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Research on Carbon Emission Reduction Effect of China's Carbon Trading Pilot - Based on Different in Different Method

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ABSTRACT

Carbon emissions trading is one of the important ways to reduce carbon emissions by giving CO_2 emission rights a commodity attribute that allows them to trade on the market and to reduce greenhouse gas emissions through the market mechanisms. Based on the inter-provincial panel data from 1997 to 2016, this paper constructs a basic theoretical analysis framework to analyze the carbon emission reduction effects of carbon trading policies, adopts PSM-DID to study the carbon emission reduction effects of carbon trading pilots. This study finds that: (1) The implementation of the carbon trading pilot can promote carbon emission reduction, but the pilot provinces and municipalities have different economic development levels, industrial structure and supporting measures adopted after the implementation of the carbon trading pilot policy, resulting in differences in carbon emission reduction effects between pilot provinces. (2) For the seller of carbon emission rights, carbon emission reduction is achieved through three effects of "market return-inducing", "technical innovation incentive" and "government support"; for the buyer, carbon emission reduction is achieved through three effects of "enterprise cost pressure", "process innovation motivation" and "market guiding". (4) The results of traditional PSM-DID further prove that the carbon trading pilot can significantly reduce CO_2 emissions.

Keywords : Carbon trading pilot; Carbon emission reduction; Different in different method

1 INTRODUCTION

At present, global warming has become a worldwide environmental problem that threatens the sustainable development of mankind and has been highly valued by countries all over the world. In 2013, the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) pointed out that global surface temperature might increase by 0.3 °C to 1.7 °C in the lowest emissions scenario during the 21st century and 2.6 °C to 4.8 °C in the highest emissions scenario[1]. President Xi Jinping promised that China's CO_2 emissions will reach a minimum level in 2030. The CO_2 emissions per unit of GDP would fall by 60-65% compared with 2005 and the proportion of non-fossil energy would increase to almost 20%, which would be China's contributions to dealing with the global warming. At present, the tools used to solve the problem of CO_2 emissions mainly include "economic policy means", "administrative command means", "legal regulation means" and "market trading means". Welfare economist Pigou（1920）believed that externalities could be solved by expropriating taxes, charging sewage and transferring the pollutant discharge permits. Although these methods can internalize some external effects, they cannot completely solve the problem of public tragedy. Dales（1968）believed that Pollution Rights Trading was based on the premise that the total amount of pollutants did not exceed the allowable amount of pollutant discharge, and inter-provincial transactions were used to trade emissions to achieve emission reductions [1]. Therefore, Carbon Emissions Trading (CET) has become a market mechanism and key tool for coping with global warming [2]. Carbon trading rights are the act of trading carbon emissions as a special commodity on the market. This act of trading is aimed at achieving the goal of carbon emission reduction through the role of market mechanism. Carbon emission trading has become one of the most important ways to reduce CO_2 emissions. In 2011, the National Development and Reform Commission issued the "Notice on Conducting Pilot Work on Carbon Emissions Trading" to approve the pilot projects of carbon emission trading rights in seven provinces and cities including Shanghai, Beijing, Guangdong, Shenzhen, Tianjin, Hubei and Chongqing, and officially launched the carbon trading pilot in 2013. The questions we face are: What is the effect of carbon emission reduction in the carbon emissions trading pilot since the implementation of this policy? What is the carbon reduction mechanism for carbon emissions trading? The answers to those questions have important theoretical and practical implications for addressing global warming and then completing China's carbon reduction targets.

