Environmental Kuznets Curve Test on the Relationship between Economic Growth and Industrial Environmental Pollution in Anhui Province

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Abstract. What relationship exists between environmental pollution and economic growth? Is the environmental pollution issue resolved with economic expansion, or will more severe environmental pollution issues result from economic growth? This article examines the relationship between economic growth and industrial three wastes by utilizing an environmental Kuznets curve, based on data of economic growth and industrial environmental pollution from 2000 to 2020 in Anhui Province. The findings indicate that there is an inverted "U" relationship between industrial waste gas emissions and economic growth, economic growth will eventually reduce industrial waste gas emissions; However, there is a "N" relationship between industrial wastewater discharge and economic growth. The province of Anhui has now passed the second turning point, industrial wastewater discharge is rising along with the economy. With the expansion of the economy, the output of industrial solid waste has been rising. In order to achieve high-quality green development, Anhui Province must accelerate the industrial structure adjustment and increase the input of human capital. This will better promote the coordinated development of the economy and environment and better meet the needs of residents for a good ecological environment.

Keywords: economic growth, industrial environment pollution, Kuznets, Anhui Province

1 Introduction

The level of urbanization and industrialization in China has steadily increased over the past 40 years, which has generated significant environmental pollution issues. It has become crucial to address the interaction between economic expansion and environmental preservation. Anhui Province is situated in the center of China, which is a significant component of the Yangtze River Economic Belt. In August, 2020, General Secretary Xi Jinping visited Anhui and gave crucial directives. Only by preserving the environment and utilizing its ecological benefits to the fullest extent is high-quality development possible. Additionally, as the economy grows and living standards rise, residents' expectations for the quality of their surroundings rise as well. Also, the public can share their opinions and comments about the local living environment more easily in the big data era of the Internet. This paper visited the Department of Ecology and

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Environment of Anhui Province's website, used python crawler technology to gather the handling content of complaints and reports about the province's quarterly ecological environment, and then created the following cloud image using word cloud technology to better understand the residents' perspectives on the surrounding environmental pollution (Figure 1). The results of the cloud image show that inhabitants are very concerned about noise pollution, water pollution, and air pollution, and residents are internally drawn to furthering environmental protection. In recent years, Anhui is in a transitional period, attempting to shift from an extensive economic growth form to one environmentally friendly and effective economic development mode. Choosing Anhui Province as the research subject at this moment has certain theoretical and practical implications.

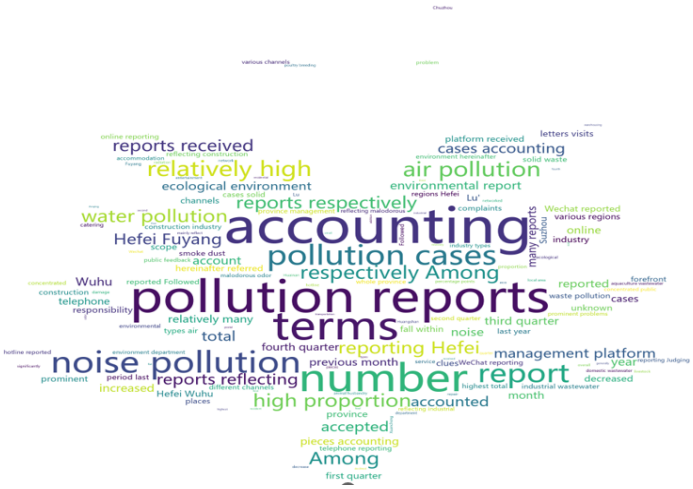

Fig. 1. nephogram of quarterly eco-environmental letters and visits, complaints and reports in Anhui Province

2 Literature review

2.1 Domestic and foreign literature research

Throughout the past century, foreign nations started investigating the link between environmental pollution and economic development. At first, academics only conducted theoretical studies and believed that economic growth would harm the environment, but as time went on, this belief was called into question. Grossman and Krueger [1] investigated the link between economic growth and air pollution and found that, at the start of industrialization, a significant amount of natural energy must be used in order to make the economy develop quickly, and the degradation of environmental quality is inevitable. However, when the industrialization development is more scientific and reasonable, the beneficial impacts of economic development on the environment will surpass the negative effects, and the environmental quality will improve, and finally there will be an inverted U-shaped relationship between the two. The environmental Kuznets curve hypothesis is based on this empirical finding.

