Research on Oil Flow Embodied in Export Trade of China

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Keywords: Embodied Oil Flow, Export Trade, Input-Output Model, Structure Decomposition Analysis, China.

Abstract: In the past 20 years, China "leaked out" a large number of oil through exporting different kinds of products. The amount and the pathway of oil flow embodied in China's export trade are calculated by using the Input Output Model and the Structure Decomposition Analysis. The total exported embodied oil has grown from 5 206 × 10^4 ton in 1997 to 15 547 × 10^4 ton in 2010, which account for a large percent of China's domestic oil consumption. The export scale effect is always the major part of positive promotion, while the technology effect is the major part of negative influence. The export structure has lesser impacts, comparing with the other two effects. The scale effect of Manufacture of equipment is the largest source for the increment of exported embodied oil.

1 INTRODUCTION

After the accession to the World Trade Organization (WTO), China's integration with the global economy has contributed to sustained growth in international trade. Both its exports and imports have grown faster during the past dozen years, while China's trade surplus increased dramatically. Although this trend was affected by the international financial crisis, the Chinese government has made some plans recently to promote the economic prosperity, including "the Silk Road Economic Belt and the 21st-Century Maritime Silk Road" and "Made in China 2025", and so forth. Under these background, China's export trade will keep on developing predictably. On one hand, the huge trade surplus has brought China a great amount of foreign exchange reserve; on the other hand, it also cost China significant volumes of oil (X. Tang, B. Zhang, L. Feng,2012), because all goods and services produced in an economy are directly and/or indirectly associated with oil use (G. Machado, R. Schaeffer, and E. Worrell, 2001)

The debate on the impacts of international trade on energy flow is not new. Many researchers have studied the embodied energy imports or exports for a number of countries and regions, such as, China, the United Kingdom, and the United States, and so on. These studies show that there are a lot of energy flow embodied in the international trade, which is not often considered and still not sufficiently clear.

China's oil supply highly dependent on import, and the gap between its consumption and production has been increasing quickly. At the same time, with the continued growth of international trade, China are "leaking" a large number of oil through exporting different kinds of products. It is significant and urgent to answer the questions including, but are not limited to: How many embodied oil are exported? Which export sectors are most oil-consuming? What is the major driving force factors of the increase for the embodied oil export? The aims of this paper focus on calculating the amount and the pathway of oil flow embodied in China's export trade by using the Input Output Model and the Structure Decomposition Analysis. The study hopefully offer consultations for the development and management of China's international trade.

2 METHODOLOGY AND DATA

2.1 Basic Input Output Model

The Input-Output Analysis was firstly developed by Leontief in the 1930s, which has been widely used for analyzing the economic relationship of linkages between different sectors. The basic Input Output Model can be expressed as equation (1):

$$X = AX + Y = \left(I - A\right)^{-1} Y \quad (1)$$

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Zhang B. and Guo K.
Research on Oil Flow Embodied in Export Trade of China.
DOI: 10.5220/0006028204430447
In *Proceedings of the Information Science and Management Engineering III (ISME 2015)*, pages 443-447
ISBN: 978-989-758-163-2

Where, X and Y represent exogenous and endogenous accounts respectively, I is identity matrix, and A is the technical coefficient matrix that can be expressed as equation (2):

$$A = \left[a_{ij} \right]_{n \times n} \tag{2}$$

Where, i = (1, n); j = (1, n); n is the count of sectors in an economy system; a_{ij} is the technical coefficient, also called as direct consumption coefficient, which can be expressed as equation (3):

$$a_{ij} = \frac{x_{ij}}{x_j} \tag{3}$$

Where, x_{ij} is marked as sector j's use of products from sector i; and x_j is marked as the total output of sector j. The matrix $(I-A)^{-1}$ is often called Leontief Inverse Matrix.

Another important conception in the basic Input Output Model is complete consumption coefficient, denoted by b_{ij}, which measures how much direct and indirect output from sector i will be used in sector j's one unit worth of value of final output. It can be expressed as equation (4):

$$b_{ij} = a_{ij} + \sum_k (b_{ik} \times a_{kj}) \tag{4}$$

Where, k means the middle sector. If the complete consumption coefficient matrix is set as B, i.e. B = $(b_{ij})_{n \times n}$, the equation (4) can be solved and transferred to equation (5):

$$B = (I - A)^{-1} - I \tag{5}$$

2.2 Exported Embodied Oil Model

Based on the basic Input Output Model, the model for calculating oil flow embodied in international trade can be established as equation (6):

$$EO = \sum_{i=1}^{n} eo_i \cdot V_i \tag{6}$$

Where, EO is the amount of embodied oil in international trade; eo_i is the amount of embodied oil in one unit worth of value of product i, i.e. embodied oil intensity; V_i is the total value of product i in import or export trade.

