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The Impact of Trade Liberalization on the Environment: A Case Study of Fujian Province, China

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Abstract

With the rapid development of international trade and the continuous deterioration of the environment worldwide, the issue of impact of trade on energy consumption and pollution emissions has drawn widespread attention of the international community. Theoretical circles have different views on the impact of trade liberalization on the environment. The hypotheses of "Pollution Haven" and "Environmental Factor Endowment" are both representative theories. Based on the revised input-output model, this paper estimates the trade embodied carbon emissions of import and export commodities in Fujian Province from 2008 to 2016. The results show that Fujian Province is a net export region with implicit carbon emissions, and there is a significant pollution surplus in international trade. But because the embodied carbon pollution per unit of imports is greater than the embodied carbon pollution per unit of exports, the terms of trade for carbon emissions are less than 1. Therefore, the hypothesis of "Environmental Factor Endowment" can explain the environmental impact of Fujian's trade liberalization better than the "Pollution Haven".

Keywords: Trade Embodied Carbon, Input-output Model, Pollution Hypothesis, Environmental Factor Endowment Hypothesis

1. Foreword

Global warming has stood the global arena several years ago, advocating low-carbon lifestyle and promoting citizens consciousness of energy conservation and emissions reduction are important measures against global warming. Since 1997, countries around the world have formulated many agreements related to environmental protection, such as the "Kyoto Protocol", "United Nations Framework Convention on Climate Change" and other agreements to limit the destruction of the environment by countries. China attaches great importance to the climate change and environmental protection. In November 2016, the Paris Agreement came into effect. China's carbon emission reduction commitments have also produced the desire results. It is promised that CO_2 emissions will peak around 2013, and that by 2030, CO_2 emissions per unit of GDP will drop by 60~65% compared to 2005. This means that our country must implement emission reduction work in a limited time.

Scholar of academia also pay lots attention on the global warming. Some scholars stand on the side of the environmentalists and believe that free trade will increase environmental pollution. They believe that especially in developing countries, environmental regulations are relatively loose. Trade liberalization can easily result in the transfer of polluting industries into their own countries, so developing countries will become "polluting paradise". However, trade advocates believe that the fundamental cause of environmental

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degradation is not trade liberalization, restricting international trade cannot solve the problem. Moreover, they believe that free trade can not only promote the transfer of environmental protection technology internationally, but also improve the efficiency of global resource allocation, thereby promoting the economic development of various countries.

There are many domestic and foreign literatures on the relationship between trade liberalization and pollution in a country, but few studies focused on embodied carbon balance from a regional perspective. This article takes Fujian Province as an example to investigate the environmental impact of regional trade development. Fujian Province is renowned as a major foreign trade province in China. Considering China has been the pioneer of foreign trade for many years, which represent significance to discuss the impact of trade liberalization on the environment. With the rapid development of foreign trade, how effective is the transformation of Fujian's foreign trade growth mode? How productive the emission reduction targets and environmental protection? This article will verify the applicability of the hypotheses of "Pollution Haven" and "Environmental Factor Endowment" in Fujian Province based on the calculation of the embodied carbon emissions from foreign trade in Fujian Province.

2. Related Theories and Literature

In the theoretical circle, there are two diametrically opposed views concerning the impact of trade on the environment. The environmental support group represented by Daly believes that free trade will aggravate environmental pollution, weaken the effectiveness of environmental protection laws. Controls in developing countries are loose, which means trade liberalization policies will directly lead to environmental degradation, making developing countries became "Pollution Haven". The trade support faction represented by Bhagwati believes that regional and global trade liberalization is not the fundamental reason for the deterioration of the ecological environment. Using trade restrictions to solve environmental problems will only create further distortions. The international specialized division of labor based on comparative advantages can improve the efficiency of resource allocation, promote economic development, and provide financial support for improving the environment. At the same time, free trade can also promote the international transfer of cleaner production technologies and environmental protection technologies.

Environmentalists' views involve an important theoretical hypothesis-the "Pollution Haven" hypothesis. The hypothesis holds that countries with higher income levels generally have higher demand preferences for environmental quality. Therefore, the environmental control standards in developed countries will be stricter than in developing countries. If the environment is regarded as a production input factor, then developing countries are countries with relatively abundant environmental resources. Therefore, developing countries have comparative advantages in producing resource-intensive and pollution-intensive products. Therefore, in pursuit of cost minimization, some multinational companies will transfer high-polluting and high-consumption industries from developed countries to developing countries, thus creating the phenomenon of so-called "Pollution Havens". However, the "Pollution Haven" hypothesis has also been opposed by the supporters of the "Environmental Factor Endowment" hypothesis, who believe that the factor endowment of a country is the main factor that determines its division of labor in international trade. Since highly polluting industries are usually capital-intensive, trade liberalization will cause pollution-intensive industries to shift to developed countries with relatively abundant capital endowments.

