Reassessing the Carbon Kuznets Curve: Panel Data Model Analysis for Prefecture-level Cities in China

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Abstract: This article is based on Environmental Kuznets Curve, and analyzes the relationship between carbon Emissions and Economic Growth in prefectural cities in China by using Panel Data Model. Variable time span is 14 years. Cross-section covers more than 200 prefecture-level cities .It shows that with the development of economic, carbon emissions are on the rise. The carbon Kuznets curve presents a curve with an upper right slant. Inverse U-shaped relationship is not obvious or the inflection point is not reached .This shows that passively waiting for economic growth to improve the quality of environment does not meet China's development model, and coordinated development of economic growth and quality of environment is the fundamental way for China's sustainable development.

1 INTRODUCTION

Carbon emission is the main reason that leads to the global warming. Controlling emission has become an important issue，for it's about the interests of people all over the world According to World Development Report 2010: Development And Climate Change published by World Bank. From Industrial Revolution to now, the average temperature of the world has risen by 1 degree. What's worse, in a decade of the 1980s, the temperature rose by 0.48 degree from 100 yearsago. As global temperature rises, there are lots of disasters which have bad impact on the survival and development of human. With the rapid development of China's economic, reliance on fossil fuels grows in multiples. According to World Energy Outlook 2007 published by International Energy Agency, the average rate of carbon emissions in China is 4.2% which ranks first in the world. China is under great pressure from domestic and international carbon emission reduction. To balance the development of economic and carbon emission is an important issue for China's current economic development. In 2015, China Fragrance "Joint International Framework Convention on Climate Change" Secretariat submitted Strengthening Actions to Address Climate Change-China's national Independent Contribution. It sets a goal for carbon emission, by 2030 China's carbon emissions per unit of GDP fell 60% to 65% from 2005. In addition, to achieve the goals of sustainable energy development and non-fossil energy accounts for 20% of primary energy .

China's per capita carbon emissions are lower than that in developed countries such as the United States, poor energy technology leads to energy utilization and higher carbon emissions per unit of GDP.As we all known, economics growth leads to increased carbon emissions. If we take unreasonably measures to control carbon emissions, it is true that it will do harm to the development of the economic. China will take economic development as its top priority for a long time; therefore, it is not a wise idea for a developing country like China to give up the development of economic in order to protect the environment. From the perspective of the development of economic in other countries, the rapid economic growth while low-carbon emission development modal; does not exist, according to the theory of the development of Environmental Kuznets Curve in Environmental Economics, The law "First pollution, after treatment" is summarized by developed countries which is not suitable for developing countries.

This article takes the environmental Kuznets curve as the research perspective, collect the panel data model and create panel data for each region spanning more than 20 years, through empirical analysis to find the relationship between the development of economic and carbon emissions in China. To have a comprehensive discussion of the form of the Kuznets curve in various regions of China according to panel data modal so that it can provide theoretical support for the promotion of building an environmentally friendly society.

2 REGRESSION RESULTS ANALYSISOF PANEL DATA MODEL

2.1 Panel Data Analysis Between Energy Consumption and Economic Growth

The theory of CKC is a great method to study the relationship between carbon emissions and economic growth. Main through regression analysis to verify whether there is an inverted U shaped relationship between economic growth and carbon emissions and decoupling theory to analyze the relationship between them. In 2008 Wagner studied the relationship between carbon emissions and GDP per capita and proved that CKC is also an inverted U shape. The general expression of CKC is: $C = f(G, G^2, G^3, W)$, C stands for environmental quality and it usually measured by indicators of carbon emissions. The formula of panel data model is:

$$C_{it} = \alpha_0 + \alpha_1 G_{it} + \alpha_2 G_{it}^2 + \alpha_3 G_{it}^3 + \alpha_4 W_{it} + \varepsilon_{it} \quad (1)$$

And α_j is the model parameter, the relationship between environment and economic growth can be reflected by the parameter value.

