Journal of Risk Analysis and Crisis Response, 2023, 13(4), 339-361
https://jracr.com/
ISSN Print: 2210-8491
ISSN Online: 2210-8505

Article

Carbon Trading Market and Green Innovation of Enterprises—Based on the Triple Difference Model

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Received: September 19, 2023; Received in revised form: November 4, 2023; Accepted: November 12, 2023; Available online: December 31, 2023

Abstract: This article takes Chinese manufacturing listed companies from 2000 to 2020 as the research object, based on enterprise green patent data, and adopts a double difference method to study the effect of carbon trading pilot policies, a quasi-natural experiment, on enterprise innovation. Research has found that: (1) The carbon trading pilot policy has significantly promoted green innovation in enterprises and increased their technological innovation efforts. This conclusion remains valid after a series of robustness tests and endogeneity treatments, including placebo testing, excluding the implementation of innovative city pilot policies, and interference from economic crises. (2) Mechanism testing has found that carbon trading pilot policies can significantly promote green innovation in enterprises by strengthening the effectiveness of environmental regulations and improving the cash flow situation of enterprises. (3) Heterogeneity analysis shows that the concentration of technology and the degree of equity dispersion in enterprises can affect the effectiveness of innovation. In response to the above conclusions, this article proposes suggestions for improving the carbon trading system, exploring multidimensional paths for carbon trading pilot projects to promote enterprise innovation, and improving policy adaptability, flexibility, and execution intensity. The research in this article provides policy inspiration for further improving the carbon trading market, enhancing the effectiveness of the carbon trading system, and fully leveraging the carbon market to promote green innovation for enterprises and achieve low-carbon development. It has reference significance for the construction and improvement of the national carbon market and promotes the improvement of national energy conservation and emission reduction policy planning.

Keywords: Carbon Emissions Trading; Green Innovation; Environmental Regulations; Enterprises

1. Introduction

Achieving "carbon peaking" and "carbon neutrality" is the key to addressing global warming and is related to sustainable human development, making it a focus of national environmental governance. Over the years, China has gradually introduced energy-saving and emission reduction policies, mainly focusing on the regulation of industrial "three wastes". The targeted restrictions on carbon dioxide emissions are insufficient, and the policy effect is not significant (Yang J, 2023) [1]. In September 2020, China explicitly proposed the goals of achieving "carbon peak" by 2030 and "carbon neutrality" by 2060. To achieve the win-win goal of economic development and environmental quality improvement, the National Development and Reform Commission of China issued the "Notice on Pilot Carbon Emission Trading" policy in 2011, requiring all provinces and cities to start exploring the carbon trading market mechanism. After granting certain carbon emission rights to enterprises, they can use carbon emission rights as the target for circulation among enterprises. China started carbon trading pilot projects in 2013 and has implemented carbon trading pilot policies in 8 provinces and cities, including Shenzhen, Beijing, Tianjin, Shanghai, Guangdong, Hubei, Chongqing, and Fujian. According to Coase's theorem, clarifying property rights can internalize the negative externalities of carbon emissions behavior, while also enabling positive externalities of green innovation in enterprises, achieving consistency between corporate effects and social benefits, and effectively promoting the driving force of green innovation in enterprises (Zhang W et al., 2018 [2]; Cheng C et al., 2019 [3]). Moreover, as the implementation of carbon trading pilot policies increases, the activity of carbon trading increases, which can significantly strengthen the green innovation behavior of enterprises (Zhou C B and Qin Y, 2020) [4]. As a policy directly transmitted to enterprises' emission reduction activities, the carbon trading pilot can, according to the theory of the "Porter Hypothesis", stimulate enterprise innovation in the long term by strengthening environmental regulation measures. Can it mobilize enterprise innovation motivation and promote enterprise innovation effectiveness in practice? This issue is worth exploring.

The carbon trading pilot policy, as an environmental regulation tool, can effectively achieve macroeconomic regulation of carbon dioxide emissions (Borsatto and Bazani, 2021) [5]. Based on the practical experience of carbon trading pilot projects in other countries (Rubashkina et al., 2015) [6]. When the marginal cost of emission reduction is less than the marginal benefit, adopting emission reduction strategies to improve economic benefits can achieve optimal utility for enterprises through green innovation. Under differentiated management, it is ensured that all types of enterprises can refine management requirements, thereby improving the policy implementation effect of enterprise innovation (Cheng B et al., 2015) [7]. Compared with carbon tax, carbon trading has a greater cost pressure on enterprises, and the policy and environmental regulations are strong, which can effectively control energy conservation and emission reduction issues. Therefore, the incentive effect for green innovation is more obvious (Feng Y et al., 2021) [8].

In recent years, many scholars have explored the role of carbon trading pilot policies in green technology innovation.

Firstly, the carbon trading pilot policy can improve the green financial market, enrich financial tools, optimize the green innovation management structure of enterprises, and provide basic conditions for the carbon trading market (Zhang X and Song Y, Zhang M, 2021) [9]. Secondly, carbon trading pilot policies can control corporate carbon emissions and encourage green innovation. According to the theory of "following the cost hypothesis", the carbon trading pilot policy leads to an increase in carbon reduction technology investment for enterprises, leading to an increase in production costs and financial tension (Zhu J et al., 2019) [10]. However, according to the "Porter Hypothesis", carbon trading pilot policies can guide green innovation in enterprises from a dynamic perspective, ultimately enhancing product competitiveness, and achieving dual dividends of increased corporate performance and sustainable socio-economic development (Bu M et al., 2020) [11].

