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Trade Liberalization and Carbon Neutralization: A Quasi-Natural Experiment Based on China-ASEAN Free Trade Area

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Abstract

Reducing greenhouse gas emissions and achieving carbon neutrality are the environmental goals of all countries in the world. Taking 45 countries in Asia from 2000 to 2021 as a sample, this paper studies the impact of China-ASEAN Free Trade Area on greenhouse gas emissions of all countries, and empirically tests whether trade liberalization contributes to achieving carbon neutrality. The study found that the establishment of China-ASEAN Free Trade Area can effectively curb greenhouse gas emissions, especially in economically and technologically backward countries. In addition, with the tightening of environmental regulations, the promotion of trade liberalization on greenhouse gas emission reduction has been strengthened. On the whole, trade liberalization can help to achieve the goal of carbon neutrality.

Keywords: trade liberalization, carbon neutrality

1. Introduction

On January 1, 2010, China-ASEAN Free Trade Area (CAFTA) was formally established. The China-ASEAN Free Trade Zone is one of the three largest regional economic cooperation zones in the world. It is also the world's most populous free trade zone and the largest free trade zone composed of developing countries. After more than ten years of development, CAFTA has stepped into the stage of consolidation and improvement from the stage of full completion. CAFTA has greatly promoted the free trade of member countries by reducing and eliminating tariffs, reducing non-tariff barriers, opening up the service trade market, simplifying the investment approval procedures and other measures. Take the trade data between China and ASEAN as an example. In 2020, China and ASEAN were each other's largest trading partners. In 2021, the trade volume between the two sides was US$ 878.2 billion, a 109-fold increase from 1991. From January to May 2022, China and ASEAN continued to be each other's largest trading partners, with trade volume reaching US$ 371.21 billion, up 10.2% year-on-year.

In 2015, the Paris Agreement proposed the long-term goal of "keeping the global average

temperature within 2 degrees Celsius as compared with the pre-industrial period, and striving to keep the temperature rise within 1.5 degrees Celsius". In order to achieve this goal, countries have formulated national independent contribution plans one after another. The national independent contribution goal established by China is "carbon dioxide emissions will peak around 2030 and strive to reach the peak as soon as possible". In 2020, Chinese President Xi Jinping announced at the 75th United Nations General Assembly that China would strive to reach a peak in carbon dioxide emissions by 2030 and strive to achieve a carbon neutral target by 2060. "Peak carbon dioxide emissions" and "carbon neutral" have become hot words in the field of climate control. Peak carbon dioxide emissions refers to the peak of total carbon dioxide emissions and the historical turning point of carbon dioxide emissions from rising to falling. Carbon neutralization refers to the total amount of six greenhouse gases including carbon dioxide, methane and nitrous oxide generated in the whole economic field offset by the total amount of emission reduction to achieve zero net carbon increment. Under the background of global warming, carbon neutrality is not only a goal to be achieved by China, but also a difficult problem to be solved in global environmental protection.

In 1991, the North American Free Trade Area negotiations, whether trade liberalization will cause environmental deterioration caused widespread concern among scholars. Grossman and Krueger (1991) proposed the classic theory of environmental Kuznets curve. They believed that there was a U-shaped curve relationship between economic growth and environmental quality, and proposed that international trade could affect the environment through scale effect, structure effect and technology effect Grossman and Krueger (1991). Since 2009, developed countries such as Europe and the United States have begun to put forward the probability of "carbon tariffs", putting the environment and trade in opposition, once again arousing people's extensive thinking on the relationship between trade and environment. How trade affects the environment is still uncertain. Examining the relationship between trade and the environment, especially the relationship with carbon neutrality, which has attracted much attention at present, is of great significance to trade policy making and environmental governance.

Based on the panel data of 45 Asian countries from 2000 to 2021, this paper takes the establishment of the China-ASEAN Free Trade Area in 2010 as a quasi-natural experiment, and uses the double difference (DID) model to analyze the effects, mechanism and heterogeneity of trade liberalization on greenhouse gas emissions. The follow-up structure of this paper is as follows: The second part reviews the relevant literature and puts forward hypotheses; The third part introduces the model and data. The fourth part analyzes the empirical results; The fifth part puts forward the conclusion and future research direction.