Regarding the impact of trade on the environment and whether the hypothesis of

"Pollution Haven" is valid, the conclusions drawn from the research literature are also conflicting. The World Bank's research on trade and environment found that the more open a country's trade policy, the slower the increase in pollution intensity of output. Trade liberalization has not caused developing countries to become pollution "havens". However, Rock (1996) and others came to the opposite conclusion. Their research pointed out that compared with inward-looking trade policies, open trade policies are often accompanied by pollution-intensive (Antweiler et al, 2001). Wei & Pan (2016) analyzed the panel data of 285 prefecture-level cities in China from 2005 to 2012, and the results showed that the increase in export trade significantly increased the environmental pollution of China's resource-based cities.

Through the study of the literature, we found that the impact of trade on the environment is uncertain. Since the achievement of national emission reduction targets depends on the concrete results of provincial emission reduction efforts. Therefore, based on the data of Fujian Province, this paper investigates the emission reduction achievements of foreign trade in Fujian province in order to provide reference for the adjustment of emission reduction in Fujian province and the whole country.

3. The State of Foreign Trade in Fujian Province

3.1 Fujian's Import and Export Volume

Fujian, a major foreign trade province in China, trading totaled 1,330.67 billion yuan in 2019, up 7.8 percent from the previous year and 4.4 percent faster than China's imports and exports in the same period. Among them, the export value was 827.79 billion yuan, an increase of 8.7%, and the import value was 502.88 billion yuan, an increase of 6.3%. According to Figure 1, the average annual growth rate of the total import and export volume of Fujian Province is 8.76%. During 2008-2018, except for 2009, 2015 and 2016, import and export trade volume continued to grow. In 2010, the growth rate of total import and export trade reached a peak of 36.57%, export growth was 34.09%, and import growth was 41.64%.

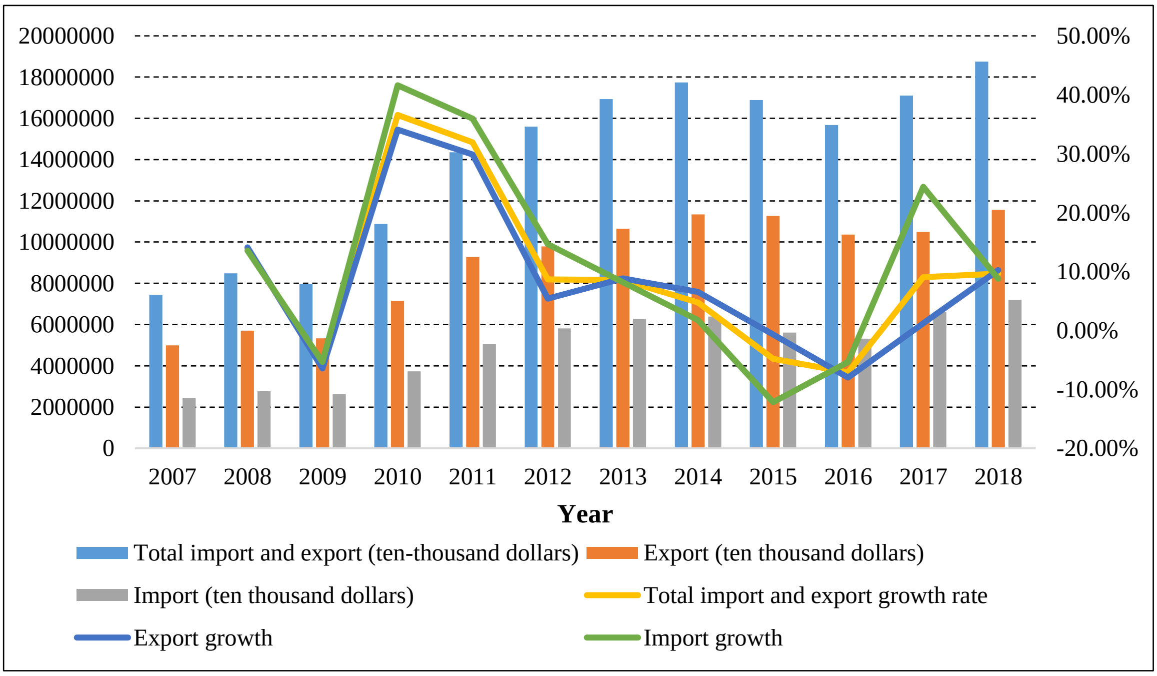

Figure 1. Fujian's import and export trade volume and growth rate from 2008 to 2018