Secondly, existing literature has scholars establishing general equilibrium models to study and analyze the significant reduction of carbon emissions through carbon trading pilot policies (Meuleman M, 2012) [12]. The carbon trading pilot policy provides a dynamic reward and punishment mechanism (Borghesi S, 2014) [13] to fill the gap in green financial instruments and markets, far surpassing the administrative guidance on carbon emission restriction enforcement (Zhao Y et al., 2023) [14], fully leveraging the function of market resource allocation. Various traders openly and transparently trade, and carbon trading prices are determined by market supply and demand, which can balance fairness and efficiency (Jiang X Y, 2013) [15], Realize the improvement of green productivity, mobilize the enthusiasm of enterprises for technological improvement, and stimulate the endogenous driving force of enterprises' independent green innovation. From the perspective of micro enterprises, carbon trading pilot policies can affect corporate efficiency and internalize the effectiveness of green innovation in enterprises. Some high innovation capability enterprises can closely follow the pace of energy conservation and emission reduction, thereby obtaining benefits and forming a positive feedback mechanism. At the same time, for high carbon emission enterprises, production costs will increase, and the economic benefits of enterprises will be negatively impacted, the two have jointly constructed a comprehensive reward and punishment mechanism, and ultimately, the carbon trading pilot policy promotes green innovation in enterprises, enhances overall enterprise value, and enhances product competitiveness of enterprises (Wang G et al., 2017) [16, 17].

The marginal contribution of this article mainly lies in the following two aspects:

First, from the perspective of research, in the mechanism analysis of this paper, the influence of internal financial indicators of enterprises on innovation is analyzed by using the cash flow status of enterprises, and it is considered that the pilot policy of carbon trading can improve the cash flow of some enterprises, and some enterprises with strong innovation ability can obtain additional income, thus promoting enterprise innovation; At the same time, enterprises with insufficient innovation ability are forced to strengthen innovation, and how the carbon trading pilot policy affects enterprise innovation is studied from within enterprises. Secondly, in terms of empirical identification, unlike using a general equilibrium model and comprehensive indicators to measure green innovation in enterprises, this article uses the quasi-natural experiment of carbon trading pilot policies to examine the impact of carbon trading pilot policies on green innovation in enterprises through the construction of a dual difference model, which has strong externalities. Moreover, this article measures green innovation in enterprises based on the number of patents obtained, It can avoid the endogeneity of constructing indicators to select variables, and more accurately identify substantive innovation of enterprises, which is better than using R&D investment as green innovation of enterprises. Then, this article constructs a triple difference model to test the mechanism of carbon trading pilot policies on green innovation of enterprises from two aspects: environmental regulation and enterprise cash flow, which has strong feasibility.

The purpose of this paper is to study whether the carbon trading pilot policy can promote enterprise innovation and improve the theoretical content in the process of carbon emission realization. The first chapter of this paper is introduction and literature review, the second chapter is theoretical analysis, the third chapter is empirical design, the fourth chapter is empirical results, and the fifth chapter is conclusion and enlightenment.

2. Theoretical Analysis and Research Hypotheses

2.1. The Impact of Carbon Trading Market on Green Innovation of Enterprises

Carbon trading, as a brand-new policy, has been deeply implemented worldwide, and China has also implemented it in regions such as Shenzhen and Shanghai. Firstly, the government sets quotas for some carbon emission rights based on established standards, while the remaining emissions rights are publicly traded and traded in the market. High polluting enterprises can purchase emission rights in the trading market. Based on this, the overall carbon emissions of enterprises are constant, and carbon trading pilot policies can limit the total emissions and play a role in resource allocation in the market.

The carbon trading pilot policy, as a measure of government environmental regulation, according to the "Porter Hypothesis", increases costs for enterprises in the short term and has a negative impact on their net profits. However, in the dynamic model, the carbon trading pilot policy strictly controls pollutant emissions and can limit enterprises' high-energy consumption activities. The carbon trading pilot policy forces enterprises to use low energy green high-tech, the application of new technologies improves the efficiency of resource utilization, reduces unnecessary losses, and thereby enhances the green total factor productivity of enterprises, incentivizes technological innovation. At the same time, green innovation promotes the continuous improvement of enterprise competitiveness. In the long run, environmental regulations play a positive role in the profitability and sustainable development of enterprises, ultimately promoting industry progress and upgrading.

Before the implementation of the carbon emissions trading pilot policy, the carbon emissions of enterprises were not limited. Enterprises could produce according to their own situation, and some pollution activities had strong negative externalities. The cost of enterprises was lower than the cost of the entire society, so the production volume was greater than the optimal, leading to excessive pollution emissions. After the implementation of the carbon trading pilot policy, the total amount of pollution emissions of enterprises can be limited. When the carbon emissions of enterprises are large, they can produce normally through two methods: firstly, enterprises can purchase carbon rights in the carbon market according to their own conditions, and the total amount of carbon emissions of enterprises in the production process remains unchanged. Purchasing carbon rights with excess emission quotas ensures the continuous high carbon emission behavior of enterprises, and secondly, conducting source innovation, adopting low-carbon production technologies and processes to improve the utilization efficiency of production materials, thereby reducing the carbon emissions of enterprises. When the production technology of the enterprise is outdated, the carbon emissions are large, and exceed the allocated quota, the enterprise needs to publicly purchase emission quotas in the trading market. The enterprise needs to innovate technology, adopt new low-carbon production processes and technologies, especially for source control, reduce carbon emissions at the production end, and achieve long-term utility maximization. Based on this, this article proposes the following hypothesis:

H1: Carbon trading pilot policies promote green innovation in enterprises.

