Estimate the Embodied Carbon Emission and Study the Influence Factors in the Sino-european Trade

Jing Ye
School of economics, Shanghai university, Shanghai 200444, China

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Abstract: In this paper, the direct carbon emission calculation method is used to analyze the hidden carbon emissions of each sector of China's trade with the EU. In this paper, the SDA analysis method is used to calculate the proportion of four factors affecting the embodied carbon emissions. Among them, the contribution rate of the improvement of energy use efficiency to the total embodied carbon reduction is 12.8%. Its technological innovation was only 6.7%. It shows that China still has a lot of room for improvement in technological innovation.

1 INTRODUCTION

As the greenhouse effect becomes more and more significant, there are different opinions about the causes of the greenhouse effect in the world, among which the widely accepted theory is that the emission of carbon dioxide causes the greenhouse effect. Rising temperatures will cause extreme phenomena such as heat waves, melting ice and rising sea levels, which in turn will further cause security problems in food, ecology, energy and water resources. As a developing country, China has abundant human resources and is in a period of rapid economic development. Due to the restrictions of emission reduction agreements, many energy-consuming departments in developed countries have been transferred to China, or they directly import high-energy-consuming production and living needs from China. This paper studies the growth factors of carbon emissions implied by Trade between China and the EU in 2010 and 2020, hoping to contribute to the reduction of carbon emissions in the future.

As regards the relationship between trade and carbon emissions, local and foreign scientists have carried out extensive studies and analyses, in particular the relationship between trade and carbon emissions, the carbon emissions traded and the factors influencing the carbon emissions traded (Ackerman et al., 2017; Peters & Hertwich, 2020; Weber & Matthews, 2018). Atkinson and Hamilton (2020) taking carbon dioxide and sulfur dioxide as environmental pollution index, the environmental effects of western, central and eastern regions of China are analyzed respectively. The results show that the environmental effects of foreign trade are closely related to pollutant types and regional differences in China. Chi et al. (2019) measuring the import pollution content of sulfur dioxide, chemical oxygen, dust and soot and the terms of trade of pollution, the study on trade and environment issues shows that international trade has a negative impact on the environment of exporting countries. Yan and Yang (2020) used the dynamic general equilibrium model to study the relationship between pollutant emissions and the international price of resources. The results show that there is a positive proportional relationship between the international price of resource products and the emission of pollution in the stable state, and it also indicates that under the open condition, the emission of pollution cannot be restrained by setting high prices of resource products.

In recent years, some scientists have begun to use the combination (SDA) with a direct carbon intensity measurement model to analyze the factors influencing carbon emissions embodied in trade (Shui & Harriss, 2016; Iftikhar et al., 2018).

Based on the existing research results at home and abroad, this paper will use the direct carbon emission model to calculate the carbon emissions implied by trade between China and the EU. At the same time, this paper also carries out structural decomposition analysis of the four factors, and tries to reveal the

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reasons that influence the growth of China's hidden carbon emissions in trade.

2 ESTIMATE THE EMBODIED CARBON EMISSION IN THE SINO-EUROPEAN TRADE

2.1 Direct Carbon Intensity Measurement

Direct carbon intensity is converted from energy consumption in each sector to CO_2 emissions. The specific formula is as follows:

$$X = Y + E \quad (1)$$

$$\begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^n \end{bmatrix} = \begin{bmatrix} \sum_{j=1}^{n} y^{1j} \\ \sum_{j=1}^{n} y^{2j} \\ \vdots \\ \sum_{j=1}^{n} y^{nj} \end{bmatrix} + \begin{bmatrix} E^1 \\ E^2 \\ \vdots \\ E^n \end{bmatrix} \quad (2)$$

In equation (1), X is the matrix of total domestic output, Y is the final use matrix in China, E is the exit matrix.

In this paper, W is set as the direct carbon dioxide emission coefficient matrix

$$\mathcal{W}_i = \frac{\alpha_K \times q_{ik}}{x_i} \quad (3)$$

α_k represents the direct CO_2 emission coefficient of various energy sources, q_{ik}/x_i represents the energy consumption intensity of type K in the industry sector i. x_i represents the total output of product department i. q_{ik} represents the total consumption of type K energy in the product sector i.

Finally, the total implied carbon emission formula of the country is obtained:

$$C = WX = WY + WE \quad (4)$$

2.2 Data Description

The study involved energy data, economic data and trade data. α K can be calculated according to the guidance of IPCC. According to the energy data published in China Statistical Yearbook, this paper divides energy consumption into eight types by department. They are fuel oil, crude oil, coal, kerosene, coke, gasoline, diesel and natural gas. The process of calculating the carbon dioxide emission coefficient α_k of these 8 major energy sources is as follows:

$$\alpha_k = CEF_K \times COF_k \times NCV_K \times (44/12) \quad (5)$$
(K=1,2,3,4........8)

α_k is the direct CO_2 emission coefficient of different energy sources, the calculation results are shown in Table 1.CEF is a carbon emission factor provided by the IPCC. COF is a carbon and oxygen binding factor (Carbon oxidation factor, take the deficiency value 1). NCV stands for average low calorific value of primary energy. Data are available from the China Energy Statistical Yearbook. The units of kerosene, crude oil, coal, coke, gasoline, and fuel oil are 10Kt/ 10Kt.The natural gas unit is 10Kt/ BCM (Billion Cubic Meters).

