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Can Emissions Trading System Aid Industrial Structure Upgrading?—A Quasi-Natural Experiment Based on 249 Prefecture-Level Cities in China

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Abstract: Emissions trading system (ETS) is a market-based policy tool that essentially provides economic compensation for corporate environmental measures. The Chinese government implemented pilot emissions trading in 2007. In order to evaluate the effect of the policy, we conducted a quasi-natural experiment to collect the data of 249 prefecture-level cities in China from 2001 to 2020 and applied the difference-in-difference method to explore the impact of ETS on regional industrial structure. The results show that the implementation of ETS can promote the upgrading of regional industrial structure but can hinder the rationalization of the upgrading. The results of regional heterogeneity regression suggest that the effects of ETS pilots on industrial structure upgrading in three regions of China are significantly different, with the strongest one being the western region, followed by the central and eastern regions. Finally, we put forward some policy proposals in terms of technological innovations, implementation of ETS in different regions and ETS improvement.

Keywords: emissions trading system; upgrading of industrial structure; DID model; quasi-natural experiment

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1. Introduction

Emissions trading originated in the United States when the economist Dales first proposed this concept in 1968 (Dales, 1968) [1]. In the face of increasingly serious pollution, the United States introduced the concept of emission reduction credit. Countries became gradually aware of environmental pollution caused by emissions, and have put forward emission reduction policies, such as the Clean Air Act passed by the United States in 1977, the implementation of EU ETS in Germany in early 2002, and the establishment of carbon trading markets, such as the European Climate Exchange in Amsterdam, the European Energy Exchange in Germany, and the Future Electricity Exchange in France.

China has also realized the importance of its ETS. The key to ecological civilization construction lies in correctly handling the relationship between man and nature, especially the relationship between economic development and ecological protection. After reform and opening up, rapid economic growth and energy consumption in China has generated increasing CO_2 and SO_2 emissions, solid waste and industrial sewage. Issues related to the environment and residents' health demanded public attention. To this end, China adopted a series of policies—including the paid use and trading of emission permits—as environmental regulations combining government regulation with the free market. These policies have been successfully implemented in many pilot areas and achieved positive results. For example, in the early 1990s, air emissions trading was carried out on a pilot basis in six cities, and was further expanded to seven provinces and cities, as well as the China Huaneng Group Corporation in 2002. Air emissions trading pilots formally started operations in 2007 and are located in 11 provinces and cities including Jiangsu, Tianjin, Zhejiang, Hubei, Chongqing, Hunan, Inner Mongolia, Hebei, Shaanxi, Henan, and Shanxi.

China introduced pilot ETS in 2007, which functions as an invisible hand in the market. The pilot ETS practice has an important impact on the behavior of Chinese government, enterprises and residents. However, its role in guiding enterprises to discover technological and institutional innovation, promoting upgrading of China's consumption and the level of opening up, especially in promoting the upgrading of industrial structure, has not been studied in theory and a scientific conclusion has not yet been reached. In addition, from the point of view of a few studies on ETS, scholars mainly study the development status and improvement measures of ETS, and the research data are mainly national or provincial. However, the ETS will eventually be implemented at the industrial level, and the national and provincial data are relatively extensive. Differing from the existing research, this paper uses the data of pilot areas and 249 prefecture-level cities in China to analyze the specific impact of ETS on industries from three major industries and three major regions of China. Relative to the existing research, this study is more specific and innovative. This has important theoretical and practical significance for exploring the mechanism of ETS, enriching the research in this field and promoting ETS implementation across the country.

Based on the existing research results, this paper makes four main contributions. First, compared with the provincial data, the prefecture-level city data used in this paper is more detailed, which can effectively avoid the estimation bias caused by endogeneity. In addition, compared with the single difference analysis method, the double difference analysis method can more effectively identify the net effect in the process of policy implementation. Therefore, this paper takes the ETS as a quasi-natural experiment to analyze the impact of emissions trading system on the upgrading of China's industrial structure from the level of prefecture-level cities, which can enrich the relevant research on the impact of the system on the upgrading of industrial structure. Secondly, in this paper, the industrial structure is divided into three dimensions: the quantity of industrial structure supererogation, the quality of industrial structure upgrading and the rationalization of industrial structure, which can further analyze the impact of ETS on industrial upgrading. Thirdly, this paper explores the mechanism of ETS on the transformation and upgrading of industrial structure, which can reveal the impact path of ETS on the transformation and upgrading of industrial structure under the influence of two intermediary effects of energy consumption and opening up. Fourthly, based on the national conditions of regional differences in China, this paper divides the selected prefecture-level cities according to the eastern, central and western regions, so as to test the heterogeneous impact of ETS on different regional cities, and lay the foundation for the further implementation of ETS.

