluation indicators for environmental governance investment efficiency factors, the use of gray correlation Analysis method to construct the key influencing factor analysis model of 15 sub-Provincial cities of China environmental governance investment efficiency and collect the input-output data of 15 sub-Provincial cities of China, autonomous regions and municipalities through 15 sub-Provincial cities of China Environmental Statistical Yearbook 2017 and 15 sub-Provincial cities of China Statistical Yearbook 2017, Investment efficiency and its key influencing factors confirm that the key factor of control the total amount of environmental governance investment, can effectively improve the efficiency of environmental governance investment.

Keywords: Governance Investment, Efficiency assessment, Data envelopment analysis, 15 sub-Provincial cities.

Introduction

In recent years, China's economic development has been rapid, and the process of urbanization and industrialization has been accelerating. The ensuing environmental problems have become increasingly serious. Although you can hold Continuing development has become a consensus and a national policy. However, it must be acknowledged that environmental problems still exist and pollution cannot be ignored. The government is ensuring the environment while managing the scale of investment, we must focus on the efficiency of environmental governance investment. From the overall situation of China's environmental investment quality, environmental governance investment Inefficiency has become an indisputable fact [1].

The report of the party's 18th National Congress also mentioned that in the past decade, the construction of ecological civilization has been carried out in a solid manner and resources have been saved. And environmental protection is fully promoted, but the contradiction between resources, the environment, and the economy cannot be ignored. It is necessary to increase environmental protection and strengthen water, air and other pollution. Prevention. Due to the vastness of China's territory, the economic and environmental pollution among regions varies, and the same scale of environmental governance investment may bring Different environmental governance effects.

On the basis of reviewing the research on the efficiency of investment in environmental governance and based on the characteristics of the government statistics, the physical and financial inputs and output benefits, this paper constructs an evaluation index system with multi-input and multi-output to measure the impacts of different regional environments Based on the data envelopment analysis, an evaluation model is established to analyze the relative efficiency of investment efficiency of environmental governance in different regions from multiple dimensions. The empirical results show that the investment efficiency of environmental governance in 15 cities, especially waste water and waste gas treatment, has higher investment efficiency, but the regional differences are obvious, the overall investment is insufficient, the technical level is not balanced, and the investment structure in some areas is unreasonable. After the system analysis, it puts forward the development strategies and suggestions that should be made to enhance the investment efficiency of environmental governance in all regions and the direction of efforts and the adjustment and improvement efforts.

Research Status of domestic and foreign research

Environment Treatment Efficiency

In view of the applicability of the concept of relative efficiency in the DEA method, this method has been gradually applied in many aspects such as economics, management, and industrial performance evaluation in recent years. Chen Mingyi (2013)

[8] reviewed the development process of the total factor productivity calculation method in the industrial environment comprehensively and found that there are four different ways to deal with the pollution discharge, that is, regardless of the pollution emission factors, use pollution emissions as an input and use the pollution emissions as the desired output and the pollution emissions as an undesirable output. He uses the Directional Distance Function (DDF) to estimate these four scenarios separately from the Chinese data. It is found that the actual total factor productivity of the environmental constraints is considered to be an estimate of the environmental factors (not correct) much lower. In fact, environmental technical efficiency is the basis for calculating the total factor productivity of the environment. In calculating the technical efficiency of the industrial environment, there are four ways of dealing with pollution emissions. If the environmental constraints are not properly considered, the same deviation will be generated, which means the importance of correctly calculating the environmental technical efficiency. Zhang Yabin et al. (2014) [7] selected seven indicators to evaluate the performance of environmental intelligence investment in China [13]. The input indicators were environmental management investment, environmental practitioners and energy consumption. The output indicators were industrial wastewater, exhaust emissions, And the cities of GDP [11]; Liu Bingxi et al (2016) [5] selected the water treatment rate, the amount of domestic waste treatment and the number of wastewater facilities as input variables, select the amount of sulfur dioxide removal, dust removal, dust removal and exhaust treatment facilities for the output variable, to evaluate environmental pollution control efficiency of local government in China.

