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An Empirical Analysis of the Environmental Kuznets Curve in China: Take R City as an Example

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Abstract

"Environmental Kuznets Curve" refers to the "inverted U" curve relationship between economic development and environmental quality, that is, with the economic development and the improvement of income level, environmental quality deteriorates first and then improves. Based on the characteristic principle of the environmental Kuznets curve, according to the economic and environmental changes of R City from 2006 to 2015. This paper focuses on the analysis of the best fitting model between the chemical oxygen demand emissions, permanganate index in surface water, sulfur dioxide emissions of air pollutants, sulfur dioxide concentration and economic development of R City. The results show that the changes of the first three factors and per capita GDP conform to the environmental Kuznets hypothesis. Although the variation rule of SO2 concentration in air to GDP per capita does not accord with the environmental Kuznets hypothesis, the SO2 concentration in air will show a downward trend.

Keywords

Environmental Quality, Economy, Environmental Kuznets Curve.

1. Introduction

As the second biggest economy, China has also been experiencing a rapid economic growth rate. At the same time, the problem of environmental pollution has been increasingly conspicuous. Under this situation, how to maintain the environment while performing even more economic activities has continually been a hot issue among people. The Chinese government considers that the treatment of waste gas and wastewater discharge is the focus of their duties. At the State Council executive meeting held in 2009, it is required that carbon dioxide emissions per unit GDP should decline by 40% to 45% compared with 2005 by 2020. On June 27, 2018, the State Council issued the "Three-Year Action Plan to Win the Blue Sky Defense War" to cope with the serious problem of gas pollution at Jing-Jin-Ji region. In fact, the relationship between economic development and environmental deterioration has been researched in many other counties decades ago. Among all these studies, the environmental Kuznets curve brought up by Grossman and Krueger linked per capita income and different environmental indicators graphically and mathematically. The main idea of environmental Kuznets curve is that in the initial period of economic development, the environment deteriorates with economic growth, after reaching a point of per capita income of approximately $8000, environment condition gets better with the development of economy. Is this environmental Kuznets curve applicable to China? If the answer is positive, then we should not hesitate to develop our economy since the concern of worsening the environment will be nonsexist in the future.

As said above, in the past decades, many scholars and researchers put efforts into researching the area of linking environments and economics together. The earliest studies on the Environmental Kuznets Curve (EKC) were Grossman (1993,1995) [1-2], Shafik (1999) [3] and

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Panayotou (2003) [4], three independent studies in the early 1990s founding that economic growth is closely related to environmental pollution, and the inverted U-shaped, U-shaped and N-shaped curves between environmental pollution and economic growth, which rose first and then decreased. In 1993, Grossman and Krueger shed light on the relationship between environment indicators and economic growth in a part of their paper “Environmental Impacts of a North American Free Trade Agreement”. Using the cross-section data from 42 countries, they found that concentrations of two air pollutants and national income presents an inverted U-shaped relationship. In 1995, they further examined relationship between national income and environmental indicators including water and air quality by using reliable panel data from lots of countries around the world. Additional empirical evidence confirmed their initial conception and determined the various critical levels of income for those indicators to be less than $8000. However, when it comes to deforestation, the environmental Kuznets curve appears to be nonexistent according to the research performed by Koop and Tole (1998). Using data of developing countries during 32 years and relaxing some restricted assumptions, they concluded that there was no strong evidence that deforestation exhibit an inverted-U shape relation with GDP per capita. Perman and Stern think the application of EKC is limited. In a paper published in 2003, they argued that EKC's experience in sulfur emissions proved unreasonable.

As to whether EKC can be applied to China, great numbers of domestic scholars have done empirical tests both for the whole country and for certain areas or provincials in the beginning of twenty-first centuries. As Chen and Liu stated in their paper about air pollution in Shanghai and local economic development, the conventional EKC theory was valid for most environmental indicators and turning points for different indicators also varied. Nevertheless, Shen and Xu (2000) discovered an unconventional relationship between quantities of three types of industrial waste and per capita income in the province of Zhejiang for the last 20 years [5]. The relation curve is first inverted U-shaped and then U-shaped. Hu et al employed panel data of carbon emission in 31 provincials of China from 1990 to 2005 and concluded that levels of carbon emission have an N-shaped relation with scales of economic activities. The EKC hypothesis of Erhai Lake and its watershed is empirically studied by using inverted U-shaped EKC and Ke Gaofeng et al(1995) [6]. It is found that the fitting curves of the EKC hypothesis are inverted U-shaped, U-shaped, N-shaped and inverted N-shaped. Zhu (2014) analyzed the empirical evidence of economic growth and water environment EKC hypothesis in Bohai Rim of Liaoning Province from 1999 to 2010, and found that the fitting curves of the region are inverted N-shaped, U-shaped, N-shaped, respectively. Environmental quality does not occur automatically with the increase of income level [7].