The remainder of this research is organized as follows. Section 2 is the literature review. In Section 3, the theoretical basis of this study is introduced and the research hypothesis is put forward. In Section 4, the research design, variable selection and data are introduced. In Section 5, empirical results are presented, including the benchmark model regression results, impact mechanism analysis and regional heterogeneity analysis. In Section 6, the conclusion of the research is summarized, putting forward the policy proposals.

2. Literature Review

2.1. Research on Emissions Trading System

The emissions trading mechanism has been considered by economists as an effective method of pollution control. Coase (1960) in his famous paper on social cost pointed out that the most efficient mechanism to solve pollution problems is to allocate emission rights through the market [2]. Crocker (1966) [3] and Dales (1968) [1] pointed out that the emissions trading mechanism is an effective solution to solve the externality of environmental resources. Montgomery (1972) theoretically proved that the emissions trading mechanism can effectively control the cost of emission reduction, which is clearly superior to the traditional command-control mechanism [4]. The research on emissions trading is very extensive, and the research on carbon emissions trading is the most abundant. In recent years, many studies have begun to focus on emissions trading in other areas. For example, Zhang Junlong et al. (2022) studied the optimization of sewage trading and risk management

schemes in agricultural basins considering dual risk aversion [5]; Wang Taishan et al. (2022) studied the optimal design of two-dimensional water trading for sustainable development of Dagu River Basin based on risk aversion [6]; Xu Zhongwen et al. (2020) studied the robust optimization of crop planting area planning and industrial production level in the presence of effluent trading [7].

At present, research on ETS has mostly focused on the relationship between the system and government subsidy as well as on the impact of policy implementation. Zhang Jixiang (2020) found that there is a two-way relationship between government subsidy and enterprise emission reduction, and subsidies from local governments would be affected by enterprises' nitrogen emissions [8]. In terms of implementation impact, Ren Shenggang (2019) analyzed ETS and its association with the environment and employment through a quasi-natural experiment and concluded that the implementation of ETS is conducive to environmental improvement and employment promotion [9]. Gao Yanli (2019) studies the impact of carbon emission rights on the industry and believes that carbon emissions trading can significantly reduce the carbon emission intensity of construction land [10]. Wang Bing (2019) [11], Huang Guangqiu (2019) [12], Li Yanpu (2020) [13], Ryan Wiser (1998) [14] and others studied energy consumption, energy utilization rate and ETS, and agreed that the implementation of ETS can be helpful to control total energy consumption and energy intensity.

There are many studies on environmental regulation and industrial structure transformation. However, there are similarities in research methods, such that scholars mostly use quasi-natural experimental research methods, evolutionary game methods, data envelopment analysis, system GMM methods, redundancy analysis and sorting diagram techniques. However, according to the results, the same object of study often leads to various conclusions due to different methods. In other words, the study has not reached a unified conclusion.

2.2. Research on the Upgrading of Industrial Structure

In the existing research on industrial structure, scholars have focused on the factors affecting industrial structure upgrading, the main types of structural upgrading and so on. Structure upgrading and structure rationalization are two lenses that scholars use to examine industrial structure. Results are often different depending on which lens is adopted. Lin Xiumei (2020) believes environmental regulations hinder the rationalization of industrial structure but can promote the upgrading of industrial structure [15]. Yang Qinglong and Jin Lei (2020) found that comprehensive cost hinders the rationalization and optimization of industrial structure, but sub-cost does the opposite [16]. In addition, Gao Xuelian (2019) [17], Chen Xuan (2020) [18], Xie Bo (2020) [19], and Richard Kneller (2012) [20] studied the issue in other industries such as the service industry and manufacturing industry. In general, current research on industrial structure upgrading is mostly at a provincial level and not so much at the city level.

Scholars have different views on factors affecting the upgrading of industrial structure. Zhao Jian-jun (2019), in the study of the impact of smart city construction on industrial structure upgrading, focused on the impact of technological innovation, financial development and human capital on industrial transformation [21]. Pang Min and Xia Zhoupei (2020) [22] also believe in the impact of financial development on industrial structure. Richard Kneller (2012) [20] concluded that technological innovation can promote industrial upgrading, Specifically, Chen Xuan (2020) found that technological innovation has a regional effect on industrial restructuring, more significant in the more developed areas of the eastern region and less so in inland areas [18]. Gao Yanli (2019) [10], Zhong Yingjia (2020) [23], Lin Xiumei and Guan Shuai (2020) [15] and Brennan TJ (2006) [24] agreed that the government's environmental regulation policy has different effects on the optimization and rationalization of industrial structure. In addition, some scholars have analyzed the influencing factors of human capital, Internet development and population migration.

2.3. Impact of ETS on Industrial Structure Upgrading

There is little literature that directly studies the impact of ETS on the upgrading of industrial structure. Only a few scholars tested the indirect relationship between ETS and industrial structure in their research. Wu Zhaoxia (2018) [25] found that regional industrial layout can affect the fairness of the transaction. Zhao Meng (2014) [26] found that the current ETS is not perfect, and the existing legal loopholes will hinder the upgrading and optimization of domestic industrial structure. In the process of studying ETS and energy efficiency, Shi Dan (2020) [27] found that the former can significantly improve regional green energy efficiency, which will promote the further transformation of industrial structure. In addition, in a case study of Hunan Province, Yi Wenjie (2020) [28] argued that due to differences among regions and enterprises, the implementation of ETS has no significant impact on Hunan's economy and its industrial structure. Accordingly, there is still a lack of research on the specific relationship between ETS and industrial structure.

