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The Empirical Analysis on the Carbon Emission Transfer by Sino-EU Merchandise Trade

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Abstract

By using input-output analysis method, this paper analyses the China and European Union's corresponding transfer amount of carbon emissions caused by Sino-EU trade in 2002, 2007 and 2012.Furthermore, the influence degree of scale, structure and intensity on the amount of carbon emission transfer of China and European Union in a specific period of time was analyzed by using the method of LMDI. The result shows that there exists carbon emissions transfer from European Union to China. Scale effect always has a positive influence on the transferred amount of Chinese and European carbon emissions during the study period. The negative effect of structure to the transferred carbon emissions of China is weakening and the effect of intensity to the transferred carbon emissions of China is from the positive influence to negative one. For the EU, the effect of structure and intensity remain relatively stable state.

Keywords: Sino-EU Bilateral Trade; Carbon Emissions Transfer; Input and Output Method; LMDI.

1. Introduction

With the rapid development of international trade, resources flow and reorganize in the global scope and the international division of labor has been further deepened. There are differences in environmental standards in different countries, which will lead to the transfer of polluting industries from countries with high environmental standards to countries with low environmental standards. The transfer of polluting industries also led to the international transfer of carbon emissions. Carbon emissions transfer is refers to the importer transfer the carbon emissions which should be produced in domestic to the exporter by the way of importing goods from abroad and the importer is not responsible for the corresponding carbon emissions.

China surpassed the United States as the world's first carbon emissions country in 2009, at the same time, China is facing enormous pressure from domestic and international energy to save and reduce carbon emission. But it is worth noting that a considerable part of China's goods which caused carbon emissions are sold to the United States, Japan and other developed countries. That is to say, the developed countries are the ultimate consumers of these commodities, while China is a producer of carbon emissions. China is in the face of increasingly severe external green trade barriers and internal environmental governance pressure.

This paper analyzes the influence of Sino-EU trade on bilateral carbon emission transfer and verifies the theory that

international trade will lead to carbon emissions transfer from the developed countries with a strict environmental regulation to the developing countries with relatively loose environmental regulation. By which we can reflect the phenomenon of EU's carbon emissions transfer to China more clearly .Through empirical study, this paper calculates the transfer amount of carbon emissions caused by Sino-EU trade and analyzes the influence degree of scale, structure and intensity on the amount of carbon emission transfer of China and European Union.

2. Review of Literature

In recent years, many scholars have conducted extensive research on the role of China in global carbon emission transfer. Weber et al. (2008) calculated that the export of China's carbon emissions transfer during 1987-2005 accounted for 12-33% of China's total carbon emissions. Qiang Liu et al. (2008) used the life cycle assessment method to calculate the carbon emissions of the forty-six main products in China's export. The result showed that these products took about 13.4% of the country's primary energy consumption in the export process and their carbon emissions accounted for 14.4% of the country's carbon emissions. Benyong Wei et al. (2009) used the input-output method to evaluate the carbon emission of China's foreign trade in 2002 .The result showed that China had become a net exporter of embodied carbon emissions in 2002 and China's foreign trade had reduced the world's 1.89 billion tons of carbon emissions. Guangyue Xu and Deyong Song (2010) calculated China's carbon emissions during 1980-2007 and used the factor analysis method to analyze the dynamic relationship among export trade, economic growth and carbon emissions.

In addition to the overall study of carbon emissions in China's foreign trade, some scholars have begun to study the carbon emission in the bilateral trade. Shui and Harriss (2006) used input-output method to study the embodied carbon problem in Sino-US trade and found that the 7%-14% of China's carbon emissions is caused by China's exports to the United States. Xianhua Wu et al. (2011) estimated the carbon emission transfer of Sino-US merchandise trade based on the input output table. The research found that: the carbon emissions embodied in China's exports to the United States accounted for 8.33% and 13.07% of the total carbon emissions of China in 2002 and 2007 respectively, while the carbon emissions embodied in US's exports to China only accounted for 0.66% and 0.21% of the total carbon emissions of US in 2002 and 2007. Xianjin Wu (2012) used the input and output method to analyze the carbon emission transfer of China and Japan in 1995, 2000 and 2005.The result showed that: the increase in carbon emissions caused by China's exports to Japan was greater than it caused by Japan's exports to China and the phenomenon of carbon emission transfer existed in Sino-Japanese trade.

Through the analysis above, we can know that the domestic and foreign scholars have made a lot of research on the carbon emission transfer in China's foreign trade. But there is less research on the carbon emission in bilateral trade. Because the EU's member states are quite a lot and the calculation is relatively complex, so the study of carbon emissions in Sino-EU trade is relatively few. Based on the domestic and foreign research, this paper makes a theoretical and empirical study on whether the Sino-EU trade produces carbon emission transfer.