2. Literature Review and Research Hypothesis

2.1 Literature Review

In the research on the impact of trade on the environment, at the enterprise level, (Tran Dang Khoa, 2020) based on the quasi-natural experiment of China's accession to the WTO, this paper investigates the impact and mechanism of the reduction of trade barriers on the environmental pollution in China, and finds that the reduction of trade barriers significantly reduces the emission intensity of SO2, the major pollutant of China enterprises. The decrease is mainly due to the decrease of enterprise pollution emissions rather than the increase of output, while the decrease of enterprise pollution emissions is mainly due to cleaner production process rather than end pollution treatment. (Tran, 2022) Taking Vietnamese manufacturing enterprises as the research object, it is found that participating in export can improve the energy efficiency and emission intensity of enterprises. At the level of cities, provinces and regions, (Kay lee & Qi Shaozhou, 2011) the static panel model and dynamic panel model are used to test the "environmental benefits hypothesis of trade" and "regulation chill hypothesis". The relationship between trade and CO2 emission level is studied earlier. It is found that trade openness increases CO2 emission and carbon intensity in China province and has negative impact on the environment. (Hu Yi et al., 2019) Then the air pollution index including SO2, NO2 and other kinds of gases is constructed, geographical factors are included, the causal relationship between export trade and air pollution is tested by using spatial econometric model, and the influence of

geographical characteristics on the air pollution effect of export trade is analyzed. It is found that export trade will aggravate air pollution, and the geographical correlation between economic activities and air pollution makes the air pollution effect of export trade underestimated. (Qi Yingying et al., 2022) Based on the calculation of urban green development efficiency, it is found that the impact of trade openness on urban green development efficiency presents a U-shaped feature of first inhibition and then promotion, and there is a "threshold effect" based on environmental regulations. The implementation of stricter environmental regulations can reduce the loss of trade openness on urban green development efficiency, and thus effectively improve urban green development efficiency. (Eva, 2022) Based on the quasi-natural experiment of China's entry into WTO, this paper probes into the relationship between trade openness, environmental pollution and public health, and considers that trade openness helps to improve public health, but at the same time it produces environmental pollution, which offsets some of the health effects of trade openness. At the national level, (Shahbaz et al., 2015) taking CO2 emissions and energy consumption as the measurement indicators of environmental quality, this paper analyzes the relationship between foreign direct investment (FDI) and environmental growth in different income countries around the world, and finds that FDI will reduce CO2 emissions in high-income countries, while it will draw the opposite conclusion in low-income countries. (Lian Yong, 2021) It is believed that the level of trade openness has little impact on carbon emissions. (Zhang Zhixin et al., 2021) Taking 61 countries along the "the belt and road initiative" as the research object, it is found that the EKC curves of trade openness and carbon emissions are all in an "inverted U" shape. Trade openness will ultimately help reduce environmental pollution and support the "trade benefit theory". (Mao Xiyan et al., 2022) Focusing on the sub-sector of environmental products trade in international trade, we found that the impact of environmental products trade on carbon emissions in China is manifested as short-term promotion and long-term inhibition. Environmental products trade mainly promotes carbon emission reduction by promoting the carbon emission reduction effect of energy efficiency and inhibiting the carbon emission effect of economic growth.

In terms of the impact of the establishment of the China-ASEAN Free Trade Zone, (Yu Miaojie & Gao Kailin, 2018) the economic impact and poverty reduction effect of CAFTA are analyzed qualitatively. (Sun Lin & Zhou Kexuan, 2020) This paper discusses the impact of trade policy uncertainty on the product quality of export enterprises in China under the framework of regional free trade agreements, and finds that the reduction of regional trade policy uncertainty significantly improves the product quality of export enterprises in China, and there is heterogeneity in enterprise type and regional level. (Tan Mi et al., 2022) This proves that the establishment of CAFTA can promote FDI in member countries. (Cao Liang et al.,2022) It is found that the tariff reduction of CAFTA intermediates is helpful to promote the high-quality development of agriculture in China. (Yang Xianli et al., 2021) Then it discusses the influence of "the belt and road initiative" on CAFTA trade, and finds that it has little influence on import trade, has certain promotion effect on total import and export trade, and has negative influence on balance of import and export trade.