To sum up, experts and scholars have done a lot of research on ETS and industrial structure upgrading, and obtained many useful results, but there are also some deficiencies: (1) There is relatively little literature around the impact of ETS on industrial structure, and no scientific conclusions have been made. (2) Most of the current empirical studies focus on inter-provincial data, and the research on prefecture-level cities is relatively small. Therefore, this paper attempts to expand the existing research as follows: (1) this paper analyzes the impact of ETS on industrial structure upgrading from the perspective of enterprises, consumers and government. Variables such as energy consumption intensity or the degree of opening up is used to test whether China's current ETS can promote the upgrading of urban industrial structure. The analysis can provide a theoretical reference for China to carry out its ETS and is significant for energy conservation and economic development in China. (2) In terms of research methods, this paper selects the data of 249 prefecture-level cities in China and uses the difference-in-difference method to conduct empirical research on industrial structure upgrading and rationalization, hoping to provide theoretical support for the promotion of China's ETS.

3. Theoretical Analysis and Research Hypothesis

In this paper, the upgrading of industrial structure is analyzed from the degree and the rationalization of upgrading. The degree of upgrading captures both quantity and quality. Energy consumption intensity and the degree of opening up are introduced as two intermediary variables to further measure the impact of ETS on the upgrading of industrial structure.

3.1. The Theoretical Basis of ETS Implementation

This section mainly discusses the basic theory of environmental economy and the basic theory related to emission rights. Firstly, Pigou's externality theory and environmental externality theory both emphasize the role of economic activities on the ecological environment. Secondly, Welfare Economics relates to the overall interests of society (including the environment) while attaching importance to private interests. In this context, the theory of utility function and Pareto optimality appeared one after another, which further provided a theoretical basis for transaction price and mode involved in emissions trading [26]. Thirdly, in the relevant theoretical basis of ETS, property rights theory requires clear property rights in the market; environmental capacity theory emphasizes that optimizing the allocation of resources is necessary despite the limited environmental resources; the theory of sustainable development is an important prerequisite for coordinated development of economy and ecology.

Environmental economic theories and emissions trading theories exposed a conflict between economic development and environmental protection, specifically in achieving a balance between economic benefits of enterprises and the protection of the external environment, and a balance between personal interests and social welfare. These components are essential for an upgrading of the current industrial structure, so that environmental

protection and economic development can be coordinated. In practice, the implementation of these theories requires collaboration between enterprises, consumers and the government. These three main bodies indirectly affect the upgrading of industrial structure from competitive markets, consumer demand and macro-control.

3.2. The Impact of ETS on the Upgrading of Industrial Structure

Gan Chunhui (2011) proposed the research method of industrial structure transformation and upgrading, which means the upgrading of industrial structure can divide into the degree of upgrading and rationalization of upgrading [29]. Based on this method, this paper also adopts the method of Yuan Hang and Zhu Chengliang (2018) to divide the discussion on industrial structure transformation into a quantitative and a qualitative analysis [30].

The degree of industrial structure is measured by assessing market dominance [14]. With the domestic economy development of China, the transition from the primary industry to the secondary and tertiary industries has become the trend. So it is uncertain whether the implementation of ETS has further promoted the optimization of industrial structure. Liu Wei (2008) believes that the upgrading of industrial structure should involve not only the quantitative level, but also the qualitative upgrading, and proposes to use the proportional relationship between labor productivity and industry to measure the qualitative transformation of industrial structure [31]. The implementation of ETS is bound to have a negative effect on the cost and competition of the first and second industries with large emission and might promote the quality of industrial structure to a certain extent. The rationalization of industrial structure requires a reasonable development trend in factor flow, the relative status of each industry, and the relationship between supply and demand. The implementation of ETS will accelerate the transformation of enterprises among the three major industries, which could hinder the rationalization of industrial structure. Therefore, this paper draws the first research hypothesis:

Hypothesis 1. *The implementation of ETS for a higher degree of industrial upgrading is uncertain. It can promote the transformation of industrial structure to improve the quality but will hinder the rationalization of industrial structure.*

3.3. The Mediating Effect of Energy Consumption Intensity and Opening Degree on ETS and Urban Industrial Structure Upgrading

ETS aims to make the emission rights traded in the market under the condition of different pollution control costs, so that enterprises with strong pollution control ability have comparative advantages in pollution control costs and can sell surplus emissions to other enterprises [32]. The following is a specific analysis regarding energy consumption intensity and the degree of opening up:

First of all, the energy industry is one of the typical industries with a large amount of pollution discharge. The level of energy consumption intensity directly reveals the energy utilization rate and production efficiency of enterprises. It can reflect the amount of pollution discharged by the energy industry. So selecting energy consumption intensity as an intermediary variable is significant for the adjustment of the whole industry, and its impacts are as follows: First, the increase in pollution control cost promotes the transformation of enterprises, and then affects the structural change of the whole industry [33]. Second, additional economic dividends encourage enterprises to reform and indirectly affect the adjustment of industrial structure. Through the primary and secondary markets, enterprises can resell their emission quotas and then obtain economic benefits [34]. Third, in order to maintain the economic dividends from emissions trading, enterprises must continue to improve pollution control technology; At the same time, in order to reduce costs, enterprises that purchase additional emission quotas must also develop pollution control technologies [35]. By that, ETS can indirectly push the structure of the whole industry to change.

Secondly, the degree of opening up affects the upgrading of regional industrial structure from the following two aspects: Firstly, the degree of opening up determines the amount of funds from international markets and whether the region can obtain advanced technologies and management experience in time. Secondly, with improvement of opening up, the inflow of foreign capital would promote the transformation of the three major domestic industries and bring advanced foreign science and technology and management experience, which will form external competition and hinder the further transformation and upgrading of domestic enterprises. Thirdly, the exchange with other countries can affect the production and lifestyle of the region, which cannot be ignored for the optimization and rationalization of the regional industrial structure. Finally, domestic high-quality enterprises will also choose to go abroad, which will undoubtedly lead to the outflow of superior resources in the domestic market. Therefore, this paper puts forward the second research hypothesis:

Hypothesis 2. *The implementation of ETS can promote energy efficiency, improve the degree of opening up, and affect the upgrading of industrial structure through energy consumption and the degree of opening up.*

3.4. The Regional Heterogeneity of ETS on the Upgrading of Urban Industrial Structure

The implementation of China's system, especially the impact of market-oriented environmental regulation, usually has certain regional heterogeneity. In 2007, 11 pilot projects of emissions trading were launched, 4 of which were distributed in the eastern region, 4 in the central region and 3 in the western region. Influenced by geographical location, resource endowment and development strategy, the development of China's three major plates is not balanced. The eastern region is superior to the central and western regions in terms of economic foundation, industrial layout, technological innovation ability and marketization degree, which may lead to regional differences in the implementation effect of the same system [19]. Therefore, this paper draws the third research hypothesis:

Hypothesis 3. *For the optimization and rationalization of industrial structure, the implementation effect of ETS has regional heterogeneity for the eastern, central and western regions of China.*

4. Model Setting and Variable Selection

4.1. Model Settings

In 2007, China approved 11 pilot areas of paid use and trading of emission rights, compared with the SO_2-based ETS in 2002, the pilot area in 2007 is larger, and the policy norms and implementation efforts are more in line with the conditions of natural experiments [36].

Taking ETS implemented in 2007 as the object of natural experimental analysis, the cities implementing the system as the experimental group and the cities not implementing the system as the control group. This paper collects the relevant data from cities from 2001 to 2020 by the difference-in-difference method and compares the changes in industrial structure before and after the implementation of the policy. From this, we can calculate whether ETS has an impact on the industrial structure change of prefecture-level cities, and construct the following model:

$$S_{it} = \beta_0 + \beta_1 TREAT_i \times PERIOD_t + \beta_2 X_{it} + \mu_i + \gamma_t + \varepsilon_{it}$$

In the formula, S_{it} represents the upgrading level of the industrial structure in the t period of i region; $TREAT_i$ represents a dummy variable of a region, and the value is 1 if the region is a pilot region of the policy of paid use and trading of emission right, otherwise, the value is 0; $PERIOD_t$ indicates the time dummy variable, and the value is 1 if it is in the policy pilot period (2007 and later), otherwise, the value is 0; X_{it} represents other control variables that affect the level of regional industrial structure. μ_i represents that fixed effect of the area; γ_t represents a time-fixed effect; ε_{it} is a random perturbation term. β_1 is the core estimated parameter, indicating the impact of ETS on the upgrading of industrial structure, if β_1 is positive, it means that the implementation of ETS is indeed conducive to promoting

the upgrading of industrial structure, on the contrary, there is an inhibitory effect. β_2 is the estimate parameters of the control variables.

4.2. Selection of Variables and Data Source

Given the relevant literature on ETS and the research needs of this paper, we selected the upgrading of industrial structure as the explanatory variable, the ETS as the core explanatory variable, and the degree of opening up and energy consumption intensity as intermediary variables, and also selected control variables from various angles to comprehensively evaluate the impact of emissions trading on the upgrading of industrial structure. Variable selection is in line with the requirements of economic theory and the general law of economic operation.

(1) Selection of variable

The dependent variable: Industrial Structure. S is used to represent the status of the industrial structure of each city every year. This paper selects three levels to measure the upgrading of industrial structure (ais1 and ais2) and the level of rationalization of industrial structure (theil).