Before calculation the technical coefficient matrix A should be modified to eliminate the influence of the processing and manufacturing trade, for example, some products are made by imported semi-finished products and be exported again after assembled. Firstly, A can be distinguished to two parts: the imported middle products part A^m and the domestic middle products part A^d, i.e. $A = A^m + A^d$. Secondly, the import coefficient matrix M are set to establish equation (7):

$$\begin{cases} A^m = MA \\ A^d = (I - M)A \end{cases} \tag{7}$$

Where, M is a diagonal matrix that can measures the dependence of sector i on the imported middle products, and the element of the diagonal matrix, marked as m_{ii}, can be expressed as equation (8):

$$m_{ii} = im_i / (X_i + im_i - ex_i) \tag{8}$$

Where, X_i is total output value of sector i, im_i is the total import value of sector i and ex_i is the total export value of sector i. It is assumed in this analysis that the share of imported products in every sector are same. Finally, the model of calculating exported oil flow embodied in international trade can be expressed as equation (9):

$$EO_{ex} = \sum_{i=1}^{n} eo_i \cdot (I - A^d)^{-1} \cdot ex_i \tag{9}$$

2.3 Structure Decomposition Analysis

Based on the exported embodied oil model, the structure decomposition analysis can be continued: firstly, set $t_i = eo_i (I - A^d)^{-1}$, which is complete oil consumption of sector i; secondly, set $s_i = ex_i / EX$, where ex_i is the total export value of sector i as mentioned above, EX is the total export value of the country, and, so, s_i is the share of sector i's export value on the total export of the country. Then, the exported embodied oil of sector i can be transferred to equation (10):

$$EO_{exi} = t_i \cdot s_i \cdot EX \tag{10}$$

The amount of exported embodied oil are divided by this equation into three parts: the complete oil consumption coefficient, the structure of export and the scale of export, which are called the technology effect, the structure effect and the scale effect. The change of the exported embodied oil from time t1 to time t2 can be expressed as equation (11):

$$\Delta EO_{exi} = EO_{exi}^{t2} - EO_{exi}^{t1} = t_i^{t2} \cdot s_i^{t2} \cdot EX^{t2} - t_i^{t1} \cdot s_i^{t1} \cdot EX^{t1} \tag{11}$$

Equation (11) can be solved by using the Logarithmic Mean Divisia Index (LMDI) method. The solution are shown as equation (12):

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$$\begin{cases} \Delta EO_{exi} = EO_{exi}^{t2} - EO_{exi}^{t1} = t_i^{eff} + s_i^{eff} + EX^{eff} \\ t_i^{eff} = L(EO_{exi}^{t2}, EO_{exi}^{t1}) \cdot \ln(t_i^{t2} / t_i^{t1}) \\ s_i^{eff} = L(EO_{exi}^{t2}, EO_{exi}^{t1}) \cdot \ln(s_i^{t2} / s_i^{t1}) \\ EX^{eff} = L(EO_{exi}^{t2}, EO_{exi}^{t1}) \cdot \ln(EX^{t2} / EX^{t1}) \\ L(EO_{exi}^{t2}, EO_{exi}^{t1}) = (EO_{exi}^{t2} - EO_{exi}^{t1}) / \ln(EO_{exi}^{t2} / EO_{exi}^{t1}) \end{cases} \quad (12)$$

Where, t_i^{eff} , s_i^{eff} and EX^{eff} mean the influence effects of the change from technology, the structure of export and the scale of export.

2.4 Data

The oil consumption and the total output value of every industries, the technical coefficient matrix A between all industries and the import and export value of every industries are need to calculate the embodied oil flow. The data above are available from China's statistical yearbooks and China's Input Output tables (1997, 2002 and 2007 are original tables, 2000, 2005 and 2010 are extended tables) that both released by the National Bureau of Statistics of China. Classification of industries are different between the two data sources, so it should be modified for consistency. Fifteen industry sectors are used in this study, as shown in Table 1.

Table 1: Modified Industry Sectors of China.

NO.	Industry Sector
1	Agriculture
2	Mining
3	Manufacture of food, beverages and tobacco
4	Manufacture of textile, wearing apparel, footwear, caps, leather, fur, feather and related products
5	Other Manufacture
6	Production and supply of power, heat and water
7	Processing of petroleum
8	Chemical industry
9	Manufacture of non-metallic mineral products
10	Manufacture of metal products
11	Manufacture of equipment
12	Construction
13	Transportation, Postal, Telecommunication services
14	Wholesale and retail trades, Hotels and catering services
15	Real estate, Banking and insurance and other services

3 RESULTS AND ANALYSIS

3.1 Amount of Exported Embodied Oil

According to the model built above and annual data, the amount of oil embodied in China's export trade of every industry sectors are calculated as shown in Table 2. The total consumption of oil in China (DC, Domestic Consumption) and the proportion of exported embodied oil on DC are also displayed.