2.2. The Impact of Carbon Trading Pilot Policies on Environmental Regulation Effects

The carbon trading pilot policy controls the total carbon emissions of pilot enterprises in market operation, which is a market-oriented environmental regulation led by the market. On the one hand, according to the signal expectation theory, carbon trading pilot policies can provide signals to businesses and governments to govern the environment, indicating the importance that the country attaches to strengthening environmental regulations. Government policies to govern the environment provide information for companies to rectify high-energy consuming industries. Even if the government has not yet implemented restrictions and punishment measures on their carbon emissions behavior, companies will adjust their own behavior according to the government's policy direction, The carbon emission pilot policy clearly demonstrates the government's determination to achieve the "dual carbon" goal, and is an environmental regulation tool and one of the government's measures to limit pollution emissions. To maintain a good business situation, enterprises need to expand their research and development investment and invest more funds in low-carbon and environmentally friendly products and projects. On the other hand, according to the "Coase Theorem", carbon emission trading rights can convert external costs of enterprises into internal costs, further clarifying property rights. Prior to the pilot implementation, there were no restrictions on the carbon emissions of enterprises. The carbon emission cost of enterprises was extremely low, but the total social cost was high, resulting in carbon emissions of enterprises far exceeding the emissions at the time of maximum total benefits. After implementation, the negative externalities of carbon emissions of enterprises were internalized, Strengthening the government's environmental regulatory capacity can effectively regulate corporate behavior. The "Porter Hypothesis" believes that emphasizing green innovation further optimizes the total factor productivity of enterprises, and gradually enhances the competitiveness of products in the market, achieving environmental improvement, optimal resource allocation, and economic benefits. Therefore, environmental regulations promote enterprise innovation in dynamic effects. In the current market economy system, the market dominates, but the guiding role of the government cannot be ignored. On the one hand, environmental regulations can play a restraining role in enterprise pollution activities, limit the entry threshold and quantity of high-energy consuming industries, prevent overcapacity in high-energy consuming industries such as steel, coal, and oil, suppress social energy consumption, optimize energy consumption structure, promote green transformation of enterprises, accelerate the process of production technology updating and iteration. On the other hand, environmental regulations force enterprises to increase their emphasis on innovation, when enterprises increase their R&D investment and technological innovation, adopt high-tech and processes, and the government has strong environmental regulations, their ability to restrict traditional industries with high pollution is relatively high. They should guide the orderly elimination of sunset industries and technologies, support high-tech industries, and play the role of high-tech clusters.

H2: Carbon trading pilot policies can strengthen the role of environmental regulations and enhance the promotion effect of green innovation for enterprises.

2.3. The Impact of Carbon Trading Pilot Policies on Environmental Regulation Effects

Good cash flow management is the most basic condition for a company to maintain its daily operations, ensuring its sustainable and stable development, and influencing its business policies and investment decisions. Before the implementation of the carbon trading pilot policy, the division of property rights for carbon emission rights was not clear. The motivation for enterprise emission reduction only came from internal innovation and the goal of improving product competitiveness. Therefore, the internal motivation of enterprises was very limited, and it was highly related to the financial situation, management decision-making, shareholder planning, and other aspects of the enterprise. These incentive channels were single. Although green innovation activities in enterprises can to some extent enhance the influence of products, the cash flow of enterprises is optimized as they develop, further promoting innovation behavior. However, after the implementation of the carbon emission pilot policy, the driving force for green innovation in enterprises has diversified. Under the role of cash flow management, enterprises can improve their cash flow situation, thereby promoting innovation and strengthening the role of cash flow management in enterprise innovation. For low-carbon enterprises, excess carbon rights can be sold in the carbon trading market to generate additional income, which improves the cash flow situation of the enterprise. This means that the enterprise has more funds for research and development, abundant cash flow ensures stable investment of innovation funds, and under the positive feedback regulation mechanism, the enterprise can obtain profits, optimize cash flow, and increase profits. Individuals with low carbon emissions gain benefits from the implementation of carbon trading pilot policies. Due to a loss aversion mentality, enterprises pay more attention to technological innovation to avoid becoming high emission enterprises, maintain their advantageous position in low carbon emissions, and maintain product competitiveness; High carbon emitting enterprises, due to insufficient allocated quotas, need to purchase additional carbon rights from the carbon trading market, which can increase production costs and make them more aware of the importance of innovation. Many scholars have found that a good cash flow situation is positively correlated with enterprise innovation. To dilute the average cost of enterprises, under the carbon trading pilot policy, when the cash flow situation of high carbon emitting enterprises is optimized, the urgency of green innovation in enterprises is higher, and the importance of financial management on reducing carbon emissions is deepening. The role of cash flow management in promoting green innovation is more obvious, strengthening the incentive effect of cash flow management on enterprise innovation. Overall, adopting new processes is beneficial for enterprises to enhance competitiveness, expand market share, improve cash flow management, and motivate long-term technological innovation. Carbon emission pilot policies can strengthen the role of cash flow management in green innovation.

H3: The carbon trading pilot policy strengthens the impact of cash flow management on corporate innovation behavior and promotes green innovation in enterprises.

3. Research Design

The pilot policy of carbon trading is to set up carbon trading markets in different provinces and cities in batches, and local governments can't know in advance whether they will become pilot cities, which is a quasi-natural experiment with many shocks. Therefore, this paper refers to the list of three batches of carbon trading pilots launched by the National Development and Reform Commission from 2013 to 2016, and adopts the multi-time double difference model, taking the year when the carbon trading market of each province and city was launched as the policy occurrence time, which can better measure the impact of the carbon trading pilot policy on enterprise innovation. The specific model is as follows:

$$Inv_{it} = \beta_0 + \beta_1 Ets_{it} + \beta_2 X_{it}^{'} + \lambda_i + \delta_t + \varepsilon_{it} \quad (1)$$

In the above model, Invit stands for enterprise green innovation, representing the interaction between the carbon trading pilot list and the start time of the carbon trading market, I stands for the company, T stands for the year, represents a series of control variables and represents the residual. This paper controls the fixed effect and time effect of enterprises.

