Study on the Temporal and Spatial Patterns of Environmental Quality in China and Its Influencing Factors Based on Two Perspectives of Pollution and Absorption

Qingwen Zhao*, Hong Li
School of Tianjin University of Technology, Tianjin, China

*Corresponding author e-mail: 2935958018@qq.com

Abstract. Based on the two perspectives of environmental pollution and environmental absorption, combined with the regional differences of environmental quality influencing factors, SDM model is used to analyse the influencing factors and spatial effects of environmental quality in China and all regions. The research shows that the spatial agglomeration characteristics of environmental quality are obvious, and the problem of regional imbalance is prominent. The environmental quality and economic development in the eastern region are gradually harmonized, but population agglomeration has a greater negative impact on the environment. The development model of “high investment, high energy consumption, high pollution and low efficiency” in the central and western regions has become a constraint to improve environmental quality.

Key words: environmental pollution; environmental absorption; spatial spillover effect; SDM model.

1. Introduction
At present, the environmental management effect in many areas of China is not good, and the environmental account is still a “confusing account”. The imbalance of long-term geographical development leads to differences in the causes of environmental quality in various regions, and the environmental quality of each region is also affected by the surrounding areas. Therefore, only by clarifying the level of environmental quality, major influencing factors and interrelationships in different regions, can we “prescribe the right medicine” according to the actual situation. In order to achieve this goal, this paper aims to measure China's environmental quality through environmental pollution and environmental absorption, analyze the key factors and spatial effects affecting environmental pollution and environmental absorption in different regions, and provide theoretical support and decision-making basis for how to improve environmental quality. To promote the Chinese economy to a high-quality development.

2. Status and regional distribution of environmental pollution in China
From Figure 1, we can see that the industrial SO$_2$ is generally in the form of “first rise and then fall”. From 2000 to 2006, it increased from 16.125 million tons to 22.348 million tons, with an average annual growth of nearly 1 million tons. From 2006 to 2018. It has dropped to 16.8 million tons, with an average
annual decline of about 460,000 tons. According to the current trend, the continuous decline in the total amount of SO2 emissions is conducive to the improvement of China's atmospheric environment. From 2000 to 2005, China's industrial smoke (powder) dust emissions totaled up to 18 million tons up and down, with little change. The total emissions from 2005 to 2011 fell year by year, with an average annual decline of more than 1.1 million, and the decline between 2005 and 2008. The largest, annual average reduction of about 1.7 million. In 2014, it showed a sharp upward trend, rising from 10.946 million tons to 14.28 million tons.

![Figure 1. China's industrial sulfur dioxide and smoke dust emissions (unit: 10,000 tons)](image1)

It can be seen from Figure 2 that the trends of industrial SO2 emissions in the three major regions are generally showing a downward trend. Industrial SO2 emissions in the eastern and western regions are large. As time goes by, the gap between the two is getting smaller and smaller. By 2014, industrial SO2 emissions in the east and west accounted for about 40% of the country. The central industrial SO2 emissions are the smallest, far less than the eastern and western regions, accounting for only about 20% of the country. However, considering that there are only six provinces in the central region, the average pollution situation in each province cannot be ignored.

![Figure 2. Industrial sulfur dioxide emissions in three major regions of China (10000 tons)](image2)

3. Environmental quality calculation

3.1. Index system construction

In this paper, the indicators of environmental quality are divided into two categories: pollution and absorption, and the three elements of atmosphere, water and soil are selected. Among them, the pollution index covers 10 kinds of pollutants in the fields of industry, agriculture and life. The absorption index selects six indicators that have the functions of reducing pollutants in dust, toxic gases, greenhouse gases, water and soil. The measured index includes two types: one is the environmental pollution index (hereinafter referred to as the pollution index). The higher the index value, the more serious the environmental pollution degree, and the lighter the pollution degree. The second is the environmental...
absorption index (hereinafter referred to as the absorption index). The higher the value, the stronger the environmental absorption capacity, and the weaker the absorption capacity.

3.2. Calculation methods and steps

The environmental quality of China is measured using the improved vertical and horizontal opening method. The steps are as follows:

Step 1: Standardization of indicator data.

\[ x_j^*(t_k) = \frac{x_j(t_k)}{m_{j}^{\text{min}}} \]  

(1)

Step 2: Calculate the real symmetric matrices \( H_k \) and \( H \).

\[
H_k = A_k^T A_k, k = 1,2,\Lambda N; \\
A_k = \begin{pmatrix} x_{it}(t_k) \Lambda x_{im}(t_k) \\ x_{st}(t_k) \Lambda x_{sm}(t_k) \end{pmatrix}, k = 1,2,\Lambda N \\
H = \sum_{k=1}^{N} H_k, K = 1,2,\Lambda N
\]  

(2)

Step 3: Solve the maximum eigenvalue of the real symmetric matrix \( H \) and the corresponding standard eigenvector \( \lambda \).