In the early stage of economic development, environmental quality may decline and deteriorate with economic growth, but at a certain turning point, environmental quality may gradually improve with the further development of the economy. Various results could attribute to many reasons, such as environmental indicators, data sources and type, countries and even certain specifications. However, the link between the economic situation and environment condition is undoubtedly to many experts in relevant fields. Thus, it is necessary and meaningful for us to investigate their relation further.

In 2015, the per capita GDP of R reached US$12,000 and crossed US$4,000 into the "middle income stage" in the sense of economics. Therefore, the Kuznets curve is proposed to analyze the relationship between economic development and environmental quality in R during the "12th Five-Year Plan".

According to the regional particularity, system coordination, comparability and operability, and based on the current environmental management model, the environmental indicators are selected as dependent variables, including chemical oxygen demand emissions, permanganate index concentration in surface water, sulfur dioxide emission and sulfur dioxide concentration

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in air, which are closely related to emission reduction. The economic development indicators per capita GDP of the whole city are selected as independent variables (X). The fitting equation is quadratic and cubic polynomial Selecting the data related to environmental quality and economic development in R from 2006 to 2015.

2. Major Socio-Economic Situation

2.1. Economic Aggregate

During the 12th Five-Year Plan period, under the strong leadership of the provincial Party Committee and the provincial government, and with the joint efforts of the people of Taizhou, great achievements were made in economic and social development and the main objectives and tasks of the 12th Five-Year Plan were accomplished. The comprehensive strength will achieve a new leap forward. The city's GDP has exceeded 360 billion yuan, and the per capita GDP has exceeded 120,000 US dollars. The average annual growth rate is 11.4% and 11.3%, respectively. The development rate is in the forefront of the province. The highest annual growth rate of per capita income is 12.6%. In the long run, the annual per capita income in Taizhou is on the rise, which shows that Taizhou's economic growth is full of vitality and has entered a period of rapid growth.

2.2. Regional Industrial Structure

During the 12th Five-Year Plan period, R comprehensively implemented various policies and measures of the central government to promote "steady growth, structural adjustment, reform, benefit people's livelihood" and the provincial Party Committee and the provincial government to make progress in a stable way. Focusing on the theme of scientific development and the mainline of changing the development mode, focusing on improving the quality and efficiency of economic growth, we should accelerate the transformation and upgrading of the province by promoting the pilot comprehensive reform of transformation and upgrading. High-end equipment, biomedicine, electronic information, new energy, smart grid, new materials, energy saving and environmental protection and other seven emerging industries are booming. The pilot work of comprehensive reform of transformation and upgrading has achieved initial results. Traditional industries have stepped forward to the middle and high end, new and emerging industries such as biomedicine have accelerated their growth. The output value of high-tech industries accounted for 42% of the industrial output above the scale, and a national innovative pilot city and a national intellectual property demonstration City have been built. By the end of the 12th Five-Year Plan, the proportion of the primary industry had been adjusted from 7.4% to 6.0% at the end of the 11th Five-Year Plan, the proportion of the secondary industry from 56.2% at the end of the 11th Five-Year Plan to 49.0%, and the proportion of the tertiary industry from 36.4% at the end of the 11th Five-Year Plan to 45.0%. Secondary industry is still the pillar industry.

3. Fitting Results of Kuznets Curve Between Environmental Quality and Social Economy

3.1. The Relationship Between Chemical Oxygen Demand (COD) Emissions and Permanganate Index Concentration in Water and Economic Development from 2006 to 2015.

The regression coefficients (R2) of COD emissions to per capita GDP quadratic curve and cubic curve fitting regression equation (R) are 0.749_0.976, respectively. R2 represents the ratio of the sum of regression squares to the sum of total deviations squares. The closer the R2 value is to 1, the more the equation is explained. The better the regression effect is, the more accurate

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the model is to fit the actual situation. Obviously, cubic curve fitting has a good correlation. The correlation between COD emissions and per capita GDP is shown in Fig. 1.