3.1. Sample Selection and Data Sources

China's carbon trading pilot policy mainly covers enterprises with high pollution and high energy consumption, so this paper selects the data of listed companies in China A-share manufacturing industry from 2000 to 2020 as the research sample. Among them, the data of enterprise status and financial indicators come from CSMAR database in Taian, and the number of environmental punishment cases comes from Peking University magic weapon. The data of green patents come from China National Intellectual Property Administration, People's Republic of China. According to the matching between the patent classification number (IPC) and the "Green Inventory of International Patent Classification" issued by the World Intellectual Property Organization in 2010, the data of green innovation of enterprises are obtained. In this paper, samples with ST, ST* and missing financial data are excluded, and finally 2903 samples and 26863 observed values are obtained.

3.2. Description of Variables

3.2.1. Explained Variables

According to the research of existing scholars, the number of green patents of enterprises can reflect the green innovation of enterprises and is widely used by scholars. In this paper, the amount of green invention patents obtained by enterprises is used as a substitute index for green innovation of enterprises. The green invention application of an enterprise belongs to the substantive innovation of the enterprise, which can really reduce the carbon emission of the enterprise and realize the long-term technological upgrading of the enterprise, while the design patent and utility model patent belong to the strategic innovation, and there is a certain deviation in measuring the green innovation of the enterprise. Therefore, the number of applications for green invention patents in this paper is more reliable and reasonable. In this paper, the number of green patent applications is added by 1 and then the logarithm is taken to get the index of enterprise innovation.

3.2.2. Core Explanatory Variables

Ets is a dummy variable of whether the enterprise starts the carbon market. Since the carbon trading pilot covers eight provinces, autonomous regions and municipalities, including Shenzhen, Beijing, Tianjin, Shanghai, Guangdong, Hubei, Chongqing and Fujian, and the pilot dates are 2013, 2014 and 2016 respectively, if the carbon trading pilot is started in the region where enterprise I is located in the t year, then in the t year and beyond, Ets will be taken as 1, otherwise it will be taken as 0.

3.2.3. Control Variables

Referring to the research of existing scholars, in order to eliminate the interference of enterprise individual level attributes on enterprise innovation causal identification, alleviate the bias caused by missing variables, and improve the accuracy of regression results, this paper introduces the following control variables: (1) Enterprise size (Lnsize) is expressed as a logarithm of the total assets of a company at the end of the year. Scholars have studied how enterprise size can affect innovation behavior. Larger companies have stronger financial strength, and green technology innovation is more active and stable for the long-term sustainability of the company's development. (2) The level of capital structure is taken as the ratio of a company's total liabilities to its total assets. It is generally believed that companies with a relatively low proportion of liabilities have less financial pressure and a good foundation for green innovation. (3) Profitability (Roa) is measured by the total asset profit margin, expressed as the ratio of net profit to total assets. The profitability of a company directly affects its competitiveness and can affect its green innovation. (4) The governance structure (Ppe) is measured by the proportion of management shareholding, taking the ratio of the total number of management shareholding to the total share capital. (5) The proportion of independent directors (Duality) is expressed as the ratio of independent directors to the number of directors. (6) Turnover is measured by the total asset turnover rate, which is the ratio of operating revenue to the average total assets. (7) The shareholding ratio of institutional investors is expressed as the ratio of the total number of shares held by institutional investors to the circulating share capital. Institutional investors will affect the company's incentive mechanism, focus on the long-term profit growth of the company, and therefore affect the green innovation of the enterprise. (8) Relative value (Q) is measured by Tobin Q, which is the ratio of market value to total assets. The Tobin Q value is positively correlated with the value created by the enterprise. The larger the indicator, the higher the value of the enterprise and the stronger its innovation ability.

3.2.4 Mechanism Variables

Table 1. Descriptive statistical results of each variable.

Define	Variables	Observations	Average	Std	Min	Max
Green innovation	Inv	26430	0.145	0.474	0	5.529
Does the carbon market activate virtual variables	Ets	26445	0.210	0.407	0	1
company size	Lnsize	26445	21.743	1.165	17.426	27.547
Asset liability ratio	Leverage	26445	0.408	0.203	0.008	3.625
Net profit margin of total assets	Roa	26442	0.043	0.076	-1.681	0.880
Management shareholding ratio	Ppe	25796	0.136	0.211	0	5.910
Proportion of independent directors	Duality	26361	0.353	0.089	0	0.800
Total asset turnover rate	Turnover	26442	0.692	0.447	0	8.455
Shareholding ratio of institutional investors	Institution	26419	0.295	0.245	0	3.267
Tobin Q value	Q	26445	1.844	0.892	0	3.434
Environmental regulations	Strpub	23728	0.002	0.031	0	0.031
Corporate cash flow	CFR	26445	0.048	0.075	-1.938	0.664

1) Environmental regulation (Strpub). This article draws inspiration from the other research of scholars. Therefore, this article uses the total investment/GDP in industrial pollution source control as environmental regulation.

2) Corporate Cash Flow (CFR). This article uses the cash flow ratio, which refers to the net cash flow generated from operating activities/total assets, to measure the cash flow status of a company, which can reflect the adequacy of the company's funds. When the cash flow in the business activities of a company accounts for a large proportion of its total assets, the company has relatively abundant

funds and can have more funds to invest in research and development, thereby ensuring green technology innovation for the company, which is more conducive to the breakthrough and application of new technologies for the company.

As shown in Table 1, as a result of each variable, it can be observed that the standard deviation of company size and Tobin Q is relatively large, indicating that the gap between these enterprises is relatively large and the variables are relatively scattered. The minimum value of management shareholding ratio, independent director ratio, total assets turnover ratio, institutional investor shareholding ratio and Tobin Q contains 0, which shows that some small and micro enterprises in this sample are backward in assets and profitability. It can be seen that the maximum value of green innovation (Inv) is 5.529, the average value is 0.145, and the standard deviation is 0.407. This shows that there are great differences between different companies in green innovation, and a considerable number of enterprises have insufficient innovation ability, resulting in the number of inventions being zero.