The methods to estimate the influence of environment management

Chinese scholars have focused their research on the qualitative analysis and quantitative analysis of environmental governance investment. Qualitative analysis mostly analyzes the benefits of environmental governance investment from the perspective of economics. Quantitative analysis mainly uses the DEA method to evaluate environmental governance. investment efficiency. Some scholars use a certain area as the research object and use the different models in the DEA method to conduct empirical analysis. Yu Pengfei and others took 17 provincial cities such as Shandong in 2017 as the research object and used the super-efficient DEA model. Li Jingyu and Sun Lei took Yingkou City of Liaoning Province as an example and used the CCR model in the DEA method to establish an environmental protection investment efficiency evaluation index system model, and on this basis, comprehensively analyzed the wastewater and gaseous pollution from 2015 to 2017. Solid waste and environmental pollution comprehensive management input efficiency. In addition, some scholars start from the national perspective to study the efficiency of environmental governance investment in different provinces and cities (regions) across the country [5].Ke Jian and Li Chao are based on the CCR model and clustering method in the DEA method, taking resources and environment as input, and economic growth as output, studying the resource-environment-economy of China's 30 provinces and regions (regions) in 2013 [6].Song Yu and Wu Fengping used the CCR model in the DEA method to establish an environmental governance investment efficiency evaluation index system, and analyzed the efficiency of comprehensive treatment of wastewater, waste gas, and environmental pollution in 28 provinces (regions) in China in 2016 [7].

Over the past few years, the calculation of China's industrial environmental technology efficiency of the article continues to emerge. The usual approach is to construct a directional environment distance function and then solve it based on the Data Envelopment Analysis (DEA) model, such as TuZhengge (2008) [19], Wang Bing et al (2011) [12]. Since Tone (2004) [35] has incorporated non-expected outputs (such as pollution emissions) into the SBM (Slack - based Measure) model, the SBM model has also become an option for the technical efficiency of the environment, such as Wang et al (2010) [13], Liu Lei Ke (2011) [12].

The literature has been more accurate to take the environmental constraints into account, and the use of different methods were calculated. However, they are unable to escape the "Black Box" problem of traditional DEA methods. Fare et al (2011) [12]point out that these documents treat environmental technology as a "black box" approach, that is, put the elements of resources into the technology, then "Good" output (i.e., normal output) and "bad" output (i.e., contaminants such as SO2) from the other side of the technology to produce it [11]. The Jointly Weak Disposability of Output is one of the four most important characteristics of the environmental technology (possibly) output set, which illustrates the "good" output and the "bad" output in terms of factor resource inputs and technical conditions In some cases, the proportion of the increase or decrease, which means that the reduction of "bad" output needs to invest in equipment, environmental pollution control, the result of "good" output because of the transfer of elements of resources and cut production. But this feature does not elaborate on how the "bad" output is reduced. Liu Libo (2016) [5] also used the DEA model to evaluate the investment efficiency of environmental management in Jiangxi Province. Wang Yingxiang (2017) [1] used this method to evaluate the efficiency of air pollution control in China.

Fare (1991) [32], Fare and Grosskopf (1996) [17] proposed the network DEA model, which solves the problem of "black box" in traditional DEA model. This method has long been applied by domestic and foreign scholars in banking, transportation and many other fields. Fare and Grosskopf (2004) [41] introduced it into environmental technical efficiency. Fare et al. [2011] further applied it to calculate the environmental technical efficiency of coal-fired power plants in the United States from (2001) [18]to (2005) [19]and found that the results calculated with the traditional DEA model Significant differences.

Main influence factors

Some scholars have studied the investment and environmental governance of Chinese cities or regional economies. Yang et al (2010) [19]Used the DEA model to measure the inter-provincial environmental efficiency in China from 1998 to (2007) [20]and found that per capita GDP had a positive impact on improving environmental efficiency, and cause the increase in industrial proportion, the increase of fiscal decentralization and the negative impact of trade liberalization on environmental efficiency. Dian Yiwen (2009) [15] used the multivariate statistics to analyze the environmental investment and output of the industrial areas in 31 provinces and regions in China in (2007) [20]. The results show that the efficiency of environmental protection investment in each region is basically consistent with the level of economic development. The efficiency of China's environmental protection investment is still low. Wu Shunqin et al. (2007) [19] focus on the focus of environmental protection investment structure and environmental protection investment. The results show that environmental management investment is too large, investment direction and demand do not match, irrational investment structure is an important factor affecting environmental efficiency. Zhang Yabin et al. (2014) [7]found that there was a negative impact from the effect of environmental impact assessment project, the number of environmental visits, and the gross domestic product (GDP) on the efficiency of environmental management investment, and the income of sewage charges, the proportion of secondary industry and the natural population growth rate has a positive impact.