Core explanatory variable: emissions trading pilot policy. According to the econometric model constructed in this paper, the cross-term of regional dummy variable and time dummy variable is introduced to measure the impact of emissions trading pilot policy on regional industrial structure.

Other control variables: There are many factors affecting the regional industrial structure, according to the theoretical and empirical research. This paper chooses economic development level (pergdp), urbanization level (urban), fiscal freedom (fiscal), technological innovation (inn), human capital level (human) and infrastructure construction level (instruct) as control variables of the model.

Mediating variable: the degree of opening up to the outside world (open) and the intensity of energy consumption (energy) are selected as mediating variables.

(2) Data source and processing

The data of this paper mainly comes from China Statistical Yearbook, China Urban Statistical Yearbook, China Economic Network Statistical Database and Guotai'an Database. In data processing, the cities with inconsistent administrative divisions and serious data loss are eliminated. For the years with missing data, this paper calculates the average change rate of the missing years in the past three years and calculates the data of the missing years. In order to prevent the endogeneity problem between data, all variable values are logarithmic. Explanations of the meaning of the variables and descriptive statistics are shown in Tables 1 and 2. Figure 1 is the average of three variables related to industrial structure. Through the change of data in Figure 1, we can see that China's industrial structure has been gradually optimized from 2001 to 2020.

Table 1. Meaning of each variable.

Variable Type	Variable Name	Evaluation Method
Explained variable	Quantity of industrial structure upgrading (ais1)	$ais1_{i,t} = \sum_{m=1}^{3} y_{i,m,t} \times m, m = 1,2,3$
	Quality of industrial structure upgrading (ais2)	$ais2_{i,t} = \sum_{m=1}^{3} y_{i,m,t} \times lp_{i,m,t}, m = 1,2,3$ $lp_{i,m,t} = Y_{i,m,t} / L_{i,m,t}$
	Rationalization of industrial structure (theil)	$theil_{i,t} = \sum_{m=1}^{3} y_{i,m,t} \ln(y_{i,m,t} / l_{i,m,t}), m = 1,2,3$

Table 1. *Cont.*

Variable Type	Variable Name	Evaluation Method
Core Explanatory Variable	Emissions trading system (did)	Dummy Variable (0, 1)
Control Variables	Economic Development Level (pergdp)	Per capita gross regional product
	Urbanization Level (urban)	Ratio of urban population to total population at the end of the year
	Financial Freedom (fiscal)	Ratio of public financial revenue to financial expenditure
	Technical Innovation (inn)	Total Government General Expenditure on Technology
	Level of human capital (human)	Ratio of the number of students enrolled in regular institutions of higher learning to the total population of the region at the end of the year
	Infrastructure Construction Level (instruct)	Urban Road Area
Mediating variable	Openness to the outside world (open)	Ratio of actual utilization of OFDI to regional GDP
	Energy Consumption Intensity (energy)	Ratio of total consumption to GDP

Table 2. Descriptive statistics of variable.

Number of Variable	Samples	Mean Value	Standard Deviation	Maximum	Minimum
ais11	4980	5.4130	0.0678	5.6411	5.0532
ais21	4980	5.3060	1.4271	10.7052	1.3348
theil1	4980	2.9246	1.0943	5.3958	−4.5168
did	4980	0.2409	0.4347	1	0
urban1	4980	−3.0641	0.9671	0.3873	−6.1095
energy1	4980	−5.9435	1.4716	2.4509	−14.1573
infrastr1	4980	−8.2725	0.9692	−4.9192	−11.5335
human1	4980	−4.8607	1.2525	−1.0370	−13.5617
hos1	4980	4.0452	0.8616	9.0676	1.0986
open1	4980	−6.2877	1.4736	−1.6131	−15.7191
fiscal1	4980	−0.6048	0.4811	2.1270	−3.5822
inn1	4980	6.9815	1.8312	15.5292	0.6831

Data source: according to the analysis results of Stata14.0 software. The software creator is StataCorp LLC from College Station, TX, USA.