If $\alpha_1 > 0, \alpha_2 = 0, \alpha_3 = 0$, there is a monotonically increasing positive correlation between carbon emissions and economic growth. In other words carbon emissions increase with economic growth, there will be no turning point of carbon emission reduction.

If $\alpha_1 > 0, \alpha_2 < 0, \alpha_3 = 0$, at this point, there is an inverted U-shaped curve between carbon emissions and economic growth, carbon emissions increase first and then decrease as the economic grows.

If $\alpha_1 < 0, \alpha_2 > 0, \alpha_3 = 0$, CKC curve is U shaped ,with the development of economic, carbon emissions first decrease and then increase.

If $\alpha_1 > 0, \alpha_2 < 0, \alpha_3 > 0$, the curve is N shaped. It shows that carbon emissions first increase and then decrease and then increase again as the economic grows.

If $\alpha_1 < 0, \alpha_2 > 0, \alpha_3 < 0$, the curve is inverted N-shaped. It shows that carbon emissions first decrease and then increase and then decrease as the economic grows.

In my perspective, the EKC curve is based on the analysis of the industrialization process in the developed countries and its inverted U pattern mainly reflects the law of economic growth in developed countries as a function of the environmental quality .However the developing world in different developing countries is different .The development path of developing countries is different from the analysis of the industrialization process of developed countries. Developing countries will not wait for the natural improvement of the environment and will therefore intervene early in the process of industrialization .These factors have an impact on the morphology of the EKC curve .So whether the inverted U shaped of the environmental Kuznets curve in developing countries needs to be verified in more sophisticated data fitting. Due to data limitations most of the literature is mainly limited to national or provincial data and the information obtained is limited.

This article will use data from various regions of China on carbon emissions and economic growth to fit the shape of the EKC curve. Since regional-level data contains more relevant information on environmental and economic growth the fitting effect is more convincing.

2.2 Reassessing the Carbon Kuznets Curve

Because the carbon emissions in prefecture level cities cannot be obtained directly and the differences between energy consumption structure and production technology in the same period in the same province are small, we use the percentage of the prefectural city GDP in the province as a weight. Estimating carbon emissions of prefecture level cities through the provincial carbon emissions. This article uses the carbon emission panel date of prefecture level cities from 2013 to 2016. According to 《China City Statistical Yearbook》 covers 283 prefecture level cities , however, in some western regions , some key date are missing . The final panel date covers 251 prefecture level cities. We use the following regression model because most studies use quadratic curve to fit the EKC:

$$plc_{it} = \alpha_1 IC_{it} + \alpha_2 IC_{it}^2 + \alpha_3 FAI_{it} + \alpha_4 IS_{it} + \delta_t + \varphi_i + \varepsilon_{it} \quad (2)$$

The subscript 'it' represents the index of the t-th year of the i-th prefecture level city, α represents the corresponding regression coefficient, PICit represents the carbon emissions of the t-th year of the i-th prefecture level city, ICit represents the per capita GDP, the date use the GDP of prefecture level city divided by the total population at the end of a year and adjusted the price index based on 2003. FAIit represents fixed asset investment of the t-th year of different regions, ISit represents the industrial structure of the t-th year of different regions, φi represents regional fixed effect variable, δt represents fixed time effect variable. This article uses a variable that lags by one period as a tool variable to conduct model estimation because there are certain entophytes in the model's explanatory variables GDP and fixed assets investment indicators.

$$\mathrm{LM} = \frac{NT}{2(T-1)}\left[\frac{\sum_{1}^{N}\left[\sum_{i}^{T}\hat{u}_{it}\right]^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}u_{it}^2}-1\right]^2 \quad (3)$$

$$\mathrm{H} = \frac{(\hat{\theta}-\tilde{\theta})^2}{s^2(\hat{\theta}-\tilde{\theta})}\sim\chi^2(\mathrm{k}) \quad (4)$$

Through the Hausman and LM tests, the results show that fixed effect model is better, and the specific regression results are shown in the table 1.