Table 1: Direct CO_2 emission coefficient of various energy sources (10Kt/ 10Kt, 10Kt/BCM).

Energy	Coal	Coke	Crude oil	gasoline	kerosene	diesel	Fuel oil	Natural gas
α_k	2.03	2.66	3.07	3.19	3.08	3.16	3.22	218.4

Note: The data sources in the table are calculated according to Formula (5) and the data provided by China Energy Statistical Yearbook and IPCC

The data of q_{ik} and x_i come from China Statistical Yearbook. All data in m_i and E come from China Statistical Yearbook of Foreign Trade. The data of China and EU interregional input-output tables are all from WIOD.

2.3 Conclusions and Discussion

Based on the model, we calculate the total implied carbon emissions of China's exports to the EU in 2010 and 2020(table 2).

Table 2: The total value of China's exports to the EU and the total carbon emissions embodied in them

year	2010	2020
Total carbon emissions implied by exports (10Kt)	39640.27	53874.21
Total exports (billion dollars)	2731.5	4449.7

From 2010 to 2020, the total embodied carbon emissions from China's exports of goods to the EU showed an upward trend. Compared with 2010, the embodied carbon emissions caused by China's commodity exports to the EU rose from39640.27Kt to 53874.21Kt in 2020.

Table 3 shows the implied carbon emissions and export amount of China's commodity sector exported to EU.

3 STRUCTURAL DECOMPOSITION ANALYSIS OF THE GROWTH OF IMPLIED CARBON EMISSIONS IN CHINA'S EXPORT TRADE TO THE EU

3.1 Structural Decomposition Analysis (SDA)

The SDA is to measure the influence of each variable on the dependent variable. This paper uses the SDA to decompose the change of embodied carbon in China's export trade to EU in 2010 and 2020.

$$C = WX = W[(I-U)Y] + WE \quad (6)$$

$$C_E = WE = W[I-(I-U)A]^{-1}E \quad (7)$$

$$E = QK \quad (8)$$

$$C_E = W[I-(I-U)A]^{-1}QK \quad (9)$$

There are four main factors affecting carbon emissions from China's export trade to the EU: energy efficiency, production technology, export scale and export structure. The structural decomposition of equation (9) can be obtained by the bipolar decomposition method (the calculation period is marked as 1 and the base period is marked as 0):

$$\Delta C_E = C_1 - C_0 = G_{\Delta W} + G_{\Delta[I-(I-U)A]^{-1}} + G_{\Delta Q} + G_{\Delta K} \quad (10)$$

$G_{\Delta W}$, $G_{\Delta[I-(I-U)A]^{-1}}$, $G_{\Delta Q}$, $G_{\Delta K}$ respectively represent the contribution value of energy utilization rate, production technology, export scale and export structure to the change of China's embodied carbon emissions from trade to EU in 2020 compared with 2010.

$$G_{\Delta W} = \frac{1}{2}\{\Delta W[I-(I-U)A]_1^{-1}Q_1K_1 + \Delta W[I-(I-U)A]_0^{-1}Q_0K_0\} \quad (11)$$

$$G_{\Delta[I-(I-U)A]^{-1}} = \frac{1}{2}\{\Delta W_0\Delta[I-(I-U)A]^{-1}Q_1K_1 + W_1\Delta[I-(I-U)A]^{-1}Q_0K_0\} \quad (12)$$

$$G_{\Delta Q} = \frac{1}{2}\{W_0[I-(I-U)A]_0^{-1}\Delta QK_1 + W_1[I-(I-U)A]_1^{-1}\Delta QK_0\} \quad (13)$$

$$G_{\Delta K} = \frac{1}{2}\{W_0[I-(I-U)A]_0^{-1}Q_0\Delta K + W_1[I-(I-U)A]_1^{-1}Q_1\Delta K\} \quad (14)$$

3.2 Results and Discussion

Decomposition results of implied carbon emission growth factors of China's export trade to the EU (Table 4).

Table 3: Implied carbon emissions from China's export goods sector to the EU.

Serial number	Industry sectors	Implicit carbon emissions from exports of goods to the EU by sector (10Kt)		Proportion of embodied carbon emissions from exports of goods to EU by sector in total emissions (%)	
		2010	2020	2010	2020
1	Agriculture, forestry, animal husbandry and fishery	187.56	206.77	0.46	0.38
2	Metal mining industry	466.38	98.28	1.16	0.18
3	Non-metallic mining and other mining industries	272.13	332.16	0.68	0.61
4	Food, beverage and tobacco processing industries	176.4	257.21	0.44	0.47
5	The textile industry	3522.45	5145.08	8.81	9.39
6	Garments, shoes, hats, leather, eiderdown and other products	433.35	891.62	1.08	1.63
7	Wood processing and furniture manufacturing	1060.27	2232.54	2.65	4.07

