

Whether the Development of Carbon Finance Contributed to Industrial Optimization and Upgrading: Evidence from A Chinese Carbon Emissions Trading Pilot

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Abstract. In recent years, there has been a lot of literature on carbon finance contributing to industrial optimization and upgrading, but the causal endogeneity between them has not been well addressed. The carbon emissions trading policy is a major exploration practice in the construction of China's carbon financial market. Using this natural event, data from 30 provinces during 2008-2018 are selected and the Differences-in-Differences method is applied to comprehensively analyze the impact of carbon emissions trading policy on industrial optimization and upgrading in pilot regions and its mechanism of action. And to conclude the driving effect of carbon finance development on industrial optimization and upgrading based on greatly reduced endogeneity. The conclusions show that carbon emissions trading policies can effectively promote industrial upgrading in the pilot regions. Further mechanism research also shows that carbon emissions trading policies promote industrial upgrading in the pilot regions through three main channels: enterprise innovation efficiency, international trade, and consumer demand, with the most obvious effect of enterprise innovation efficiency. This paper concludes with recommendations for industrial upgrading based on a carbon finance perspective.

Keywords: Carbon emissions trading; Industrial upgrading; Carbon finance; Path analysis.

1. Introduction

Since the reform and opening up, China's economy has achieved a high growth rate of about 9% per annum. In 2021, China's GDP per capita exceeds US\$12,000, surpassing the world's GDP per capita level for the first time. However, under the dual constraints of resource scarcity under the crude industry and the ecological environment, there is an imbalance between the speed and quality of China's economic development. To alleviate the imbalance, China has made green development the theme of the times for the development of society today. China supports the development of green industries, promotes industrial structure transformation in the direction of less environmental pollution and lower resource consumption, and enhances the greening of the economy to promote China's industrial structure's optimization and upgrading.

Carbon finance refers to financial activities aimed at reducing greenhouse gas emissions. In the context of the world's "low-carbon transition" trend and China's "30-60" climate target, carbon finance has become a powerful engine for China's energy transition and green economic development. Over the next 30 years, China's carbon-neutral investment is expected to exceed \$138 trillion, yet the government's financial outlay is only 15.94%. Carbon finance is the main way to bridge the funding gap of carbon-neutral economy, and it also shows the essential attribute of carbon finance to support and serve the carbon market. Carbon trading is an important element of carbon finance and a strong growth area. Carbon trading is a way of giving use value to carbon dioxide emissions, which, through the act of trading in the market, generates economic value; it also encourages enterprises to actively engage in technological innovation and adjust their industrial structure.

Given the current situation in China, can the development of carbon finance promote the optimization and upgrading of industries and thus the quality development of the Chinese economy? This paper attempts to answer these questions by exploring the relationship between the development of green carbon finance and industrial upgrading through a natural experiment of the 2013 carbon emissions trading pilot project in seven Chinese provinces. The marginal contribution of this paper

may be that: (i) For the first time, the pilot provinces of carbon emissions trading are used to eliminate the causal endogeneity problem that has been widely found in the previous research literature, and the impact on China's industrial upgrading is systematically explored using the Differences-in-Differences (DID) method, which will be a useful addition to the existing research. (ii) In-depth discussion of the mechanisms of carbon emissions trading policies on China's industrial upgrading and optimization is made, which deepens the intrinsic logical links between carbon emissions trading policies on China's industrial upgrading and optimization. (iii) Based on the results of previous studies, the industrial structure index system is constructed from the advanced and rationalized level of industrial structure, which can comprehensively reflect the characteristics and dynamic changes of industrial structure and more comprehensively measure industrial optimization and upgrading. (iv) Provides targeted policy recommendations for the development of China's industrial optimization and upgrading from the perspective of carbon finance development.

2. Literature Review

2.1 Carbon Finance And Industrial Optimization And Upgrading

In 1998, Jose Salazar (1998) first introduced the concept of environmental finance and defined it, a conclusion that laid the theoretical foundation for the development of carbon finance. Eric Cowan (1999) explored how environmental finance, as a cross-discipline between environmental economics and finance, should finance the development of the environmental economy and, in the process, achieve the intersection of environmental economics and finance. Masakazu and Chihiro (2011) argued that industrial restructuring and upgrading means that the tertiary sector becomes the dominant industry in a country, and the key factor that drives industrial restructuring and upgrading is the effective demand in the market. Mei Xiaohong (2015), through a panel data analysis of provincial and urban areas, argued that the increase in CDM carbon trading would bring about industrial restructuring. And the differences in culture, development stage, and policy orientation of different regions made the differences between different regions. Jing Ma et al. (2021) examined the relationship between the level of development of carbon finance, technological progress and industrial structure upgrading using the OLS method based on panel data from 2014 to 2018 in seven pilot regions, including Beijing and Shanghai, and found that financial decarbonization would significantly optimize and upgrade the industrial structure. However, there is a lack of research on the role of carbon finance in promoting industrial upgrading, and the existing quantitative studies do not effectively avoid the issue of causal endogeneity.

