An Empirical Analysis of the Relationship Between Economic Development and Environmental Quality in Eastern China

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Abstract This paper takes the eastern China as an example, the relationship between environmental pollution and economic development is analyzed, and then the breakthroughs in the development path of EKC turning point are sought. Furthermore, the paper uses the environmental data of the eastern China from 1996 to 2007, with GDP per capita as an economic development index, and with volume of industrial waste water discharge, industrial waste gas emission and industrial solid wastes produced as environmental quality indices, to adopt EKC curve for data fitting, coming to the conclusion that eastern China can be basically explained by EKC curve theory. In the meanwhile, the result shows that the relationship between water environment and economic development is in accordance with the characteristics of EKC, and environmental pollution in eastern China has been in a rapid growth in recent years, which is not very optimistic.
Key words Eastern China; Environmental quality; EKC curve; Sustainable development

1 Introduction

In western countries, economic development is so rapid that environmental issues are highlighted earlier than China. So in these countries, about a few decades ago, the importance of environmental problems was realized, and a series of researches about environmental issues were conducted. In the middle of 20th century, an economist called Kuznets proposed a hypothesis that in the process of economic development, the income gap initially increases with the economic development, followed by gradual reduction of the gap. When illustrated in the Cartesian coordinate system, per capita income is made as the abscissa to indicate economic growth and changes of the income gap are made as the vertical axis, so this hypothesis can be expressed as an arch-shaped curve, commonly referred to as "inverted U"-shaped curve, but also is called the Kuznets curve [1].

In the early 1990s of the last century, U.S. economists found through research that this hypothesis also applies to environmental issues. Environmental pollution conditions do not actually become serious with economic development. In the early stages of economic development, environmental quality deteriorates with economic development. Until the economic development reaches a certain degree, the environmental quality will improve along with economic development, generally considering a turning point in 8000 U.S. dollars per capita GDP. While the corresponding Kuznets curve, also known as the Environmental Kuznets Curve, that is EKC curve. Subsequently, many western scholars have studied and found that this hypothesis holds true in western countries. Similarly, in areas such as South Korea, Hong Kong, Singapore and some other newly industrialized countries, this hypothesis is valid. In short, in those countries and regions with rapid economic development, Environmental Kuznets Curve is established.

Since the late 1970s of the last century, China's economic development has been on track, while environmental issues have gradually emerged only in recent years, but the hazards of environmental problems are not reduced. On the contrary, China's rapid economic development compared to western countries is still in a backward state, the study of environment problems is urgency. "China's sustainable development in the 21st century action program" clearly points out that one of the problems in China's current implementation of sustainable development is the contradiction between rapid economic growth, consumption of resources and ecological damage. This problem has a direct impact on the effectiveness of China's economic development, touching on all aspects of social development if it cannot be solved. For this reason, in recent years, many Chinese scholars have studied relations between environmental issues and economic development from both theoretical and empirical aspects. Yufeng (2006), based on American scholar Stern's theory, use 1999~2004 panel data for six years between provinces and cities in China to give a comprehensive analysis about economic development impact on environmental quality, the results showing that expansion of economy and change of industrial and energy structure increases environmental pollution, while productivity improvement, innovation and promotion of environmental technologies reducing environmental pollution. And he also calculated the contribution of various pollutants on environmental pollution[2]. Zhao Haixia (2006), analyzing the mechanism of economic

growth factors impact on environmental emissions, built an environmental pollution and econometric comprehensive analysis model and took Jiangsu Province as an example to analyze the causes of environmental pollution between 1990~2002[3]. WU Hai-Ying (2005) used a revised EKC curve to analyze the relevant data of economic growth and major industrial pollutant in China's western region between 1986 and 2003, and found that the western region's economic growth and environmental quality had shown a "U" curve relationship, rather than Western scholars' conclusion, the "inverted U" -type relationship[4]. Liang Liutao (2008) analyzed the impact of the total economic growth, economic structural change and technological progress on changes of environmental quality from1986 to 2005 in Jiangsu Province, and found that the relationship between emission of pollutants in Jiangsu Province and economic development does not comply with environmental Kuznets hypothesis. The result also shows that the impact of economic growth on the scale effect of environmental quality of is negative, there being a spontaneous trend of environmental degradation. Structural effect on the quality of the environment is positive, and to a certain extent it is able to improve environmental quality. However, technological effect on the quality of the environment impact is not obvious[5]. Chen Banghua (2007) explore this problem through the system theory and propose to look at this issue from a height of strategic development, and propose some appropriate environmental protection measures[6].

