

A Comparative Analysis on Carbon Emission Effect of Trade in Eastern, Middle and Western Regions in China

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Abstract. Using the annual statistics from 1990 to 2010, this paper applies the panel model to verify the effect of trade openness on carbon emission in the three regions. The study shows: considering the average personal income and the policy effect, in Eastern China, both foreign trade dependency and FDI dependency have negative effects on carbon emission, but the former one is not statistically significant; In Middle China, the foreign trade dependency has a positive effect on carbon emission, while FDI dependency has a negative effect, both effects are statistically significant. In Western China, the degree of trade openness have positive effects on carbon emission, but the results are not statistically significant.

Introduction

The carbon dioxide generated by burning fossil fuel such as coal, petroleum and natural gas the primary reason causing the global warming. The statistics from International Energy Agency showed that in China, the carbon emission has increased rapidly from 1.43 billion tons in 1979 to 7.26 billion tons in 2010.^[1] China has now become the largest CO₂-emission country in the world. With carbon emission accelerating, China's foreign trade has developed rapidly. The total amount of trade has increased from 280.1 billion US dollars in 1979 to 2972.8 billion US dollars in 2010. As a result, people start to connect trade openness with China's carbon emission naturally. Therefore, the study on the effect of trade openness on carbon emission in China has become the emphasis of academic research. This paper takes advantage of China's panel data, comparing the effect of trade openness on carbon emission in the three regions of east-central-west (according to the National Development and Reform Commission's No.33 File in 2000). Each region formulates policies for energy conservation and emission reduction according to the degree of trade openness.

Model Setup and Data Declaration

A. Model Setup

Considering that carbon emission and economic growth are closely related, so the role that the economic growth plays on carbon emission can't be ignored when we study the effect of trade openness on carbon emission. Hence, the Environmental Kuznets Curve (EKC) is an effective tool. This paper refers to the EKC Model in Grossman G and Kreuger A's article (1993),^[2] and builds an econometric model of the effects of trade openness on carbon emission. The model is as follows:

$$\ln TC_{it} = c_{it} + \alpha_1 \ln Y_{it} + \alpha_2 (\ln Y_{it})^2 + \alpha_3 \ln TR_{it} + \alpha_4 \ln FD_{it} + \alpha_5 \ln GR_{it} + \varepsilon_{it}. \quad (1)$$

As can be seen from the model above, *i* presents provincial cross-sectional unit, *i* equals to 1, 2, ..., 29; *t* is time; TC stands for the total amount of carbon dioxide emission; Y means per capital GDP; TR and FD show the degree of trade openness, TR is foreign trade dependency while FD is foreign direct investment (FDI) dependency; GR indicates the policy variable of heteroscedasticity. Each variable is dealt with natural logarithm.

B. Data Declaration

1) *The estimate of carbon emission.* Based on provincial consumption of petroleum, coal and

natural gas, also, according to the transformation of each carbon emission coefficient of the three kinds of the energy, the provincial carbon emission is obtained. The carbon emission coefficient in this paper adopts the carbon emission coefficient mentioned in The Sustainable Development of China's Energy and Carbon Emissions released by National Development Agency Energy Research Institute. In this article, the carbon emission coefficients of petroleum, coal and natural gas are 0.58 tons of carbon/tons of standard coal, 0.75 tons of carbon/tons of standard coal, and 0.44 tons of carbon/tons of standard coal, respectively.

2) *Per capital GDP*. To ensure the comparability, take 1990 the base year. The provincial per capital GDP from 1990 to 2010 could be gained via GDP index.

3) *The degree of regional openness*. The percentage of foreign trade volume brought by foreign enterprise in the total amount of foreign trade is over 50% in most provinces. In view of that, this paper divides the degree of trade openness into two parts: foreign trade dependency and FDI dependency. Foreign trade dependency is the ratio of foreign trade volume to GDP; FDI dependency is the ratio of the real FDI that very year to GDP.

4) *The policy variable of carbon emission*. To a large extent, investment in pollution control can reflect the level of government controlling environmental pollution. Taking that factor into consideration, this paper selects the ratio of the investment amount of provincial industrial pollution control project to the provincial GDP as substitute variables of carbon emission policy variables.

All basic data in this paper is from China Statistics Yearbook over the years, China Environmental Statistical Yearbook over the years and other provincial statistical yearbook over the years.

The Estimate of Empirical Model

To understand the effect of trade openness on carbon emission in three regions, this paper estimate the panel data in three regions based on static panel. In order to analyze the cross-sectional differences, regardless of the differences among provinces in the three regions, the variable coefficient model will not be taken into account.^[3] When we estimate in the first place, we should use the F Statistics Test Model to see whether there is individual effect or not. If the individual effect doesn't exist, the mixed effect regressive model will be adopted to estimate, otherwise, the variable intercept model will be used to estimate. There are fixed effect and random effect in the variable intercept model, therefore, we'll use Hausman Test to check out if the individual effect is related to explanatory variables in the random effect model.

The result is shown in Table I. Model 1 to Model 3 are the results of the three regions based on static panel, respectively. By using F Test and Hausman Test, the result supports the fixed effect model. Besides, we may often encounter problems that the cross-sectional heteroscedasticity and autocorrelation sequences when we estimate using static panel model. Therefore, to eliminate these problems when we estimate the three regions, we adopt Seemingly Unrelated Regression (SUR) to do the estimate. The results of the three models are significant, the goodness of fit is all 99%, but the estimate results are quite different among the three regions.