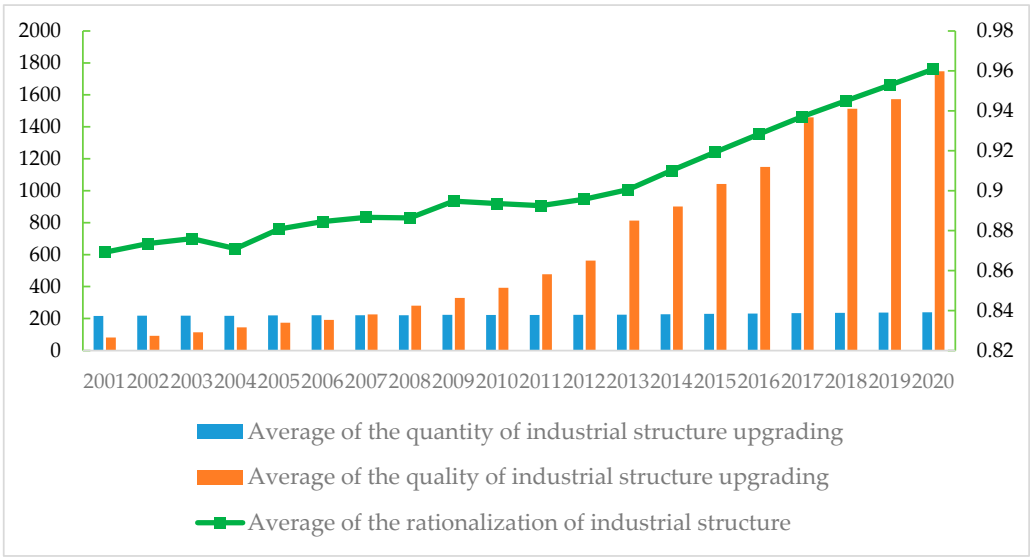

Figure 1. Average of three variables related to industrial structure. The figure shows the average of the quantity of industrial structure upgrading, the average of the quality of industrial structure upgrading and the average of the rationalization of industrial structure.

5. Empirical Test

5.1. Baseline Model Regression Result

Table 3 is the regression results of the impact of ETS on industrial structure upgrading by using Stata14.0 software. Model 1 and Model 2 represent the regression results of the upgrading of industrial structure in quantity and quality, respectively. Model 3 represents the regression results of industrial structure rationalization. Based on the regression results, the model 2 and model 3 DID indicators were significantly under the 1% and 5% level. Model 1 is not significant and the control variable of economic development level, urbanization level, the technical innovation ability, the level of human capital and infrastructure level all have a significant impact on the three dimensions of industrial structure.

Table 3. Baseline Regression Result.

Explanatory Variable	Ais1 (Model 1)	Ais2 (Model 2)	Theil (Model 3)
Did	−0.0018 (−0.60)	0.5224 *** (8.01)	0.1160 ** (1.86)
Urban1	−0.0028 (−0.98)	0.4868 *** (6.40)	0.1004 (1.32)
Infrastr1	0.0285 *** (8.23)	0.6581 *** (11.69)	−0.0778 (−1.35)
Human1	0.0094 *** (3.40)	0.3046 *** (6.59)	−0.0232 (−0.88)
Hos1	0.0074 *** (4.24)	0.2223 *** (4.34)	−0.0057 (−0.15)
inn1	0.0102 (10.27)	0.2328 *** (13.75)	0.0402 ** (2.22)
Fiscall1	0.0039 (1.35)	−0.0293 (−1.23)	−0.0273 (−0.59)
Time effect	YES	YES	YES
Regional effect	YES	YES	YES
_cons	5.5850 *** (176.61)	11.0309 *** (21.23)	2.1685 ** (4.08)
N	4947	4947	4947
R^2	0.5753	0.7525	0.1519

Note: The number in the bracket is the Z value or t value, and the superscripts ** and *** represent the passing of significance test at 5% and 1% level respectively.

However, the effect of fiscal freedom is insignificant. The implementation of ETS has no significant effect on the upgrading of urban industrial structure in terms of quantity. However, it has a significantly positive effect on the upgrading of urban industrial structure in terms of quality, which indicates that the implementation of ETS promotes the upgrading of industrial structure quality. At the same time, the rationalization index of industrial structure is a negative indicator, and the coefficient is positive, which indicates that the implementation of ETS hinders the rationalization of industrial structure. The Hypothesis 1 is verified through regression analysis.

5.2. Analysis of Impact Mechanism

The test results of the impact of ETS on two intermediary variables are shown in Table 4. The DID coefficient significantly shows that the implementation of ETS can reduce the intensity of energy consumption, which means it can force enterprises to improve energy efficiency, reduce energy consumption, and indirectly promote the quality of industrial

structure. In addition, the implementation of the system has a significantly positive effect on opening up and can promote opening up.

Table 4. Impact of Emissions Trading System on Two Mediating Variables.

Variables	Energy Consumption Intensity (Energy)	Openness to the Outside World (Open)
did	−0.5614 *** (−5.79)	0.4038 *** (3.61)
Control Variables	YES	YES
Time effect	YES	YES
Regional Effect	YES	YES
_cons	−8.3183 **	−7.1895 ***
N	4935	4935
R^2	0.3096	0.1437

Note: The number in the bracket is the t value, and the superscripts ** and *** represent the passing of significance test at 5% and 1% level respectively.

The test results of the two intermediary variables on the upgrading of industrial structure are shown in Table 5. Energy consumption intensity and the degree of opening up are not significant in the model ais1. In the model ais2 and the model theil, the coefficient of energy consumption intensity and the degree of opening up to the outside world to the rationalization of the industrial structure and the quality of the industrial structure is significant. The results demonstrate that ETS does promote the upgrading of industrial structure through energy consumption intensity and opening degree. Specifically, ETS promotes the upgrading of urban industrial structure in quality, quantity and the rationalization of industrial structure by promoting regional energy consumption intensity and the degree of opening up but its effect on the upgrading is not significant, which verifies the Hypothesis 2.