Many scholars' studies of the relationship between economic development and environmental quality are many, but involve little in the research of China's eastern region, where economic development is developed. And looking at recent studies, many scholars make researches or in only a single region, such as a province or municipality, in a large time span, or for a large area, such as the western regions, in a small time span. Moreover, the data is analyzed, using per capita GDP as the main factor or pollution factors, to make a complex multivariate analysis. In this paper, the author extracts data from the Statistical Yearbook of the calendar year in 10 provinces in the eastern China from 1996 to 2007, which is 12 years, uses per capita GDP to indicate economic activities to analyze the relationship between economic development and environmental quality. In this way, a relatively simple way can be used to discard those shortcomings, and gives a clear conclusion.

2 Status of Economic Development and Environmental Quality in Eastern China

Table 1 Population and GDP Development in the Eastern Region of China(1996~2007)

Year	R1	R2	R3	R4	R5
1996	34699.58	41257.00	8410.59	33.71%	50.59%
1997	39058.81	41619.00	9384.85	33.67%	52.24%
1998	42329.77	41907.00	10100.88	33.58%	53.31%
1999	45439.26	42223.00	10761.73	33.53%	55.47%
2000	51020.52	44895.00	11364.41	34.66%	57.07%
2001	56060.09	43728.00	12820.18	34.26%	58.44%
2002	62830.84	44028.00	14270.66	34.28%	59.96%
2003	73280.86	44411.00	16500.61	34.37%	62.50%
2004	88433.10	45034.00	19636.96	34.64%	64.61%
2005	109924.64	46388.00	23696.78	35.48%	60.04%
2006	128593.05	46906.00	27415.05	35.68%	60.98%
2007	152346.38	47476.00	32089.14	35.93%	61.05%

Data from "China Statistical Yearbook" (1997-2008), where, GDP data in this table are calculated at constant price of 1995

Eastern China includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan of 10 provinces and municipalities, covering 91.6 million square kilometers, accounting for 9.5% of China's total land area. The eastern region beside the mainland, faces the ocean, has flat terrain and good conditions for agricultural production and is rich for aquatic products, petroleum, iron ore, salt, and other natural resources. This region plays a leading role in the whole

economic development due to a long history of exploitation, superior location, high-quality workers, strongly technical force, firmly industrial and agricultural foundation.

It can be seen from the table that the eastern region covers an area of only 9.5% of the country, but the total population rises almost every year, from 412.57 million in 1996 to 474.76 million in 2007, accounting for 35.93% of the total population. Development of the population can be seen following diagram:

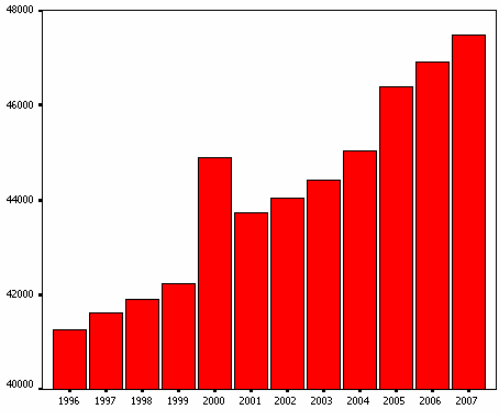


Figure 1 Population Per Year

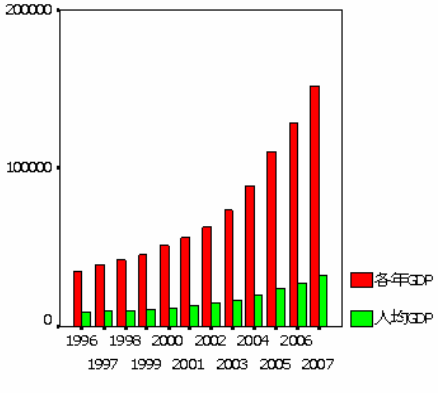


Figure 2 GDP and Per Capita GDP Per Year

And the GDP development of the eastern region is even more alarming, in a 916,000-square kilometers area, from 3.469958 trillion Yuan in 1996 to 15.254638 trillion Yuan in 2007 through twelve years development, accounting for 61.05% of all, more than half the whole country. GDP per capita developed from 8410.59 Yuan in 1996 to 32,089.14 Yuan in 2007. The development of GDP and per capita GDP in eastern region can be seen in the above figure 2.