A. The Relationship between Per Capital GDP and Carbon emission Show Different Shapes in the three Regions

The coefficient of LnY in Eastern China is 1.8534, the coefficient of $(LnY)^2$ is -0.0623; while in Middle China, the coefficient of LnY is 0.1684, the coefficient of $(LnY)^2$ is -0.0477. All the results satisfy the significant level test. This shows that in Eastern and Middle China, the relationship between per capital GDP and carbon emission is an inverted U-shape, thus the EKC Hypothesis is valid. In Western China, the coefficients of LnY and $(LnY)^2$ are -0.4129 and 0.0321, respectively, the results satisfy the significant level at 5%. Because of the coefficient of LnY is negative and the coefficient of $(LnY)^2$ is positive, the carbon emission curve is also U-shaped in the west, the EKC Hypothesis is invalid. As for the reasons, this paper believes that, in Western China, there are less industrial manufacturing enterprises relatively, with the economic growing, the carbon emission will be less.^[4] When reached the infection point, the economic growth will come to a certain stage, a large number of infrastructure investment will lead to a surge of energy consumption, the carbon

emission will increase ever since.

TABLE1 ESTIMATE RESULTS OF PANEL DATA OF THREE REGIONS

Explanatory Variable	Explained LnTC		
	<i>Eastern China</i>	<i>Middle China</i>	<i>Western China</i>
	Model 1FE	Model 2FE	Model 3FE
Constant C	-1.9081*** (-3.4577)	7.4691*** (6.5350)	3.5289*** (4.2832)
LnY	1.8534*** (16.0214)	0.1684* (-0.5964)	-0.4129** (2.0277)
(LnY) ²	-0.0623*** (-9.6267)	-0.0477*** (2.7504)	0.0321** (2.5394)
LnTR	-0.0049(-0.4066)	0.1254*** (6.6776)	0.0034 (0.3299)
LnFD	-0.1188*** (-15.067)	-0.0137** (-2.0904)	0.0074(1.2794)
LnGR	-0.0182** (-2.4880)	0.0372*** (3.8325)	0.0448*** (5.4071)
R ²	0.9982	0.9885	0.9918
Adj R ²	0.9981	0.9876	0.9911
Hausman Test	11.519 (0.04)	27.352 (0.00)	30.977 (0.00)
F Value	7693.02 (0.00)	1054.07 (0.00)	1588.98 (0.00)

Note: The number of regression coefficient in parentheses is t value; ***, **, * represent that the results are significant at 1%, 5% and 10% level, respectively; R² means the goodness of fit; the number of Hausman Test and F Test in brackets is possibility value; FE stands for fixed effect estimate.

B. The Correlation between Trade Openness and Carbon Emission is Different

In Eastern China, the foreign trade dependency is negatively related with carbon emission, but not statistically significant, suggesting that the proportion of low-carbon products in exporting is getting higher, leading to the raise of foreign trade dependency and less carbon emission,^[5] but the influence is not obvious for now. The FDI dependency is also negatively related with carbon emission, the variable estimate satisfies a higher significant test. When the FDI dependency increases by 1%, the carbon emission will decrease by 0.12%, indicating that the increase of FDI will ease the pressure of carbon emission in Eastern China to a certain degree. The emergency of this result is due to the technology spillover effect.

In Middle China, the foreign trade dependency is positively related with carbon emission, which is significant at 1% level, indicating that once the foreign trade dependency increases by 1%, the carbon emission will increase by 0.13% or so accordingly, that is, the expansion of trade scale increases carbon emission significantly. As can be seen from Table 1, compared with Eastern China and Western China, the scale of foreign trade influences carbon emission the most in Middle China. On one hand, it is because the middle region undertakes many high energy consumption industrial transfers from the eastern region. On the other hand, this may have something to do with the resources endowment in Middle China. The FDI dependency is negatively related with carbon emission in Middle China, which is significant at 5% level. Although this is the same with Eastern China, the elastic coefficient is small, that is, when the FDI dependency increases by 1%, the carbon emission will decrease by 0.01% or so only.

The degree of trade openness are positively related with carbon emission in Western China, but the coefficients are not significant statistically. This is mainly because, in the west, the foreign trade and the scale of FDI have a small share of local GDP, thus the influence of trade openness on carbon emission is not obvious.

C. The Correlation between the Policy Effect and Carbon Emission is Different

The policies and measures have a positive effect on carbon emission. This shows that in economic comparatively developed eastern areas, people demand relatively higher environmental quality. Yet in Midwest area, due to the restriction of economic development, people's demand for environmental quality remains at a lower level. Besides, the positive correlation between the policy effect and carbon emission means that the policies and measures haven't functioned well in environment protection, there's a need to strengthen management to a great extent.

Conclusion

In Eastern and Middle China, EKC Hypothesis is valid. In Western China, however, EKC Hypothesis is invalid. It explains that the development of economic is quite different from natural resources endowment. Thus there's a need to make proper policies based on the heterogeneity of regional economic development that coordinate the relationship between economic development and carbon emission .

The results explain that the deepness of foreign trade is at the cost of the growth of carbon emission in most of China. Constantly, the three regions must fundamentally change the extension type growth mode of trade growth at the expense of high carbon emission, making the new low-carbon trade strategies.

The policies and measures have negative effects on carbon emission in Eastern China, while in Midwest, the effects are positive and significant statistically. The estimate is just the opposite to the anticipation in Midwest, this may likely indicates that policy option exists problems on applicability. But this paper believes that the main reason lies in that the supervision of the environment protection policies and measures is not in place.

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