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Does Environmental Regulation Promote the Upgrading of China's Chemical Industry? ——A Case Study of Chemical Industry in Jiangsu Province China

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Chemical industry is one of the most important industries in China, which is closely related to people. However, environmental pollution caused by chemical industry in China seriously restricts the sustainable development of China Therefore; environmental regulation is implemented in China to promote the green development of chemical industry. In order to test whether the production efficiency of chemical industry in our country is affected by environmental regulation measures, this paper takes Jiangsu Province's chemical industry as an example to conduct empirical analysis. The study finds: As a whole, there are no typical characteristics of EKC between the three types of environmental pollution caused by economic growth and the development of chemical industry in Jiangsu and the whole country; Under the same GDP level, per capita industrial emissions and per capita COD emissions of chemical industry in Jiangsu Province are respectively higher than the national overall level, which means that Jiangsu Province has achieved certain environmental regulatory performance, but its overall of the environmental regulation level is inferior to the national average, and the impact of environmental regulation on China's chemical industry is very limited. The level of environmental pollution in China's chemical industry is still high. Finally, this paper puts forward the suggestion to promote the green development of China's chemical industry.

1. Introduction

The chemical industry has the characteristics of resources, capital and technology-intensive. The chemical industries have a high degree of correlation and can promote the development of related industries and occupy a very important position in the national economic development. However, at the same time, the chemical industry belongs to the high-energy and high-pollution industries in China. With the weakening of our low-cost labour force and energy supply, the traditional extensive mode of growth in the chemical industry aggravates the contradiction between environment and economic development. Therefore, how to realize the synergistic development of economic growth and ecological environment has become an important issue to be solved urgently. As an important content of social regulation, environmental regulation can regulate the environmental pollution in the economic activities of enterprises and promote the coordinated development of environment and economy. Since the middle of 1990s, China has implemented a series of environmental regulatory policies. Whether these environmental regulatory policies have an impact on the production efficiency of China's chemical industry and how influential? In this paper, from the perspective of the development of chemical industry in Jiangsu Province China, Longitudinal comparisons of the emissions of the three major pollutants to evaluate the effectiveness of the environmental regulatory policies in the chemical industry, which have important practical significance for how to further improve the environmental regulation measures of our country.

At present, the environmental problems have become increasingly prominent in economic development, stimulating scholars to study the relationship between economic growth and environmental regulation. Generally, the achievements achieved by foreign scholars in the performance of environmental regulation can be divided into three aspects: (1) the research on the impact of environmental regulations on the emission of various pollutants and wastes (Magat and Viscusi, 1990; Laplante and Rilstone, 1996; Ricci, 2007). (2) EKC-

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based measurement and evaluation of the performance of environmental regulation (Panayoutou, 1997; Hettige et al, 2009). (3) Analysis of the impact of environmental regulation on industrial development (Greenstone, 2002; Berman and Bui, 2008; Cole et al., 2010). Compared with the overseas research, the domestic empirical research on the performance of environmental regulation has lagged behind in China. The representative studies are as follows: some scholars have empirically tested the relationship between economic growth and environmental pollution with the environmental Kuznets Curve (Zhang et al, 2009; Zang and Lv, 2016). Other scholars researched the relationship between government environmental regulation and regional economic growth with the panel data model (Xiong, 2011; Zhang, 2014).

From the above research literature, we can see that domestic and foreign scholars have carried out a series of researches on the impact of environmental regulation on industrial development, but the research in many aspects is not comprehensive yet, and there are almost no studies on the influence of environmental regulation on the development of the chemical industry, Which is not conducive to promoting the development of China's green chemical industry. The chemical industry is the pillar industry of national economy and the basic industry of economic and social development. Therefore, this article attempts to overcome the shortcomings of previous studies. Taking the chemical industry in China's Jiangsu Province as an example, this paper deeply analyzes the current situation of the development of chemical industry in Jiangsu Province under environmental regulation.

2. Empirical analysis

2.1 Selection of evaluation indicators

In the analysis of the relationship between regional economic development and environmental pollution, this paper selects the per capita GDP to measure the economic development level in the region. And the discharge of industrial waste gas, the generation of industrial solid wastes and the chemical oxygen demand of the waste water of chemical industry are selected as evaluation indicators to characterize the environmental pollution in the region (Table 1).

