Environmental Pollution Management and Suggestions in Anhui Province

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Keywords: Environmental pollution management; Economic development; EKC; Cluster analysis; Principal component analysis

Abstract: Based on the environmental-income EKC curve assumption, this paper selects six types of environmental indicators for industrial waste gas, wastewater discharge, industrial solid waste production, industrial sulfur dioxide, soot and dust emissions from 2007 to 2017, and adopts the main environmental indicators. The component analysis method is used to construct a comprehensive index of environmental pollution, and then clustering analysis is used to group 16 cities in Anhui Province. Finally, the panel model is used to simulate the relationship between the comprehensive indicators of environmental pollution and the per capita GDP in each group. The econometric method and statistical test analyze the characteristics and the stage of the EKC curve of each group, so as to provide policy recommendations for urban environmental management and sustainable development in Anhui Province.

1. Introduction

The environmental Kuznets curve was proposed by Grossman et al. in 1991 to introduce the Kuznets curve into the relationship between environmental pollution and economic growth. It was found that the relationship between SO2 emissions and economic growth is in line with the Kuznets hypothesis. If the vertical axis represents pollution levels (or pollution emissions, etc.) and the horizontal axis represents economic growth (GDP or GDP per capita), then the scatter curve between pollution levels and economic growth is inverted "U". As the economic level reaches a saturated state, the continued rise of the economy will contribute to the improvement of environmental quality. Of course, with the complexity of the environment, other factors will also affect the curve changes, such as regional factors, policy factors. Therefore, in real life, the relationship between environmental pollution and economic growth is not static, and the graph between them may also be in the form of positive “U” type, “N” type, and inverted “N” type. This study analyzes the relationship between economic growth and environmental pollution in Anhui Province based on a model of time series data analysis.

2. Model Design

This paper selects the panel data of 16 cities in Anhui Province from 2007 to 2017 to verify the relationship between economic growth and environmental pollution in Anhui Province. The per capita GDP represents the economic growth index, and the environmental pollution index is calculated by principal component analysis. . The function expression is:

$$y_{it} = \alpha_0 + \alpha_i + \beta_{1i}x_{it} + \beta_{2i}(x_{it})^2 + \beta_{3i}(x_{it})^3 + u_{it} \quad (1)$$

Where y_{it} represents the comprehensive indicator of environmental quality, x_{it} and x_{it}^2 and x_{it}^3 represent the logarithm of the primary, square and cubic terms of GDP per capita, respectively, α_0 represents the common constant term, α_i indicates that there are differences constant terms in different individuals. The coefficients ofβ_{1i}, β_{2i} and β_{3i} vary from individual to individual, and u_{it} represents random error terms. The undetermined coefficients(β_{1i},β_{2i},β_{3i})of the model can

  DOI: 10.25236/iciss.2019.019

reflect the different relationship between economic growth and environmental pollution comprehensive indicators.

(1) $\beta_{1i} = \beta_{2i} = \beta_{3i} = 0$ indicates that there is no relationship between per capita GDP and environmental quality comprehensive indicators, that is, there is no relationship between economic growth and environmental pollution.

(2) β_{1i} is not equal to 0, $\beta_{2i} = \beta_{3i} = 0$, indicating a linear relationship between per capita GDP and environmental quality.

(3) β_{1i} and β_{2i} are not equal to 0 and $\beta_{3i} = 0$, indicating a quadratic curve relationship between per capita GDP and environmental quality, where $\beta_{2i} > 0$, the relationship between per capita GDP and environmental pollution present a "U" sharp. When $\beta_{2i} < 0$, there is an “inverted U” relationship between per capita GDP and environmental pollution indicators.

(4) $\beta_{1i}, \beta_{2i}, \beta_{3i}$ are not 0, that indicating a cubic curve relationship between per capita GDP and environmental pollution. When $\beta_{1i} > 0$, $\beta_{2i} < 0$, $\beta_{3i} > 0$, there is an "N"-type curve relationship between GDP and the comprehensive index of environmental pollution. When $\beta_{1i} < 0, \beta_{2i} > 0, \beta_{3i} < 0$, there is an "inverted N"-type curve relationship between the per capita GDP and the comprehensive index of environmental pollution.

The estimation idea is as follows: firstly, it is assumed that there is a model containing both the squared term of per capita GDP and the third term, and the estimated coefficient is used to judge whether there is an "N" type or "inverted N" type Kuznets curve. If the coefficient of the cubic term is not significant, then the cubic term is eliminated, and the model containing the squared term and the primary term is estimated. The estimated coefficient is also used to determine whether there is a "U" or "inverted U" Kuznets curve. If the coefficient of the squared term is not significant, then the squared term is eliminated and the linear model with only one term is estimated.