Table 2: Exported embodied oil and the share on domestic consumption of sectors. The No. from 1 to 15 represent 15 industry sectors mentioned in Table 1. Unit: 10^4 Ton.

No.	1997	2000	2002	2005	2007	2010
1	49	745	62	49	41	48
2	237	242	234	199	111	72
3	93	111	114	144	141	155
4	508	6214	954	1197	1422	1389
5	243	226	428	590	591	649
6	16	0	13	13	11	10
7	712	525	784	1539	1196	1180
8	674	844	1232	1592	2011	2352
9	101	125	138	202	234	319
10	416	556	639	1030	1506	1084
11	1119	1704	2674	4142	4499	5389
12	8	9	36	38	62	131
13	249	275	652	1049	1212	1146
14	245	282	316	609	396	465
15	537	569	600	858	1061	1158
Total	5206	6164	8877	13250	14493	15547
DC	17367	21232	22541	30086	34032	42875
Share	30%	29%	39%	44%	43%	36%

Two sectors, No. 11 (Manufacture of equipment) and No. 8 (Chemical industry), are the first and second largest sources of exported embodied oil. In 2010, the amount of exported embodied oil of the two sectors account for about 50% in total. There is a clear increase trend of exported embodied oil for the sector of Manufacture of equipment, and the total increase rate between 1997 and 2010 is 382%, which is larger than any other sectors.

It also can be seen from Table 2 that both the total domestic consumption of oil and exported embodied oil have massive growth from 1997 to 2010. The growth rate of exported embodied oil is 199%, which is larger than that of domestic consumption (147%). In recent years, the percentage of exported embodied oil is around 40%, which means there are about 40% of China's oil consumption per year are contributed to other countries through international trade. But the trend has revealed a clear decline trend after 2005.

3.2 Influence Factors of Embodied Oil

Influence factors of the increase for exported embodied oil are analyzed by using the Structure Decomposition Analysis method. The results of the analysis on embodied oil between 1997-2000, 2000-2002, 2002-2005, 2005-2007 and 2007-2010 are displayed in Figure 1-5.

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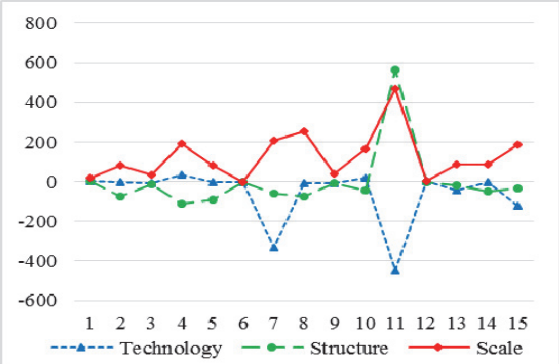

Figure 1: Influence factors of the change on exported embodied oil between 1997 and 2000. Unit: 10^4 Ton.

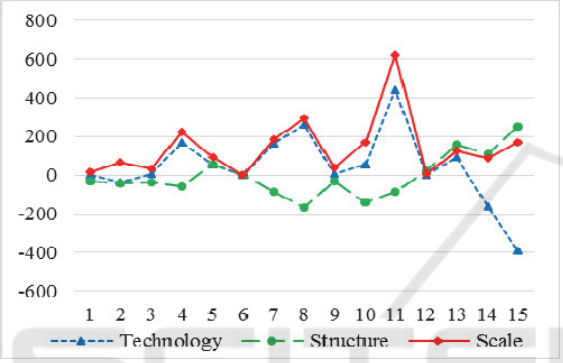

Figure 2: Influence factors of the change on exported embodied oil between 2000 and 2002. Unit: 10^4 Ton.

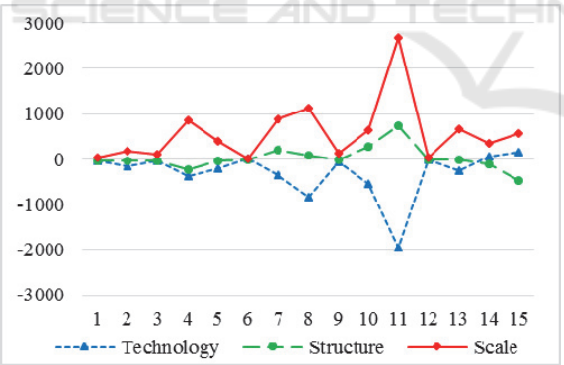

Figure 3: Influence factors of the change on exported embodied oil between 2002 and 2005. Unit: 10^4 Ton.

