The Effect of Exports on Carbon Emission in China: An Empirical Study Based on panel data of 28 manufacturing industries

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Abstract—With continuous increase of carbon emission, China is facing more and more pressure from international community. However, what is the driving force of China's carbon emission growth? Whether China's carbon emission should be borne by the Chinese people? Based on carbon accounting resulted from energy consumption, this paper quantitativly analyze the effect of exports on carbon emission using China's 28 manufacturing industrial panel data from 2001 to 2007. The results show that: There is a close link between China's exports and carbon emission, and the increasing commodity exports are an important factor for China's carbon emission in recent years, so the developed countries should bear some responsibility for China's carbon emission. Finally, according to the results of this study, this paper proposes some recommendations to reduce carbon emission.

Keywords: export; carbon emission; low-carbon economy

I. INTRODUCTION

Entering into the 21st century, with joining a comprehensive, multi-level, wide-open new field, China's economy is becoming more extensive and deeper. Since the reform and opening up, China's exports have grown rapidly, the amount of which increase from 22.01 billion U.S. dollars in 1981 up to 1.202 trillion U.S. dollars in 2009, and it is becoming the largest exporting countries in the world. With the constant expansion of trade and rapid growth of China's energy consumption, the rise of carbon emission has become the focus of international concern. China's CO₂ emission increased from 1460 million tons (MMT) to 6499 MMT through 1980-2007. According to the estimation of Energy Information Administration (EIA) in U.S., without any control, China's CO₂ emission will reach 11.4 billion tons by 2030.

As China's emission of greenhouse gas increase rapidly, western countries continue to put pressure on China due to China's economic growth and the increase of coal-fired power plants, so China is required to reduce emission with the developed countries together, but China's carbon emission should be borne by the Chinese people? How about the relationship between China's exports and carbon emission? Therefore, to clarify the relationship between exports and carbon emission, objectively interprete the drive force of China's carbon emission growth, not only help China control and reduce trade carbon pollution, but also help China respond to the future international climate negotiations. In addition, through the analysis of the relationship between carbon emission and exports, it is of great practical significance to reduce China's emission from the perspective of foreign trade structure.

II. MODEL SETTINGS AND MEASUREMENT OF VARIABLES

Exports have an important effect on carbon emission for a country, the following paper will use a panel data of
China's 28 manufacturing industries from 2001 to 2007 to test the impact of exports on carbon emission.

A. Model Settings

Refering to the model of Cole & Elliott (2003), and taking Heteroskedasticity between the variables and the existence the impact of relevant variable increment on the explained variable increment into account, we take on the values of all variables and set the following model:

\[
\ln CE_t = \beta_0 + \beta_1 \ln Y_t + \beta_2 \ln EX_t + \beta_3 \ln EF_t + \varepsilon_t
\]  

(1)

In this equation, \( CE \) means carbon emission, \( i \) express industries, \( t \) means the year, \( Y \) means the level of economic development, \( EX \) means the exports, \( EF \) means energy efficiency, \( \varepsilon \) express random disturbance.

B. Measurement of Variables

1) Calculating Carbon Emissions

\( \text{CO}_2 \) emission can be divided into natural and artificial discharge. The artificial emission is caused by human activities, and mainly include fossil fuel consumption and biomass burning, in which the \( \text{CO}_2 \) emission of fossil fuel consumption account for more than 95%. As this study is industrial carbon emission, so fossil fuel consumption is the main carbon source. The estimation formula of industrial carbon emission is:

\[
CE = \sum_j CE_j = \sum_j m_j \times \eta_j
\]

(2)

In this equation, \( CE \) is total carbon emission, \( CE_j \) is the energy carbon emission of species \( j \), \( m_j \) is the energy consumption of species \( j \), \( \eta_j \) is the energy carbon emission factor of species \( j \). Here we mainly refer to the way of decomposition model of carbon emission improved by Xuguo Quan et al (2006). In this paper, we use primary energy coal, oil and natural gas, and in the first place, we change these various industrial energy consumption into standard coal (also known as coal equivalent, a heat value of the standard) and then calculate the carbon emission of various industries with energy carbon emission factors.

<table>
<thead>
<tr>
<th>Energy Name</th>
<th>Coal (kg tce/kg)</th>
<th>Oil (kg tce/kg)</th>
<th>Natural gas (kg tce/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>0.7143</td>
<td>1.4286</td>
<td>1.3300</td>
</tr>
</tbody>
</table>

Source: "China Energy Statistical Yearbook"

<table>
<thead>
<tr>
<th>Energy Name</th>
<th>Coal (k ton/k tce)</th>
<th>Oil (k ton/k tce)</th>
<th>Natural gas (k ton/k tce)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>0.7476</td>
<td>0.5825</td>
<td>0.4435</td>
</tr>
</tbody>
</table>

Source: National Development and Reform Commission, Energy Research Institute

2) Measurement of Other Variables

The level of economic development is measured by the industrial per unit of output (unit: yuan / person). Because of the data availability, we use exports delivery value measure industrial exports (Unit:billion). The energy efficiency is measured by the industrial unit output of energy consumption (Unit: tons / million).

Industrial output data and exports delivery data are available from China Industrial Statistical Yearbook, which is converted into 2001 constant price by industrial producer price index (industrial producer price index data is available from China Statistical Yearbook). The average number of employees data in industrial various sector is available from State Statistical Bureau. The industrial energy consumption data is available from China Energy Statistical Yearbook.