At present, the researches on the evaluation of carbon trading pilot policies are mainly divided into the following three methods: firstly, using the DEA model and the CGE model to study the policy effects of carbon trading pilots. Wang et al. (2014) took seven carbon emission rights pilots as research objects and constructed a DEA model to evaluate the management efficiency of carbon trading [3]. The management efficiency of carbon emission mechanisms in Beijing, Guangdong, Shenzhen and Chongqing were effective in the pilot. The carbon trading systems in Shanghai and Tianjin were in an increasing scale, while Hubei was in a phase of decreasing scale. Cheng et al. (2015) constructed the Computable General Equilibrium (CGE) to assess the impact of carbon emissions trading policies on air pollution in Guangdong Province [4]. They found that the carbon trading policy's benefits in reducing SO_2 and NO_x emissions were 12.4% and 11.7%, respectively. Tang et al. (2015) studied the effects of different carbon trading systems based on the Multi-Agent Simulation Model [5]. The simulation results showed that the carbon trading system could effectively

[1] "IPCC, Climate Change 2013: The Physical Science Basis – Summary for Policymakers (AR5 WG1)". p.17. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

reduce carbon emissions. Wang et al. (2015) used the Dynamic CGE Model to analyze the economic impact of carbon emissions trading policies in energy-intensive industries in Guangdong Province and carbon trading policies could significantly reduce the cost of the economy [6]. The use of CGE model and DEA model are more common in demonstrating the feasibility of carbon reduction mechanisms. Such researches focus on the prediction of carbon trading policies. Because the carbon trading system is a complex system and is also be affected by many unobservable factors. Therefore, the conclusions of the research based on the predictive evaluation method do not have high credibility.

Secondly, the single difference method is used to illustrate the implementation effect of the carbon trading pilot by comparing the changes in CO_2 emissions before and after the implementation of the carbon trading pilot. Xiao and Yin (2017) conducted a comparative analysis of the implementation effects of the seven carbon trading pilots in terms of the total quotas for the first year, the coverage industry, the number of first enterprises, the ways of distribution of quotas and the proportion of compliance [7]. The results showed that Shanghai carbon trading pilot had achieved obvious effect. Deng (2016) compared the carbon emissions of the first batch of low-carbon pilot cities around 2010 [8]. The study found that the total carbon emissions and per capita carbon emissions growth rate of low-carbon cities were significantly lower than those before the pilot. The emission intensity also showed a continuous downward trend. The single difference method could be used to directly compare the carbon emissions before and after the implementation of the carbon trading pilot. However, if only the carbon emissions of the carbon trading pilot before and after 2013 are compared (before and after implementation), the carbons caused by other factors (technical progress, production process innovation) that may exist during the carbon trading pilot implementation cannot be realized. The change in emissions is effectively divorced from the policy effects of the carbon trading pilot. If the carbon emissions of different provinces are compared only after the implementation of carbon trading pilot (experimental group and control group), it is easy to misinterpret the systematic differences of the unobservable characteristics that may exist in different provinces before the implementation of carbon trading as the impact of carbon trading pilot policies.

Thirdly, in order to make up for the error caused by the single difference method, the academic community turns the research point to the evaluation method. At present, the authors often use the double difference method to evaluate the carbon trading pilot policy. Due to the different assumptions applied, the double difference method can be divided into the traditional double difference method and the propensity score matching double difference method (PSM-DID). Wang et al. (2018) used the double difference method to evaluate the effectiveness of China's seven carbon trading pilots in reducing emissions [9]. The study found that five pilots in Beijing, Tianjin, Shenzhen, Guangdong and Hubei had emission reduction effectiveness, but the emission reduction effects of Chongqing and Shanghai were weakened. The traditional DID method needs to meet the assumption that the carbon emissions of the experimental group and the control group have a common trend. In fact, due to the large differences in inter-regional economic development level, emission reduction technology level and energy utilization rate, there are not only significant differences in inter-provincial carbon emissions across regions [10], but also significant differences in the convergence rate of carbon emissions [11-12]. The traditional DID method cannot completely strip off the emission reduction effects of policy effects and other influencing factors. The policy evaluation effect of the DID method had been questioned [13-14]. Heckman (1997) was the first one to put this issue on the agenda [15]. He developed the traditional DID method into PSM-DID. Therefore, the academia began to use PSM-DID to study the carbon emission reduction effect of the carbon trading pilot. Zhang and Peng (2017) used PSM-DID to study the carbon emission reduction effect of the carbon trading pilot [16]. The study found that the carbon emission reduction effect coefficient of the carbon trading pilot was -1.783 and passed the 5% significance level test. Those explained that China's carbon trading pilot policy had a significant effect on reducing CO_2 emissions. Fan et al. (2017) used the nuclear matching DID method to study the carbon emission reduction effect of the carbon trading pilot [17]. The carbon emission trading mechanism reduced the total carbon emissions in the carbon trading pilot area to a certain extent. Li and Zhang (2017) also used DID and PSM-DID to study the impact of carbon trading policies on industrial carbon emissions and industrial carbon intensity [18]. The study found that carbon trading policies had improved energy technology efficiency and energy allocation efficiency.