4. Empirical Results

4.1. Benchmark Regression

This article analyzes the test results of enterprise innovation. The initial assumption of ADF Fisher and PP Fisher is that there is a unit root, while the original assumption of KPSS is that there is no unit root. From the test results, it can be seen that the P-value in the ADF-Fisher test is 0.335, which is greater than 0.05, indicating the absence of a unit root. The P-value in the PP-Fisher test is 0.307, which is less than 1, indicating the absence of a unit root. The P-value in the KPSS test is 0.493, which is not equal to 0, indicating that the original hypothesis cannot be rejected, indicating the absence of a unit root. Overall, it can be concluded that there is no unit root in the data of the enterprise innovation panel, There is stochastic convergence, and since the carbon trading pilot policy is a dummy variable, the paper did not test this.

Table 2. Unit Root Test.

Unit root test						
variable	Augmented Dickey-Fuller Results		Phillips-Perron Test (Z-tau)		KPSS Stationarity Test Results	
	Test Statistic	P-value	Test Statistic	P-value	Test Statistic	P-value
Inv	-1.986	0.335	-1.895	0.307	0.131	0.493

Table 3 reports the basic regression results of the double difference. Column (1) is the regression result without adding control variables, while column (2) controls individual effects and time effects. It can be seen that the estimated coefficients of Ets are all greater than 0, and they pass the significance level of 5% when adding all control variables. The implementation of carbon trading policies can significantly stimulate enterprise innovation, which confirms hypothesis 1. The implementation of carbon trading markets can clarify property rights, effectively internalize carbon emission costs, weaken negative externalities of carbon emissions, reduce carbon emissions, adopt new processes and technologies, and enhance the green innovation ability of enterprises. On the other hand, enterprises can achieve a surplus of carbon emission rights through green innovation, sell them in the carbon trading market, and obtain profits. The increase in corporate profits will also stimulate enterprises to engage in green innovation. Based on the above results, the author thinks that the carbon trading pilot policy can promote enterprise innovation and effectively promote enterprise transformation and upgrading.

Table 3. Impact of Carbon Trading Pilot Policies on Enterprise Innovation.

Variables	Inv	Inv
Ets	0.0543** (0.0274)	0.0614** (0.0274)
Lnsize	——	0.0732*** (0.0125)
Leverage	——	0.0584 (0.0360)
Roa	——	-0.0965* (0.0531)
Ppe	——	0.0109 (0.0324)
Duality	——	0.0411 (0.0759)
Turnover	——	-0.0700*** (0.0269)
Institution	——	-0.0321 (0.0210)
Q	——	-0.0172 (0.0146)
Constant	0.1337*** (0.0060)	-1.4044*** (0.2562)
Fixed year effect	Yes	Yes
Corporate fixed effects	Yes	Yes
Observations	26,112	25,368
R-squared	0.5649	0.5768
Adjust R-squared	0.5167	0.5285

4.2. Robustness Testing

To ensure the reliability of the regression results, this article conducts robustness tests on the benchmark regression results from aspects such as parallel trend testing, event study method, placebo test, exclusion of innovative cities, interference from economic crises, exclusion of some pilot areas, and PSM-DID method.

4.2.1. Parallel Trend Test

There is no statistically significant trend difference in enterprise innovation between the experimental group and the control group. In order to eliminate the possibility of complete collinearity and test the differences before and after the carbon trading policy, in order to better measure the policy effect, this article uses the year before the implementation of the carbon trading pilot policy as the benchmark period for regression and compares the trend of enterprise innovation changes in pilot provinces and cities and non pilot regions. As shown in Figure 1, before the implementation of the policy, the difference between pilot and non pilot provinces and cities was not significant. Starting from the current period of policy implementation, there was a significant difference in enterprise innovation between pilot and non pilot provinces and cities. The significant reason for the first two phases of the pilot policy may be that the carbon trading pilot was announced in advance. In 2011, the National Development and Reform Commission issued a notice on conducting carbon emission trading pilot work. However, the carbon trading pilot policy was officially launched in 2013. According to signal theory, enterprises will respond under the guidance of policies and increase their green innovation efforts. The reason for the poor effectiveness of green innovation in the fifth phase of enterprises after implementation may be due to the impact of the 2018 economic crisis. This article investigates samples from carbon trading pilot provinces and cities, and finds that in the fifth phase of samples after the implementation of carbon trading pilot projects, the number of samples belonging to the year 2018 was 653, accounting for 88.36% of the samples of that year. In 2018, a global economic crisis occurred, and many enterprises went bankrupt, The financial issues of enterprises are relatively tight, and innovation is not the main goal. The funding for green innovation is limited, thus inhibiting enterprise innovation. The robustness test will be analyzed later in this article. According to the following figure, it can be considered that the experimental group and control group have a common trend before the implementation of carbon trading pilot policies.