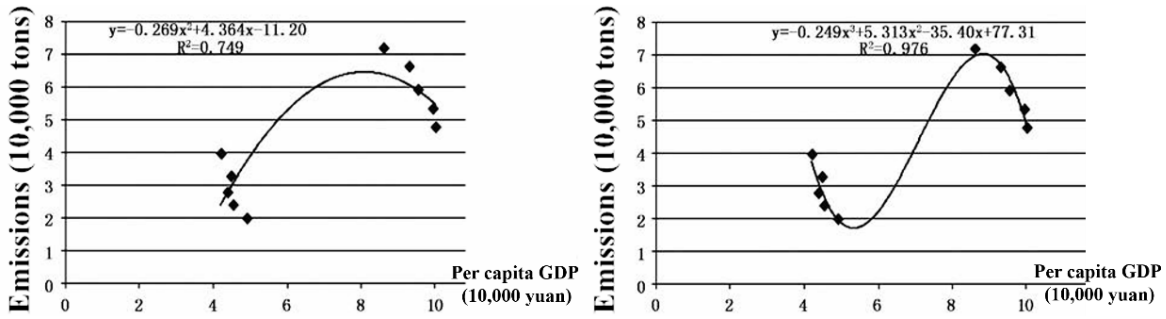

Fig 1. The correlation between chemical oxygen demand emissions and per capita GDP

As can be seen from Figure 1, the regression models obtained by cubic curve fitting are as follows:y = - 0. 249x3 + 5. 313x2 - 35. 40x + 77. 31

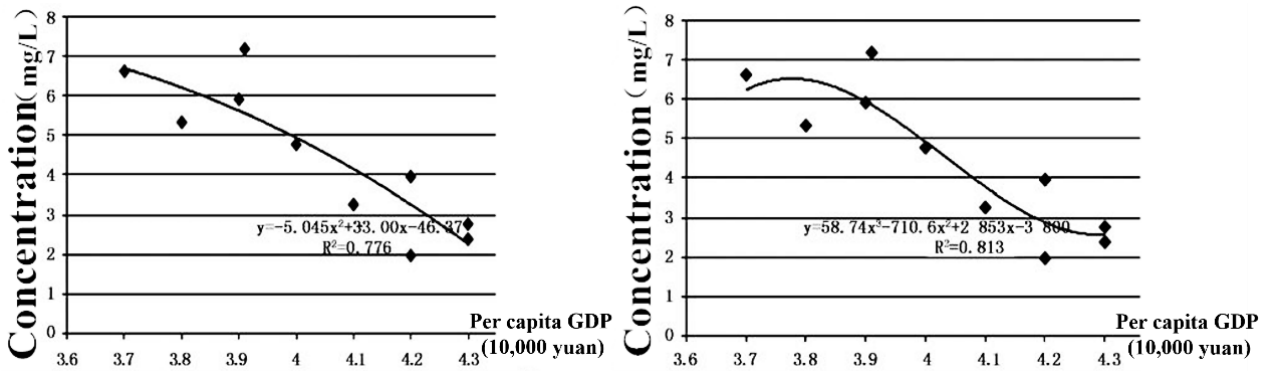

Fig 2. The correlation between permanganate index and per capita GDP in surface water

As shown in Fig. 2, the regression model of cubic curve fitting is y = 58. 74x3 - 710. 6x2 + 2 853x - 3 800. The cubic curve fitting models of COD emissions and surface water permanganate index concentration on per capita GDP conform to the environmental Kuznets hypothesis, showing N-shaped and inverted U-shaped curves respectively. The highest inflection point of COD emissions occurred in 2011, when GDP per capita was 47.8 million yuan ($7966); the highest concentration of permanganate index in surface water occurred in 2007, and GDP per capita was 24 million yuan ($4000).

3.2. The Relationship Between SO2 Emission and SO2 Concentration in Air and Economic Development

From 2006 to 2015, the fitting regression coefficients (R2) of sulfur dioxide emissions to per capita GDP quadratic curve and cubic curve were 0.738 and 0.913, respectively. Cubic curve fitting has a good correlation. The correlation between sulfur dioxide emissions and per capita GDP is shown in Fig. 3.

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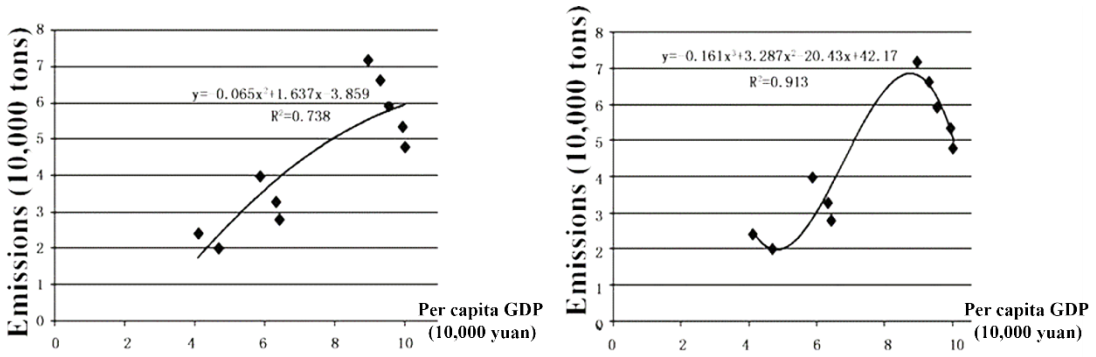

Fig 3. The relationship between sulfur dioxide emissions and per capita GDP

As can be seen from Fig. 3, the regression models obtained by cubic curve fitting are: y = - 0. 161x3 + 3. 287x2 - 20. 43x + 42. 17. The cubic curve fitting models of sulfur dioxide emissions to per capita GDP all conform to the environmental Kuznets hypothesis, showing a N-shaped curve the highest inflection point of sulfur dioxide emissions occurred in 2011, and the per capita GDP of that year was 4. 780,000 yuan ($7,966).