8	Paper printing, culture and education, sports goods manufacturing industry	1602.24	3130.73	4	5.71
9	Petroleum processing, coking and nuclear fuel processing industry	632.44	295.11	1.58	0.54
10	Chemical industry, plastic and rubber manufacturing	6313.39	13387.48	15.79	24.43
11	Nonmetallic mineral products industry	2338.15	4517.46	5.85	8.24
12	Metal smelting and rolling processing industry	9016.54	3532.01	22.56	6.44
13	Metal products industry	1077.13	1443.23	2.69	2.63
14	General, special equipment manufacturing	8736.42	11490.01	21.85	20.97
15	Transportation equipment manufacturing	756.21	1221.45	1.89	2.23
16	Electrical, machinery and Equipment manufacturing	2462.13	5421.28	6.16	9.89
17	Instrument and cultural office machinery manufacturing industry	722.3	798.33	1.8	1.46
18	Crafts and other manufacturing	200.2	221.34	0.5	0.4
19	others	54. 61	169.98	0.13	0.31

Table 4: Decomposition results of implied carbon emission growth factors in China's export trade to EU.

Influencing factor	Contribution value (10Kt)		Contribution (%)	
	formula	results	formula	results
Energy efficiency	$G_{\Delta W}$	-1415.39	$\frac{G_{\Delta W}}{\Delta C_E}$	-12.8
Production technology	$G_{\Delta[I-(I-U)A]^{-1}}$	-993.96	$\frac{G_{\Delta[I-(I-U)A]^{-1}}}{\Delta C_E}$	-6.7
Exports to the EU	$G_{\Delta Q}$	15458.31	$\frac{G_{\Delta Q}}{\Delta C_E}$	104.2
Export structure to EU	$G_{\Delta K}$	786.27	$\frac{G_{\Delta K}}{\Delta C_E}$	5.3

It can be seen from table 4 that among the four decomposition factors affecting the growth of carbon emissions in China's export trade with the EU, the improvement of energy efficiency and production technology have played a certain role in reducing carbon emissions.

4 CONCLUSION AND COUNTERMEASURES

It is of great theoretical and practical significance to calculate the carbon emissions of China EU trade and decompose the factors affecting the growth of EU export carbon emissions, so as to deeply understand the specific law of China's carbon emissions, advocate the formulation of fair and effective energy conservation and emission reduction policies, and draw the following conclusions and suggestions:

4.1 Conclusion

(1) From 2010 to 2020, the implied carbon emissions carried by China's exports to the EU showed a growing trend, with a cumulative increase of about 1.36 times.

(2) China is in the process of moving away from the dominance of labor-intensive exports. In the long run, industries with high added value and low energy consumption will dominate exports.

(3) The improvement of China's energy efficiency and production technology contributed to the reduction of embodied carbon emissions from EU exports, of which the improvement of energy efficiency played a major role. The scale and structure

of export to EU lead to the increase of carbon emission implied by export commodities. Since China's accession to the WTO in 2003, the foreign trade volume has shown a trend of rapid growth. In 2020, the EU became China's largest trading partner. The expansion of export scale makes China bear a considerable part of the hidden carbon emissions for the EU.

(4) The EU's CBAM applies first to cement, electricity, fertilizer, steel, and aluminum, and among them, steel and aluminum are China's main export commodities. Chinese steelmakers will face higher carbon tariffs than advanced foreign producers. Aluminum exports will also be affected, with exports falling sharply.

4.2 Policy Suggestions

(1) China should take an active part in international carbon reduction technology cooperation projects. The introduction of projects such as the open utilization of green energy and the development of environmental protection technology into China can greatly shorten the adjustment time of China's energy consumption structure. In addition, Chinese enterprises can also have access to international advanced technology, equipment and do a good job in technological reserve for the technological update and product transformation of Chinese enterprises.

(2) Although the Chinese government spends a lot of money on energy conservation and emission reduction every year, there is still a big gap in funding for the more serious climate problem. Therefore, climate finance is an effective way to mobilize funds to address climate change. China should formulate regulations on climate finance as soon as possible to encourage international and domestic capital to invest in energy conservation and emission reduction.

(3) In order to achieve the real reduction of implied carbon emissions, we should not only rely on "production responsibility system", but should adopt "per capita consumption implied carbon emissions responsibility system". This can effectively avoid because of the implicit calculation error caused by the transfer of carbon emissions, in addition, such not only can the pressure force of greenhouse gas emissions for each country, more able to assign the responsibility of the climate change everyone, let everyone feel climate change is not only the governments, but also related to their own actions.

This study mainly measures the implied carbon emissions of China's exports to the EU. However, due to the difficulty of obtaining EU energy use data, the implied carbon emissions of EU exports to China cannot be measured. In future research, we can collect and sort out EU energy use data to measure the carbon emissions reflected by EU exports to China. In this document, the carbon change factors embodied in export goods emissions are broken down and analyzed from a global perspective. In future studies, the analysis can be carried out by sector according to SDA, so that the reasons for the growth of red carbon emissions from each sector can be more deeply and clearly calculated.

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