From the perspective of the foreign trade market, the United States, ASEAN, and the EU rank among the top three foreign trade partners. In 2019, the import and export volume of Fujian Province to the United States was 174.22 billion yuan, a decrease of 14.3%. The import and export volume of Fujian Province to the EU was 186.63 billion yuan, an increase of 9.4%. The import and export volume of Fujian to ASEAN was 248.57 billion yuan, an increase of 17.5%. The scale of emerging markets has also continued to rise, with imports and exports to Africa and Latin America increasing by 22.4% and 17.9% respectively. In 2019, the accumulated trade volume of Fujian Province with the trading countries along the Belt and Road Initiative reached 455.1 billion yuan, an increase of 16.3%.

3.2 Structure of Import and Export Commodities in Fujian Province

The imports and exports of Fujian Province are mainly manufactured products. From 2007 to 2018, the proportion of industrial exports in Fujian's total exports fell from 94.8% to 90.6%, and the proportion of industrial imports in total imports fell from 79.9% to 53.49%, both showing a downward trend.

Fujian's industrial exports are dominated by mechanical, electrical products and labor-intensive products. The total export value of the two exceeds 70% of Fujian's total exports. For example, in 2019, Fujian Province exported 301.36 billion yuan of mechanical and electrical products, an increase of 8.2%, accounting for 36.4% of the province's total exports. Exports of labor-intensive products such as textiles, garments and shoes were 307.17 billion yuan, an increase of 13.6%, accounting for 37.1% of the province's total exports. The export structure of other export products, including food and tobacco, wood processing and furniture, chemical products, and non-metallic mineral products, is basically stable.

The main imported products of Fujian Province mainly include machinery and transportation equipment, chemical products, metal mining products, fuels and other resource processed products. Among them, imports of machinery and transportation equipment accounted for about 1/3 of the total imports, and imports of chemical products, petroleum and fuels, and metal mining products accounted for 20%, 10% and 8% respectively. The structure of each item is generally stable, but the internal structure has slightly changed. For example, especially since 2012, imports of general equipment and special equipment have declined while imports of transportation equipment have increased.

4. Estimation of Embodied Carbon in Industrial Import and Export Trade in Fujian Province

4.1 Input-Output Model (I-O Model)

In 1936, the American economist Vasily Leontiev created the input-output method. The model in this article is based on the basic framework of the input-output method, using matrices and algebra. We can express the model as:

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

$$X = (1 - A)^{-1}Y \quad (2)$$

Among them, X is the total output vector in the national economic sector, and Y is the final demand vector.

The input-output model also involves the concept of consumption coefficient. In this article, there are two main indices needed for calculation: direct consumption coefficient and complete consumption coefficient.

(1) direct consumption coefficient

The direct consumption coefficient is the amount of the "i"th good that is directly consumed for each unit of product "j" produced, which can be expressed as "a_{ij}". The resulting matrix is called the direct consumption coefficient matrix and can be denoted as matrix "A". The calculation method is to divide the total amount of the "i"-th product directly consumed when producing "j" product by the total output of "j" product, the expression is:

$$a_{ij} = \frac{x_{ij}}{x_j}(i, j = 1,2,\ldots,n) \quad (3)$$

(2) complete consumption coefficient

Total consumption refers to the sum of direct and indirect consumption. That is, for every unit of "j" product produced, the amount of "i" sector product that needs to be completely consumed. The resulting matrix can be called the complete consumption matrix, denoted as matrix "B", and expressed as:

$$B = (I - A)^{-1} - I \quad (4)$$

The matrix "I" is the identity matrix and has the same order as the matrix "A" and "B". $(I - A)^{-1}$ is called the Leontief inverse matrix.