From 2006 to 2015, the regression coefficients (R2) of sulfur dioxide concentration in air to the conic and cubic curve fitting of per capita GDP were 0.100 and 0.184, respectively. The regression coefficients of the conic and cubic curve fitting were far less than 0.8. The results show that the variation of SO2 concentration in air and GDP per capita in the past ten years does not accord with the environmental Kuznets hypothesis, and the regression model obtained has no practical significance, as shown in Fig. 4.

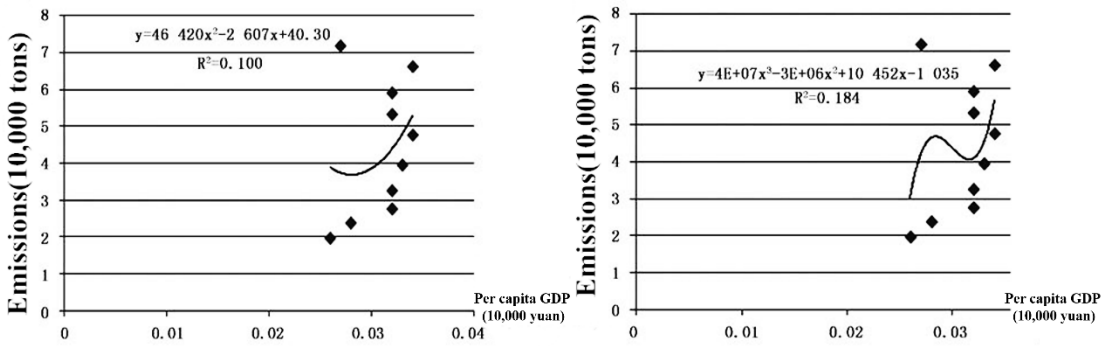

Fig 4. The correlation between SO2 concentration in air and GDP per capita

4. Conclusion

(1) COD emissions and permanganate index concentration in water accord with the environmental Kuznets hypothesis. It is predicted that COD emissions and permanganate index concentration will turn to a downward trend.

(2) The change rule of SO2 emission and per capita GDP is in line with the environmental Kuznets hypothesis, and the trend of SO2 emission is predicted to decline.

In the past ten years, R City has strictly controlled the total amount of major atmospheric pollutants, vigorously promoted the upgrading of desulfurization and denitrification standards focusing on the power industry. The cubic curve fitting model of sulfur dioxide emission and per capita GDP conforms to the environmental Kuznets hypothesis, showing a N-shaped curve. The highest inflection point and the lowest obedience point of sulfur dioxide emission conform to the range of 15,000 to 59,000 yuan per capita GDP. The sulphur dioxide emission has reached a turning point of 47,800 yuan per capita GDP in 2011, while R's economic development has entered the "middle income stage" as early as 2007. It can be seen that the sulphur dioxide

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emission lags behind the GDP per capita, which is also in line with the concept that environmental indicators are not necessarily synchronized with economic indicators. Some scholars believe that economic indicators themselves may not be able to understand. In order to solve environmental problems, the trend of environmental deterioration will continue to increase with the expansion of economic scale, even if the per capita income level exceeds the average level of inflection point without corresponding policy regulation.

(3) The variation of sulfur dioxide concentration in the air of R City to GDP per capita does not accord with the environmental Kuznets hypothesis, but the concentration of sulfur dioxide in the air will show a downward trend.

Environmental-economic system is a complex system. In addition to the influence of GDP per capita, the interaction of SO2 concentration in air is also affected by many other factors, such as population, coal consumption, meteorological conditions, motor vehicle ownership, etc. Therefore, the traditional Kuznets model with GDP per capita as a single independent variable sometimes fails to reflect the impact of other factors on the environment in economic development.

In short, economic development and environment are interdependent and mutually restrictive, and they are dialectical relations of unity of opposites. Therefore, the benefits of economic development can not only be measured by speed indicators but also consider the environmental impact. At the same time, we should emphasize the important role of environmental policy and investment in environmental protection in improving environmental quality, so as to promote the sustainable development of the city.

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