2 THEORETICAL MODEL

Fig.1 shows the cost-benefit analysis of carbon emissions trading, with the vertical axis representing the marginal cost of carbon emissions for both companies A and B, and the horizontal axis representing carbon emissions. Since company A is a technology-intensive enterprise, the marginal cost of carbon emission reduction is MAC_A. B is a resource-intensive enterprise, the marginal cost of carbon emissions is MAC_B. In Fig.2, Q_1Q_2 represents the government's carbon emission reduction target. Due to the existence of information asymmetry, the government does not know the carbon emission reduction costs of enterprises A and B, thus the government distributes the carbon emission rights Q_1Q_2 equally to enterprises A and B. When the volume of carbon emission floating within Q_0 to Q_E, the margin carbon emission reduction cost of enterprise A's MAC_A is higher than enterprise B's MAC_B (the ME segment is higher than the NE segment in Fig.2). If the marginal cost of carbon emissions is between P_N and P_M, enterprise A and B will have incentives to conduct carbon emission trading. The cost saved by enterprise A through carbon emission trading is $\triangle Q_2EQ_E$ and the cost saved by enterprise B is $\triangle Q_1EQ_E$. By comparing the cost of two enterprises before and after carbon trading, we find that after carbon emission trading, the total amount cost of carbon emission reduction is reduced by $\triangle$MNE and carbon emissions rights trading can reduce the cost of carbon reduction. Therefore, the carbon emission trading rights policy not only helps to improve the emission reduction efficiency of low-carbon emission enterprises, but also promotes the carbon emission reduction efficiency of high-carbon emission enterprises. Ultimately, CO_2 emissions are reduced.

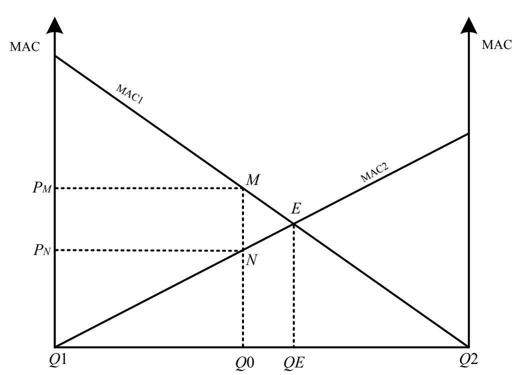

Fig.1. Cost-benefit analysis of carbon emissions trading

3 DIFFERENCE-IN-DIFFERENCES MODEL

In the first part of the paper, the carbon emission reduction effect of the carbon trading pilot is evaluated by the different in different method. Also the effectiveness of the different in different method is tested for the effectiveness of the placebo. In order to ensure the robustness of the research conclusions, this part will use the PSM-DID to test the carbon emission reduction effect of the carbon trading pilot further.

The carbon trading pilot policy is implemented to reduce CO_2 emissions through carbon emissions trading based on total carbon emissions control. This paper uses the DID method to test the robustness of the carbon emission reduction effect of the carbon trading pilot. The carbon trading pilots mainly include seven provinces and cites: Beijing, Tianjin, Shanghai, Guangdong, Hubei, Chongqing and Shenzhen. In this paper, six provinces and cities are selected as experimental groups and the others are control groups[2]. This paper regards the implementation of the carbon trading pilot policy in 2013 as the time demarcation point. The period from 1997 to 2016 will be divided into two groups, 1997-2013 before the policy implementation and 2013-2016 after the policy implementation. In this way, the 30 provinces in China from 1997 to 2016 are divided into four groups, the experimental group that implements the carbon trading pilot, the control group that does not implement the carbon trading pilot, the experimental group after the implementation of the carbon trading pilot policy and the control group before the implementation of the carbon trading pilot policy. Based on this, this paper sets the dummy variables of T and D. T represents the time dummy variable, the carbon trading pilot policy is 0 before the implementation, after the implementation is 1. D represents the inter-group dummy variable, the carbon trading pilot is 1, non-carbon trading pilot is 0. Then this paper builds a specific measurement model as shown below:

$$
\begin{aligned}
LnCO_{2it} &= \beta_0 + \beta_1 dt_{time} + \beta_2 du_{group} + \beta_3 (dt_{time} \times du_{group}) + \beta_4 Lnrgdp_{it} + \beta_5 Lnindust_{it} \\
&+ \beta_5 Lnserv_{it} + \beta_6 Lntech_{it} + \beta_7 Lnstru_{it} + \beta_8 Lnpopu_{it} + \varepsilon_{it} \qquad (1)
\end{aligned}
$$

In the above model, i represents the province; t represents the year; *CO_2* is the explanatory variable, indicating the CO_2 emission of the province; *rgdp* represents the economic development level; *indust* represents the development level of the secondary industry; *serv* represents the development level of the tertiary industry; *tech* represents technology level; *stru* represents the advanced industrial structure; *popu* represents the population density. *dt* is a time dummy variable. It is 0 before the implementation of the carbon trading pilot in 2013 and after the implementation of the carbon trading pilot policy is 1. *du* is a dummy variable between groups. The provinces implementing carbon trading pilot projects (Beijing, Tianjin, Shanghai, Guangdong, Hubei and Chongqing) are 1 and the other provinces are 0. *dt × du* is a double difference term and the regression coefficient β_3 is the carbon emission reduction effect of the carbon trading pilot.

[2] In 2011, the National Development and Reform Commission officially approved seven provinces and municipalities, such as Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen, as pilot carbon emissions trading markets. From 2013 to 2014, seven provinces and municipalities' carbon trading markets opened one after another. In this paper, in order to ensure the consistency of sample spatial scale and since Shenzhen belongs to Guangdong Province, this paper will delete Shenzhen.

4 EMPIRICAL RESULT ANALYSIS

As one of the important measures of the carbon emission reduction market, the carbon trading pilot is an important measure to achieve China's carbon emission reduction targets and realize China's commitment to the world. The carbon emission reduction effect of the carbon trading pilot is an important part of improving the efficiency of carbon trading pilot implementation. Therefore, this paper first uses the traditional DID method to evaluate the carbon emission reduction effect of the carbon trading pilot.

Table1. Results of the DID test for the pilot implementation of carbon emissions trading

Variables	CO_2	$lnCO_2$	CO_2	$lnCO_2$
du	-0.612	-0.071	0.0739	-0.081
	(0.795)	(0.371)	(0.018)	(0.332)
dt	1.812***	0.714***	-0.132	-0.0479
	(0.135)	(0.049)	(0.132)	(0.030)
du×dt	-1.127***	-0.369***	-1.262***	-0.225***
	(0.310)	(0.111)	(0.231)	(0.053)
cons	2.334***	9.669***	-0.815	8.553
	(0.355)	(0.166)	(0.625)	(0.189)
Control variables	No	No	Yes	Yes
Adj-R^2	0.12	0.086	0.256	0.314

Note: *, ** and * indicate the significance level test of 1%, 5% and 10%, respectively. T - statistics are in the parentheses.**