Table 5. Impact of Emissions Trading System and Two Mediating Variables on Industrial Structure Upgrading.

Variables	Energy Consumption Intensity (Energy)			Openness to the Outside World (Open)		
	Ais1 (Model 4)	Ais2 (Model 5)	Theil (Model 6)	Ais1 (Model 7)	Ais2 (Model 8)	Theil (Model 9)
did	−0.0044 (−1.35)	0.4138 ** (6.42)	0.1319 ** (2.07)	−0.0014 (−0.44)	0.5357 *** (8.29)	0.1295 ** (2.08)
Energy Consumption Intensity (energy)	−0.0045 *** (−4.40)	−0.1898 *** (−8.19)	0.0256 (1.36)			
Openness to the outside world (open)				−0.0015 * (−1.79)	−0.0311 ** (−2.27)	−0.0336 ** (−2.04)
Control Variables	YES	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES	YES
Regional Effect	YES	YES	YES	YES	YES	YES
_cons	5.5482 *** (166.33)	9.5108 *** (17.47)	2.3725 ** (4.11)	5.5788 *** (166.69)	10.8778 *** (19.87)	1.9258 *** (3.41)
N	4454	4454	4935	4453	4879	4443
R^2	0.5821	0.6913	0.1331	0.5824	0.7540	0.2842

Note: The number in the bracket is the t value, and the superscripts *, ** and *** represent the passing of significance test at 10%, 5% and 1% level respectively.

5.3. Heterogeneity Analysis

Taking into account the impact of regional development differences, this paper divides the eastern, central and western regions according to the pilot areas of emissions trading policy and estimates and compares the effects of ETS on the industrial structure of different regions. The regression results are shown in Table 6.

Table 6. Analysis of regional heterogeneity.

Variables	East			Middle			West		
	Ais1	**Ais2**	**Theil**	**Ais1**	**Ais2**	**Theil**	**Ais1**	**Ais2**	**Theil**
did	0.0023	0.0971	0.1610	0.0006	0.3160 ***	0.2177 *	0.0364 ***	0.2115 **	0.1168
	(0.40)	(1.34)	(1.14)	(0.16)	(3.28)	(1.69)	(4.37)	(2.06)	(0.66)
Control Variables	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Regional Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
_cons	5.5018 ***	5.5294 ***	3.4504	5.5486 ***	5.7999 ***	1.933 **	5.6517 ***	6.3652 ***	1.8004 *
	(110.81)	(5.08)	(1.53)	(138.98)	(5.70)	(2.18)	(67.39)	(9.87)	(1.79)
N	1920	1920	1920	1901	1901	1901	1126	1126	1126
R^2	0.6785	0.8277	0.3986	0.5187	0.8043	0.2659	0.6080	0.8629	0.5949

Note: The number in the bracket is the t value, and the superscripts *, ** and *** represent the passing of significance test at 10%, 5% and 1% level respectively.

Overall, the impact of ETS implementation on the urban industrial structure has different effects in the eastern, central and western regions. The promotion effect in the western region is the strongest and the promotion effect in the central and eastern regions is weaker than that in the western region. Among them, in the western region, ETS implementation can promote the upgrading of the quality of industrial structure and hinder the upgrading of industrial structure. For the central region, the implementation of ETS for high-quality industrial structure has a catalytic role. In the eastern region, the impact is not significant. The above conclusions partly confirm Hypothesis 3.

6. Conclusions and Discussion

Based on the panel data of 249 prefecture-level cities in China from 2001 to 2020, this paper uses the difference-in-difference method to study whether the emissions trading policy affects the upgrading of industrial structure. Through the research, this paper draws the following conclusions:

First, there is a degree of uncertainty regarding the impact of ETS implementation on industrial structure. ETS implementation can promote the quality of industrial structure but will hinder the rationalization of industrial structure. For the results above, the reason mainly relates to the following points. Firstly, during ETS implementation, due to the shift of China's current economic center of gravity to the third industry, the effect of ETS implementation on the quantity of domestic industrial structure upgrade does exhibit a certain degree of uncertainty. Secondly, ETS implementation has a significant effect on the quality of industrial structure upgrade, mainly because the cost and industry competition of enterprises that produce large sewage discharges in the first and second industry will eliminate organizations with low productivity. Thus, the entire industry will be relatively high in labor productivity, which promotes the overall industrial structure upgrade. Finally, the result of ETS implementation is contrary to the rationalization requirements. The rationalization of industrial structure requires that all factors of production can flow reasonably between industries, that the relationship between supply and demand is also a reasonable development trend, and that the implementation of ETS is tied to the transformation of

enterprises to the tertiary industry. The factors of production and supply will also tend to the tertiary industry, thus hindering the rationalization of industrial structure.