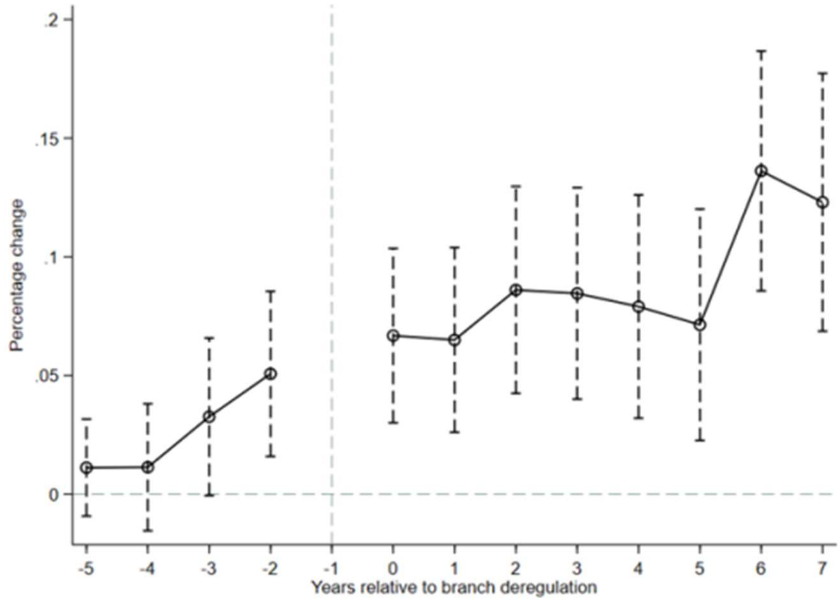

Figure 1. Parallel Trend Test.

To further test parallel trends, this article draws on the other literatures, and uses event study method to further conduct rigorous analysis. The time of carbon trading pilot policies is pushed forward or backward by t years for regression, and the reliability of the hypothesis conditions for parallel trend testing is judged by the significance of the coefficients. Due to the launch of the carbon trading pilot policy, the maximum number of periods until 201 is the 6th period. This article uses the first 5 periods before the launch of the carbon trading pilot as a comparative benchmark, and conducts regression analysis until the 6th period after the launch to test the significance of the estimated coefficients to determine the reliability of the parallel trend assumption conditions. As shown in Table 4, Before5-After6 represents the period from 5 years before policy implementation to 6 years after policy implementation, and Current represents the period when the pilot policy occurs. It can be observed that the coefficients before policy implementation are not significant, while the coefficient from the beginning of the policy implementation period (Current) is significantly not 0, indicating that the parallel trend assumption is valid. Therefore, both Figure 1 and Table 4 indicate that the double difference method used in this article satisfies the conditions of the parallel trend assumption, and the estimated policy effects are effective.

Table 4. Test for Dynamic Effects of Parallel Trends.

time	Inv	time	Inv
Before 5	0.0112 (0.0204)	After 1	0.0650* (0.0389)
Before 4	0.0113 (0.0267)	After 2	0.0860* (0.0436)
Before 3	0.0326 (0.0332)	After 3	0.0845** (0.0445)
Before 2	0.0507 (0.0348)	After 4	0.0790* (0.0470)
Before 1	0.0460 (0.0366)	After 5	0.0713 (0.0487)
Current	0.0668* (0.0367)	After 6	0.1230*** (0.0505)
Constant		-1.417*** (0.2599)	
Fixed year effect		Yes	
Corporate fixed effects		Yes	
Observations		25,364	
R-squared		0.5774	
Adjust R-squared		0.5288	

4.2.2. Placebo Test

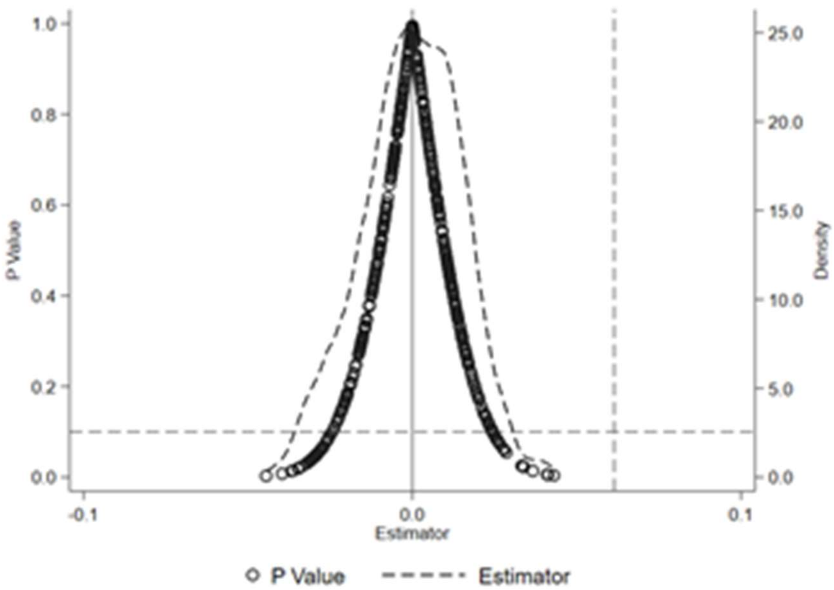

Figure 2. Placebo test 1.

To test the non-randomness of carbon trading pilot policies and verify the rationality of the double difference model, it is necessary to prove that the benchmark regression results are not driven by non observational factors. For example, with the passage of time and the need for technological progress, enterprises spontaneously innovate to meet the trend of the times, which may lead to the possibility that enterprise innovation is not related to carbon trading pilot policies. Therefore, based on the actual policy pilot time, this article adopts a randomized experimental group approach for placebo testing. This article randomly selects enterprises at the corresponding pilot time as pseudo experimental groups. Pseudo DID variables are generated based on the pseudo experimental group and the implementation time of the pilot policy. Pseudo DID variables are used to regress with enterprise innovation, and this process is repeated 500 times to observe whether the mean coefficient of the pseudo experimental group is 0. If the results approach 0, it indicates that there is no significant difference between the randomly generated pseudo experimental group and the control group. Figure 2 shows the p-values and kernel density distribution of 500 self sampling regression coefficients. According to the distribution map, it can be seen that the estimated coefficients are concentrated around 0, and the majority of the estimated values correspond to p-values greater than 0.1, with a significant deviation from the estimated coefficient of 0.0614 (the dashed vertical line in Figure 2 is the benchmark regression coefficient). At the same time, the probability of the true values of the benchmark regression in this article appearing in the placebo test is low, belonging to extreme outliers, There is reason to believe that the benchmark estimate is different from the sampling results of the placebo test, indicating that the pilot provinces and cities randomly sampled cannot have an impact on enterprise innovation. The regression results in this article are unlikely to be caused by non observational factors. The counterfactual analysis method verifies that the carbon trading pilot policy has a significant impact on enterprise innovation. Therefore, the benchmark regression results in this article are robust.