3. Empirical Analysis

3.1. Building the Comprehensive Indicator of Environmental Pollution.

In the existing research on EKC, domestic and foreign scholars mostly use environmental pollution concentration, pollutant emissions and ecological environment to measure the environmental quality of a region. In this aspect of research, looking at the research status at home and abroad, most of the single pollutant emissions are used as indicators of environmental quality, which does not reflect the overall situation of environmental quality. With the economic development of Anhui Province, the advancement of technology and people's further understanding of the environment, the national environmental protection policy has made new changes in the environmental pollution structure of Anhui Province. In order to more accurately reflect the current environmental conditions in Anhui Province, this paper will use principal component analysis to construct a comprehensive indicator that can assess environmental quality. According to the availability of data and the status quo of environmental pollution, this paper selects the data of the six most widely used environmental pollutions in Anhui Province from 2007 to 2017 for the economic impact of Anhui Province as a sub-indicator for the comprehensive indicators of Anhui Province. They are mainly industrial wastewater discharge (x_1), industrial exhaust emissions (x_2), industrial smoke (powder) dust emissions (x_3), general industrial solid waste emissions (x_4), respirable particulate matter (x_5), sulfur dioxide (x_6), can be obtained from the index tables of various cities in 2007-2017:

Among the 16 prefecture-level cities in Anhui Province, Ma'anshan City has the largest comprehensive environmental pollution index, followed by resource-based cities such as Huainan and Tongling. These cities have developed rapidly and have serious environmental pollution. Secondly, we can know that the environmental pollution index of Huangshan, Chizhou and other cities is relatively low, and it is far lower than the rest of the cities. This is mainly affected by the Huangshan Mountain Scenic Area and cultural tourism attractions. These areas mainly develop tourism, so industrial pollution relatively small.

Table 1 Environmental Pollution Comprehensive Index of 16 Cities

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Hefei	-1.12	-1.81	-1.81	-1.45	1.21	1.17	1.17	2.06	0.83	0.03	-0.28
Huaibei	-2.28	-1.82	-1.16	-1.15	0.26	0.28	0.36	0.70	2.17	1.45	1.21
Bozhou	-1.96	-2.33	-0.75	-0.22	0.97	0.20	0.43	1.44	1.36	0.01	0.85
Suzhou	-1.19	-0.60	0.02	-0.18	2.19	0.66	-0.28	0.32	0.53	-0.63	-0.83
Bengbu	1.75	1.78	1.23	0.50	-0.37	-0.48	-0.59	-1.15	0.32	-1.36	-1.63
Fuyang	-1.04	-0.97	-0.12	-0.09	1.23	0.27	-0.02	0.58	0.86	-0.47	-0.22
Huainan	0.31	-0.69	-1.56	-0.98	0.84	1.48	1.25	1.32	-0.29	-1.05	-0.63
Chuzhou	0.85	0.58	0.60	1.37	-0.57	-0.42	0.50	0.30	-0.46	-0.99	-1.75
Luan	0.82	1.59	0.48	-0.10	-0.06	-0.04	-0.03	0.55	0.17	-1.66	-1.73
Maanshan	1.40	1.07	0.94	-0.66	-0.10	-0.97	-1.78	-0.75	-0.14	0.39	0.58
Wuhu	1.97	1.36	0.70	0.54	-0.74	-0.90	-0.33	-0.35	-0.35	-0.82	-1.08
Xuancheng	1.53	1.13	1.25	1.24	-0.24	-0.10	0.02	-0.49	-0.69	-1.87	-1.78
Tongling	1.08	-0.64	0.79	0.43	-0.30	-0.24	0.78	1.08	-0.19	-1.20	-1.59
Chizhou	1.88	1.30	0.34	0.19	-0.26	-0.41	0.14	0.45	-1.78	-0.63	-1.22
Anqing	0.17	-0.02	1.11	1.06	0.47	0.22	0.39	-0.01	-0.80	-0.69	-1.90
Huangshan	1.85	2.43	1.94	2.17	-1.12	-1.31	-1.26	-1.41	-1.27	-0.73	-1.28

3.2. Regional Clustering.

The gap between the regions of Anhui Province is very large, especially the economic development level between different cities. Therefore, the overall study in all areas of Anhui is likely to make the conclusions unreliable. In order to eliminate the impact of this problem on the research, this paper will use cluster analysis method to group the various cities and cities in Anhui according to the different development levels of each region, and use the panel data of different grouping areas to carry out the empirical Research between environmental pollution and economic growth.

This paper selects the first two or three industry value-added proportions, the per capita GDP, the average wage, the total fixed assets investment, and the local fiscal revenue of each city in Anhui Province in 2017. These seven indicators are used as indicators to evaluate the economic development of Anhui Province. In the “Annual Statistical Yearbook of 2017 in Anhui Province”, each city of Anhui Province was grouped by the minimum clustering method. The result is as follows:

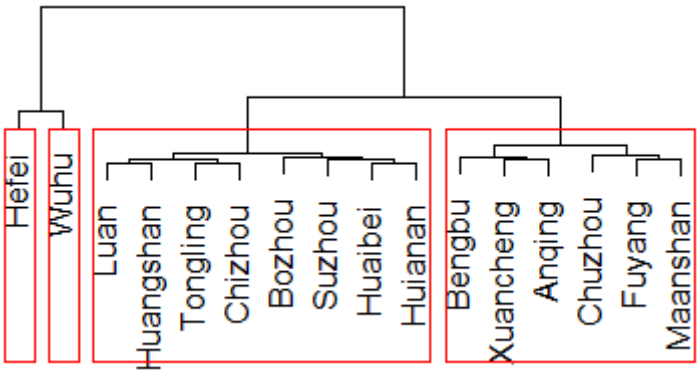

Figure 1. Minimum distance method clustering diagram

We have seen 16 cities in Anhui Province divided into 4 groups according to the level of economic development. The first type of area is Hefei. Hefei is the center of politics, economy, culture, science, education and transportation in the province. The output value of the second and third industries both exceeded 200 billion yuan, and the sum of the two exceeded 500 million yuan. The second category is Wuhu, which is close to the Yangtze River and has geographical and

cultural advantages. The third category is the seven cities of Bengbu, Fuyang, Chuzhou, Maanshan, Xuancheng and Anqing, which are mainly based on agriculture. The fourth category is Huaibei, Bozhou, Suzhou, Huainan, Lu'an, Tongling, Chizhou and Huangshan. It is mainly in the southern part of Anhui Province, with tourism and transportation as its development prospects.

3.3. Results.

After discussing the 16 cities, we found that under different economic development levels, there are different curve relationships between per capita GDP and environmental pollution indicators in different regions, including: inverted “N” type, inverted “U”type, "N" type and monotonically decreasing linear relationship, and the curves of different regions of different groups are basically the same. The specific results are as follows:

Table 2 Regional results of EKC

Regions	Model form	Curve shape
The first group (Hefei)	$y = \alpha + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + u$	Inverted "N" type
The second group (Wuhu)	$y = \alpha + \beta x + u$	Monotonically decreasing
The third group (Bengbu, Fuyang, Chuzhou,Maanshan, Xuancheng, Anqing)	$y_{it} = \alpha_i + \beta_1 x_{it} + \beta_2 x_{it}^2 + +u_{it}$	Inverted "U" type
The fourth group (Huaibei, Bozhou, Suzhou, Huainan, Lu'an, Tongling, Chizhou,Huangshan)	$y_{it} = \alpha_i + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 x_{it}^3 + u_{it}$	"N" type

According to the empirical results, by observing the curve shape of each region, we found that the first group (Hefei) showed an inverted “N” type, and the per capita GDP of Hefei was in the decline phase of the inverted “N” curve. From 2011 to 2014, with the scale of Hefei's economy and the scale of various projects, the investment in industrial “three wastes” and air pollutants has been greatly reduced. Economic growth has destroyed the quality of environmental development. After this period, the country has abandoned industrial waste. The problem of emissions and air quality has been severely punished and actively treated, so the situation of environmental pollution has slowed down in recent years.

The relationship between the third group of environmental quality and per capita GDP is inverted "U" type. In view of the actual situation, Maanshan is a resource-based city with strong dependence on mineral resources such as iron ore and coal mines. Due to large-scale mining, the mining area has formed a large-scale open-pit mine, a large number of waste gangue and iron ore reservoirs. As well as the large surface subsidence caused by mining, it has caused great obstacles to the ecological protection of the mining area. With the implementation of the spirit of the 19th Party Congress, in 2017, Maanshan City's chemical oxygen demand emissions were 23,690 tons, a decrease of 15.05% compared with 2015, and ammonia nitrogen emissions of 2,748 tons, a decrease of 21.18% compared with 2015. The traffic conditions in Bengbu, Fuyang and Chuzhou are superior, the development of the hinterland is broad, and the labor resources are abundant, but the level of economic development is low, and the technical level of environmental protection is relatively backward. With the local government's strict control of factories and pollutant emissions, the ecological environment has also improved in recent years.

The EKC curve of the fourth group (Huaibei, Bozhou, Suzhou, Huainan, Lu'an, Tongling, Chizhou, Huangshan) showed an "N" trend. Since the beginning of 2017, Huaibei City has been guided by the scientific development concept and closely works around the environmental protection center. Therefore, the environmental quality is gradually improving. Suzhou City has

positioned environmental protection from the overall economic and social development, promoted ecological civilization construction and pollution reduction, and comprehensively completed various environmental protection objectives, including unit GDP energy consumption, chemical oxygen demand, nitrogen oxides and sulfur dioxide emissions. Lu'an, Huangshan, Chizhou and other places have a long history and culture, and they are receiving more and more attention from people of all nationalities in the country. Not only because culture attracts tourists, but also because they have achieved good results in ecological construction.

4. Summary

The panel model is used to simulate the economic-environment relationship of each group in Anhui Province. It can be concluded that the relationship between economic growth and environmental quality is affected by many factors, and the factors in each region are different. The shape of the EKC has its own characteristics, that is, under different economic development levels, environmental pollution and economic growth in different regions have different relationships, which is consistent with the empirical results in this section. In addition, there are great differences between different groups, which are related to the economic development roads and environmental protection policies in these areas.

Combined with the provincial conditions and economic development of Anhui Province, the secondary industry in the three major industries has the most serious environmental pollution, while the tertiary industry has little pressure on the environment. Therefore, we can optimize the industrial structure by vigorously developing the tertiary industry. Focus on the development of the financial industry, tourism, information, consulting and technology services, and residential services to improve environmental quality.

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