2.2 Environmental Policy And Industrial Optimization And Upgrading

The economic effects of environmental policies have been a popular topic of research among scholars, and from the existing research literature, most scholars believe that environmental policies can promote the optimization of industrial structure to a certain extent. Yang Xiu Wang et al. (2021) analyzed the impact of environmental policies on the industrial structure using panel data from 30 provinces in China, and the results showed that environmental policies have a certain promotion effect on the optimization of industrial structure. Since carbon emissions trading has been applied relatively early in developed countries, the international academic community has conducted studies on carbon emissions trading much earlier, and the studies mainly focus on its incentive effect on enterprises' actual operation process. Demailly and Quirion (2008) took steel enterprises in pollution-intensive industries as the research object and found that carbon emissions trading can positively. Stern (2007) argued that carbon emissions trading is more effective than carbon taxes in restraining high emissions.

3. Model

3.1 Model Setting

This paper uses the Differences-in-Differences method to empirically investigate the impact of the pilot carbon trading rights on the optimization and upgrading of industries in the pilot regions. To verify the impact effect of carbon finance development on industrial optimization and upgrading, the seven carbon trading pilot regions in China are used as the treatment group for policy impact, and the other 23 provinces out of the 30 provinces in the eight economic zones mentioned above are used as the control group. Considering the time when the policy comes into play, with 2013 as the time point, 2008-2013 as the pre-policy observation period, and 2013-2018 as the post-policy observation period, we set up a Differences-in-Differences model with the benchmark regression equation set as following equation.

$$SO_{it} = \alpha_0 + \beta_1 treat_{it} \cdot post_{it} + \sum_{i=1}^6 \alpha_i X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

In the above equation, the explained variable is SO_{it} , the subscripts i and t denote the i province and t year respectively, and $treat_{it} \cdot post_{it}$ is the core explanatory variable, which is the implementation of the carbon emissions trading policy. X_{it} are a set of other selected control variables, including GDP per capita, urbanization rate, openness to the outside world, level of human capital, government fiscal expenditure, and level of consumption. γ_t represents the timely fixed effects for each pilot, μ_i represents the regional fixed effects for each pilot, and ε_{it} is the random error term. In the above model, β_1 is the core estimated parameter, indicating the net impact of carbon trading policy on industrial upgrading. If β_1 is positive, it means that the implementation of carbon emissions trading policies can indeed promote industrial upgrading, which further suggests that carbon finance development has a positive effect on industrial upgrading; otherwise, there is a suppressive effect.

3.2 Variables Selection

3.2.1 Explanatory Variable:

Carbon Trading Policy Dummy Variable ($treat_{it} \cdot post_{it}$)

The explanatory variable in this paper is the dummy variable for the implementation of carbon trading policies ($treat_{it} \cdot post_{it}$). If a region is implementing or has implemented a carbon trading policy in the current year, the dummy is assigned a value of 1, otherwise, it is assigned a value of 0, resulting in the core explanatory variable $treat_{it} \cdot post_{it}$.

3.2.2. Explained Variable:

Industrial Structure Optimization Index (SO)

Existing relevant studies on the measurement of industrial structure optimization often ignore the internal measurement factors of industrial structure in the selection of indicators. This paper draws on Han Jing's (2019) approach to measuring industrial structure optimization, and constructs industrial structure optimization indicators from two aspects: rationalization and advancedization, which can measure the level of industrial structure upgrading more comprehensively and make up for the inadequacy of considering only the aggregate effect of structure, with innovative significance.

(1) Rationalization Of Industrial Structure

Industrial structure rationalization is a measure of the degree of coupling between factor input and output structures. We choose the degree of industrial structure deviation to examine the degree of industrial structure rationalization, which can be expressed by the following equation.

$$E = \sum_{i=1}^n \left| \frac{Y_i}{L_i} / \frac{Y}{L} - 1 \right| \quad (2)$$

Where E is the industrial structure deviation, Y is the total output value, L is the total labor force, Y_i is the output value of the i industry, L_i is the labor force of the i industry, and n indicates the number of industrial sectors.