4.2 The Calculation Method of Trade Embodied Carbon

4.2.1 Calculating Method of Embodied Carbon Emission in Export Sector

When calculating the embodied carbon emissions of the export sector, there are three main steps:

(1) First, calculate the direct carbon emission coefficient "W_j" of each export industry, and its matrix is the direct carbon emission matrix , denoted as "W". The calculation process of "W_j" is as follows:

$$W_j = e_j \times f_j \quad (5)$$

$$e_j = \frac{E_j}{P_j} \quad (6)$$

e_j represents the energy output consumption of sector "j", that is, the energy consumption E_j of sector "j" divided by the total output P_j of sector "j".

$$f_j = \sum_{i=1}^{n} \theta_i * \varepsilon_{ij} \quad (7)$$

f_j is the energy carbon emission coefficient of sector "j", θ_i is the carbon emission coefficient of energy "i", and ε_{ij} is the consumption proportion of energy "i' in sector "j". θ_i can be calculated according to the method provided by IPCC, the formula is as follows:

$$\theta_i = NCV_i * CEF_i * COF_i * \frac{44}{12} \quad (8)$$

CEF represents the carbon emission factor, the data of which can be obtained from the IPCC; NCV refers to the average low calorific value of primary energy, which can be found in the China Energy Statistical Yearbook; COF refers to the carbon oxidation factor, with a default value of 1.44 and 12 respectively represent the molecular weight of carbon dioxide and carbon.

（2）Calculate the complete carbon emission matrix D:

$$D = (I - A)^{-1} * W \quad (9)$$

（3）Finally, by multiplying the industrial export trade volume matrix EX (column vector) of each sector and the complete carbon emission coefficient matrix D, we can get the export trade implied carbon matrix P of each sector, and the total trade embodied carbon is obtained by adding up the values of each sector :

$$P^{ex} = W * (1 - A)^{-1} * EX \quad (10)$$

4.2.2 Calculating Method of Implicit Carbon Emission of Import Department

The method chosen in this paper is to use a single-region input-output model to measure the carbon embodied in import trade. Compared with the multi-region input-output model, the single-region input-output model is more feasible. The single-region input-output model uses the input-output table of a single country or region to analyze the embodied carbon emissions of trade in that region. Mainly based on the assumption of technological homogeneity. Use the direct emission coefficients of each industry in your country to replace the direct emission coefficients of each importing country's industry, calculate the direct carbon emission coefficient to get the full carbon emission coefficient, multiply it by the import amount of each sector, and add the values of each industry to get The total carbon emissions implied by import trade:

$$P^{im} = W * (1 - A)^{-1} * IM \quad (11)$$

4.2.3 Adjustment of Input-Output Model

Considering the issue of processing trade, we need to adjust the input-output model. Fujian Province participates in the international vertical division of labor, so it is necessary to consider the carbon dioxide that is implied in exported goods from foreign production. This paper draws on other authors' method of calculating the vertical division of labor in regional export trade, and processes the direct consumption coefficient matrix *A*. Decompose the direct consumption coefficient matrix A into a domestic consumption matrix and an import coefficient matrix:

$$A = A^D + A^M \quad (13)$$

A^M is the import coefficient matrix, and A^D is the domestic consumption matrice. Subtract A^M from A and get A^D.

Then the next step is to calculate the value of A^M. ${C_i}^D$ and ${C_i}^M$ respectively represent the domestic production quantity and imported production quantity of the final product of sector "i"; ${I_i}^D$ and ${I_i}^M$ represent the domestic production quantity and the imported production quantity of the intermediate product of sector "i" . We can get:

$$\frac{C_i{}^M}{C_i{}^D} = \frac{I_i{}^M}{I_i{}^D} \tag{14}$$

It can be derived from this formula:

$$\frac{C_i{}^M}{C_i{}^D} = \frac{I_i{}^M}{I_i{}^D} = \frac{I_i{}^M + C_i{}^M}{I_i{}^D + C_i{}^D} \tag{15}$$

Finally:

$$\frac{I_i{}^M}{I_i{}^D + I_i{}^M} = \frac{I_i{}^M + C_i{}^M}{I_i{}^D + C_i{}^D + I_i{}^M + C_i{}^M} \tag{16}$$

We multiply each row of the direct consumption coefficient matrix A by the department's import coefficient to get A^M, then subtract A^M from A and calculate A^D.