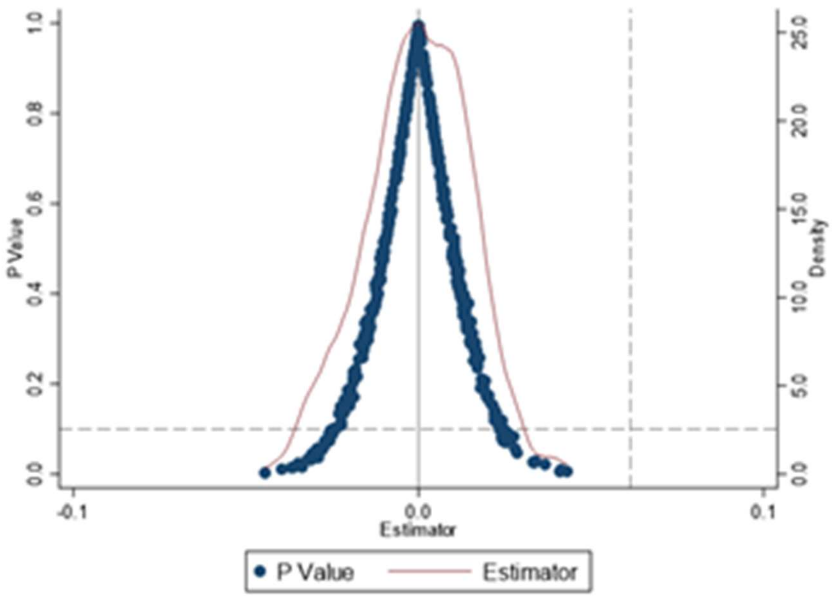

Figure 3. Placebo test 2.

This article randomly selects enterprises at the corresponding pilot time as a pseudo experimental group. Pseudo DID variables are generated based on the experimental group and the implementation time of the pseudo pilot policy. Pseudo DID variables are used to regress with enterprise innovation. This process is repeated 500 times, and the mean coefficient of the pseudo experimental group is observed to be 0. The results are shown in Figure 3. It is found that the regression results of this article are unlikely to be caused by non observational factors.

4.2.3. Eliminate the Interference of Innovative City Pilot Policy Implementation, Economic Crisis, and PSM-DID Method

Another concern of using the double difference method to evaluate the impact of carbon trading pilot policies on corporate innovation is that during the sample period, government budget deviations are inevitably influenced by other policies, which may overestimate or underestimate policy effects. In 2010, the National Development and Reform Commission of China proposed to build innovative cities, put forward requirements for technological and industrial innovation in the scientific and technological fields of enterprises, stimulate the transformation of enterprise development models, and achieve industrial upgrading and upgrading. For example, it requires enterprises to increase investment in education and technology, build high-level research and development institutions, increase the demand for high-level talents, and improve their innovation capabilities. Therefore, this article has reason to believe that the implementation of innovative city pilot policies will affect the effectiveness of carbon trading pilot policies. Therefore, to identify and exclude the impact of innovative city pilot policies, innovative pilot cities will be used as experimental groups with a value of 1, and the rest will be used as control groups with a value of 0; Secondly, assign a value of 1 to the corresponding implementation year of the innovative city, otherwise it will be 0; Finally, a dummy variable composed of two dummy variables interacting with each other is added to the benchmark regression equation to control the impact of innovative city pilot policies on enterprise innovation. If the Ets coefficient becomes insignificant after adding the policy dummy variable, it indicates that the effect of carbon trading pilot policies on promoting enterprise innovation does not exist. On the contrary, if the Ets coefficient is still significant, but the estimated absolute value of the coefficient increases, it indicates that the carbon trading pilot policy has a promoting effect on enterprise innovation, which will lead to underestimating the effect of the carbon trading pilot policy. Column (1) is the regression result of the dummy variable implemented by adding innovative cities. The coefficient of Ets is still significant, but it is greater than the benchmark regression result of column (2) in Table 4. Moreover, the coefficient of the innovative city pilot policy is significant, indicating that the innovative city pilot policy can improve the innovation level of enterprises. However, this policy absorbs the role of the carbon trading pilot policy, The implementation of the innovation city pilot policy and the carbon trading pilot policy have duplicate pilot regions and years, leading to an underestimation of the effectiveness of the carbon trading pilot policy. After excluding the interference of other policies, the impact of the carbon trading pilot policy on enterprise innovation is still significant, thus proving the robustness of the estimation results in this article.

In the carbon trading pilot provinces and cities, drawing on the research of Wang Huaiming et al, The cumulative trading volume ranks last among the eight pilot provinces and cities, and the carbon quota allocation methods in other pilot areas are based on the historical intensity method and baseline method. However, Chongqing City uses the method of "combining government total control with enterprise competition game to allocate initial quotas for free", which is different from the initial quota standards of other provinces and cities, and may affect the regression results. This article excluded the samples from Chongqing for regression, and the regression results are shown in column (2) of Table 5. Based on the regression results, it can be seen that the estimated coefficients are still significant, indicating that the regression results are robust.

Table 5. Excluding interference from innovative cities and economic crises, excluding some pilot areas and the PSM-DID method.