Table 1: The selection of evaluation indicator variables and the symbols

Indicator variable	Symbol	Indicator variable	Symbol
Industrial waste gas emissions(m^3)	*PCE*	Per capita industrial waste gas emissions (m3 / person)	*aPCE*
Industrial solid waste production (tons)	*PSW*	Per capita industrial solid waste production (tons / person)	*aPSW*
Chemical oxygen demand emissions (tons)	*PCW*	Per capita Chemical oxygen demand emissions (tons/person)	*aPCW*

2.2 The establishment of evaluation model

Based on the environmental Kuznets curve theory and the study of some scholars, the logarithmic regression equations are constructed to carry out the evaluation research on the economic growth and environmental pollution. We assume the following model:

$$LnY_{1t} = \beta_0 + \beta_1 LnX_{1t} + \beta_2 (LnX_{1t})^2 + \beta_3 (LnX_{1t})^3 + \varepsilon_{1t} \quad (1)$$

$$LnY_{2t} = \beta_0 + \beta_1 LnX_{2t} + \beta_2 (LnX_{2t})^2 + \beta_3 (LnX_{2t})^3 + \varepsilon_{2t} \quad (2)$$

Where Y_{1t} is the index value of chemical industry's environmental pollutants (per capita industrial waste gas emissions, per capita industrial solid waste production and per capita emissions of chemical oxygen demand) in the t th year in Jiangsu ; Y_{2t} is the index value of chemical industry's environmental pollutants (per capita industrial waste gas emissions, per capita industrial solid waste production and per capita emissions of chemical oxygen demand) in the *t*th year in China; X_{1t} is the per capita (aGDP_1) in the *t*th year in Jiangsu; X_{2t} is the per capita (aGDP_2) in the *t*th year in China; β_0 is the specific cross-section effect; β_1, β_2 and β_3 are parameters to be estimated, whose different values will lead to the different shapes of the final curves; ε_{1t} and ε_{2t} are the random error terms.

2.3 Data sources and model analysis

2.3.1 Data sources

The data in this paper is based on Statistical Yearbook of Jiangsu (1997-2016), China Statistical Yearbook (1997-2016) and China Statistical Bulletin of Environment (1997-2016).

2.3.2 Model Analysis

Based on the panel data of per capita industrial waste gas emissions, per capita industrial solid waste production, per capita emissions of chemical oxygen demand of chemical industry and per capita GDP from 1997 to 2016 in Jiangsu and the whole country, we first analyze the evaluation index variables of the three kinds of environmental pollutants and the per capita GDP in model (1) and (2). The Hausman test proves that the fixed effect model is superior to the random effect model and the mixed model. Therefore, we choose the fixed effect model to estimate the related variable parameters, and the curvilinear relationship is analyzed and judged in accordance to the t value of the estimated coefficient, R^2, A-R^2 and F value. When the cubic term of per capita GDP is not significant in the estimated result, it is to be further eliminated. And then we estimate the environmental Kuznets curve between the index variables of the three types of environmental pollutants and the per capita GDP. The regression results of the model are shown in Table 2.

Table 2: The regression results of the model

	Region	parameters	β_0	*Ln*(a*GDP*)	Ln^2(a*GDP*)	R^2 & A-R^2
Per capita industrial waste gas emissions (*Ln*(a*PCE*))	Jiangsu	coefficient	22.149 *	-3.667 *	0.251 *	0.990
		t value	(3.018)	(-2.431)	(3.2342)	(0.988)
	China	Coefficient	-16.745 *	4.615 *	-0.191 *	0.989
		t value	(-2.957)	(4.004)	(-3.261)	(0.987)
Per capita industrial solid waste production (*Ln*(a*PSW*))	Jiangsu	Coefficient	-89.533 *	19.803 *	-1.049 *	0.791
		t value	(-3.609)	(3.884)	(-4.015)	(0.757)
	China	Coefficient	-0.649 *	0.792 *		0.987
		t value	(-2.608)	(31.470)		(0.986)
Per capita emissions of chemical oxygen demand (COD) (*Ln*(a*PCW*))	Jiangsu	Coefficient	36.907 *	-7.665 *	0.426 *	0.869
		t value	(2.426)	(-2.451)	(2.656)	(0.847)
	China	Coefficient	47.747*	-9.474*	0.494 *	0.693
		t value	(3.477)	(-3.39)	(3.481)	(0.642)

Note: * indicates significance at 5% level; in the list of R^2 & A-R^2, the adjusted R^2 is in the brackets; in the list of F value, the unilateral test probabilities are in brackets.

