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# Development Performance and Influencing Factors of Environmental Protection Industry in China

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## ABSTRACT

As a strategic emerging industry, environmental protection industry is important in the development of national economy. However, few empirical studies on the performance of environmental protection industry are carried out. In order to explore development performance and influencing factors of environmental protection industry in China, the selection of development data of China's 31 provincial regions under the environmental protection industry was conducted based on industrial efficiency, economic contribution, industrial scale, and development speed. Development performance of environmental protection industry was qualitatively analysed and influencing factors were explored by using the method of factor analysis. Results show that the factor score of the eastern region is positive in both industry scale and pollution treatment. Factor score of industry scale, industry contribution and pollution treatment in the central region is positive. Development of environmental protection industry in the western region lags far behind other areas, and only factor score of industry contribution are positive and significantly higher than other areas. Factor score of industrial scale, industrial contribution, and pollution treatment in the northeast region is lower than that in the eastern and central region. Suggestions and countermeasures are proposed to promote the development of the environmental protection industry.

## INTRODUCTION

Since the mid-1970s, the development of the world environmental protection industry has entered a relatively stable period and formed the development characteristics of production pollution control equipment. After the 1990s, the development of the industry has been characterized by the multi-disciplinary integration of technology-intensive industries. In view of the environmental protection industry and other industries that are relatively strong, the permeability of industry boundaries has become unclear, leading to difficulty in forming very uniform and clearly defined boundaries. Thus, the widely used definition of the organization for economic cooperation and development is that it holds the environmental protection industry to control and eliminate pollution, to improve resource utilization, and to reduce environmental risks to provide products, services, and clean technology. The state environmental protection administration defines the industries related to environmental protection as those in the national economic structure that are environmental pollution prevention and control, ecological protection and restoration, effective utilization of resources, meeting people's environmental needs, and providing products and services for the sustainable development of society and economy. The environmental protection industry is an emerging manufacturing and service industry. This strategic and fundamental industry is characterized by high growth rate, high added value, high technological content, high industrial correlation, provincial resources, low energy consumption, and lack of pollution. According to statistics, 2007-2018, China's environmental protection industry output value rose from 199.49 billion RMB to about 1.32 trillion RMB, the average annual growth rate of the environmental protection industry was close to 21%. The growth rate of China's environmental protection industry was far higher than that of the global environmental protection industry. At present, the contradiction between economic development and environmental protection of China is increasing. With increasing efforts of environmental governance in China, the environmental protection industry has been the focus of the government; the traditional development path with high energy consumption and pollution level cannot satisfy the public's expectation of sustainable development model. The modern environmental protection industry has changed from the natural conquest type of human society to the coordinated ecological economic structure. The industry has also shifted from the track of high-speed economic growth and unreasonable consumption at the cost of environmental damage and resource depletion to the sustainable development track

of coordinated economy, population, resources, and environment.

However, the previous research methods of performance evaluation of the environmental protection industry have some limitations, and cannot reflect evaluation results objectively and truly. The advantage of subjective weighting method is that experts can reasonably determine the ranking among the weight coefficients of various indicators based on practical problems. The objective weighting method does not need to seek the opinions of experts, cutting off the subjective source of the weight coefficient, making the coefficient have absolute objectivity, but an inevitable defect is that the determined weight is sometimes contrary to the actual importance of the index. Thus, it is important to give a true and comprehensive evaluation of the performance and changing trend of environmental protection industry. This study analyses the development performance and influencing factors of the environmental protection industry in China to determine the entry point for its future development.