III. EMPIRICAL RESULTS AND ANALYSIS

Because the endogeneity problem may exist between the variables, and the estimation results of fixed effects or random effects may be biased, so this paper use the method of Generalized Method of Moments (GMM) to estimate. This method uses the tools within the system to deal with the endogenous variable problem, while allow for weak exogenous of explanatory variables and the prerequisite of GMM data validity is that new instrumental variable is valid. Arellano & Bover (1995) recommend the use of Sargan statistic tests to determine the effectiveness of instrumental variables, and the GMM estimation methods also need to test the existence of serial correlation. The
empirical results are presented corresponding to the value of the Sargan statistic and testing autocorrelation AR (1), AR (2).

In addition, because different sectors have different manufacturing nature, intensive use of elements types, technical content and industry size, and in order to further compare the various industry, referring to the OECD classification of products according to technical standards, the World Bank classification, and JianGuo Xie (2003) and Xianhai Huang (2006) classification results, we classified China's 28 manufacturing industries into three types: labor-intensive, capital-intensive and technology-intensive. According to the regression results, we compare the influence of these three types industrial exports on carbon emission. Empirical results are as follows:

### TABLE III. REGRESSION RESULTS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
<th>Labor intensive</th>
<th>Capital intensive</th>
<th>Technology intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln Y_{it}$</td>
<td>0.232*** (2.07)</td>
<td>0.171*** (2.57)</td>
<td>0.376*** (8.40)</td>
<td>0.346*** (2.09)</td>
</tr>
<tr>
<td>$\ln E_{it}$</td>
<td>0.225*** (3.09)</td>
<td>0.346*** (3.24)</td>
<td>0.305*** (4.13)</td>
<td>0.263*** (2.01)</td>
</tr>
<tr>
<td>$\ln E_{it}$</td>
<td>0.400*** (3.69)</td>
<td>0.288*** (4.49)</td>
<td>0.737*** (14.22)</td>
<td>0.394*** (2.23)</td>
</tr>
<tr>
<td>Sargan检验值</td>
<td>0.2754</td>
<td>0.9994</td>
<td>0.8391</td>
<td>0.4603</td>
</tr>
<tr>
<td>Wald 值</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>AR(1) p</td>
<td>0.000</td>
<td>0.004</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td>AR(2) p</td>
<td>0.526</td>
<td>0.781</td>
<td>0.265</td>
<td>0.909</td>
</tr>
</tbody>
</table>

A. **The Effect of Economic Development Level on Carbon Emission**

The influence of industrial output on carbon emission is positive in the 5% significant level, which indicates that industrial output has a major impact on carbon emissions. In general, accompanied with a country's economic growth, the economic output is rising and industrial scale is gradually expanding. Currently, as the energy consumption of domestic industrial sectors are still the extensive traditional patterns, so the energy consumption and carbon emission increase year by year. Because the nature of labor-intensive, capital-intensive and technology-intensive industries are different, the effect of industrial output on carbon emission respectively through 1%, 1% and 5% significant tests.

B. **The Effect of Exports on Carbon Emission**

With the expansion of the exports, the energy consumption of commodities production rise rapidly. The effect of industrial exports on carbon emission in 1% significant level is positive, which indicates that the exports have a strong dependence on energy consumption, and the pulling effect of exports on carbon emission is significant. In addition, different industrial sectors have different effects on carbon emission. For labor-intensive, capital-intensive and technology-intensive industries, their effects of exports on carbon emission respectively through 1%, 1% and 5% significant tests. And because of the existence of ferrous metal smelting and rolling processing industries, non-metallic mineral manufacturing industries and oil processing industries, the effect of capital-intensive industrial exports on carbon emission is greater than the other two types of industries.

C. **The Effect of Energy Efficiency on Carbon Emission**

The effect of industrial unit output of energy consumption on carbon emission through a 1% significant test, for labor-intensive, capital-intensive and technology-intensive industries, their effects of unit output of energy consumption on carbon emission respectively through 1%, 1% and 5% significant tests. As labor-intensive industries use less energy, so when its unit output of energy consumption change, there is little effect on carbon emission. On the contrary, the effect of capital-intensive industry is bigger than labor-intensive and technology-intensive industries.

IV. **CONCLUSIONS AND RECOMMENDATIONS**

Based on the empirical results we can see that the contribution rate of China's exports on carbon emission is 0.225, so the export of goods increased China's carbon emission in recent years, and exports are the important pulling force of carbon emission. China provides the final products for the United States and other developed countries, but also remain the pollution, and the carbon emission of our own is increasing correspondingly. It can be said that a considerable portion of carbon emission in China is a
"alternative" of other countries, so developed countries are responsible for China's carbon emission. To measure the reducing carbon emission of China and other developing countries with the existing low-carbon economy level, and require the developing countries to share carbon emission responsibility with developed countries is not fair. Besides, to solve this problem, we should:

A. Expanding Domestic Demand, and Adjusting the Export Structure

In order to make consumption as the most important driving force for economic growth, we should expand domestic demand actively and make great efforts to change the current growth model which over-rely on exports. Meanwhile, encourage low energy products exports, and restrict or prohibit the exports of energy-intensive products.

B. Develop a Low Carbon Economy

At present, climate change has become one of the hot issues of global concerning, the development of low-carbon economy and the reduction of carbon emission are the inevitable choices in the process of China's current economic development.

1) Promote the development of high-tech, high value-added industries by accelerating economic reconstruction, optimizing domestic industrial structure, and reorganizing the traditional industries. Meanwhile, to realize low-carbon of our national economy, we also should improve the proportion of services in the industrial structure, and reduce the energy consumption and the emission of carbon intensive degree.

2) Develop the renewable energy as the core of the energy revolution, and focus on the development of new energy sources. At the same time, we should combine the energy structure adjustment and energy efficiency improvement, gradually reduce the excessive dependence of the traditional industries on coal and other fossil fuels, and curb the increase in the total fossil energy consumption.

REFERENCES