Empirical Analysis Based on DEA Model

To build the evaluation indexes system of the efficiency of the environmental treatment

In this section, we choose fixed asset Environmental governance investment as the input index and choose waste utilization product output value (Million Yuan), waste conversion Derivative Products Output value (Thousand Yuan) and Industrial sulfur dioxide emissions up to scalar (T) as Output index. The indicator Environmental Governance Investment [10] reflects the fixed assets investment scale, social structure and development speed of the comprehensive indicators is an important basis for assessing the investment effect. The greater the investment in fixed assets indicates that the economic development platform is better, so the fixed asset investment as an input index. The following three indicators are present as Output index.

(1) Waste utilization product output value can be presented as the production value of waste, which is the economic benefit of the recycling of recycled items.

(2) This indicator Waste Conversion Derivative Products Output Value is Output value of waste conversion derived products (Yuan), economy generated after processing with waste utilization.

(3) Industrial sulfur dioxide emissions up to scalar refers Industrial sulfur dioxide emissions refers to the amount of sulfur dioxide emitted into the atmosphere by enterprises during fuel combustion and production processes.

Table 1 Environment treatment efficiency evaluation indexes system

Input-output oriented	Indicators
Input	Environmental governance investment（Million Yuan）
Output	Waste utilization product output value（Million Yuan）
	Waste Conversion Derivative Products Output Value（Thousand Yuan）
	Industrial sulfur dioxide emissions up to scalar（T）

Environmental efficiency assessment based on BCC-DEA model

Each of the assessment method is to calculate an index value to assess how good a scheme is according to its assessment indexes values. However, most of them have calculated the goodness while they cannot give how to better and adjust the production schemes to improve it. So, we assess the investment efficiency of the environmental governance by use of the non-uniform assessment model base on DEA and regard the efficient degrees of DEA as the investment efficiency. At the same time, we utilize the project theory on DEA efficient frontier of DMU to better and adjust the decision-making schemes to improve their investment efficiency for non-DEA effective DMU.

(a) Set: there are n cities s with $m+s$ indexes to assess. Regard each city as a Decision-Making Unit (DMU), and we list the steps of the non-uniform assessment model based on DEA as follows (Quanling Wei, 2006).

(b) Ascertain the negative indexes and positive indexes: To use DEA model, we must divide the indexes into two groups. If the worse it is thought when the bigger its value is, the index is called a negative one like total investment in the treatment of environmental pollution. On the other hand, if the better it is thought when the bigger its value is, the index is called a positive one, for example, industrial waste water meeting discharge standards. For each DMU, let m negative indexes be input indexes, and s positive indexes be output indexes; denote x_{ij} is the value of No. i input index of No. j DMU and y_{ij} is the value of No. r output index of No. j DMU, where $i=1,\ldots,m;\ j=1,\ldots,n; r=1,\ldots,s$. Let $X_j=(x_{1j},...,x_{mj})^T \geq 0$, $Y_j=(y_{1j},...,y_{sj})^T \geq 0$. So, (X_j,Y_j) can represent No. j DMU.

(c) We adopt the C^2R model to assess the technical efficiency and the scale efficiency of each DMU. That is, the investment efficiency of DMU j_0 is decided by the mathematical programming as follows:

$$
(D)\begin{cases}
\min \theta = V_D \\
s.t.\ \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_{j_0} \\
\sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_{j_0} \\
\sum_{j=1}^{n} \lambda_j = 1 \\
\lambda_j \geq 0, j = 1, \ldots, n+1 \\
S^+ = (S_1^+, \ldots, S_m^+) \geq 0 \\
S^- = (S_1^-, \ldots, S_s^-) \geq 0
\end{cases} \quad (1)
$$

The optimal value of (D) is the investment efficiency of DMU j_0. So, we can get the investment efficiency of n cities by solving n linear programming. And according to the calculated values to decide the investment efficiency of a DMU is good or bad. If it is 1, then the DMU is an efficient one.