## PAST STUDIES

According to existing literature, it does not form a rigorous theoretical system for the performance of environmental protection industry, which can be divided into three aspects: performance evaluation system, the influence of factor endowment on the performance, and promotion of relevant policies and legislation on the performance of the industry. The performance evaluation system of the environmental protection industry mainly focuses on the construction of the evaluation system of its regional industrial competitiveness. Christopher et al. (2018) used the linear weighted model of comprehensive competitiveness of industry comparative analysis and argued that evaluation index system of regional industry competitiveness included real competitiveness, potential competitiveness, and environmental competitiveness, and carried on the empowerment of each index. Du (2015) argued that the current developmental prospect of environmental protection industry in our country is good, but the environmental protection industry equipment production is still relatively low and has not yet entered the high level field of product research and development and technical services. Gao et al. (2010) found the production lacks the marketization of China's environmental protection industry and local government regulation, which severely hindered the development of environmental protection industry. The consumption of environmental protection products has evident positive externalities, so environmental legislation and law enforcement play an important role in stimulating the development of the environmental protection industry. Larry (2018) believed that strict law enforcement must be carried out to develop the environmental protection industry; the environmental protection industry should be regarded as public welfare, and the government should provide corresponding subsidies. Rani et al. (2017) believed that the effect of factor endowment on the performance of environmental protection industry exhibits regional difference. Li et al. (2012) believed that China's environmental protection industry is currently developing from pollution to clean products and environmental protection; the concept of China's environmental protection industry is gradually evolving into a "green industry". Wang et al. (2010) believed that if driven by the government, then the environmental protection industry is fully possible and can become a new growth point of the next round of economic development and a new pillar of the industry, leading to the development of green economy. Zhang et al. (2008) showed that technology, science, and innovation can be used to empirically analyse the specific city's environmental protection industry; they found two elements that influence the performance of city environmental protection industry, namely, economic production ability and innovation ability of science and technology, from the two aspects of input and output indicators, on the basis of the evaluation of the variation coefficient method; the production capacity and technological innovation ability are proportional to the degree of environmental protection industry development. In summary, scholars have conducted in-depth research on the performance of the environmental protection industry. Nevertheless, further qualitative analysis, policy and suggestions, and less empirical analysis should be performed. In particular, the comprehensive evaluation and comparative analysis of the regional performance and influencing factors of the environmental protection industry remain insufficient when evaluated by combining the index system with regional analysis. This study selects 31 provincial regions in China, and such provincial regions can be divided into four regions. The research object establishes the scale system, which can reflect the regional environmental protection industry performance. It uses factor analysis method can analyse the regional advantages and problems in the development of the environmental protection industry, which can determine the main factors that hinder the development of the regional environmental protection industry. The corresponding opinions and suggestions are proposed.

## METHODOLOGY

**Selection of indicators:** Based on the particularity of the development of China's environmental protection industry, evaluating and analysing factors influencing its performance are important. Therefore, this study follows the

principles of comprehensive, conciseness, completeness, objectivity and operability and consider the reliability of data that are authoritative and practical in accordance with China's Environment Statistical Yearbook and China Statistical Yearbook, which are constructed based on industry, industrial investment, performance output of three secondary indices, and the 11 three-level index system of performance evaluation of the China's environmental protection industry. The specific evaluation index system is shown in Table 1.

**Data processing:** Given that the dimension of index selection is different, the data should be dimensionless to eliminate the influence of dimensionalization on the original data. In this study, the dimensionless linear standardization method is adopted, that is:

$$Z_{ij} = \left(x_{ij} - u_j\right)/\sigma_j \quad \left(i = 1,2,\cdots, p; j = 1,2,\cdots, n\right) \qquad ...(1)$$

Where $n$ is the sample quantity; $p$ is the number of indicator variables; $z_{ij}$ is the dimensionless sample value; $u_j$ is the mean value of $x_{ij}$; and $\sigma_j$ is the standard deviation of $x_{ij}$.

**Factor analysis:** The idea of factor analysis can be represented by a mathematical model. Assuming that there are $p$ variables, namely $x_1, x_2, \ldots, x_p$. The standardized mean of them is 0, and the standard deviation of them is 1. $x_1, x_2, \ldots, x_p$ can have linear representation with ($k$ ($k<p$) factors, namely $f_1, f_2, \ldots, f_k$, which is shown in the following equation (2).

$$\begin{cases} x_1 = a_{11}f_1 + a_{12}f_2 + \ldots + a_{1k}f_k + \varepsilon_1 \\ x_2 = a_{21}f_1 + a_{22}f_2 + \ldots + a_{2k}f_k + \varepsilon_2 \\ \ldots \\ x_p = a_{p1}f_1 + a_{p2}f_2 + \ldots + a_{pk}f_k + \varepsilon_p \end{cases} \qquad ...(2)$$

Equation (2) represents the system of equations for this method. The matrix expression is:

$$X = AF + \varepsilon \qquad ...(3)$$

Where, $F$ is the factor, and $f_i$ ($j=1,2,\ldots,k$) correlation coefficient is 0. $A$ is the factor load matrix, $a_{ij}$ ($i=1,2,\ldots,p$; $j=1,2,\ldots,k$) is the factor load; and $\varepsilon$ is a special factor, independent of $f_i$ ($j=1,2,\ldots,k$).