From the perspective of labor productivity, $\frac{Y_i}{L_i}$ is the labor productivity of industry i , when $\frac{Y_i}{L_i} > \frac{Y}{L}$ is higher than the national average of all industries, which means there is a pull of resource inflow, and vice versa, there is a push of resource outflow. When the economy reaches equilibrium, $E = 0$. And the higher the value of E , the more the economy deviates from equilibrium, which means the more unreasonable the industrial structure is. To take into account the different importance of different industries to economic development when examining the degree of rationalization of the industrial structure, we draw on the method of Gan Chunhui et al. (2011) and introduce the weights of each industry into the Thiel index to measure the rationalization of the industrial structure, the specific formula is shown in the following equation.

$$SR = \sum_{i=1}^n \left(\frac{Y_i}{Y} \right) \ln \left(\frac{Y_i}{L_i} / \frac{Y}{L} \right) \quad (3)$$

SR is the index of industrial structure rationalization, Y is the value of output, L is the number of people employed and $i = 1, 2, 3 \dots$ represents specific industries. This equation incorporates the economic theoretical basis of structural deviation and gives weights to different industries that are more in line with economic reality. SR It is an inverse indicator, with smaller values for SR indicating a higher degree of industrial rationalization.

(2) Advanced Industrial Structure

Advanced industrial structure refers to the evolution of the industrial structure from a low level to a high level.

In this paper, based on the method of Fu Linghui (2010), we redefine the index of advanced industrial structure based on the M0re value, and take the output value of each industrial sector in the tertiary industry as a component of the spatial vector, thus forming a set of three-dimensional vectors: $X_0 = (x_{1,0}, x_{2,0}, x_{3,0})$, and then calculate the angle between the vector X_0 and the base vectors $X_1 = (1, 0, 0)$, $X_2 = (0, 1, 0)$, $X_3 = (0, 0, 1)$, which are arranged from the lowest to the highest industrial structure: $\theta_1, \theta_2, \theta_3$, as shown in the following equation.

$$\theta_j = \arccos \left(\frac{\sum_{i=1}^3 (x_{i,j} \cdot x_{i,0})}{\left(\sum_{i=1}^3 (x_{i,j}^2) \right)^{\frac{1}{2}} \cdot \left(\sum_{i=1}^3 (x_{i,0}^2) \right)^{\frac{1}{2}}} \right), \quad j = 1, 2, 3 \quad (4)$$

The formula for the advanced structure of the industry SU is shown in the following equation.

$$SU = \sum_{k=1}^3 \sum_{j=1}^k \theta_j = 3\theta_1 + 2\theta_2 + \theta_3 \quad (5)$$

If the share of tertiary output in a region relatively increases, the angle between the X_0 vector and the base vector X_3 decreases, and the angles with X_1 and X_2 increase. SU indicator will eventually increase as θ_1 and θ_2 are given higher weights, which means the industrial structure is upgraded.

(3) Degree Of Optimization Of Industrial Structure

Empirically, the resulting industrial structure rationalization index and advanced index are geometrically averaged to obtain a score for the degree of industrial structure optimization, which can be used to measure the level of industrial structure optimization, as follows.

$$SO = \sqrt{SR \cdot SU} \quad (6)$$

Where SO stands for the Industrial Structure Optimization Index, SR represents the Industrial Structure Rationalization Index and SU represents the Industrial Structure Advancement Index.

3. Control Variables

This part of the study focuses on the effect of the implementation of carbon emissions trading policy on industrial upgrading, but many other factors affect regional industrial upgrading, so six control variables are introduced after screening based on previous research by scholars: GDP per capita, level of consumption of residents, level of human capital, urbanization rate, openness to the outside world, and government fiscal expenditure. [14-19]

Table 1. Variables Explanation Table

Variable Property	Variable Name	Variable Measurement
Explained Variables	Industrial structure optimization index (SO)	Geometric mean of industrial structure rationalization index and advanced index
Explanatory Variables	Carbon trading policy ($treat_{it} \cdot post_{it}$)	Dummy variable, assigned a value of 1 when the region has a carbon trading policy
Control Variables	GDP per capita ($perGDP$)	Ratio of GDP to population size
	Level of consumption of the population (HC)	Gross domestic consumption in the reporting period / average annual population in the reporting period (yuan/person)
	Level of human capital ($human$)	(Number of students enrolled in general higher education institutions/total population at the end of the year) \times 10,000
	Urbanization rate (UR)	Ratio of urban population to the total resident population
	Openness to the outside world ($Open$)	(Actual utilization of foreign direct investment in the region/regional GDP) \times 100
	Government financial expenditure (GE)	The total annual expenditure of local government finance (yuan billion)