2.2 Hypothesis

Through literature review, it can be found that scholars have carried out research on the issue of trade's impact on the environment from different levels of enterprises, cities, provinces and countries. Some take economic indicators as independent variables, others consider exogenous policy shocks, and there are various indicators to measure environmental conditions, and the conclusions drawn are also different. Based on the environmental Kuznets curve theory, under the scale effect, trade expands economic activities, resulting in an increase in emissions and pollution. With the increase in wealth, people will be more inclined to adopt clean technologies, resulting in technological effects. In addition, the increase in people's demand for environmental quality will cause changes in consumption structure, resulting in structural effects. Under the superposition of the three effects, the impact of trade on the environment is uncertain. "Trade Benefit Theory" holds that in the process of international trade, the host country can learn advanced clean technology and management experience, and obtain support from technology,

capital, human resources and other aspects, so as to improve its resource utilization efficiency, improve its environmental management system and raise its environmental standards. In the process of improving the environment through trade, technology plays an important role. The technologically developed countries are the learning objects of the technologically backward countries. The generally backward economies of the technologically backward countries are also relatively backward and need more financial support. It can be concluded that the technologically backward and economically backward countries can obtain more marginal environmental improvement from trade than the technologically advanced countries. The point of view supporting the harmful trade theory is that trade gives polluting enterprises an opportunity to transfer polluting production activities to countries with weak environmental regulations. Some countries maintain or even relax environmental regulations in order to promote economic development, thus causing further deterioration of the environment. The theory of harmful trade actually contains two aspects. First, trade will cause environmental deterioration in some countries. Second, weak environmental regulations will aggravate the deterioration. On the contrary, if trade can improve the environment, the more stringent environmental regulations are, the more likely it is to enhance environmental improvement. Based on this, this paper puts forward the hypothesis:

Hypothesis H1: Trade Liberalization Helps Achieve Carbon Neutralization Goals.

Hypothesis H2: The stronger the environmental regulation, the stronger the promotion effect of trade on carbon neutrality.

Hypothesis H3: For countries with lower levels of economic development, the more significant the promotion effect of trade liberalization on carbon neutrality.

Hypothesis H4: The more backward the technology is, the more obvious the role of trade liberalization in promoting carbon neutrality.

3. Model Setting and Data Description

3.1 Sample Selection and Data Sources

This paper takes the establishment of China-ASEAN Free Trade Area in 2010 as a quasi-natural experiment, takes the countries joining CAFTA as the experimental group, and the remaining 45 countries in Asia as the control group. It excludes North Korea, Syria and Palestine with more missing data, and uses the World Bank's World Development Indicators Database from 2000 to 2021 for empirical analysis.

3.2 Model Building and Indicator Selection

Based on the DID model, this paper constructs the following model to identify the impact of trade liberalization on greenhouse gas emissions:

$$\ln gas_{it} = \alpha_0 + \alpha_1 treat_i + \alpha_2 post_t + \alpha_3 trade_{it} + \beta x_{it} + \mu_{it} + \varepsilon_{it} \quad (1)$$

In model (1), i and t represent the GHG emissions of each country. $treated_{it}$ and $post_{it}$ are virtual variables. If the country is a member of CAFTA, $treat_{it}$ is 1; otherwise, 0 is taken; if the year is after the establishment of CAFTA (after 2010), $post_{it}$ is 1; otherwise, 0 is taken. $trade_{it} = treat_{it} \times post_{it}$, which is also the most concerned variable in this paper, examines the impact on greenhouse gas emissions before and after the establishment of CAFTA. If α_3 is significantly different from less than 0, it indicates that trade liberalization represented by CAFTA can significantly inhibit greenhouse gas emissions and help to achieve the carbon neutralization target, thus improving the environment. x_{it} is a control variable, including economic development ($\ln gdp$) and energy efficiency ($\ln EE$), μ_{it} is an individual fixed effect, ε_{it} is a random error term.

In order to verify H2, the enterprise information disclosure index is used to measure the intensity of environmental regulation. The higher the degree of enterprise information disclosure, the more stringent the regulation the enterprise faces. In model (1), the intensity of environmental regulation law_{it} is introduced and model (2) is constructed:

$$\begin{aligned} \ln gas_{it} = {} & \alpha_0 + \alpha_1 treat_i + \alpha_2 post_t + \alpha_3 trade_{it} + \alpha_4 law_{it} + \\ & \alpha_5 trade_{it} \times law_{it} + \beta x_{it} + \mu_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Specific descriptions of the variables involved in model (1) and model (2) are as follows table 1 Indicated.