The connection between economic growth and air pollution was then examined by numerous academics using the environmental Kuznets curve in various countries and at various times. Nemat S[2]collected data from different countries and examined the relationship between them, they discovered that the regression results were more consistent. Vincent [3] examined the connection between them using Italian data and found that the regression results match the inverted U-shape.

Domestic academics looked into the relationship between economics and ecology after realizing how serious the conflict between the two was. Data collection initially focused on a single region, but later included panel data from provincial and municipal governments. Shen Manhong[4]used the data of Zhejiang Province to analyze the relationship between them and discovered that environmental damage will unquestionably result from economic expansion. Liu Jiaqi et al. [5] took Wuhan as the research object, and found that industrial wastewater discharge coordinated with economic development, but the total amount of wastewater discharge was not coordinated with economic development. Guo Chenglong[6] took Jiangsu, Zhejiang and Shanghai as the research object, and found that three areas' per capita carbon dioxide emissions and per capita GDP displayed an inverted "U" connection and they have all crossed the inflection point at the moment. Yang Ting et al.[7] used urban agglomerations as the research object for an investigation into the relationship between environmental pollution and economic growth. They discovered that while the emissions of industrial wastewater and industrial sulfur dioxide were inverted "U-shaped" with per capita GDP, the emissions of industrial smoke (dust) did not. Wang Shuwen et al.[8] used the provincial panel data of China from 2005 to 2019 to find that the overall domestic waste and economic growth in China showed an inverted "S" shape, the eastern and western regions showed an inverted "U" shape, and the central region showed a "U" shape. Liu Yuanshu et al.[9]studied the relationship between environmental pollution and economic development in six cities in Shandong Province, and put forward the pollution control model on the eastern route. Chen Hanlin et al.[10] found that Wuhan's economic growth promoted carbon dioxide emissions.

2.2 Literature review

China has a vast territory, and various provinces and cities are at different stages due to different development such as resource endowments, and regional development has its own characteristics. Most current research examines the connection between economic expansion and environmental pollution from the viewpoint of an entire nation or large urban areas. Even in a single province or city, the majority of them are concentrated in economically developed areas, which are essentially in a period of continuous improvement with economic growth, while some provinces and cities in the central region are in a period of development and transformation, which are more complicated and changeable than those in developed provinces and cities. Therefore, this research uses the tool of environmental Kuznets to investigate the connection between industrial waste indicators and economic growth in Anhui Province.

3 The relationship model construction between economic growth and industrial environmental pollution in Anhui Province

3.1 Index selection and data sources

To explore the relationship between economic growth and industrial environmental pollution in Anhui province, the specific indicators include economic indicators and environmental indicators. Economic indicators are generally expressed by per capita GDP, which can better reflect the relationship between personal income level and environment compared with the total GDP. Industrial environmental pollution indicators are generally expressed by industrial wastewater discharge, industrial waste gas discharge and industrial solid waste discharge, that is, industrial "three wastes" indicators, which can well reflect the environmental pollution caused by industrial production in Anhui Province, and the statistical time is long, which can meet the requirements of empirical analysis. The index time span selected in this paper is from 2000 to 2020, and the per capita GDP and industrial "three wastes" indicators are all from Anhui Statistical Yearbook.

3.2 Analysis of correlation

Using python software to draw a visual chart of the correlation between industrial waste and per capita GDP. Figure 2's findings show that their relationship is not simply linear, indicating the need for a more complicated model to be created in order to fully understand it.