3.3 Data Sources And Processing

The primary data designed for the empirical part of this paper were mainly sourced from the website of the China Statistics Bureau and the China Statistical Yearbook from 2008-2018. The significance of the control variables is enhanced by taking the logarithm of all four variable indicators: the level of resident consumption (HC), per capita GDP, the level of human capital (Human), and openness to the outside world (open); and for the variable indicators of fiscal expenditure, openness to the outside world, GDP and per capita capital level, the GDP deflator of each city with 2008 as the base period is used to The GDP deflator for each city was used to eliminate the effect of inflation.

4. Results

4.1 Base Model Regression Results

The regression results based on the base model (1) to estimate the impact of the pilot carbon trading pilot on the optimization and upgrading of industries in the pilot areas are shown in Table 2. Model (1) is the regression result without the inclusion of control variables and province-level and year-level fixed effects; model (2) is the regression result without the inclusion of control variables; model (3) is the regression result with the inclusion of other control variables and province-level and year-level fixed effects. The results show that the carbon emissions trading pilot scheme has a significant positive effect on the industrial upgrading of the pilot areas, regardless of whether the control variables are included or not, and whether the province-year fixed effects are controlled or not.

For control variables, GDP per capita, the consumption level of residents, human capital level, urbanization rate, openness to the outside world, and government fiscal expenditure are all significantly positive, which indicates that these variables have a significant contribution to China's high-quality economic development, which is also consistent with the findings of the theoretical analysis.

Table 2. DID-Benchmark Regression Results

	(1)	(2)	(3)
Post*treat	0.219** (3.93)	0.219*** (3.93)	0.121*** (3.93)
lnHC			1.156** (2.06)
lnperGDP			-1.542*** (-7.58)
lnHuman			-0.037** (-2.40)
lnOpen			-3.188*** (-2.74)
UR			-0.018** (-2.18)
GE			-0.306* (-1.70)
Constant	13.921*** (3.97)	13.921*** (3.97)	11.797*** (5.67)
observations	330	330	330
Number of id	31	31	31
R-squared	0.141	0.188	0.231
City FE	NO	YES	YES
Year FE	NO	YES	YES

t-statistics in parentheses

Note: Figures in brackets are t-statistics; *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

4.2 Robustness Tests

4.2.1 Parallel Trend Test

Table 3. Parallel Trend Test Results

	(1)	(2)	(3)
treat x 2008	0.073 (0.089)	0.059 (0.041)	0.037 (0.029)
treat x 2009	0.013 (0.014)	0.013 (0.011)	0.015 (0.011)
treat x 2010	0.023 (0.032)	0.024 (0.021)	0.023 (0.022)
treat x 2011	0.072 (0.058)	0.032 (0.095)	0.028 (0.162)
treat x 2012	0.051 (0.041)	0.047 (0.052)	0.029 (0.030)
treat x 2013	0.056* (0.031)	0.051** (0.021)	0.029** (0.011)
treat x 2014	0.070*** (0.011)	0.054*** (0.015)	0.038*** (0.011)
treat x 2015	0.081*** (0.012)	0.055*** (0.015)	0.040*** (0.009)
treat x 2016	0.109*** (0.010)	0.062*** (0.012)	0.041** (0.017)
treat x 2017	0.106*** (0.012)	0.083*** (0.010)	0.052*** (0.011)
treat x 2018	0.108** (0.051)	0.092*** (0.013)	0.057*** (0.011)
Constant	0.427*** (0.001)	0.152*** (0.012)	0.139*** (0.012)
Control variables	No	Yes	Yes
year fixed effect	No	No	Yes
province fixed effect	No	No	Yes
observations	330	330	330
adjusted R ²	0.300	0.521	0.590

Note: Figures in brackets are standard errors; *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

The most important assumption of the Differences-in-Differences method is the assumption of parallel trends, and the results are shown in table 3. It's easy to find that coefficients are insignificant before the start of implementation of the carbon emissions trading pilot policy, regardless of controlling for province-year's level fixed effects and adding control variables. And after the implementation of the pilot carbon trading policy, the coefficients of the interaction terms are all significantly positive, and the coefficient values are increasing, thus indicating that carbon trading can effectively enhance the optimization and upgrading of the industrial structure in the pilot areas.