5. Empirical Analysis and Results of I-O model

5.1 Data Source and Industry Classification Adjustment

The data of article comes from the input-output tables compiled by China and various provincial statistical bureaus and the "Fujian Provincial Statistical Yearbook". According to the input-output table and the input-output extension table, we learn from others and use the data of adjacent years to replace the input-output relationship of the missing years. In data compilation, we divided the industrial sector of Fujian Province into the following 19 sub-sectors, as shown in Table 1:

Table 1. Division of industrial sectors in Fujian province

Numbering	Industry title	Numbering	Industry title
1	Coal mining and washing industry	11	Papermaking, printing and cultural, educational and sporting goods manufacturing
2	Petroleum processing, coking and nuclear fuel processing industry	12	Chemical industry
3	Metal mining and dressing industry	13	General and special equipment manufacturing industry
4	Non-metallic mining and other mining and dressing industries	14	Transportation equipment manufacturing
5	Metal smelting and rolling processing industry	15	Electrical machinery and equipment manufacturing
6	Metal products industry	16	Computer, communications, and other electronic equipment manufacturing
7	Non-metallic mineral products industry	17	Instrumentation Manufacturing
8	Food and tobacco processing industry	18	Other manufacturing
9	Textile, clothing, shoes, hats, leather, and its products industry	19	Electricity, heat, gas and water production and supply industry
10	Wood processing and furniture manufacturing		

Data source: Fujian Provincial Statistical Yearbook

5.2 Energy Carbon Emission Coefficient

Mainly adopt internationally accepted methods and refer to the reference methods of IPCC2006 guidelines to calculate the carbon emission coefficients of various energy sources. The carbon emission coefficients of the seven types of energy in Fujian Province to be examined in this article are shown in Table 2 below:

Table 2. Energy carbon emission coefficient table

Energy	Original coal	Coke	Steam Oil	Coal Oil	Firewood Oil	Fuel oil	Electricity
Carbon Emission Coefficient	1.9779	3.0444	3.1901	3.0953	3.1591	3.2352	0.3403

5.3 Implied Carbon Emissions from Import and Export Trade

Table 3 shows the calculated embodied carbon emissions from imports and exports of various departments in Fujian Province from 2008 to 2016. From 2008 to 2016, the embodied carbon emissions of the export sector showed an overall downward trend. Taking 2016 as an example, the sectors with the highest embodied carbon emissions in export trade include textile and apparel, shoes, hats, leather and their products, and general and special equipment manufacturing. The coal mining and washing industry, petroleum processing industry, coking and nuclear fuel processing industry, and metal mining and processing industry have relatively low carbon emissions.

Table 3. The embodied carbon exported by various industrial sectors in Fujian Province from 2008 to 2016 (tons)

Industrial Sectors	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	2	1	2	16	33	21	461	85	1,975
2	1,763	2,734	10,018	16,263	5,383	2,015	1,033	560	122
3	127	193	364	3,133	3,912	1,596	560	524	257
4	6,885	7,970	6,370	10,127	6,961	8,058	8,293	5,663	5,386
5	193,937	85,606	150,190	182,452	205,785	201,813	50,381	166,290	169,390
6	144,469	108,375	163,760	235,224	221,332	188,182	207,481	164,436	146,668
7	469,492	441,108	518,558	699,361	375,465	394,879	363,711	320,127	298,797
8	43,620	37,025	48,915	61,394	127,093	133,922	123,618	94,618	98,917
9	677,688	500,675	576,069	849,008	635,878	726,554	664,823	508,145	457,802
10	122,076	104,213	131,700	169,681	242,263	219,672	204,771	155,279	146,474
11	22,333	20,463	27,831	63,507	32,442	31,384	35,997	29,037	27,692
12	192,240	99,850	144,126	209,645	210,443	210,959	221,841	150,622	147,419
13	314,834	188,878	250,693	319,238	429,984	477,863	452,078	331,889	327,475
14	190,323	72,107	95,874	97,818	261,328	244,532	253,864	158,588	143,829
15	401,680	318,168	415,080	406,131	372,696	388,442	342,275	262,928	242,605
16	486,943	330,425	402,507	428,752	277,199	277,121	265,220	217,314	186,912
17	430,280	298,404	334,926	339,691	403,775	431,428	343,344	251,977	217,833
18	499,288	365,250	451,348	589,580	453,146	466,044	434,536	328,544	298,456
19	109,178	103,733	148,649	272,786	131,893	158,271	207,314	197,506	175,494
total	**4,307,158**	**3,085,180**	**3,876,981**	**4,953,807**	**4,397,010**	**4,562,750**	**4,381,601**	**3,344,132**	**3,093,503**

According to the calculation data in Table 4, the import embodied carbon emissions of various industrial sectors also showed a downward trend in general during 2008-2016. It can be seen that Fujian’s imports have a positive impact on environmental protection, which can not only reduce the province's carbon dioxide emissions, but also help protect the global environment. Among them, the implied carbon emissions of the production and supply of electricity, heat, gas and water have dropped significantly, and the carbon emissions in 2016 were less than 1/4 of that in 2008.