The change on the amount of embodied oil in international trade are derived from combined action of three effects. It can be seen from Figure 1-5 that the export scale effect is always the major part of positive promotion, while the technology effect is the major part of negative influence. The only exception of the technology effect appeared at the change from 2000 to 2002. The export structure has lesser impacts, comparing with the other two effects.

The industry sectors of No.1 Agriculture, No.3 Manufacture of food, beverages and tobacco, No. 6 Production and supply of power, heat and water, No. 9 Manufacture of non-metallic mineral products and No. 12 Construction export pretty small amount of oil embodied in international trade. The reason is all of these sectors are low energy consuming or have very small value of exports because their own industrial characteristics.

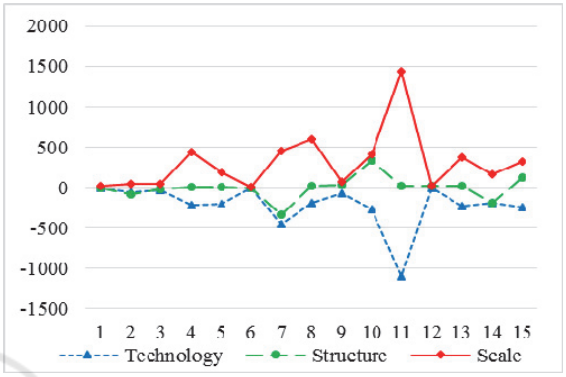

Figure 4: Influence factors of the change on exported embodied oil between.2005 and 2007. Unit: 10^4 Ton.

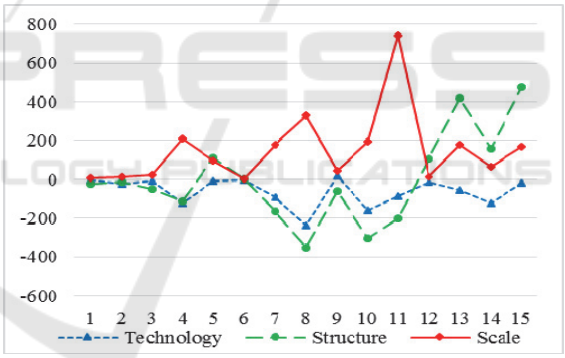

Figure 5: Influence factors of the change on exported embodied oil between 2007 and 2010. Unit: 10^4 Ton.

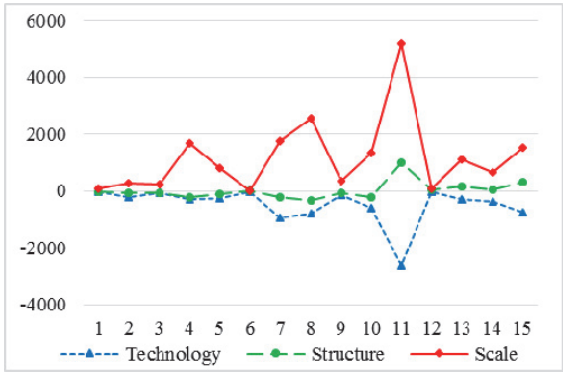

Figure 6: Influence factors of the change on exported embodied oil between 1997 and 2010. Unit: 10^4 Ton.

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The total Influence factors of the change on exported embodied oil between 1997 and 2010 are also calculated, as shown in Figure 6. The scale effect of Manufacture of equipment is the largest source for the increment of exported embodied oil, even its technology effect also is the largest. Which is in line with the result in Table 2.

4 CONCLUSIONS

The amount and the pathway of oil flow embodied in China's export trade are calculated by using the Input Output Model, the Structure Decomposition Analysis and China's annual data (1997-2010).

The results show that, in the past 20 years, Manufacture of equipment and Chemical industry are the first and second largest sources of exported embodied oil. The total exported embodied oil has grown from 5 206 × 10^4 ton in 1997 to 15 547 × 10^4 ton in 2010, which account for a large percent of China's domestic oil consumption. The export scale effect is always the major part of positive promotion, while the technology effect is the major part of negative influence. The export structure has lesser impacts, comparing with the other two effects. The scale effect of Manufacture of equipment is the largest source for the increment of exported embodied oil.

The oil flow embodied in international trade and its influence factors should be considered during the development and management in the future.

ACKNOWLEDGEMENTS

The authors would like to give many thanks to the National Social Science Foundation of China (No. 13&ZD159) for sponsoring this research.

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