4.2.2 Counterfactual Test

To remove the noise effects that other stochastic factors may bring to the base regression model, this paper, based on the practice of Shi Daqian et al. (2018), Sun Lin and Zhou Ke Xuan (2020b) and others, assumes that the carbon emission trading pilot is implemented one year earlier, that is, from the original 2013 to 2012. And the base model is re-regressed and analyzed based on this. The results are shown in Table 4 Scheme (1). It is easy to find that the core explanatory variables are no longer significant at this point, thus indicating that the carbon emissions trading pilot is an important influencing factor in the optimization and upgrading of industries in the pilot region, and thus verifying the robustness of the baseline regression.

4.2.3 Identification Conditions For The Year Of The Restrictive Policy

The start of the carbon emissions trading pilot in 2013 took place on June 18 of that year, but the base model was set up in a way that did not take into account the possible differences in policy implementation effects due to the short duration of the year in which the pilot started. Based on this consideration, this paper refers to Lu et al. (2017) and adopts the constraint policy implementation year identification condition, that is, for the carbon emissions trading pilot provinces implemented in June 2013, it is set to 0 before 2013 and 1/2 in the year of 2013 (the length of policy implementation in the year of 2013 for IPR demonstration cities is only 6 months); after 2013, it is set to 1. On this basis, the base model was re-regressed and analyzed as shown in Table 4, Scheme (2), and it was concluded that there was no significant change in the core explanatory variables, thus indicating the robustness of the base regression model.

4.2.4 Endogenous Problem Solutions

Table 4. Robustness test results

	(1)	(2)	(3)
	Counterfactual test	Identifying conditions for restrictive policy years	Endogenous problems
Post*treat	0.126 (1.32)	0.132*** (3.15)	0.134*** (3.44)
lnperGDP	-1.057*** (-8.03)	-1.405*** (-7.69)	-1.087*** (-6.82)
lnHC	1.441*** (5.69)	0.998*** (4.91)	1.251*** (6.01)
lnhuman	-0.023*** (-3.72)	-0.024*** (-2.91)	-0.023** (-2.33)
LnOpen	-3.113*** (-3.34)	-3.315* (-1.91)	-2.915*** (-2.59)
UR	-0.017*** (-3.63)	-0.018*** (-5.01)	-0.012*** (-4.07)
GE	-0.703** (-2.18)	-0.519** (-2.34)	-0.327*** (-3.59)
Constant	13.821*** (7.14)	11.128*** (4.14)	11.167*** (4.05)
year fixed effect	Yes	Yes	Yes
province fixed effect	Yes	Yes	Yes
observations	330	330	330
adjusted R ²	0.284	0.189	0.231

Note: Figures in brackets are t-statistics; *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

Considering the possible endogeneity problems of the underlying model, this paper attempts to build a dynamic GMM panel model to deal with this problem accordingly by adding a one-period lag of the explanatory variable (SO) based on the approach of Manuel and Stephen (1991). The regression results are presented in Table 4 Scheme (3). It is easy to find that the core independent variables are still highly significant at this point, thus also validating the robustness of the baseline model regression.

4.3 Mechanisms Analysis

The DID model has confirmed that the carbon emissions trading pilot can significantly contribute to the upgrading of Chinese industries. However, it is worth considering that what intermediate mechanisms do the carbon emissions trading pilots promote industrial upgrading in China? This paper explores the intermediate channels through which the carbon emissions trading pilot has influenced the optimization and upgrading of China's industries by constructing a mediating effects model. With the help of the theoretical part of the mechanism of action analysis, the intermediate transmission mechanism is verified through three channels: enterprise innovation efficiency, international trade, and residential consumption demand.[14,25-39] To test the influence of different factors on carbon emissions trading and industrial upgrading, the interaction terms of three path variables (EIE, IT, and RCD) and industrial upgrading (S0) are introduced in the benchmark regression model to test how the three path variables affect carbon emissions trading and the relationship between carbon finance and industrial upgrading is examined. And the significance and magnitude of the interaction between the three path variables in the interaction term regression are used to preliminarily investigate the specific mechanism of carbon finance to promote industrial upgrading.