(1). EKC test of per capita industrial waste gas emissions of chemical industry and per capita GDP

As can be seen from Table 2, the regression results show that there is a "U" curvilinear relationship between per capita industrial waste gas emissions of chemical industry and per capita GDP in Jiangsu and the whole country. The model results can be expressed as:

$$Ln(PCE_1)=22.149-3.667[Ln(aGDP_1)]+0.251[Ln(aGDP_1)]^2 \quad (3)$$

$$Ln(PCE_2)=-16.745+4.615[Ln(aGDP_2)]-0.191[Ln(aGDP_2)]^2 \quad (4)$$

From the model regression equations (3) and (4) above, it can be seen: first, the curve relationship between per capita industrial waste gas emissions of chemical industry and per capita GDP in Jiangsu is not the inverted U-shape of the environmental Kuznets curve but a U-shaped one. Second, there is an inverted U-shape curve relationship of the environmental Kuznets between the national per capita waste gas emissions of chemical industry and per capita GDP. It shows that the national per capita waste gas emissions of chemical industry decrease with the growth of per capita GDP after reaching the inflection point of the inverted U-shape curve of environmental Kuznets.

In Figure 1, the comparison of the curves for national per capita waste gas emissions and per capita GDP show that: at the same level of per capita GDP, the per capita waste gas emission in Jiangsu is larger than that of the whole country. And the gap between the two presents a gradually increasing trend, exclusive of a few years when the national per capita waste gas emission is more than that in Jiangsu.

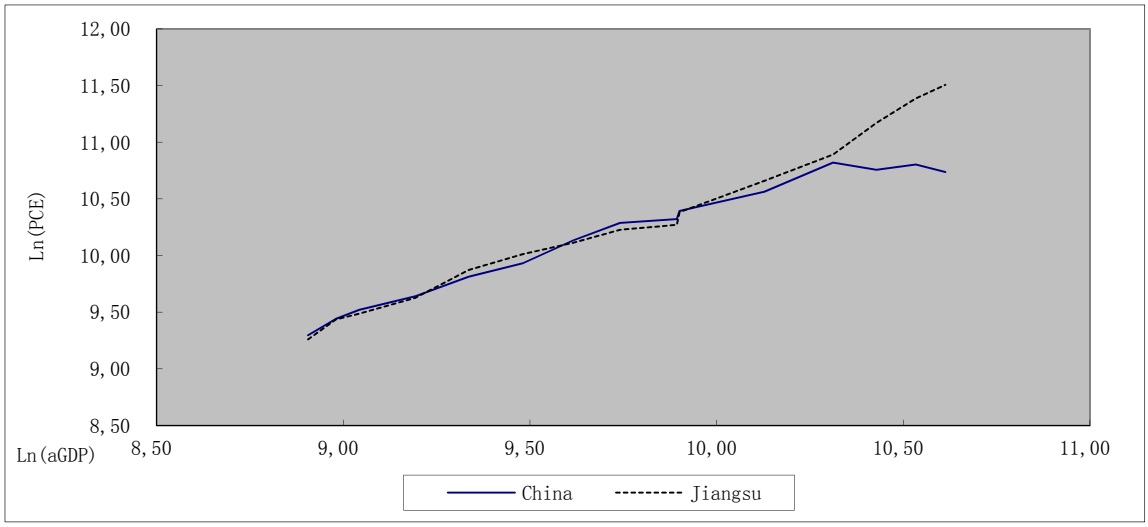

Figure 1: Relationship between per capita GDP and per capita industrial waste gas emissions of chemical industry

(2). EKC test of per capita industrial solid waste production of chemical industry and per capita GDP
As is known from Table 2, the model regression results can be expressed as:

$$Ln(PSW_1) = -89.533 + 19.803[Ln(aGDP_1)] - 1.049[Ln(aGDP_1)]^2 \quad (5)$$

$$Ln(PSW_2) = -0.649 + 0.792Ln(aGDP_2) \quad (6)$$

The regression results show that there exists the inverted U-shaped curvilinear relationship of environmental Kuznets between per capita industrial solid waste production of chemical industry and per capita GDP in Jiangsu. However, there is an increasing linear relationship between the per capita industrial solid waste production of chemical industry and the per capita GDP in the whole country, indicating that the industrial solid waste output of chemical industry of chemical industry in China is still increasing rapidly with the economic development.