Step 4: Normalize the standard feature vector to obtain the weight \( \omega_j \).

Step 5: Calculate the environmental pollution index and the environmental absorption index. The calculation function is as follows:

\[
\text{index}_i(t_k) = \sum_{j=1}^{N} w_j x_j^*(t_k), k = 1,2,\Lambda N, i = 1,2,\Lambda n
\]  

(3)

Where: \( \text{index}_i(t_k) \) is the comprehensive measurement index value of the measured province in the \( t_k \) period; \( \omega_j \) is the weight value of the \( j \)-th sub-indicator; \( x_j^*(t_k) \) is the \( j \)-th normalized measured sub-indicator of the \( i \)-province in the \( t_k \) period.

3.3. Calculation results

3.3.1. Environmental pollution perspective. From figure 3, China's pollution level is more serious, the pollution level is increasing, the pollution index rose from 3.98 to 85.23 in 2015, an increase of 2.5 times. From a regional perspective, the concentration of pollution in North China is severe. Among the 30 provinces, the average environmental pollution index of Hainan Province is 4.80, the pollution level is the lightest, and the pollution degree of Hebei Province is the highest, which is 35 times that of Hainan Province. Among all the provinces, only Beijing's environmental pollution showed a general downward trend. Except for Xinjiang, Guizhou and Jiangxi provinces, the pollution index of most provinces in 2016 fell.
3.3.2. **Environmental absorption perspective.** From a global perspective, the overall absorption capacity of the environment is not strong, and the absorption index fluctuates significantly. In 2001, the lowest was 163.95, and in 2016 it reached a maximum of 232.56. Overall, it showed a good development trend. From the regional level, the environmental absorption capacity is constrained by natural conditions, showing a "south strong north weak" situation. Among all the provinces, Sichuan Province has the strongest absorptive capacity, with the average absorption index reaching 558.02, which is more than 100 times the lowest in Tianjin and three times the national level. Sichuan, Yunnan, Guangxi, Hunan, Jiangxi and other provinces have relatively strong absorption capacity, and Beijing, Tianjin, Shanghai, Hebei and other places are relatively weak. Among all the provinces, only Beijing's absorption capacity continued to increase, and Heilongjiang, Shaanxi, Inner Mongolia, Hebei and other places also showed an increasing trend, while Hainan, Hunan, Sichuan, Guangxi, and Yunnan provinces with strong environmental absorption capacity declined.

4. **Spatial impact mechanism of environmental quality**

4.1. **Model Construction and Variable Description**

Through the above test of the spatial spillover effect of environmental quality, it is concluded that there is significant autocorrelation of environmental quality, and the spatial panel regression model can be used to study the impact mechanism of environmental quality. When selecting variables, this paper studies with reference to the STIRPAT model, the formula is as follows:

\[
\ln I_i = a + b \ln P_i + c \ln A_i + d \ln T_i + e_i
\]  

(4)

Where: i stands for environmental quality; P stands for population factor, usually measured by population size or population density; A stands for economic development level, usually measured by total GDP and GDP per capita; T stands for technological development level, usually uses R&D investment, etc. Indicators to measure.

Based on the model, this paper further introduces variables such as urbanization development, industrial structure, energy structure and degree of openness, and analyzes the influencing factors of environmental quality. In addition, under the premise of not changing the original characteristics of the data, in order to eliminate the heteroscedasticity in the data and ensure the smoothness of the data, the logarithmic values of all variables are studied. Immediately afterwards, the Hausman test was performed on the data, and the results all rejected the null hypothesis at the 1% significant level. Therefore, the fixed effect panel regression model was selected for research. Finally, this paper constructs a fixed effect SDM model:
In formula (5): indexit represents the environmental pollution index or environmental absorption index; i represents the province; t represents the year. \( W^*indexit \) is the spatial lag of environmental quality, indicating the interaction between adjacent regions; \( W \) is the first-order spatial neighboring weight matrix; \( \lambda_t \) is the time fixed effect; \( \mu_i \) is the spatial fixed effect; \( \varepsilon_{it} \) is the random error term.