However, the rapid economic development, on the other hand, makes environmental pollution more serious. This paper selects the total discharge of industrial waste water, industrial waste gas emissions and industrial solid waste produced as a measure of the degree of environmental pollution indicators. The data extracted from statistical yearbooks is processed as the table below:

Table 2 Emission of Waste Water, Waste Gas and Solid Waste

Year	S1	S2	S3	S4	S5	S6
1996	842544	44029	19825	40.92%	39.60%	30.08%
1997	738729	44138	19504	39.23%	38.93%	29.66%
1998	857845	49390	22481	42.76%	40.75%	28.09%
1999	826732	52060	22905	41.90%	41.05%	29.20%
2000	830230	59943	23803	42.74%	43.39%	29.17%
2001	947380	73905	30732	46.75%	45.94%	34.59%
2002	979980	74655	30179	47.30%	42.60%	31.95%
2003	990129	87933	30438	46.65%	44.21%	30.31%
2004	1063358	104907	41627	48.08%	44.13%	34.68%
2005	1216274	121107	44846	50.03%	45.02%	33.36%
2006	1212430	146497	47684	50.48%	44.26%	31.47%
2007	1223931	167879	47476	49.62%	43.25%	31.46%

In the table Ⅱ，S1, S2 and S3 separately mean Wastewater(million tons), Waste gas(million standard cubic meters), Solid waste (million tones)，while S4, S5 and S6 separately mean proportion of wastewater, waste gas, solid waste.

From 1996 to 2007, GDP of the eastern region grew by 339.04%, while correspondingly industrial wastewater emission by 45.27%, industrial waste gas emission by 281.29%, industrial solid waste

produced by 139.48%. Of all, industrial waste water emission accounts for 45.54% on average, industrial waste gas emission 42.76% on average, industrial solid waste produced 31.17% on average. This shows that rapid economic development will inevitably produce a certain degree of environmental pollution.

3 The Empirical Analysis of the Relationship Between Economic Development and Environmental Quality

This paper attempts to the use of environmental Kuznets curve theory and the use of SPSS11.5, per capita GDP as economic development, to study the relationship between economic level and the environment quality, respectively, from industrial waste water emission, industrial waste gas emission and industrial solid waste produced. Taking into account the accuracy of the model parameters, this paper uses the following model:

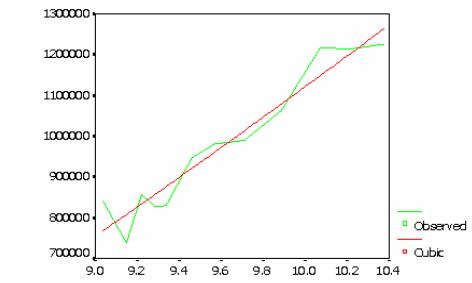
$$y = b_0 + b_1 Lnx + b_2 (Lnx)^2 + b_3 (Lnx)^3 + \varepsilon_0$$

In this model, x is per capita GDP, measured in Yuan per person. y is for the industrial wastewater emission or industrial waste gas emission or industrial solid waste produced, and its unit is respectively 10000 tons, 100 million cubic meters and 10000 tons. b_0, b_1, b_2 and b_3 are model coefficients, and ε_0 is a random disturbance term. The data is from 1996 to 2007. Fitting results are as follows:

Table 3 Data Fitting Results

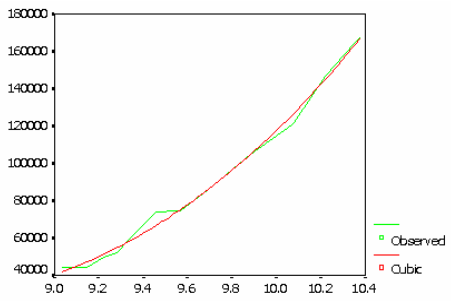
Dependent	Rsq	d.f.	F	Sigf
Wastewater	0.930	9	60.03	0
Waste Gas	0.994	9	767.80	0
Solid Waste	0.960	9	108.21	0
Dependent	b0	b1	b2	b3
Wastewater	-1.E+06	/	28592.7	-658.27
Waste Gas	671216	/	-28080	2254.53
Solid Waste	-283080	37057.9	/	-46.203

The corresponding fitting graph as follows:



Per Capita GDP

Figure 3 Fitted Curve of Waste Water



Per Capita GDP

Figure 4 Fitted Curve of Waste Gas

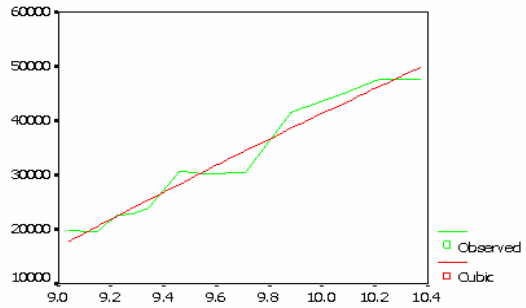


Figure 5 Fitted Curve of Solid Waste

The results show that when per capita GDP as the independent variable, the industrial wastewater emission, industrial waste gas emission and industrial solid waste produced can be seen in a general growth. With per capita GDP increases every year, the dependent variable is also increasing. Of these, the fitted curves of industrial wastewater emission and industrial solid waste produced is almost a straight line, and only the fitted curve of industrial waste gas emission is a graphic that can be looked like a U-shaped curve. The calculated differential functions of the three fitted curves are as follows:

Wastewater: $y = 57185.4x - 1974.81x^2$

Waste gas: $y = -56160x + 6763.59x^2$

Solid waste: $y = 37057.9 - 138.609x^2$

By an analysis of the three differential functions, we may further understand that although the three fitted curves are a growth trend, they are yet different. The wastewater fitted curve is between the minimum point and the inflection point, on the left of the maximum point, and the curve slope is on the increase, indicating it is still in the extreme left of the EKC curve. The waste gas fitted curve is on the right of the inflection point, the minimum point and the maximum point, and the slope is also on the increase, indicating at least in the next few years, waste gas emission will have been in a growing stage, which has not yet entered the EKC curve . The solid waste curve is on the right of the minimum point of the entire curve, between the inflection point and maximum point. And the slope of the curve continues to decrease, indicating that this fitted curve is already part of the EKC curve, and in the next few years it could reach the highest point and slowly decline as mentioned in the theory.

Overall, except the waste gas fitted curve, EKC curve is more in line with China's real situation. As for the waste gas fitted curve, if the state gives a certain degree of intervention, it should also be consistent with the EKC curve. At the same time, it should be noted that the factors that affect data fitting are many. For example, an accurate per-capita GDP requires accuracy of population and GDP estimates first of all. The latter errors will inevitably result in distortion of per capita GDP, thus causing inconsistent with the theoretical curve.

It should be noted, EKC curve theory similar to the “invisible hand” theory in economics, is a ultimate result from a variety of human factors. When specific to the EKC theory, that is the booming economy, on the one hand, will lead to a large number of pollutants, causing environmental pollution. On the other hand, it gives birth to the technological level and industrial structure upgrade. These two forces balance each other, and then they will cause the initial pollution gradually reducing into a low level. This also explains, that EKC curve is the need to bring people's awareness of environmental protection, and if people are unaware of the importance of environmental protection, but only blind to be in the pursuit of economic interests, the EKC curve will could not achieve in any case and the situation of the environment will be worse.