(d) The projection of an inefficient DMU onto the efficient frontier: In order to better and adjust the decision-making schemes to improve the investment efficiency of the DMU whose efficiency is less than 1, we can utilize the theory on DEA efficient frontier of DMU (Decision Making Unit). And it can be calculated by the following formulations:

$$\hat{X}_{j_0} = \theta^0 X_{j_0} - S^{-0} = \sum_{j=1}^{n} X_j \lambda_j^0 \quad (2)$$

$$\hat{Y}_{j_0} = Y_{j_0} + S^{+0} = \sum_{j=1}^{n} Y_j \lambda_j^0 \quad (3)$$

It is proved that the decision-making schemes, whose index values are accorded to the project, is efficient.

Results analysis

Crste does not consider the technical efficiency (comprehensive efficiency) of scale returns. Data Envelopment Analysis (DEA) is a famous operational researcher. Charnes and W. W. A new efficiency evaluation method developed by Cooper et al. based on the concept of relative efficiency. Following the advent of the first model in 1978, the C2R model, new models and other important theoretical results have emerged, and the practical application of the model has continued to occur. Also, increasingly widespread. From the table 2, it can be seen that, in addition to the Nanjing efficiency rises from 0.775 in 2012 to 0.855 in 2016, the five-year average comprehensive efficiency score is better for most cities, and the average efficiency of the top five banks is above 0.816. The comprehensive investment efficiency scores of economically developed cities are also very high. They are basically based on efficiency. The reason for the analysis is mainly because the influence of the economic city policy is relatively large, and its regional impact is limited, so the development of environmental protection efficiency is faster.

From the analysis in the chart, it can be seen that the comprehensive efficiency of the 15 sub-Provincial cities of china has first risen. In 2014, the efficiency of the city has been reduced. In 2013, it recovered slightly in 2012. On the whole, the average efficiency level of environmental protection investment efficiency has exceeded 0.8, which is an increase of more than 30% compared to the expected average of 0.6. Among them, the efficiency improvement ratio of the banking industry from 2015 to 2016 was around 8%, which shows that in fulfilling China's environmental protection commitment, the overall technical efficiency of China's environmental protection efficiency has a certain degree of improvement. As a whole, although China's environmental protection industry has made great improvements, the overall efficiency is still about 15% from the frontier efficiency. Therefore, there is still room for China's environmental protection investment to use output efficiency.

Table 2 The **Crste** efficiency of environmental governance in 15 sub-Provincial cities

City	2012	2013	2014	2015	2016	Average
Chengdu	0.601	0.7	0.519	0.582	0.632	0.6068
Dalian	0.671	0.718	0.728	0.696	0.72	0.7066
Guangzhou	0.625	0.516	0.486	0.475	0.461	0.5126
Harbin	0.752	0.536	0.531	0.517	0.512	0.5696
Hangzhou	0.449	0.408	0.422	0.326	0.355	0.392
Jinan	0.257	0.585	0.458	0.476	0.454	0.446
Nanjing	0.775	0.787	0.798	0.865	0.855	0.816
Ningbo	0.401	0.461	0.492	0.545	0.56	0.4918
Qingdao	0.235	0.218	0.226	0.3	0.334	0.2626
Xiamen	0.734	0.556	0.59	0.589	0.524	0.5986
Shenzhen	0.166	0.334	0.823	0.388	0.41	0.4242
Shenyang	0.866	0.284	0.503	0.557	0.625	0.567
Wuhan	1	0.72	0.517	0.459	0.384	0.616
Xi'an	0.556	0.372	0.472	0.332	0.406	0.4276
Changchun	1	0.471	0.54	0.452	0.038	0.5002

Table 3 The **Vrste** efficiency of environmental governance in 15 sub-Provincial cities