### 4.2. Analysis of regression results

The estimated results of environmental quality impact factors at national and sub-regional levels are shown in Table 1.

**Table 1. Estimation results of factors affecting environmental quality**

| Variable name | Environmental pollution | Environmental absorption |
|---------------|-------------------------|--------------------------|
| LnGDP         | 0.567*** (4.331)        | -0.178*** (-3.310)      |
| LnPD          | 0.560* (1.699)          | -0.032* (-1.870)        |
| LNRD          | -0.142* (-1.757)        | 0.070* (1.773)          |
| LNIS          | 0.188*** (4.171)        | -0.065* (-1.839)        |
| INES          | 0.141** (2.355)         | -0.002* (-1.685)        |
| LNURB         | 0.253*** (3.561)        | 0.017* (1.689)          |
| LNOPEN        | -0.167*** (-5.050)      | -0.013*** (-3.854)      |
| W*LNPGDP      | 0.107* (1.800)          | 0.245 (4.422)           |
| W*LNPD        | 1.209** (2.193)         | 0.162* (1.692)          |
| W*LNRD        | -0.486*** (-3.392)      | 0.011* (1.817)          |
| W*LNIS        | -0.027* (-1.689)        | 0.031* (1.782)          |
| W*LNES        | 0.357*** (3.605)        | -0.038* (-1.734)        |
| W*LNURB       | 0.098* (1.689)          | -0.026 (-0.420)         |
| W*LNOPEN      | -0.063 (-1.467)         | 0.030 (0.964)           |
| W*INDEX       | 0.589*** (20.334)       | 0.712*** (21.553)       |
| \( R^2 \)     | 0.598                   | 0.699                   |
| Obs           | 480                     | 480                     |

### 4.2.1. Analysis based on pollution perspective

From a national perspective, the above factors have a significant impact on environmental pollution. First, economic development, population density, industrial structure, energy structure, and urbanization have intensified environmental pollution. This is related to the extensive economic development model of “first pollution after governance” in the early
At the same time, a large amount of waste generated by the combustion of coal-based black energy has become a major source of air pollution. The development of urbanization and the growth of population density have produced economies of scale. The increase in total pollutants caused by traffic congestion, domestic waste, and engineering construction, in addition to emission reduction technologies, will also increase production capacity utilization and accelerate the development of green processes. Thereby reducing pollution emissions.

4.2.2. Analysis based on absorption angle. Nationally, variables have a significant impact on environmental absorption. First, economic development, population density, industrial structure, energy structure, and opening up have hindered the ability to enhance environmental absorption. Human production and life behaviors and growing populations are increasingly demanding resources, severely interfering with the original ecosystem, leading to climate anomalies and degrading ecosystem regulation. The development idea of the supremacy of interests leads to the natural resources being freely and freely requested. The extensive development and construction has caused a large amount of natural resources such as trees, land and water to be seriously wasted. The level of technology and urbanization have contributed to the enhancement of environmental absorption capacity.

5. Conclusion
Based on the existing research, this paper firstly estimates the environmental pollution index and absorption index of 30 provinces in China from 2001 to 2016, and further analyzes the influencing factors and spatial effects affecting environmental quality, and targets the east, middle and west. The regional differences were compared, and the following main conclusions were drawn: (1) The spatial agglomeration characteristics of environmental quality are obvious, the geographical imbalance is prominent, and the trend of environmental degradation has not been fundamentally reversed. (2) The high proportion of heavy industry is the most important cause of poor environmental quality, which not only aggravates the pollution level but also reduces the absorption capacity, while industrial transformation and upgrading can have a positive spatial effect on environmental quality. (3) The environmental and economic development in the eastern region has become more coordinated, but the negative impact of population agglomeration on the environment is more Big.

References
[1] MICHAEL COMMON, SIGRID STAGL. Ecological economics an introduction[M]. Beijing: Higher Education Press, 2012.
[2] HUANG W M, LEE G W M, Wu C C. GHG emissions, GDP growth and the Kyoto protocol: A revisit of environmental Kuznets curve hypothesis[J]. Energy Policy, 2008, 36(1):239-247.
[3] LIN B Q, JIANG Z J. Prediction of environmental kuznets curve of carbon dioxide in China and analysis on influencing factors[J]. Management World, 2009, 39(4):27-36.
[4] ZHANG Y, SONG W, NUPPENAU E A. Farmers changing awareness of environmental protection in the forest tenure reform in China[J]. Society & Natural Resources, 2016, 29(3):299-310.