Table 4. The embodied carbon imported by various industrial sectors in Fujian Province from 2008 to 2016 (tons)

Industrial sectors	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	15,841	13,385	21,270	37,142	54,490	80,435	56,841	27,844	40,413
2	11,171	19,128	54,258	213,157	201,030	174,655	182,201	87,255	61,931
3	93,967	61,885	82,713	210,802	283,786	279,525	257,975	137,558	213,089
4	71,359	80,613	111,347	139,401	111,962	146,959	127,449	76,490	72,668
5	180,116	183,501	192,232	182,044	149,536	153,201	146,730	109,889	148,967
6	31,634	19,677	26,301	27,396	27,184	26,005	22,360	16,030	16,069
7	26,671	15,389	47,132	60,267	32,532	42,303	24,517	17,864	14,815
8	27,018	22,156	27,022	29,407	65,154	82,778	80,610	70,405	61,304
9	52,283	31,709	35,573	45,810	34,300	39,207	35,967	27,326	22,256
10	14,654	12,039	25,014	44,180	64,419	86,077	94,778	50,889	47,198
11	60,551	46,704	55,150	66,352	43,194	46,689	52,640	40,979	41,968
12	385,505	296,715	331,020	463,222	524,272	537,425	440,529	268,745	246,340
13	253,604	153,627	233,028	274,655	326,728	276,310	224,468	174,388	248,410
14	45,435	26,635	34,605	32,461	75,089	87,235	65,589	86,614	80,801
15	348,315	279,738	355,372	362,287	356,387	363,558	279,872	207,051	203,093
16	63,973	40,652	44,203	62,970	40,022	47,770	41,082	31,682	21,425
17	412,294	286,465	412,201	383,447	373,606	383,955	305,785	220,851	197,366
18	140,878	111,744	129,233	275,005	192,049	323,919	326,549	245,996	129,709
19	4,404	2,854	4,037	3,590	1,377	1,845	1,791	1,153	969
total	**2,239,671**	**1,704,613**	**2,221,711**	**2,913,596**	**2,957,121**	**3,179,851**	**2,767,734**	**1,899,008**	**1,868,791**

6. Research on the Balance of Implied Pollution in Industrial Trade in Fujian Province

6.1 The Test of "Pollution Haven" Hypothesis and "Environmental Factor Endowment" Hypothesis

In order to better measure the embodied carbon emissions in trade and its impact on the regional environment, this article uses two related indicators, Balance of Embodied Emissions in Trade (*BEET*) and Pollution Term of Trade (*PTT*), to study trade embodied carbon balance.

6.2 Analysis of Trade Implicit Pollution Balance

The Balance of Embodied Emissions in Trade (*BEET*) is an indicator that refers to the net export value of the implied pollution of foreign trade of a country or region, which can be obtained by subtracting the implied pollution emissions of import trade from the implied pollution emissions of export trade. The calculation formula is as follows:

$$BEET = P^{ex} - P^{im} \quad (17)$$

Among them, P^{ex} represents the embodied carbon emissions of industrial export trade in Fujian Province, and P^{im} represents the embodied carbon emissions of industrial import trade in Fujian Province. When $BEET > 0$, it means that the embodied carbon emission of export trade is higher than the embodied carbon emission of import trade, and the pollution flows into Fujian Province through trade as a carrier. The environment has caused a negative impact and brought about a phenomenon of "environmental deficit". On the contrary, when $BEET < 0$, it means that the embodied carbon emission of import trade is higher than that of export trade. This is called embodied carbon. The pollution deficit is conducive to the improvement of Fujian's environmental quality, which is called the "environmental surplus".

The values of the total embodied carbon and $BEET$ indicators of trade imports and exports from 2008 to 2016 are shown in Figure 2.