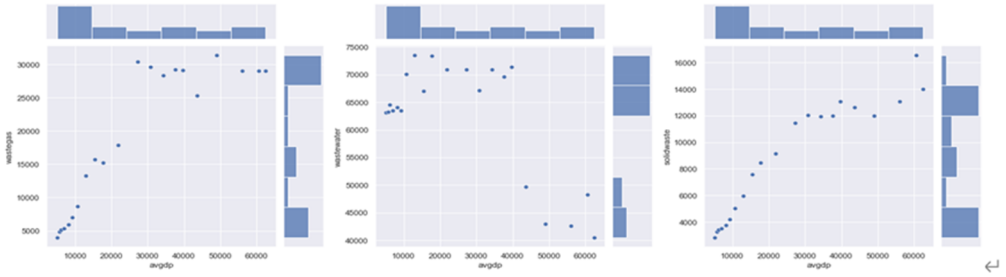

Fig. 2. correlation between industrial waste and per capita GDP (from left to right, industrial waste water, industrial waste gas and industrial solid)

3.3 Measurement model construction

According to the research results of Liu Yuanshu (2020), this paper chooses quadratic and cubic curves to construct the econometric model:

$$Y = \alpha + ax + bx^2 + \varepsilon, \tag{1}$$

$$Y = \alpha + ax + bx^2 + cx^3 + \varepsilon, \tag{2}$$

Y is the industrial environmental pollution index, which is the industrial wastewater discharge, industrial waste gas discharge and industrial solid waste production from 2000 to 2020 in Anhui

Province. X is an indicator of economic growth, that is, the per capita GDP of Anhui Province from 2000 to 2020; α is a constant and ε is a random perturbation term.

Regression analysis was carried out by stata software, and the model was selected according to the fitting degree and the significance of explanatory variable coefficient. Firstly, the quadratic curve fitting or cubic curve fitting is selected according to the fitting degree of the model. Secondly, whether the model passes the T test and the F test is judged. If it fails to pass the test, the suboptimal model is selected.

4 The empirical analysis of the relationship between economic growth and industrial environmental pollution in Anhui Province

4.1 The empirical results of industrial "three wastes" and economic growth

The following empirical results can be drawn from Table 1.

Empirical results of industrial wastewater discharge and economic growth;

$$Y = 49745.53 + 2.593x - (8.29\text{e} - 05)x^2 + (6.29\text{e} - 10)x^3, \quad (3)$$

Empirical results of industrial waste gas emissions and economic growth;

$$Y = -3854.981 + 1.450x - (1.51\text{e} - 05)x^2, \quad (4)$$

Empirical results of industrial solid waste production and economic growth;

$$Y = -1280.526 + 0.789x - (1.6\text{e} - 05)x^2 + (1.20\text{e} - 10)x^3, \quad (5)$$

Table 1. Empirical results of industrial "three wastes" and per capita GDP[1]

	Industrial wastewater discharge	Industrial waste gas emission	Output of industrial solid waste
a	2.593(***)	1.450(***)	0.789(***)
b	-8.29e-05(***)	-1.51e-05(***)	-1.6e-05(***)
c	6.29e-10(**)	-	1.20e-10(**)
α	49745.53(***)	-3854.981(**)	-1280.526
Adjusted determinable	0.7928	0.9544	0.969

4.2 Curve simulation diagram of industrial "three wastes" and economic growth

According to the simulation results of stata, the final industrial wastewater discharge and industrial solid waste discharge are simulated by cubic curve, and the industrial waste gas discharge

[1] "* * *", "* *" and "*" mean passing the test at the significance level of 1%, 5% and 10% respectively.

is simulated by quadratic curve. The coefficients in front of the explanatory variables are all significant at the level of 5%.

According to this function, the function image is as follows. From left to right, it is the simulated relationship diagram between industrial wastewater discharge, industrial waste gas discharge and industrial solid waste discharge and per capita GDP:

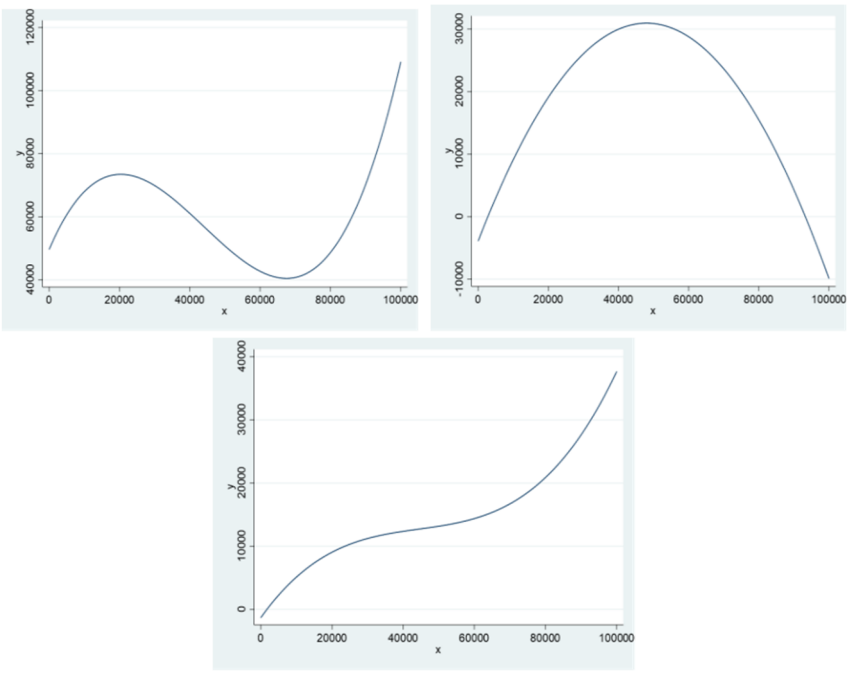

Fig. 3. Simulation diagram of industrial "three wastes" and per capita GDP in Anhui Province (Y is industrial "three wastes" and X is per capita GDP)

Figure3 illustrates the positive "N" relationship between the province of Anhui's industrial wastewater discharge and per-capita GDP. According to the function calculation results, the per capita GDP at the first inflection point is 20,355 yuan, and Anhui Province successfully crossed the first inflection point in 2010 and entered a period in which industrial wastewater discharge decreased with the increase of per capita GDP. The per capita GDP of the second inflection point is 67,510 yuan, the release of industrial wastewater will keep rising along with the per capita GDP. Figure 1 also illustrates the relationship between industrial waste gas emissions and per capita GDP in Anhui Province as an inverted "U" shape. Calculations show that Anhui Province effectively passed the inflection point in 2017 when per capita income hit a high of 48,013 yuan, meaning that while per capita GDP increased, industrial waste gas emissions decreased. As can be seen from Figure 1 shows that in Anhui Province, the output of solid waste and per capita GDP generally have a positive relationship, meaning that as per capita GDP grows, so does the output of solid trash.

5 Conclusions and recommendations

This research investigates the relationship between economic growth and industrial environmental pollution using data from Anhui Province from 2000 to 2020. The empirical study indicates that there is an inverted "U" relationship between industrial waste gas emissions and economic growth, and a positive "N" relationship between industrial waste water emissions and economic growth. With the expansion of the economy has come an increase in industrial solid waste production. In light of this circumstance, the following recommendations are made.

First and foremost, the industrial structure must be continuously improved and optimized in order to meet the twin objectives of economic expansion and the decrease of industrial pollutant emissions. In recent years, China's transformation from the secondary industry to the tertiary industry is getting faster and faster, but regional differences in development mean that Anhui Province still retains a sizable amount of secondary industry. Faced with this situation, Anhui Province needs to offer inclined policy support that is inclined to minimize pointless administrative barriers; Secondly, the efficient upgrading of the industrial structure is inextricably linked to the investment of a significant amount of human capital. Anhui Province needs to increase investment in educational resources, actively introduce high-tech talents, raise the technical and cultural level of workers, prevent needless unemployment brought on by industrial upgrading, and finally achieve rapid economic development, so that the positive impact of economic growth on the environment is more and more obvious.

Secondly, Anhui is in a phase of transition, and the market mechanism and various forms of government administration are not adequate. The government is able to lower the wastewater and industrial waste gas discharges by means of prices and taxes. For example, the government raises the cost of factory sewage by collecting sewage charges and other means, and then presses relevant factories to limit pollution discharge or to undertake the necessary cleaning preparations before discharging pollutants, and the problem of negative externalities is solved to a certain extent through government intervention.

Finally, regardless of the kind of atmospheric environmental control approaches, we need excellent environmental legislation. Although some issues can be resolved by economic means, the market will also fail for various reasons, necessitating the use of law. In addition, only the implementation of high standards can promote healthy economic development.

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