## RESULT ANALYSIS AND DISCUSSION

**Result analysis:** Factor analysis is used to analyse the internal structure of the correlation coefficient matrix of variables, reduce the original variable to few random variables, and categorize it as a common factor. $F$ should include as much information as possible from the original variables and build new model $X = AF + \varepsilon$, ignore ε, replace $F$ with $X$ to reproduce the correlation between the numerous components of the original variable $X$, thereby simplifying scalars and reducing dimensionality. In this study, Bartlett's sphericity and KMO tests and correlation coefficient matrix

Table 1: Performance evaluation index system of environmental protection industries.

| Level indicators | The secondary indicators | Index coding | Level 3 indicators | Unit |
|---|---|---|---|---|
| China's environmental protection industry performance | Industrial base | $X_1$ | Gross regional product | One hundred million yuan |
| | | $X_2$ | Employment in environmental management | Ten thousand people |
| | | $X_3$ | Number of nature reserves | / |
| | | $X_4$ | Per capita park green area | ha |
| | Industry investment | $X_5$ | Investment in the treatment of industrial pollution has been completed | Ten thousand yuan |
| | | $X_6$ | Forestry state investment accounts for the proportion of investment sources | % |
| | | $X_7$ | The proportion of investment in environmental pollution control in GDP | % |
| | The performance of output | $X_8$ | Comprehensive utilization of general solid waste | Ten thousand tons |
| | | $X_9$ | Harmless disposal rate of household garbage | % |
| | | $X_{10}$ | Environmental taxes take up a proportion of tax revenues | % |
| | | $X_{11}$ | The reduction rate of energy consumption per ten thousand yuan of GDP | % |

were used to determine the suitability of indicator variables for factor analysis. The KMO value calculated is 0.630, the chi-square value is 163.734, and the significance level of observation is 0.000. Therefore, the null hypothesis that states that the correlation coefficient matrix is an identity matrix was rejected. The variables are not completely independent, and a simple linear relationship exists between them, which can be used for factor analysis. In this study, SPSS 22.0 statistical analysis software was used to conduct the factor analysis of index variables by using principal component analysis method, and to process data of 11 indexes of 31 provinces, autonomous regions and municipalities in 2018. By collecting the coefficient matrix eigenvalues greater than 1 common factor to express the 11 indexes of information, the analysis result shows that the former four eigenvalues of the common factor is greater than 1. Cumulative contribution rate of common factors is 71.417%, which can sufficiently explain the original indexes, contain most of the information. Principal component analysis is used to extract four common factors and obtain the component matrix. Kaiser orthogonal rotation is used to obtain the rotation component matrix of factors. According to the factor rotation component matrix (see Table 2), the first principal component ($F_1$) includes $X_1$, $X_2$, $X_5$, $X_6$ and $X_8$, and it's named as industry scale. The second principal component ($F_2$) includes $X_7$ and $X_{10}$, and it's named as industry contribution. The third principal component ($F_3$) includes $X_3$ and $X_4$, and it's named as the environmental foundation. The fourth principal component ($F_4$) includes $X_9$ and $X_{11}$, and it's named as pollution treatment.

According to the factor score coefficient matrix, the linear combination equation of the four principal components can be obtained. Considering the variance contribution rate of the common factor as its score weight, the comprehensive factor scores of the eastern region, the northeastern, central, and western regions can be obtained. Given the space limitation, Table 3 only lists the regional scores. The calculation method is:

$$F = (32.095 \times F_1 + 17.431 \times F_2 + 11.786 \times F_3 + 10.105 \times F_4)/71.417 \quad ...(4)$$

After the standardization of the original data, 0 is set as the average of the common factor and the comprehensive factor, whereas negative value indicates lower than the average level. The higher the public factor score is, the higher the industry scale, industry contribution, environmental foundation, and pollution treatment level are.