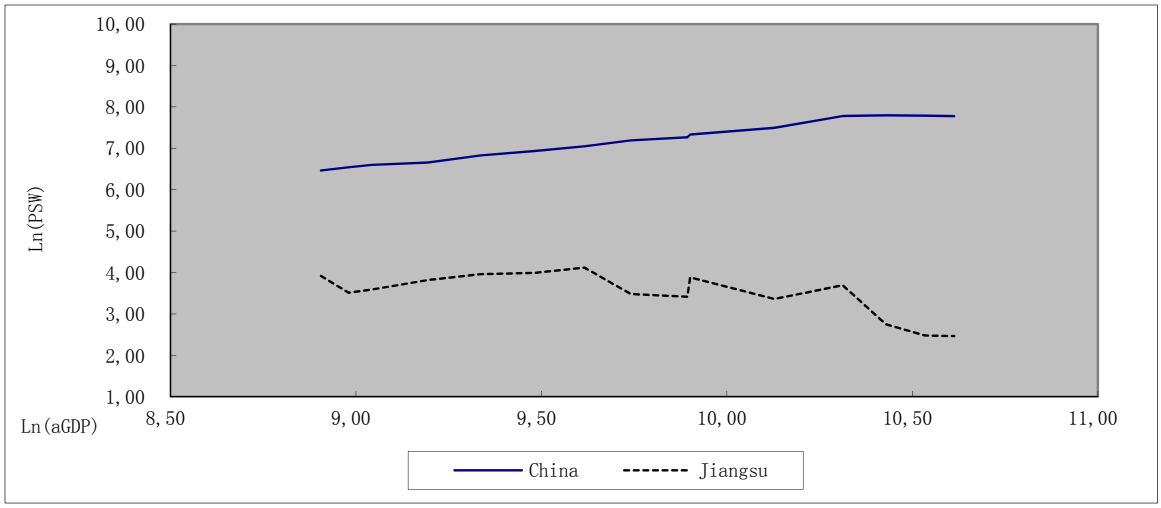

Figure 2: Relationship between per capita GDP and per capita industrial solid waste output of chemical industry

Figure 2 shows that the per capita industrial solid waste production of chemical industry in Jiangsu presents a declining trend with the rapid growth of per capita GDP and that the national per capita industrial solid waste production of chemical industry is positively correlated with the per capita GDP.

By comparing with the curve of per capita GDP and per capita industrial solid waste production in Jiangsu, it can be seen that the per capita industrial solid waste production of the whole country far exceeds that in Jiangsu at the same level of per capita GDP.

(3). EKC test of per capita COD emissions of chemical industry and per capita GDP

As can be seen from Table 2, there is a U-shape curvilinear relationship instead of an inverted U-shape curve relationship between per capita COD emissions and per capita GDP in Jiangsu and China as a whole. The model regression results can be expressed as:

$$Ln(PCW_1) = 36.907 - 7.665[Ln(aGDP_1)] + 0.426[Ln(aGDP_1)]^2 \quad (7)$$

$$Ln(PCW_2) = 47.747 - 9.474[Ln(aGDP_2)] + 0.494[Ln(aGDP_2)]^2 \quad (8)$$

As can be seen from the model above, the inflection point of the "U" curve of Jiangsu appeared in 2013 at the per capita GDP of 8075 yuan; and that of the "U" curve of China as a whole occurred in 2006 at the critical point of the per capita GDP of 14604 Yuan. The U-shape curve indicates that when the per capita GDP in Jiangsu is lower than the critical value of 8,075 yuan, the per capita COD emissions of chemical industry decrease with the increase of per capita GDP. Similar to the situation in Jiangsu, the change of national per capita COD emissions of chemical industry is in line with that of per capita GDP.