Secondly, testing the two mediating variables of energy consumption intensity and the degree of opening up indicates that ETS implementation improves energy utilization efficiency, the degree of opening up, urban industrial structure in quality and quantity and the rationalization of industrial structure but has no significant effect on the optimization of industrial structure upgrading. On the one hand, energy is one of the main production factors of the first and second industries, and energy consumption is the main influencing factor of enterprise pollution discharge. Therefore, the implementation of ETS encourages enterprises to increase the cost of pollution control, trade emission rights and promote the transformation and upgrading of industrial structures. On the other hand, the degree of opening up to the outside world of the region is closely related to foreign capital, technology, management experience acquired and domestic enterprises' international expansion. In addition to the influence of the enterprise level, influence also exists for the general mode of production in regions. As mentioned above, it is an overall trend that the primary and secondary industries are gradually transforming to the tertiary industry at present, so the influence is not significant.

Thirdly, in view of the upgrading and rationalization of industrial structure, the implementation effect of ETS has regional heterogeneity for the eastern, central and western regions. The pilot policies in the eastern, central and western regions have significantly affected the upgrading of regional industrial structure, but the effects are different. The promoting effect of the western region is the strongest, and the promoting effect of the central and eastern regions is weaker. On the one hand, the western region is highly concentrated with energy industry in China, which accounts for a large proportion of the total emissions. Once the policy of energy consumption is implemented, it will have a greater impact on the local industry. On the contrary, the industry in the eastern region is more concentrated in the tertiary industry. Therefore, the impact of ETS on the eastern region is lower than that of the central and western regions. On the other hand, the eastern region is more economically developed, and there are clear advantages in technology compared to the central and western regions. With the use of advanced technology, the emissions of related industries in the eastern region will be reduced more than the central and western regions, so ETS implementation has no significant impact on the transformation of industrial structure in the eastern region.

In view of the empirical results above, this paper proposes the following policy recommendations:

(1) Accelerate the pace of technological innovation, optimize the industrial structure and coordinate the optimal proportion of secondary and tertiary industries. Technological innovation is still a link that cannot be ignored by enterprises. Advanced technology should be actively introduced while accelerating the pace of research and development of advanced technology to improve pollution control, reduce the cost of pollution control, and develop technological and cost advantages in the industry. Industrial production is bound to discharge more pollutants than the service industry, so we should coordinate the proportion of the industrial output value to the total output value, so as to reduce pollution.

(2) Adjust measures to local conditions and implement ETS with characteristics. Different regions have different economic development and environmental conditions. Therefore, a detailed investigation should be carried out before the implementation of ETS, such as for areas with backward economic development and industrial development. We should vigorously introduce talents and technology and improve the enterprise production efficiency and resource utilization rate in order to achieve a win-win situation of economy and environment. For economically developed regions, we should learn from the experience of developed countries and take measures to optimize the local industrial structure according to local conditions.

(3) China needs to improve ETS, play a role in market regulation and optimize the allocation of resources. The prerequisite for ETS implementation to achieve desired results

is that the system can be effectively operated. Therefore, the provisions of the system in the early stage of implementation, the strict implementation of the system in the process of trading and the timely improvement of the system after trading should be gradually executed to provide a good superstructure for the operation of free market.

On the basis of the above countermeasures and suggestions, it should also be noted that the implementation of the countermeasures of prefecture-level cities will be affected by various factors, such as political and economic environment (market situation, other policy effects, etc.), main bodies (different development of regions, provinces and prefecture-level cities, different main bodies of governments and enterprises) and so on. According to the actual situation, flexible measures should be taken to maximize the role of countermeasures. For further research, this paper puts forward the following research prospects. First, this paper analyzes the impact of the implementation of ETS on the upgrading of China's industrial structure from the macro level. To further analyze the impact of ETS, future studies can analyze the impact of ETS on the industrial structure of a certain industry, such as the energy industry or the manufacturing industry, etc. Secondly, although the basic framework of ETS has been established, there are still some problems, such as the imperfect ETS, the imperfect initial allocation method of emission indicators, the lack of relevant norms in the secondary market trading of emission rights. Implementing the ETS in specific industries also needs further analysis. Thirdly, promoting the upgrading of industrial structure through the implementation of ETS still has many problems. In future research, we should deepen the analysis of this problem, further optimize ETS and promote the upgrading of industrial structure through the ETS. Fourthly, the current epidemic of COVID-19 continues to spread worldwide. In response to the epidemic, countries have taken various measures and carbon emissions have also been significantly reduced in the short term; the whole society is in a passive low-carbon lifestyle, and the industrial structure will also change. In the post-epidemic era, the economic recovery policies adopted by countries is not clear, and neither is how to develop each industry and how to develop emissions trading. Therefore, the possible impact of COVID-19 on emissions trading system and of upgrading the industrial structure need to be studied further by experts.

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