Factor score of the eastern region is positive in both industry scale and pollution treatment, indicating that the eastern region has evident advantages in these two aspects, and the factor score of pollution treatment is significantly higher than that of other regions. Factor score of environmental foundation and industry contribution is negative, indicating that compared with the developed economy in the eastern region, the investment intensity and output of environmental protection are insufficient, and the construction of urban green space and other environmental infrastructure needs to be improved, which restricts the development of environmental protection industry to some extent.

In the central region, factor score of industry scale, industry contribution and pollution treatment are positive, but it is negative on environmental foundation. The comprehensive score is already close to the eastern region. The central region attaches great importance to development scale and investment of environmental protection industry, and contaminated processing ability also constantly improve. However, environmental infrastructure investment remains inadequate in the central region.

In the western region, development of environmental protection industry lags far behind other areas. Only factor score of industry contribution is positive and significantly higher than other areas. Government should emphasize the environmental protection industry in recent years from the segmentation index. Environmental protection investment in GDP is high, and tax contribution of environmental protection industry in the western region is large. However, the comprehensive competitiveness of environmental protection industry belongs to the lowest level.

The northeastern region is the old industrial base in China with severe industrial pollution, and environmental protection industry started later than the eastern region and the central region. Even though the factor score of industrial scale, industrial contribution, and pollution treatment in the northeast region are positive, the score is significantly lower than that in the eastern and central region. From the subdivision of indicators per capita park green space, nature reserves and other infrastructure construction are evidently insufficient.

**Discussion:** Based on the above qualitative and quantitative analyses, the level of economic development is the fundamental basis for the development of the environmental protection industry. Investment in environmental protection, environmental protection infrastructure construction, and pollution control ability are factors that affect the development of environmental protection industry. Government support and good system environment at also largely affect the development of the industry. The following suggestions and countermeasures are proposed to promote the healthy and sustainable development of China's environmental protection industry.

Firstly, investment in infrastructure development to con-

Table 2: Rotation component matrix.

| | Ingredients | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| $X_1$ Gross regional product | 0.640 | -0.237 | 0.277 | -0.245 |
| $X_2$ Employment in environmental management | 0.709 | -0.182 | 0.484 | 0.217 |
| $X_3$ Number of nature reserves | -0.044 | -0.104 | 0.888 | 0.106 |
| $X_4$ Per capita park green area | 0.357 | 0.213 | 0.502 | -0.108 |
| $X_5$ Investment in the treatment of industrial pollution has been completed | 0.881 | -0.021 | -0.052 | 0.132 |
| $X_6$ Forestry state investment accounts for the proportion of investment sources | -0.548 | -0.027 | 0.213 | -0.228 |
| $X_7$ The proportion of investment in environmental pollution control in GDP | -0.002 | 0.889 | -0.116 | 0.071 |
| $X_8$ Comprehensive utilization of general solid waste | 0.761 | 0.409 | 0.111 | 0.020 |
| $X_9$ Harmless disposal rate of household garbage | 0.303 | -0.211 | -0.242 | 0.657 |
| $X_{10}$ Environmental taxes take up a proportion of tax revenues | -0.068 | 0.906 | 0.095 | -0.056 |
| $X_{11}$ The reduction rate of energy consumption per ten thousand yuan of GDP | 0.014 | 0.173 | 0.303 | 0.831 |

Table 3: Comprehensive performance scores of major regional environmental protection industries in China.