3. Methodology

3.1 Environmental Input-Output Model

According to the balance in the horizontal of the value input output table, total output, intermediate use, end use, import and export have the following relationship:

$$X + M = AX + Y + E$$

X represents the total output, M represents import, AX represents intermediate use, Y represents end use, E represents export. A is direct consumption coefficient matrix:

$$A = (a_{ij})_{n \times n} \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & & a_{nn} \end{bmatrix} (i, j = 1, 2, \cdots, n)$$

a_{ij} is direct consumption coefficient($a_{ij} = X_{ij} / X_j$), it denotes the product number the ith sector consumes directly when the jth sector produces one unit product.

As the input-output tables of China and the EU are competitive, assume that the import volume m_i of the department i is proportional to the total demand of the department i and the ratio coefficient is k_i :

$$k_i = \frac{m_i}{\sum\limits_{i=1}^{n} a_{ij} x_j + y_i}$$

The corresponding matrix form is:

$$M = K(AX + Y)$$

The horizontal balance of the input-output table can be expressed as:

$$X = [I - (I - K)A]^{-1} [E + (I - K)Y]$$

Assume the direct carbon emission coefficient matrix is C_d , the total amount of carbon emissions is:

$$Q = C_d X = C_d [I - (I - K)A]^{-1} [E + (I - K)Y]$$
$$= C_d [I - (I - K)A]^{-1} E + C_d [I - (I - K)A]^{-1} (I - K)Y$$

$[I - (I - K)A]^{-1}$ is Leontief inverse matrix, it represents complete consumption coefficient.
$C_d [I - (I - K)A]^{-1} (I - K)Y$ represents the carbon consumed by domestic demand. $C_d [I - (I - K)A]^{-1} E$ represents the carbon consumed by export.

The direct carbon emission coefficient matrix reflects the direct carbon emission intensity of various sectors in the economic system. Since there is only one direct carbon emission factor for each sector, it is a diagonal matrix:

$$C_d = \begin{bmatrix} C_1 & 0 & 0 & 0 \\ 0 & C_2 & 0 & 0 \\ 0 & 0 & L & 0 \\ 0 & 0 & 0 & C_n \end{bmatrix}$$

$C_i (i = 1, 2, \frac{1}{4}, n)$ represents the direct carbon emissions volume of the ith sector in the case of unit value output:

$$C_{d(i)} = \frac{Q_i}{X_i} = \frac{Fq_{E(i)}}{X_i} \, (i = 1, 2, \cdots, n)$$

F refers to the average carbon emission factor of energy consumption, it can be calculated through the carbon emission intensity and energy consumption structure of the main energy varieties (coal, natural gas, oil, etc.) . $q_{E(i)}$ refers to total energy consumption of the ith sector.

The carbon emission transfer by Sino-EU merchandise trade is:

$$Q* = C_d^a [I - (I - K^a)A^a]^{-1} E^a - C_d^b [I - (I - K^b)A^b]^{-1} E^b$$

$C_d^a [I - (I - K^a)A^a]^{-1} E^a$ represents a country's exports to the b country corresponding to total carbon emission matrix of various departments, $C_d^b [I - (I - K^b)A^b]^{-1} E^b$ represents b country's exports to the a country corresponding to total carbon emission matrix of various departments.

3.2 LMDI Model

Based on LMDI model, the changes of carbon emissions by Sino-EU trade can be divided into:

$$Q^a = \sum_{i=1}^{n} Q_i^a = \sum_{i=1}^{n} E^a \frac{E_i^a}{E^a} \frac{Q_i^a}{E_i^a} = \sum_{i=1}^{n} E^a S_i^a I_i^a$$

Q^a refers to total carbon emission of a country, Q_i^a refers to carbon emissions of the ith sector, E^a refers to the export of a country, E_i^a refers to the ith sector's export of a country, S_i^a refers to the ratio of the ith sector's export to the total export of a country, I_i^a refers to carbon emission coefficient of the ith sector.