City	2012	2013	2014	2015	2016	Average
Chengdu	0.748	0.809	0.618	0.679	0.738	0.7184
Dalian	0.748	0.839	0.849	0.814	0.84	0.818
Guangzhou	0.748	0.577	0.569	0.552	0.688	0.6268
Harbin	0.748	0.619	0.614	0.598	0.599	0.6356
Hangzhou	0.748	0.433	0.487	0.38	0.536	0.5168
Jinan	0.748	0.672	0.504	0.547	0.528	0.5998
Nanjing	0.748	0.913	1	1	1	0.9322
Ningbo	0.492	0.537	0.598	0.629	0.647	0.5806
Qingdao	0.629	0.462	0.485	0.414	0.39	0.476
Xiamen	0.829	0.649	0.69	0.765	0.752	0.737
Shenzhen	0.218	0.436	1	0.443	0.471	0.5136
Shenyang	0.94	0.604	0.63	0.645	0.8	0.7238
Wuhan	1	0.799	0.698	0.656	0.695	0.7696
Xi'an	0.964	0.941	0.883	0.707	0.67	0.833
Changchun	1	0.471	0.608	0.522	0.624	0.645

Table 4 The **Scale** efficiency of environmental governance in 15 sub-Provincial cities

City	2012	2013	2014	2015	2016	Average
Chengdu	0.804	0.866	0.838	0.856	0.856	0.844
Dalian	0.857	0.856	0.857	0.855	0.858	0.8566
Guangzhou	0.86	0.894	0.854	0.859	0.67	0.8274
Harbin	0.752	0.867	0.865	0.864	0.856	0.8408
Hangzhou	0.934	0.941	0.866	0.86	0.662	0.8526
Jinan	0.774	0.87	0.908	0.87	0.86	0.8564
Nanjing	0.815	0.862	0.798	0.865	0.855	0.839
Ningbo	0.816	0.858	0.823	0.866	0.866	0.8458
Qingdao	0.374	0.472	0.466	0.726	0.855	0.5786
Xiamen	0.885	0.857	0.855	0.771	0.697	0.813
Shenzhen	0.765	0.765	0.823	0.874	0.872	0.8198
Shenyang	0.922	0.47	0.798	0.863	0.781	0.7668
Wuhan	1	0.901	0.741	0.699	0.552	0.7786
Xi'an	0.577	0.396	0.534	0.47	0.606	0.5166
Changchun	1	0.999	0.888	0.864	0.06	0.7622

The key influencing factors of environmental governance

Current environmental input system in the 15 sub-Provincial cities of china is basically a continuation of the planned economic system. Environmental responsibility and investment are basically borne by the government. The research shows that more than 70% of the environmental protection investment in 15 sub-Provincial cities of china is invested by the government and the public sector. However, due to the limited government financial resources, the government's current investment and financing supply capacity is insufficient, and the actual funding needs are enormous. With the worldwide economic growth and pressure on natural resources, existing technologies can no longer guarantee the demand for sustainable development.

Here the Waste utilization product output value, Waste Conversion Derivative Products Output Value, Industrial sulfur dioxide emissions up to scalar and Total environmental governance investment is introduced as the analyzed models. The degrees of grey incidences are shown in Table3. Waste utilization product output value shows the result of 0.9997, Waste Conversion Derivative Products Output Value gives the value 0.9205, Industrial sulfur dioxide emissions up to scalar gives the results of 0.964 and the Total environmental governance investment shows the result of 0.9998.

Table 5 The degrees of grey incidence of each index

Index name	Waste utilization product output value（Million Yuan）	Waste Conversion Derivative Products Output Value（Thousand Yuan）	Industrial sulfur dioxide emissions up to scalar（T）	Total environmental governance investment（Million Yuan）
The degrees of grey incidence	**0.9997**	**0.9205**	**0.964**	**0.9998**