Table 1. Variable declaration

Name	Symbol	Definition	Mean	Std	Min	Max
Greenhouse gas emissions	$\ln gas$	The total amount of greenhouse gas emissions is converted into carbon dioxide equivalent in kilotons, and then the logarithm is taken.	11.25	1.83	6.33	16.40
CAFTA member states	$treat$	CAFTA countries take 1, other countries take 0	0.23	0.43	0	1
Policy pilot	$post$	After the establishment of CAFTA, i.e., 1 in 2010 and beyond, 0 before	0.55	0.43	0	1
trade liberalization	$trade$	$treat \times post$	0.13	0.34	0	1
economic development	$\ln gdp$	The logarithm of GDP	24.72	2.10	19.72	30.35
energy efficiency	$\ln EE$	The amount of energy consumed per unit of GDP is converted into kilogram equivalent of oil, which is taken as logarithm.	2.09	0.55	-0.51	4.01
Environmental regulation intensity	law	Enterprise Information Disclosure Index	6.34	2.35	1	10

4. Empirical Results and Analysis

4.1 Benchmark Regression Results

The model (1) is regressed and the results are as follows Table 2 As shown, the coefficients of $trade$ in columns (1) and (2) are significantly negative at 1%, indicating that the establishment of CAFTA can significantly reduce the emission of greenhouse gases, and trade liberalization can help achieve the goal of carbon neutralization, and hypothesis H1 can be proved. All the coefficients of $\ln gap$ are significantly positive, indicating that economic growth will increase greenhouse gas emissions. The coefficient of $\ln EE$ is significantly negative, indicating that the higher the energy efficiency, the more conducive to the suppression of greenhouse gas emissions.

Table 2. Benchmark regression results

variable name	$\ln gas$	
	(1)	(2)
$trade$	-0.1007***	-0.0893***
	(0.0236)	(0.0221)
$\ln gdp$	0.2921***	0.2141***
	(0.0150)	(0.0205)
$\ln EE$	-0.1172***	-0.1169***
	(0. 0210)	(0.0197)
$cons$	4.2574***	6.0531***
	(0.3483)	(0.4784)

$treat$ and $post$	Yes	Yes
Individual effect	Yes	Yes
time effect	No	Yes
N	939	939
R^2	0.8324	0.7877

Note: Standard errors are shown in brackets. *p < 0.10, **p < 0.05, ***p < 0.01. The following is the same.

4.2 Robustness Test

The premise of using the double difference method is that there is a parallel trend between the experimental group and the control group before the event occurs. For this reason, the event research method is used to conduct the annual dynamic effect analysis. The specific method is: taking 2010 as the base period, constructing a period virtual variable, and cross each period virtual variable with $treat$ in model (1) for estimation. The estimation results are shown in figure 1, where the solid line represents the estimation coefficient and the dotted line represents the 95% confidence interval. The results show that before the establishment of CAFTA, the confidence intervals of the coefficients all include 0, indicating that it is not significant. After the establishment of CAFTA, the coefficients have been negative and significantly different from 0. The parallel trend test has passed.

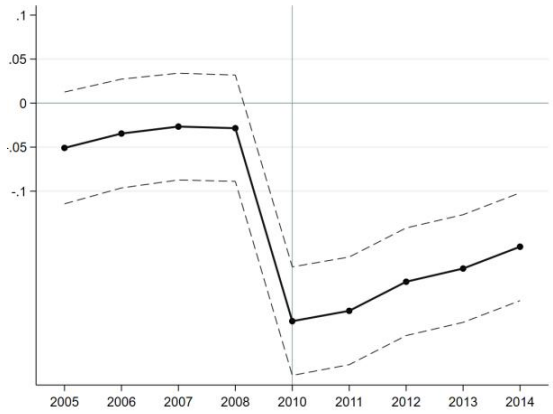

Figure 1. Parallel trend test

Considering the possible omission of variables, two variables, industrial structure ($indstru$) and energy structure ($ffuel$), are introduced into the model (1). The industrial structure is measured by the proportion of industrial added value to GDP, and the energy structure is measured by the proportion of fossil fuels to total energy. The data are all from the World Development Indicators Database of the World Bank. Table 3 shows that after the introduction of these two control variables, the coefficients of each variable are still significant, and the direction of the coefficients has not changed, indicating that the model results are relatively robust.