$$\Delta Q = Q^T - Q^0 = \Delta F_{act} + \Delta F_{str} + \Delta F_{int}$$

ΔQ refers to the change of carbon emission in bilateral trade from base period to report period, ΔF_{act} represents scale effect, ΔF_{str} represents structure effect, ΔF_{int} represents intensity effect. Their expressions are as follows:

$$\Delta F_{act} = \sum_{i=1}^{n} \frac{Q_i^T - Q_i^0}{lnQ_i^T - lnQ_i^0} (ln \frac{E^T}{E^0})$$

$$\Delta F_{str} = \sum_{i=1}^{n} \frac{Q_i^T - Q_i^0}{lnQ_i^T - lnQ_i^0} (ln \frac{S_i^T}{S_i^0})$$

$$\Delta F_{int} = \sum_{i=1}^{n} \frac{Q_i^T - Q_i^0}{lnQ_i^T - lnQ_i^0} (ln \frac{I_i^T}{I_i^0})$$

4. Empirical Analysis

4.1 Data Sources and Division of Departments

In this paper, the data of import and export of Sino-EU mainly come from UN Commodity Trade Statistics Database, the input-output tables of Sino-EU come from OECD Database, the energy consumption data come from China Energy Statistical Yearbook. Due to different types of data sources are not the same classification criteria, this paper merge these data sources and get ten departments, specific department codes and names are shown in Table 1.

Table 1: Department Codes and Names	
Department Codes	**Department Names**
1	Agriculture, Mining and Quarrying
2	Food, Beverages and Tobacco
3	Textiles，Leather and Footwear
4	Wood and Products of Wood and Cork
5	Paper and Printing
6	Chemicals and Chemical Products
7	Basic Metals and Fabricated Metal
8	Machinery and Transport Equipment
9	Electricity, Gas and Water Supply
10	Other activities

4.2 The Total Carbon Emissions of Sino-EU Merchandise Trade

According to the method described above, we can calculate the carbon emissions of various sectors caused by China's exports to the EU, carbon emissions of various sectors caused by EU's exports to the China and the transfer amount of carbon emission caused by Sino-EU merchandise Trade, the results are shown in table 2.

Table 2: The Total Carbon Emissions of Sino-EU Merchandise Trade (Unit: Ten Thousand Tons of Carbon)									
Department Codes	**Carbon emissions of various sectors caused by China's exports to the EU**			**Carbon emissions of various sectors caused by EU's exports to the China**			**The transfer amount of carbon emission caused by Sino-EU merchandise Trade**		
	2002	**2007**	**2012**	**2002**	**2007**	**2012**	**2002**	**2007**	**2012**
1	26.76	50.16	89.33	1.32	3.13	7.33	25.44	47.03	86.21
2	3.95	6.31	10.37	3.25	7.08	24.83	0.70	-0.78	3.29
3	46.84	70.31	64.47	2.17	3.86	13.09	44.67	66.45	60.61
4	139.97	291.59	194.49	13.18	2.51	21.77	126.79	289.09	191.9
5	6.26	18.71	13.43	0.53	0.22	0.92	5.73	18.49	13.21
6	716.98	4785.61	7148.35	63.21	167.16	387.48	653.77	4618.45	6981.
7	1300.31	3980.62	7597.25	48.23	144.12	227.52	1252.08	3836.50	7453.
8	150.29	578.79	1029.60	158.88	351.89	789.17	-8.58	226.90	677.7
9	136.11	277.57	461.04	9.58	28.70	72.92	126.52	248.87	432.3
10	1.91	1.88	5.70	1.74	0.40	0.41	0.17	1.48	5.29
Total	2529.38	10061.56	16614.03	302.07	709.07	1545.43	2227.31	9352.49	15904

We can see from the table 2, as China's exports to the EU continue to expand, the carbon emissions of various sectors caused by China's exports to the EU are increasing year by year. In 2002, 2007, 2012, the sectors of relatively high carbon emissions are always Chemicals and Chemical Products (Department 6), Basic Metals and Fabricated Metal (Department 7), Machinery and Transport Equipment (Department 8). In 2002, the carbon emissions of these three sectors were 2167.58 ten thousand tons, accounting for 85.70% of China's carbon emissions. In 2007, the carbon emissions of these three sectors increased to 9345.02 ten thousand tons, accounting for 92.88% of China's carbon emissions. In 2012, the three sectors' carbon emissions were 15775.2 ten thousand tons, accounting for the highest proportion of total carbon emissions in China.

There is a certain increase in carbon emissions of various sectors caused by EU's exports to the China, but the increase amplitude is less than the carbon emissions of various sectors caused by China's exports to the EU. In EU, the sectors of relatively high carbon emissions are mainly concentrated in Chemicals and Chemical Products (Department 6), Basic Metals and Fabricated Metal (Department 7), Machinery and Transport Equipment (Department 8). It's the same with China. Table 2 also shows that there exits carbon emissions transfer in Sino-EU merchandise trade, the top two sectors of carbon emissions transfer are Basic Metals and Fabricated Metal (Department 7), Chemicals and Chemical Products (Department 6). In 2012, the carbon emissions transfer of the two sectors reached 7453.13 and 6981.19 ten thousand tons.