Model 1 just see per capita GDP and its quadratic term as explanatory variables, the result shows that at the 1% level of significance, the coefficient of one term is obviously a positive value, the coefficient of quadratic term is not obvious. This indicates that when the model does not include other explanatory variables, the relationship between carbon emission and economic growth is linear relationship. With economic growth, carbon emission is also growing. CKC curve is a straight line that leans toward upper right.

Table 1 Regression results of panel date.

	model1	model 2	model3	model 4
C	-0.639	-1.3415	-1.1135	0.3028
	(-1.31)	(-1.910)	(-1.9982)	-1.9075
IC	0.935*	0.972**	0.9998**	0.9102**
	(0.311)	(0.4323)	(0.4454)	(0.3982)
IC^2	-0.023	-0.0129	-0.0231	-0.0197
	(-0.02)	(-0.016)	(0.0145)	(0.0312)
IS		-0.4582	-0.4971	-0.0975
		(0.3998)	(0.4009)	(0.3029)
FAI		0.09108*	0.08972*	0.0831*
		(0.0382)	(0.0409)	(0.03917)

Note: '*' means the significance level is 5%. '**' means the significance level is 1%.

Model 2 adds the influence of fixed assets investment and industrial structure, regression result shows that carbon emission and economic growth still take on positive linear correlation. The influence of fixed assets investment on the carbon emission will show some continuity, therefore, in order to solve the sequence related problems in the model, the model evolved into the form of model 3, that is, fixed assets investment will lag one phase before participating in regression. The quadratic coefficient is still not obvious at this time; the coefficient of one term is a positive value. Further consideration of the problem of mutual cause and effect between carbon emission and per capita GDP, therefore, model 4 uses the date on per capita GDP which lags one phase, the result still indicate a positive linear relationship between the two variables. A comprehensive analysis of these four models, the relationship between carbon emission and economic growth is monotone increasing; indicating that they are linear relationship or they are in the ascending phase of an inverted u-shaped curve with the inflection point has not yet appeared.

In the model, the percentage of secondary industry in explanatory variable is not significant, mainly because when these models were established, author used various type of primary energy consumption to calculate carbon emission, but carbon emission from the primary and tertiary industries mainly occur during the production of the products that people used, mainly because of the use of electric energy, so carbon emission actually happens in the secondary industry. So, industrial structure cannot influence the carbon emission in the prefecture level city obviously. Besides, the impact of fixed asset investment on carbon emissions in prefecture level cities is obviously positive and it has a lasting influence in the future.

In summary, there is a positive linear correlation between carbon emission in prefecture level cities and economic growth; it can also be explained as the inflection point of inverted u-shaped curve has not appeared. But CKC curve means that we cannot simply expect economic growth to the inflection point so that the environmental quality in China can be improved naturally, we should take the initiative to improve the environment, improve the efficiency of energy using, and reduce carbon emission.

3 CONCLUSIONS AND POLICY RECOMMENDATIONS

Traditional library environmental Kuznets curve shows that, with the growing of economy, the carbon emission will first increase and then decrease. Associated with economic growth, the change of environmental quality will improve gradually. But traditional EKC curve is according to the experience of the developed country industrialization, so the trend of developing countries is not applicable. Developing countries with the advantage of backwardness can draw lessons from experiences and lessons in the process of industrialization in developed countries, and take measures to control environmental quality management.

According to the district cities more than 20 years of data, this paper draws a conclusion that the relationship between carbon emissions and economic growth mainly appears a sloping straight line, so the Kuznets Curve is not an inverted U curve. This means that the carbon emissions control problem and environment problem in economic growth cannot be solved automatically. After pollution then management way is not suitable for our country's development present situation; we should take active measures, reasonably control energy consumption, and improve the efficiency of energy utilization.

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