Table 5. Path Test Results

	(1)	(2)	(3)	(4)	(5)	(6)
	EIE	SO	IT	S0	RCD	SO
Post*treat	0.266*** (0.051)	0.031** (0.013)	0.266* (0.141)	0.032** (0.015)	0.032*** (0.009)	0.031*** (0.003)
EIE		0.086*** (0.004)				
IT				0.020*** (0.001)		
RCD						0.085** (0.041)
InperGDP	0.287*** (0.029)	-0.005** (0.002)	0.483 (0.379)	-0.002 (0.002)	-0.002 (0.002)	-0.004*** (0.001)
lnHC	-0.081*** (0.019)	0.004*** (0.001)	0.039 (0.046)	0.003*** (0.001)	0.003*** (0.001)	0.004 (0.009)
lnhuman	-0.022 (0.24)	0.013*** (0.001)	0.260 (0.229)	0.013** (0.006)	0.013*** (0.001)	0.014*** (0.001)
lnOpen	-0.013 (0.014)	0.018*** (0.001)	0.232*** (0.039)	0.017*** (0.001)	0.018*** (0.001)	0.018*** (0.001)
UR	0.028*** (0.009)	0.003*** (0.001)	-0.009 (0.026)	0.003** (0.001)	0.003*** (0.001)	0.003*** (0.001)
GE	6.214*** (0.221)	0.009 (0.011)	-1.571*** (0.399)	0.073*** (0.008)	0.075*** (0.008)	0.008 (0.011)
Constant	3.908*** (0.021)	0.093*** (0.013)	5.172*** (0.611)	0.132*** (0.012)	0.128*** (0.012)	0.097*** (0.013)
year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
observations	330	330	330	330	330	330
adjusted R ²	0.709	0.593	0.078	0.583	0.582	0.593

Note: Figures in brackets are standard errors; *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

Firstly, the coefficients of post * treat in columns (1)(3)(5) of Table 5 are all significantly positive, which indicates that carbon trading pilot provinces can significantly promote the development of enterprise innovation efficiency, international trade, and consumer demand. At the same time, the coefficients of post * treat in columns (2)(4)(6) of Table 5 are significantly positive, which indicates that the pilot carbon emission trading pilot can promote the industrial optimization and upgrading of the pilot areas by enhancing the innovation efficiency of enterprises, international trade, and consumption of residents. The coefficients of 38.59%, 31.29%, and 30.21% are calculated for the technological innovation mechanism, national trade development, and consumer demand respectively, which indicates that the technological innovation mechanism plays the largest role in the promotion of China's economic quality development by the pilot carbon trading pilot cities, with a contribution rate of 38.59%.

5. Conclusions And Recommendations

5.1 Research Findings

By selecting provincial panel indicators and removing the noise interference of endogeneity with the help of DID, this paper discusses the impact and mechanism of the pilot carbon trading pilot on industrial upgrading in the pilot provinces, thus confirming that the development of carbon finance can promote the optimization and upgrading of the industrial structure under the scenario of maximizing the reduction of endogeneity.

The empirical study led to the following conclusions.

(1) Whether or not the control variables are included and whether or not the fixed effects of province and year are controlled, there is a significant positive correlation between the carbon emissions trading pilot and the optimization and upgrading of industries in the pilot areas.

(2) By examining the mechanism of the carbon emission trading pilot, it is found that the carbon emission trading pilot mainly promotes the optimization and upgrading of the industries in the pilot areas in three ways: technological innovation mechanism, international trade, and consumer demand, and the technological innovation mechanism plays the largest role, with a contribution rate of 38.59%.

5.2 Suggestions For Industrial Upgrading Based On A Carbon Finance Perspective

Firstly, the government should adopt a categorical approach and make gradual progress to improve the relevant market trading system nationwide. To give better play to the role of market mechanisms in promoting emission reduction, the government should, based on the practice of pilot work, continue to complete and standardize the relevant laws and regulations, continue to promote the construction of relevant systems, create a fair and transparent, orderly and convenient market trading atmosphere, increase the transparency of market information, reduce market transaction costs, and mobilize the enthusiasm of enterprises to participate in the market. In addition, the government should gradually bring more industries into the scope of market transactions and enhance the vitality and dynamism of the market.

Secondly, the government should let the innovation lead and promote the transformation of achievements, accelerate the transformation and upgrading of industrial structure, and promote green technological innovation. The intermediary effect test in this paper shows that technological innovation is the most important intermediary factor for carbon emissions trading to promote industrial optimization and upgrading. The government should make comprehensive use of financial subsidies and actively encourage key domestic enterprises to participate in technological innovation to promote the transformation of green technology achievements. At the same time, it should reduce the absorption cycle of technology spillovers from foreign direct investment by local enterprises and promote the independent R&D capability of local enterprises.

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