Table 1 shows the results of the DID test for the pilot implementation of carbon emissions trading. Columns 2 and 3 are regression results obtained without control of other explanatory variables, while columns 4 and 5 are regression results for controlling other explanatory variables. According to Table 2, we found that the carbon trading rights pilot has a significant effect on reducing CO_2 emissions, whether or not it is added to the control variables. The estimated coefficients of the double difference term (*D×T*) are both negative and both pass the significance test, which indicates a significant drop in CO_2 emissions after the implementation of the carbon trading pilot policy. The reason may be that under the implementation of the carbon trading pilot policy, enterprises with surplus carbon credits can trade carbon emissions in the pilot carbon trading market and transfer CO_2 emission rights to enterprises with insufficient carbon credits. For those enterprises with excess carbon credits, they can obtain the benefits of transfer of carbon emission rights from emission reductions. These benefits can encourage enterprises to improve production processes and technologies to achieve carbon emission reduction and corporate profitability. For companies with insufficient carbon credits, they internalize carbon emissions, which are inherently external. This is because the increased cost of purchasing carbon credits is directly factored into the cost function of the firm, so companies will consider cost changes. The impact of corporate output and profits has forced high-carbon companies to innovate equipment, promote technological advances, reduce costs and increase corporate profits. The adjustment of R^2 in Table 2 with the addition of control variables is significantly better than the adjustment of R^2 without the addition of control variables, indicating that the influencing factors in the control variables are important variables affecting CO_2 emissions.

The implementation effect of the carbon trading pilot policy is often influenced by the follow-up measures of each province and the local government's experience in implementing carbon trading policies (Chen and Lee, 2005). The implementation of the carbon trading policy cannot immediately have an immediate effect when the policy is proposed. After the implementation of the carbon emission trading rights pilot policy, the governments of the pilot provinces and cities successively launched supporting measures for carbon trading policies. With the continuous improvement of the carbon trading market environment and infrastructure, the effects of the carbon trading pilot policy may be revealed. In order to examine the dynamic effects of carbon emission reduction in the carbon trading pilot policy, this paper returns the cross-term ($du \times dt$) of 2015-2016 into the model.

Table 2. Long-term effects of carbon trading pilot

Variables	CO_2	$lnCO_2$	CO_2	$lnCO_2$
$du \times dt_{2015}$	-0.322**	-1.011**	-1.323***	-0.237***
	(0.160)	(0.437)	(0.284)	(0.065)
$du \times dt_{2016}$	-0.311	-0.969	-1.350***	-0.273***
	(0.228)	(0.621)	(0.384)	(0.087)
Control variables	No	No	Yes	Yes

Note: *, ** and * indicate the significance level test of 1%, 5% and 10%, respectively. T - statistics are in the parentheses.**

Table 2 shows the test results of the long-term effects of the carbon trading pilot. It can be found that the carbon trading pilot policy has a significant carbon emission reduction effect. The columns 2 and 3 in Table 5 are the carbon emission reduction effects of the carbon trading pilots when they are not included in the control variables. The regression coefficient is negative, which indicates that the carbon trading pilot policy has a certain effect on reducing dioxide emissions. In the absence of other explanatory variables, the regression results of the carbon trading pilot policy implemented in 2016 are negative, but they have not passed the significant test. This shows that the realization of carbon emission reduction can be achieved not only by implementing carbon trading policy pilot, but also by formulating comprehensive and effective measures to reduce carbon emissions after fully considering the economic structure, industrial structure, technological level and other factors. Therefore, regression results that control other explanatory variables are reported in columns 4 and 5 of Table 3. After considering the control variables, whether the regression coefficient of 2015 or 2016 after the policy implementation is significantly negative and passed the significance level test, this shows that the carbon trading pilot has played a role in carbon emission reduction by comparing the regression coefficients again. By comparing the magnitudes of the regression coefficients, we find that when the total amount of carbon dioxide (CO_2) is used as the explanatory variable, the regression coefficient of the 2015 double difference term is -1.323, which passes the 1% significance level test. In 2016, the regression coefficient of the double difference item is -1.350, which also passes the significance level test of 1%. This shows that the carbon emission reduction effect of the policy has gradually increased after the opening of the carbon trading market[3].