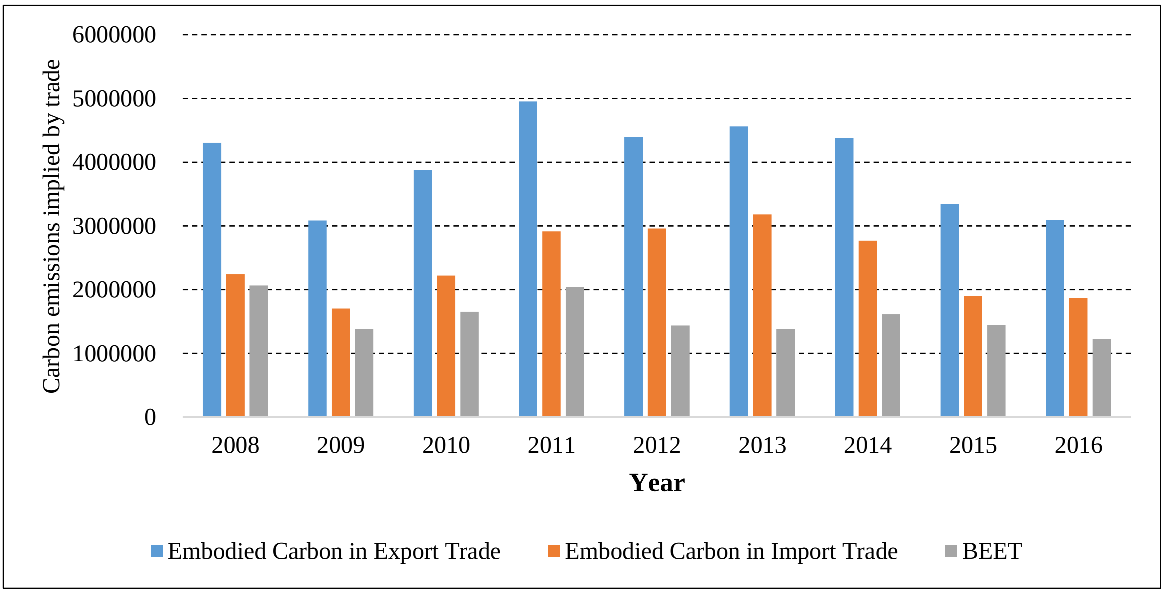

Figure 2. Comparison of the embodied carbon in Fujian's industrial imports and exports from 2008 to 2016

As can be seen from the above table and figure, from 2008 to 2016, the $BEET$ index of Fujian is greater than 0, indicating that the implied carbon of the net industrial trade export of Fujian is greater than 0, that is, Fujian Province is a region with a surplus of industrial carbon emissions. Therefore, the influence of free trade on the industrial environment of Fujian province is negative on the whole.

Because the value of the $BEET$ indicator is also related to the balance of trade scale. $BEET > 0$ may also be caused by trade surplus. Therefore, it cannot be judged that Fujian Province has become a "Pollution Haven" based on $BEET > 0$ alone. We need to use the Pollution Term of Trade index to retest.

6.3 Analysis of The Pollution Term of Trade Index

The Pollution Term of Trade index, also known as the PTT index, is the ratio between the implied pollution emissions per unit of export trade of a country or region and the implied pollution emissions per unit of import trade. The calculation formula can be expressed as:

$$PTT = \frac{P^{ex}/Y^{ex}}{P^{im}/Y^{im}} \quad (18)$$

Among them, Y^{im} and Y^{ex} respectively represent the total amount of imports and exports of industrial products in Fujian Province; P^{im} and P^{ex} respectively represent the embodied carbon emissions of imports and exports of Fujian Province. $\frac{P^{im}}{Y^{im}}$ and $\frac{P^{ex}}{Y^{ex}}$ actually represent the weighted average of the full carbon emission coefficients of imports and exports of various industries, and the weight is the proportion of imports and exports of each industry. When $PTT > 1$, it indicates that the embodied carbon of unit export trade in Fujian Province is higher than that of unit import trade, and the environment has deteriorated. When $PTT < 1$, it means that environmental pollution has improved. The larger the PTT index, the greater the pressure on the environment caused by the country's trade liberalization, which is not conducive to improving and enhancing the country's environmental quality. After calculation, the embodied carbon and PTT indicators of industrial units' imports and exports from 2008 to 2016 are shown in Table 5 below:

Table 5. The embodied carbon in Fujian Province from 2008 to 2016

Year	Embodied carbon in industrial exports	Embodied carbon in industrial imports	Industrial export trade volume	Industrial import trade volume	Embodied carbon per unit of export	Embodied carbon per imported unit	PTT
2008	4,307,158	2,239,671	5,644,618	2,717,942	0.763	0.824	0.926
2009	3,085,180	1,704,613	5,281,200	2,577,292	0.584	0.661	0.883
2010	3,876,981	2,221,711	7,080,513	3,645,624	0.548	0.609	0.898
2011	4,953,807	2,913,596	9,184,938	4,962,091	0.539	0.587	0.919
2012	4,397,010	2,957,121	9,686,085	5,698,731	0.454	0.519	0.875
2013	4,562,756	3,179,851	10,552,103	6,174,271	0.432	0.515	0.840
2014	4,381,601	2,767,734	11,257,343	6,317,637	0.389	0.438	0.888
2015	3,344,132	1,899,008	11,196,349	5,550,125	0.299	0.342	0.873
2016	3,093,503	1,868,791	10,307,907	5,258,982	0.300	0.355	0.845

It can be seen from Table 5 that from 2008 to 2016, the industrial carbon pollution conditions in Fujian Province were all less than 1. $PTT < 1$ indicates that the embodied carbon per unit of export trade in Fujian Province is less than the embodied carbon per unit of import trade, and the carbon pollution density of industrial exports is lower than that of industrial imports, that is, exported goods are "cleaner" than imported goods. And trade development has an improving effect on the environmental development of Fujian Province. It should be said that the "Pollution Haven" hypothesis is not valid for Fujian Province. Compared with the "Pollution Haven" hypothesis, the "Environmental Factor Endowment" hypothesis can better explain the impact of trade liberalization in Fujian Province.

7. Conclusion and Inspiration

From the results of the empirical analysis of this article, due to the imbalance of trade import and export scale, trade liberalization will indeed aggravate environmental pollution. However, there is no "zero-sum game" between environmental protection and trade development in Fujian Province. Although the development of foreign trade is a factor that drives the growth of carbon emissions in Fujian Province, it cannot be ignored. However, there are two important reasons for the continued pollution surplus in Fujian Province: On the one hand, the scale of exports has grown too fast compared with the scale of imports, which has resulted in a huge trade surplus for a long time. On the other hand, compared with technological progress and the optimization of export structure, export growth is too fast, causing the negative scale effect of exports on pollution emissions to exceed its positive technical and structural effects, resulting in the embodied carbon in exports of Fujian Province Emissions continue to increase.

Our test of the “Pollution Haven” hypothesis and the “Environmental Factor Endowment” hypothesis shows that Fujian Province is not a “Pollution Haven”. The reason is that although in the early stage of economic development in Fujian Province, its environmental policies and standards were relatively loose, and the cost of corporate governance was relatively low. However, as trade freedom continues to deepen, trade openness continues to increase, per capita income has also increased, and environmental controls have become more and more stringent. This has led to increased pollution discharge costs and Weakened the tendency of foreign investment and foreign trade to transfer pollution-intensive industries to Fujian Province. Therefore, Fujian Province’s efforts to transform the growth mode of foreign trade are generally fruitful.

By testing the hypothesis of “Environmental Factor Endowment”, the study found that although the structure of import and export commodities in Fujian Province is constantly optimized and adjusted, and its capital density is also continuously increasing. However, from the perspective of the comparative advantages of Fujian Province, to a large extent export commodity still depend on the abundance of labor endowments, and the embodied carbon of export trade in Fujian Province is also mainly concentrated in labor-intensive industries. As the capital factor endowment of Fujian Province changes, it may also reduce the positive impact of “Environmental Factor Endowment” on the environmental improvement of Fujian Province.

Overall, the development of trade in Fujian Province can relatively alleviate environmental pollution due to its factor endowment advantages. Although Fujian Province has a pollution surplus, the pollution surplus is showing a shrinking trend. In the process of studying the relationship between the environment and trade in Fujian Province, there are the following main revelations: First, in order to protect the environment in Fujian Province, it cannot be at the expense of free trade, and the fundamental reason for environmental deterioration is not trade liberalization. International trade cannot solve the problem of environmental degradation. We should continue to focus on optimizing and adjusting the trade structure, and promote the transformation of Fujian’s export trade from a quantity-expansion type to a quality-oriented type, to alleviate the adverse environmental impact of excessive export growth. Second, with the continuous increase in the capital density of export commodities in Fujian Province, on the one hand, we should actively promote the export of low-polluting capital-intensive commodities, and restrict the export of high-polluting commodities. On the other hand, it can also guide foreign capital to invest in low-pollution industries, and actively introduce and promote foreign advanced technologies, thereby reducing the export carbon emission coefficient and achieving the goal of reducing environmental pollution.

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