4 Conclusion

First, in the eastern part of China the relationship between economic development and environmental quality in general has not far reached the theoretical EKC curve, but this can not rule out some problems of the historical data and the model omissions. However, on the basis of the fact that more and more environmental pollution incidents have occurred in the eastern part of China in recent years, it could be concluded that environmental conditions in the eastern region can not be optimistic, and it is reflected in the fitted curve of this paper. The eastern region is a leader in the national economy,

and also should be a leader in environmental management. Only in this way it can achieve the double harvest of the environmental protection and economic development.

Second, the overall sustainable development effort is not enough. Although China many years ago proposed the idea of sustainable development, but based on the domestic and international situation, economic and technological status, population size and quality as well as natural disasters and other reasons, the implementation of this concept has not really go on. Environmental law enforcement is not enough and publicity on environmental protection has not yet deeply rooted among people. In some large projects, consideration on the economic benefits and environmental impacts are biased, and people tend to give up for the interests of short-term plans. China's concern for the environment has increased than in the past, but that is often started to pay attention afterwards, such as decline in the quality of drinking water and air, loss of species. China is lacking in an effective mechanism for ex-ante controls. Sustainable development in the eastern region, or the whole country is just a slogan, and it is still a long way to implement the slogan.

Finally, China should intensify studies about the relationship between economic development and environmental quality. In recent years, domestic concern for the environment is more than before, and universities set up an environmental professional, environmental awareness gradually enjoying popular support. However, there is still a lack of a unified and targeted research in China. There is really not a theoretical model consistent with the environment condition of China, and many Chinese scholars conducting research often have to resort to the western theoretical results, but these theoretical results are not necessarily consistent with China's reality. For example in this paper related to the EKC curve theory, although the results can be fitted very well, it does not mean that the real situation in China will be thoroughly explained by the EKC theory. Because there is a huge difference between China and the West in every aspect, such as culture, politics, economy, humanistic quality and so on, hence, it is necessary to rely on the efforts of Chinese scholars to work out the relationship in China between economic development and environmental quality, combining with the domestic situation and reference to the foreign theories, at last to derive a theoretical model of the environment with Chinese characteristics. This is the solution to the problem.

In short, in order to achieve truly sustainable development, the eastern region must change its mode of economic growth, get rid of the old one which focuses only on economic benefits and ignores environmental benefits. The original single-mode of production should be changed into the cycle mode of production, and investment in environmental protection equipment should be increased. The output of pollutants could be minimized. All of these can lead a maximum utilization of resources so that the adverse effects on the environment will be reduced to the minimum. Today, environmental problems are increasingly serious, “the first treatment after pollution” no longer meets the requirements of the times, and sustainable development is the theme of the times. Only when we truly have a harmony with nature, and promote economic development and the coordination of resources and the environment, we can ultimately continuously improve China's comprehensive national strength and competitiveness.

References

[1] Liu Rongmao,Zhang olixia, Mely lingjie. Economic Growth and Environmental Quality: Evidence from Provincial Panel Ddata in China[J]. Economic Geography, 2006, 26(3): 374-377 (In Chinese)

[2] Yu Feng, Qi Jianguo, Tian Xiaolin. Empirical Analysis on Impact of Economic Development on Environmental Quality: Based on the Panel Data of Chinese Provinces & Municipal Cities from1999 to 2004[J]. China Industrial Economics, 2006,(8): 36-44 (In Chinese)

[3] Zhao Haixia,Qu Futian,CTuo Zhongxing. Environmental Pollution and Its Affecting Factors: A Theoretical Model and Its Application to Jiangsu in China[J]. Environmental Protection, 2006, (4): 43-49 (In Chinese)

[4] Wu Haiying, Zhang Shenglin. An Empirical Research of the Relationship Between Economic Development and Environmental Quality in the Western Region[J]. Social Sciences in Ningxia, 2005, (5): 29-33 (In Chinese)

[5] Liang Liutao. The Relationship Between Economic Growth and Environmental Quality: A Case Study of Jiangsu Province[J]. Journal of Nanjing Agricultural University, Social Sciences Edition, 2008, (1): 20-25 (In Chinese)

[6] Chen Banghua,Qian Fenglin. Economic Growth and Its Impact on Environmental Pollution and Environmental Protection the Measures[J]. Market Weekly, Disquisition Edition, 2007, (5): 94-96 (In Chinese)