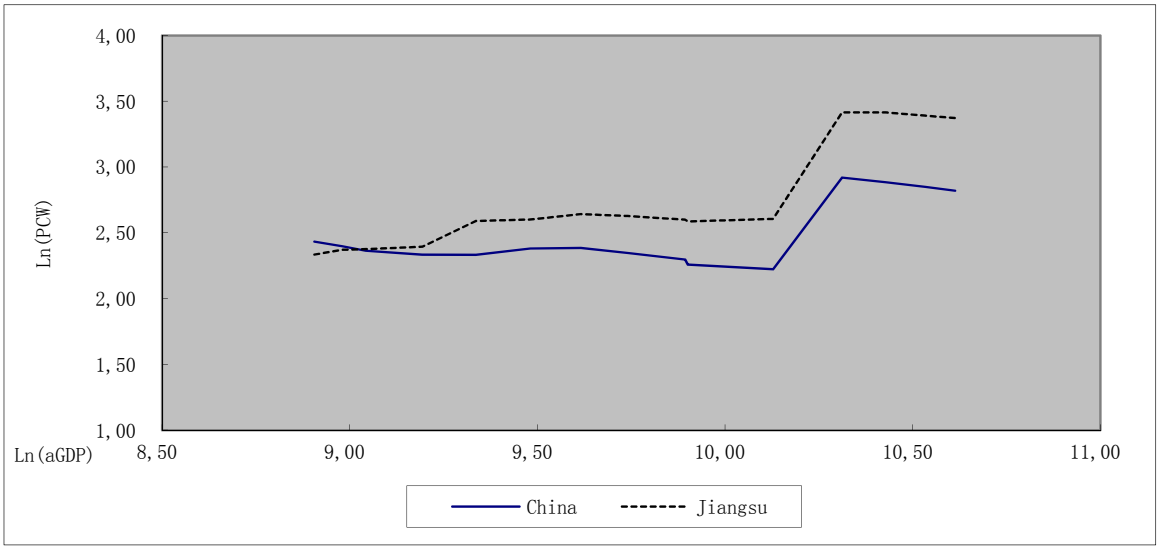

Figure 3: Relationship between per capita GDP and per capita COD emissions of chemical industry

The analysis of Fig.3 shows that the per capita COD emission of chemical industry in Jiangsu does not increase but decrease with the growth of per capita GDP in individual years. But generally, the per capita COD emission of chemical industry in Jiangsu increases rapidly with the growth of per capita GDP. The further comparative analysis with the whole country shows that the per capita COD emission of chemical industry in Jiangsu is higher than that of the whole country at the same period.

3. Conclusions

As a pillar industry of the national economy, the sustainable development of the chemical industry directly affects the sustainable development of other sectors of the national economy. In this paper, the development of chemical industry in Jiangsu Province as an example, a systematic empirical study to explore the impact of environmental regulation on the development of the chemical industry, the main conclusions of the study are as follows: there are no typical characteristics of EKC between the three types of environmental pollution caused by economic growth and the development of chemical industry in Jiangsu and the whole country; Under the same GDP level, per capita industrial emissions and per capita COD emissions of chemical industry in Jiangsu Province are respectively higher than the national overall level, which means that Jiangsu Province has achieved certain environmental regulatory performance, but its overall of the environmental regulation level is inferior to the national average, which means that the impact of environmental regulation on China's chemical industry is very limited. In order to effectively curb the emission of environmental pollutants in

China's chemical industry and improve the efficiency of environmental regulation, we need to further regulate the development of the chemical industry in the future. We should extensively apply new chemical technology, develop green chemical industry, and take resource conservation and environment-friendly New Industrialization Road.

References

Berman E., Bui L.T., 2008, Environmental regulation and productivity: evidence from oil refineries, The Review of Economics and Statistic, 3, 498-510.

Cole M.A., Elliott R.J.R., Okubo T., 2010, Trade environmental regulations and industrial mobility: an industry-level study of Japan, Ecological Economics, 10, 1995-2002.

Greenstone M., 2002, The impacts of environmental regulation on industrial activity: evidence from the 1970 and 1977 clean air act amendments and the census of manufactures, Journal of Political Economy, 6, 1175-1219.

Hettige H., M.Mani, D. Wheeler., 2009, Industrial pollution in economic development: Kuznets revisited, Journal of Development Economics, 2, 445-476.

Laplante B., Rilstone P., 1996, Environmental inspections and emissions of the pulp and paper industry in Quebec, Journal of Environmental Economics and Management, 1, 19-36.

Magat W.A., Viscusi W.K., 1990, Effectiveness of the EPA'S regulatory enforcement: the case of industrial effluent standards, Journal of Law and Economics, 33, 331-360.

Panayotou T., 1997, Demystifying the environmental Kuznets curve: Turning a black box into a policy tool, Environment and Development Economics, 2, 465-484.

Ricci F., 2007, Environmental policy and growth when inputs are differentiated in pollution intensity, Environmental and Resource Economics, 3, 285-310.

Xiong Y., 2011, Research on the relationship between environmental regulation and economic growth based on the provincial data in China, China Population, Resources and Environment, 5, 126-131.

Zang C.Q., lv j., 2016, Environmental Kuznets curve of the regional difference-based on 1995-2014 panel data of 29 provinces in China, Macroeconomics, 4, 62-69, DOI: 10.3969/j.issn.1002-2104. 2016.01.007.

Zhang T.T., 2014, The empirical study of China's environmental regulation and economic, growth relationship Modernization of Management, 4, 68-70. DOI: 10.3969/j.issn.1002-2104.2014.06.030.

Zhang H.F., Zhou F., Yang H., Guo Q., 2009, Regulation performance of the win-win of environmental protection and economic development, Economic Research Journal, 3, 14-26. DOI: 10.3321/j.issn: 0375-5444.2009.08.009.