Table 3. Balance test of tendency score matching

Weighted variables	Control group mean	Processing group mean	Difference	|t|	P（|T|>|t|）
rgdp	17000	21000	3859.311	1.89	0.0599*
indust	0.520	0.546	0.026	1.48	0.1395
serv	0.449	0.474	0.025	1.75	0.0825*
stru	0.877	0.884	0.007	0.29	0.7698
popu	0.039	0.040	0.000	0.13	0.8949
tech	0.006	0.006	0.000	0.30	0.7666

Traditional DID method requires that the variables of the carbon trading pilot provinces and non-carbon trading pilot provinces must meet the common trend assumptions. However, according to the neoclassical economic convergence theory, whether there is convergence in China's inter-provincial carbon dioxide, this issue has not yet reached consensus in the academic world [11]. Therefore, it is questionable to use the traditional DID method to evaluate the carbon emission reduction effect of the carbon trading pilot.

This paper uses PSM-DID method to further explore the carbon emission reduction effect of the carbon trading pilot. PSM-DID method can solve the problem that the estimation result of the traditional DID method does not satisfy the common trend. The scientific nature of the PSM-DID test results depend entirely on whether the observed values of the samples satisfy the assumption of "conditional independence"[19]. In other words, the matching experimental group provinces and the control group provinces in the carbon trading pilot policy are no significant differences before implementation. If there is a significant difference between the experimental group and the control group after the implementation of the carbon trading pilot policy, this will result in a matching error caused by the inappropriate matching method. Therefore, it is necessary to perform a balance test on variables before performing PSM-DID regression. Table 4 shows the test results of the propensity score matching balance test. The test results in Table 4 show that the average values of covariate per capita GDP (*rgdp*), the second industry share (*indust*), the tertiary industry share (*serv*), advanced industrial structure (*stru*), energy efficiency(*energy*), population density (*popu*) and technical turnover (*tech*) are not significant different between the experimental group and the control group, indicating that the PSM-DID method can be used to evaluate the carbon emission reduction effect of carbon trading pilot projects.
This paper adopts Kernel Matching to determine the weight and uses the diff command of STATA software to evaluate the carbon emission reduction effect of the carbon trading pilot. Table 7 shows

[3] When the logarithm of carbon dioxide ($lnCO_2$) is taken as the explanatory variable, the regression coefficient of the double difference term in 2015 is -0.237 and passes the1% significance level test. The regression coefficient of the double difference term in 2016 is -0.273. From the magnitude of the coefficient, the carbon emission reduction effect of carbon trading pilot is more and more obvious.

the evaluation results of the carbon emission reduction effect PSM-DID. According to Table 5, we can find that when the total amount of CO_2 emissions is regarded as the explanatory variable, the regression result of the policy variable is -1.884 and passes the 1% significance level test, which means that when the carbon trading pilot policy is implemented, the CO_2 emissions are gradually decreasing. When the logarithm of CO_2 emissions is regarded as the explanatory variable, the regression coefficient of the policy variable is -0.521 and passes the 1% significance test. This shows that the carbon trading pilot has played a significant role in carbon emission reduction.

Table 4. Implementation effect of carbon trading pilot: PSM-DID test

	Before Control	Before Treated	Diff(T-C)	After Control	After Treated	Diff(T-C)	Diff-in-Diff
CO_2	2.482	2.435	-0.047	5.241	3.310	-1.931	-1.884
Standard error	—	—	0.227	—	—	0.454	0.508
T -statistic	—	—	-0.21	—	—	4.25	3.71
P>|t|	—	—	0.835	—	—	0.000**	0.000***
$lnCO_2$	9.944	9.982	0.037	10.799	10.315	-0.484	-0.521
Standard error	—	—	0.082	—	—	0.162	0.181
T -statistic	—	—	0.46	—	—	2.99	2.88
P>|t|	—	—	0.649	—	—	0.003***	0.004***

Note: *, ** and * indicate the significance level test of 1%, 5% and 10%, respectively.**

5 RESEARCH CONCLUSIONS AND POLICY RECOMMENDATIONS

Carbon emission trading is an important environmental policy that uses market mechanisms to reduce greenhouse gas emissions. It has received extensive attention from the academic community. The implementation of the carbon emission trading pilot policy has important practical significance for reducing greenhouse gas emissions and helping achieve China's carbon emission reduction goals, thus achieving the green development of Chinese economy. Based on the Chinese provincial panel data from 1997 to 2016, this paper uses the different in different method to evaluate the carbon emission reduction effect of the carbon emission trading pilot and analyzes the internal mechanism of carbon emission reduction effect of the carbon emission reduction pilot.