4.3 The Analysis about Influencing Factors of Carbon Emission Transfer

By using the LMDI method, the effects of scale, structure and intensity on the carbon emission transfer are analyzed. The calculation results are shown in Table 3. In 2002-2007, the carbon emissions caused by China's exports to the EU increased 7532.18 ten thousand tons. Structural effects reduced carbon emissions of various sectors in China, the effects of scale and intensity increased carbon emissions of various sectors in China. In 2007-2012, the carbon emissions caused by China's exports to the EU increased 6552.47 ten thousand tons. The scale effect played a positive role, and the structure effect and strength effect all played a reverse role. Whether in 2002-2007 or 2007-2012, the scale effect plays an important role in the increase of carbon emissions transfer. The structural effect on the impact of China's carbon emissions export changed from -994.003 ten thousand tons in 2002-2007years to -344.15 ten thousand tons in2007-2012years, indicating that China is gradually turning to the export of high carbon emission products. The intensity effect on the impact of China's carbon emissions export changed from 1720.79 ten thousand tons in 2002-2007years to -3034.41 ten thousand tons in2007-2012years, it shows that China has begun to attach importance to the improvement of technology while it is expanding its export.

In 2002-2007, the carbon emissions caused by EU's exports to the China increased 407 ten thousand tons. The effects of scale and structure all played a positive role, making the total effect of each increase 402.99 and 9.95 ten thousand tons. The intensity effect played a reverse role, making the total effect decrease 5.94 ten thousand tons. In 2007-2012, the carbon emissions caused by EU's exports to the China increased 836.36 ten thousand tons. The effects of structure and intensity made the total effect of each decrease 40.35 and 20.22 ten thousand tons. However, the scale effect increased 896.93 ten thousand tons of carbon emissions. In general, the effect of scale has played a key role in the transfer of carbon emissions from the EU to China, and the function is more and more important. On the other hand, the structure effect and the strength effect are relatively stable

Table 3: The Structural Decomposition of Changes in Carbon Emission Embodied in China and EU's Export Unit: Ten Thousand Tons of Carbon								
Type	**2002-2007(China)**		**2007-2012(China)**		**2002-2007(EU)**		**2007-2012(EU)**	
	Changes	**Rate**	**Changes**	**Rate**	**Changes**	**Rate**	**Changes**	**Rat**
Scale Effect	6805.38	90	9931.03	152	402.99	99	896.93	101
Structure Effect	-994.00	13	-344.15	-47	9.95	2	-40.35	-1
Intensity Effect	1720.79	23	-3034.41	-5	-5.94	-1	-20.22	0
Total Effect	7532.18	100	6552.47	100	407.00	100	836.36	100

5. Conclusion

Based on China and EU's input-output tables, the input-output method is used to calculate the carbon emissions embodied in export of China and EU. It is found that the EU has transferred a large amount of carbon emissions to China. The EU has a certain responsibility for China's carbon emissions. Through the LMDI method, it can be known that the scale effect has positive effects on the growth of carbon emissions in China and EU, and it is the main influence factor. In addition to the trade imbalance between China and the EU, the reason for the transfer of the huge carbon emissions is the differences of the trade structure and energy intensity between China and EU. From the structure effect, we can see China has gradually turned to the export of high carbon emission products. The intensity effect shows that China has begun to pay more attention to the improvement of technology, but there is a certain gap between the level of China's manufacturing technology and the developed countries', so the energy utilization technology of china still needs to be further strengthened.

Why Sino-EU Merchandise Trade can produce so much carbon emissions transfer? The main reason is that since China joined the WTO in 2001, the bilateral trade volume between China and the EU has increased rapidly. As China's production technology level is relatively low and resource utilization is not high, it causes China has a large number of carbon emissions in the process of producing export products. In addition, China's exports are mostly primary products and low value-added industrial products, resulting in a large number of polluting gases and carbon emissions in China, which is not conducive to the sustainable development of China's economy and the improvement of people's living standard. Therefore, China should optimize the structure of export trade, change the export growth mode, reduce the proportion of pollution intensive products and improve the proportion of low carbon products in the export. For example, it can be used to impose export duties or reduce the export tax rebate for products with low added value, high energy consumption and high emission, guiding the structure of export products to the high-tech products and service industry with high value-added, low energy consumption. Through these measures to improve the ecological environment, while alleviating the contradiction between economic development and resource environment.

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