| Region | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F$ |
|---|---|---|---|---|---|
| | Industry scale | Industry contribution | Environmental foundation | Pollution treatment | Composite scores |
| The eastern region | 0.399 | -0.2970 | -0.056 | 0.282 | 0.224 |
| The central region | 0.496 | 0.258 | -0.304 | 0.134 | 0.224 |
| The western region | -0.439 | 0.411 | -0.052 | -0.220 | -0.136 |
| The northeast region | 0.152 | 0.024 | -0.137 | 0.065 | 0.061 |

solidate the foundation for industrial development should be increased. According to the results of empirical analysis, China's environmental infrastructure construction is generally backward, which severely restricts the development of related industries in China, which needs focus on infrastructure construction. Experience of major environmental projects should be learned, such as the "three north shelterbelts". On the basis of the leading role of administration, additional market mechanisms could be used to guide the full input of social resources into energy conservation and environmental protection industries to continuously improve the level of relevant environmental infrastructure construction in China. Combined with environmental protection actions, such as waste classification and water treatment, we will guide local governments to upgrade and upgrade relevant environmental protection facilities according to local conditions, comprehensively improve environmental infrastructure, and effectively consolidate the foundation of industrial development.

Secondly, the government should strengthen environmental policy guidance and accelerate the optimization of industrial structure. Compared with developed countries, China's energy conservation and environmental protection industry are still at an early stage of development, which requires great assistance in environmental policies. (1) Strengthening the policy planning is necessary. By improving the environmental policy system, a mature and complete system from investment in environmental industries and technological transformation to product research and development should be formed to provide policy support for the development of energy conservation and environmental protection industries. (2) Policy guidance should be strengthened by implementing reward subsidies and tax breaks, such as preferential loans of low interest rates and depreciation, in particular, to provide the role of tax leverage, encourage enterprises to conduct technological innovation, research new technologies, develop new materials, produce cleaning products, and to guide the environmental protection industry from the end of the existing governance mainly to clean production, environmental services, and comprehensive utilization of waste. (3) Policy publicity should be increased, especially through the rapid dissemination and great influence of new media. In addition, it should comprehensively publicize relevant environmental laws, regulations and policies, and further popularize environmental protection knowledge. Citizens' participation in environmental protection should be expanded.

Thirdly, industrial technological innovation and improving industrial performance should be encouraged. From the perspective of performance analysis, some problems exist

in the development of China's energy conservation and environmental protection industry, which are highlighted by weak independent innovation capacity, lack of fundamental, pioneering, and subversive technological innovation. Some key equipment and difficult technologies must produce breakthroughs. In view of the current practical problems, such as system energy conservation, pollution control, tailings resource utilization, and industrial waste residue utilization, great importance should be attached to the supporting role of technology in the environmental protection industry, so as to establish industrial alliance, and to strengthen research and development of key technology and equipment products. The market main body role can draw lessons from advanced experience of other countries to encourage enterprises to cooperate with academics, to push the national engineering research centre of energy conservation, environmental protection, and construction of key laboratories to conduct energy conservation. At the same time, industrial talent team should be constructed to accelerate the training and introduction of high-level talents in the field of environmental protection through external introduction and independent training and provide powerful intellectual support for the development of environmental protection industry.

Fourthly, full attention should be paid to regional synergy in industrial development. China's environmental protection industry is developing in a balanced way. Performance of environmental protection industry in the western China is evidently lower than that in other regions. Therefore, considering balanced development of regional environmental protection industry is the top priority for accelerating the development of environmental protection industry in the future. The western region should acquire its own resource advantages and introduce numerous advantageous environmental protection enterprises, advanced environmental protection technologies and equipment by strengthening the cooperation with the central and eastern region to overtake on curves. The comprehensive and balanced development of China's environmental protection industry is promoted through mutual benefit and complementary advantages between the eastern and western regions. Industries between provinces and markets should be opened to create a fair market environment for competition, thereby promoting the formation of a unified national environmental protection market and forming a good and orderly industrial development environment.

## CONCLUSION

In summary, the performance of China's environmental protection industry follows the order of the eastern region, the central region, the northeast region, and the western region, among which comprehensive competitiveness of environmental protection industry in the eastern region, the northeast region, and the central region is above the average level. The western region, however, is lagging behind, well below the average. Therefore, it can be concluded that the performance of environmental protection industry is closely related to the level and stage of regional economic development. At the same time, it shows that the input of environmental infrastructure is all negative, which indicates that the per capita infrastructure construction in China, such as parks and natural reserves, is obviously insufficient.

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