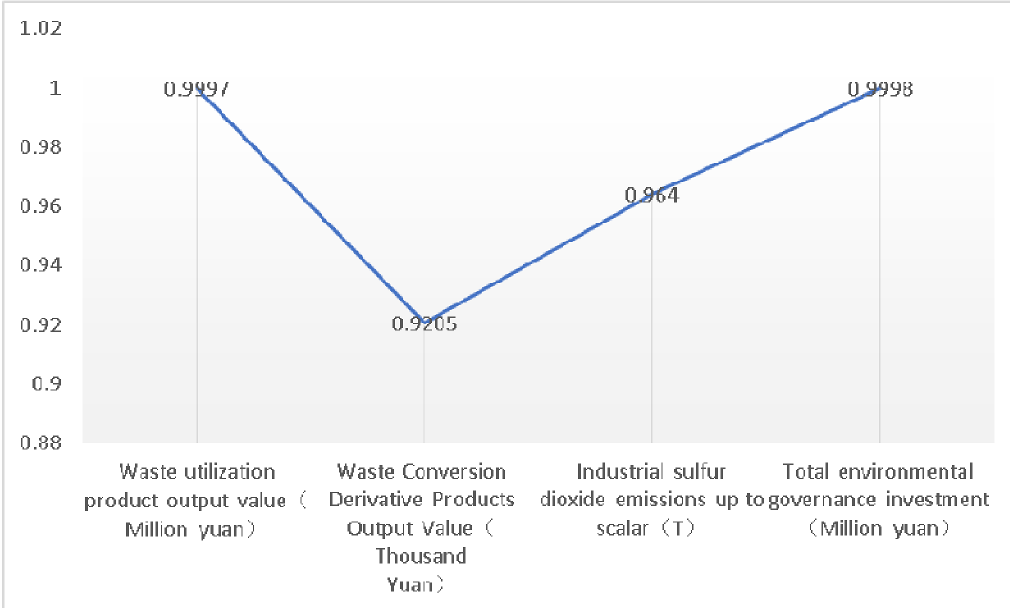

Figure 1 The degrees of grey incidence of each index

Counter measure to improve the efficiency

The impact of the scientific feasibility analysis, making them very popular and cause significant pollution hazards in the local environment. On the other hand, in the decision-making process of local governments, due to the lack of systematic decision-making, when a problem industry has just emerged, due to its small scale, inconspicuousness, and concealed nature, the regulatory authorities often pay little attention to such issues. The investment structure is irrational. For a long period of time, the focus of environmental protection investment in 15 sub-Provincial cities of china has been in the field of industrial pollution prevention and control. There have been few investments in the construction of urban environmental infrastructure, the construction of environmental management departments, the comprehensive remediation of trans-regional environments, and the prevention and control of SME pollution. From 10 years from 2006 to 2016, the proportion of pollution prevention and control funds for new construction and expansion projects in the total amount of environmental protection investment has been maintained at more than 30%. Although 15 sub-Provincial cities of china have increased their environmental protection investment in urban infrastructure by a certain percentage each year, they still have a long way to go compared with the urbanization process of 15 sub-Provincial cities of china and the rapid expansion of large and medium-sized cities.

Review and summary

At present, the rapid development of the social economy, the problem of ecological environment construction has gradually become the biggest bottleneck of local governments in implementing the concept of sustainable development. How to scientifically and objectively understand the necessity of the research on the local government's environmental governance capacity, and effectively analyze its influencing factors, and ultimately it is important to propose practical and feasible government behavior choices and countermeasures for solving the main problems of the local government's ecological environment construction in China.Since the reform and opening up, the rapid development of China's economy has continued to suffer from the plight and distress of the natural ecological environment. The main reason for exploring is that it is caused by the unreasonable existence of China's economic production and social life (including government behavior). On the deteriorating eco-environmental issues, whether or not there is a strong environmental governance capability has deeply reflected the ability and level of public management of Chinese local governments [11], and to a certain extent, determines whether China's economic and social society can be harmonious and healthy. development of. Because the special "public goods" of the ecological environment have highlighted its scarcity and irreversibility characteristics, local governments should break through the old paradox in solving the problem of ecological environmental issues and then play an irreplaceable key role.

Comprehensively evaluate the local government's environmental governance capacity, and scientifically and objectively recognize the necessity of the research on local government capacity in China for sustainable economic and social development and social smooth transformation and make an effective analysis of its influencing factors. It is still a social science major issue in the field of environmental science, and even ecology [14].

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