5.1 Research conclusions

The Empirical result analysis of PSM-DID shows that, whether the total amount of CO_2 emissions is used as the explanatory variable or the logarithm of total CO_2 emissions is used as the explanatory variable, the estimated coefficient of policy effect $du \times dt$ are negative values, indicating that the carbon trading pilot has significant carbon emission reduction effects. Lastly, the carbon emission reduction mechanism of the carbon trading pilot shows that for enterprises with excess carbon emissions, the surplus carbon emissions can be sold in the carbon trading market. Due to the regulation of market operation mechanism, enterprises under the premise of maximizing profit can achieve carbon emission reductions through mechanisms such as the inductive effects of carbon market benefits, technological innovation incentives and government policy support effects. For enterprises with insufficient carbon emissions, in order to ensure the normal operation of production and the expansion of production scale, it is necessary to purchase carbon emission rights in the carbon trading market. The CO_2 emission rights are priced as a commodity, it will internalize pollutants with externalities. When enterprises make decisions to maximize profits, the cost of purchasing carbon emission rights should be include into the cost-benefit analysis of enterprises. Therefore, through the role of market mechanisms, the cost pressure effect of enterprises, process innovation effect and market-oriented incentive effect to achieve carbon emission reduction.

5.2 Policy recommendations

The conclusions of this paper have great significance for promoting the effective implementation of carbon emission trading policies and giving full play to the carbon emission reduction effect of carbon trading pilots. This could promote to reduce carbon dioxide emissions and then achieving China's carbon reduction targets. According to the research conclusions of this paper, the following four aspects of policy recommendations are proposed: Firstly, the development of the carbon trading pilot policy should always adhere to the development strategy of combining "market decision" and "government regulation". On the one hand, we must continue to adhere to the market in a decisive role in the allocation of carbon emission rights, and use market means such as "supply and demand mechanism", "competition mechanism" and "price mechanism" to promote the effective operation of carbon emission trading market. Continuously adjust the benefit mechanism of carbon emission rights surplus and insufficient enterprises through the market regulation, internalize the carbon emissions into the company's cost-benefit analysis, it will become an important decision-making variable to maximize corporate profits and promote carbon emission reduction. On the other hand, we should give full play to the government's regulation and support role. The government should formulate laws, regulations and policies that are suitable for the healthy and effective operation of the market to make up for the market failures caused by the monopoly, information asymmetry and externalities brought about by the market's own limitations. Those could improve the market environment constantly. Secondly, to promote the carbon emission reduction effect of the carbon trading pilot plays a role, the key is to promote the technology R&D and technological innovation of enterprise. The government, enterprises and society should give special attention to the fact that technology R&D and technological innovation are the inherent mechanism of the carbon trading pilot policy to achieve carbon emission reduction effects. We should continuously increase the investment in R&D of all enterprises, encourage enterprises to carry out technological innovations, continuously update production processes and promote enterprises to achieve green development. Thirdly, it is necessary to change the mode of economic development, optimize and upgrade the industrial structure and energy structure, and adhere to the guiding role of the "two mountains theory" on carbon emission reduction. Transforming the previous development model of "high input, high emission, high output". Promoting the "new energy technology revolution" to push the use and research and development of clean energy and clean technologies, reducing energy consumption and realizing the green development of the entire national economy. Lastly, the carbon emission reduction effect of the carbon trading pilot policy is heterogeneous. Because of significant differences in economic development, industrial structure, energy structure and other factors in different pilots, the implementation effect of carbon trading policies are significantly different. Therefore, each pilot should not adopt the "one size fits all" approach when formulating policies, but should recognize its own speciality and use "adapting to local conditions" for the construction of the carbon trading pilot, so as to achieve the carbon emission reduction targets and promote economic green development.

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