Table 3. Robustness test

variable name	$\ln gas$		
	(1)	(2)	(3)
$trade$	-0.1016***	-0.0890***	-0.0873***
	(0.0266)	(0.0195)	(0.0217)
$\ln gdp$	0.3332***	0.2937***	0.3419***
	(0.0198)	(0.0130)	(0.0172)
$\ln EE$	-0.1320***	-0.1551***	-0.1787***
	(0.0229)	(0.0173)	(0.0186)

$indstru$	0.1050***		0.1415***
	(0.0377)		(0.0322)
$ffuel$		0.0015***	0.0010**
		(0.0004)	(0.0005)
$cons$	3.2119***	4.3547***	3.1684***
	(0.4694)	(0.3012)	(0.4080)
$treat$ and $post$	Yes	Yes	Yes
Individual effect	Yes	Yes	Yes
time effect	No	No	No
N	939	939	939
R^2	0.8582	0.8072	0.8402

4.3 Analysis of Regulation Mechanism

To test hypothesis H2, model (2) is regressed. Table 4 shows that the coefficients are all positive. After controlling the time effect, the coefficient of law is significant at the level of 1%, indicating that the more stringent environmental regulations are, the more conducive to the suppression of greenhouse gas emissions. The coefficient of $trade \times law$ is positive and significant at 1%, which indicates that the improvement of national environmental regulations can significantly enhance the inhibition of trade liberalization on greenhouse gas emissions.

Table 4. Regulatory effect test

variable name	$\ln gas$	
	(1)	(2)
$trade$	-0.2597***	-0.2298***
	(0.0455)	(0.0430)
law	-0.0046	-0.0099***
	(0.0034)	(0.0032)
$trade \times law$	0.0214***	0.0186***
	(0.0050)	(0.0048)
Other variables	Yes	Yes
Individual effect	Yes	Yes
time effect	No	Yes
N	939	939
R^2	0.8367	0.8008

4.4 Heterogeneity analysis

In order to test hypotheses H3, H4 and H5, GDP is used to measure the degree of economic development of each country, and the proportion of high-tech manufactured goods to total manufactured goods exports is used to measure the level of technological development of each country. The average value of these two indicators of each country in 2000-2021 is calculated. The group with the average value greater than or equal to the median value is regarded as the developed region, otherwise it is regarded as the backward region, and then model (1) and model (2) are grouped for regression. The first two columns of table 5 show that the coefficient of $trade$ is significantly negative at the level of 1%, but in economically backward areas, the coefficient value is about 2.6 times of the coefficient value in economically developed areas, indicating that the establishment of CAFTA in economically backward areas has more obvious inhibition on greenhouse gas emissions than in economically developed areas. It also shows that for countries with lower levels of economic development, the promotion effect of trade liberalization on carbon neutrality is more obvious, which verifies H3. In columns (3) and (4), the coefficient of $trade$ is significantly negative at the level of 1%, and the coefficient value in the technologically backward regions is significantly larger, which also indicates that the more backward the countries are in technology, the more obvious the promotion effect of trade liberalization on carbon neutralization, verifying H4.

Table 5. Heterogeneity analysis

variable name	$\ln gas$			
	(1) economically developed areas	(2) economically backward areas	(3) technically developed areas	(4) technologically backward areas
$trade$	-0.0570***	-0.1481***	-0.0806***	-0.1826***
	(0.0162)	(0.0493)	(0. 0284)	(0.0415)
Other variables	Yes	Yes	Yes	Yes
Individual effect	Yes	Yes	Yes	Yes
time effect	No	No	No	No
N	484	455	528	411
R^2	0.7636	0.3599	0.8188	0.5176

5. Conclusion

In order to analyze the impact of trade liberalization on carbon neutrality, this paper uses DID model to analyze the impact of CAFTA on the greenhouse gas emissions of Asian countries based on the World Development Indicators Database of the World Bank from 2000 to 2021. The main conclusions of the study are as follows: First, trade liberalization inhibits the greenhouse gas emissions and helps to achieve the carbon neutrality target; Secondly, with the strengthening of environmental regulation, the promotion of trade liberalization on carbon neutrality is strengthened; Finally, in countries with backward economy or technology, trade liberalization has a more obvious role in promoting carbon neutrality.

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