Variables	(1) Excluding interference from innovative cities	(2) Excluding some pilot areas	(3) Economic crises	(4) PSM-DID
	Inv	Inv	Inv	Inv
Ets	0.0663**	0.0642**	0.0665**	0.0610**
	(0.0269)	(0.0278)	(0.0264)	(0.0274)
Innovative cities	0.0387*	——	——	——
	(0.0211)	——	——	——
Fixed year effect	Yes	Yes	Yes	Yes
Corporate fixed effects	Yes	Yes	Yes	Yes
Constant	-1.4261***	-1.398***	-1.4232***	-1.4028**
	(0.2550)	(0.2565)	(0.2512)	(0.2564)
R-squared	0.5772	0.5758	0.5701	0.5769
Adjust R-squared	0.5289	0.5272	0.5159	0.5285
Observations	25,358	25,007	23,236	25,364

In the parallel trend test, it was found that enterprise innovation was significantly weaker in 2018. The global economic crisis in 2018 significantly affected the survival of enterprises, with many companies experiencing cash flow disruptions and even leading to bankruptcy. Enterprises had a lower willingness to innovate under poor income conditions. Therefore, this article excluded the samples from 2018 for regression, as shown in column (4) of Table 5. It was found that the absolute value of t increased compared to the baseline regression, with a significant increase, In addition, the regression coefficient of the carbon trading pilot policy is 0.0665, an increase of 8.81% compared to the benchmark regression of 0.0614, indicating that excluding the impact of the economic crisis, the effect of the carbon trading pilot policy is more significant, and the results of this article are robust.

Due to the initiation of carbon trading pilot policies in eight provinces and cities, these pilot cities have a relatively deep degree of marketization, strong enterprise strength, and relatively high level of technological innovation. Therefore, there may be sample selection bias in policy implementation, leading to regression not meeting the strict externality of policies, and the possibility of biased or inconsistent policy estimation results. This article further uses the dual difference method of propensity matching score (PSM-DID) to reduce the systematic differences between the experimental group and the control group based on their changing trends. In the specific regression process, this article uses control variables such as company size and asset liability ratio as matching variables. According to the regression results in column (4) of Table 5, the carbon trading pilot policy has a promoting effect on enterprise innovation, and the regression results are still significant, further indicating that the benchmark regression results of this article are robust.

4.3. Endogenous Processing

Although quasi natural experiments greatly reduce the existence of endogeneity, due to the relatively developed economies of some provinces and cities, according to the environmental Kuznets curve, regions with high per capita GDP can realize the importance of the environment after experiencing rapid economic development, and economic growth is no longer the primary goal of the government. Moreover, these provinces and cities have strong research and development capabilities, high levels of enterprise innovation, and corresponding innovation foundations to reduce carbon emissions Ensuring sustainable environmental development has become a key direction. Regions with strong innovation capabilities place a higher emphasis on reducing carbon emissions, leading to the possibility of mutual causality, resulting in biased and unreliable regression results.

Table 6. Regression results of instrumental variable method.

Variables	**IV**	
	Inv	**Inv**
Ets	——	0.3782** (0.1967)
IV	0.0159*** (0.0025)	——
Control variable	Yes	Yes
Constant	-0.1717*** (0.058)	-2.6158*** (0.1160)
Fixed year effect	Yes	Yes
Corporate fixed effects	Yes	Yes
Observations	21,560	21,560
R-squared	0.2278	0.0720
Adjust R-squared	0.2268	——
Kleibergen-Paap rk LM	40.1000 [0.0000]	——
Kleibergen-Paap rk Wald F	39.0160 {16.38}	——

To handle the endogeneity of mutual causality, this article uses the instrumental variable method for estimation. In terms of the selection of instrumental variables, this article uses air circulation coefficient as the instrumental variable for carbon trading pilot policies. The data comes from the ERA Interim database, including wind speed at a height of 10 meters and daytime boundary layer height data. Based on this, the air circulation coefficient is calculated. The rationality of using this indicator as a tool variable is that, on the one hand, the air circulation conditions of different cities are different. Under the premise of the same emissions of urban pollutants, cities with low air circulation coefficients dissipate gases more slowly and emit less exhaust gas within the same time. In order to ensure air conditions, under the policy indicators of energy conservation and emission reduction in each province and city, it will affect the environmental supervision efforts in the region, Therefore, the carbon trading pilot policy will be related to the air circulation coefficient; On the other hand, the air circulation coefficient is the product of wind speed and boundary layer height, and the wind speed and boundary layer height in a region are natural and have no direct correlation with enterprise innovation. Therefore, it is believed that this instrumental variable satisfies exogeneity.

Column (1) of Table 6 shows the results of the first stage least squares regression, indicating that there is no weak instrumental variable problem and all instrumental variable tests have passed. The results of column (2) show that the carbon trading pilot policy still significantly promotes enterprise innovation after considering endogeneity issues, and is significant at the 5% level.

4.4. Mechanism Verification

Based on the above empirical regression results, carbon trading pilot policies can promote enterprise innovation. Therefore, this article further studies the mechanism of carbon trading pilot policies. Environmental regulations and corporate cash flow are important factors that affect whether enterprises strengthen green innovation. When the carbon trading pilot policy can strengthen environmental regulations and promote the enthusiasm of enterprises for research and development investment, then the carbon trading system can motivate enterprises to engage in green innovation. Therefore, this article adopts the triple difference method to verify the role of carbon trading pilot policies in strengthening environmental regulations, optimizing cash flow conditions, and ultimately promoting the mechanism of enterprise innovation.

4.4.1. Strengthen the Role of Environmental Regulation

Currently, most environmental regulations focus on policy guidance, but their intervention in market resource allocation is relatively limited. The carbon trading pilot policy can effectively combine policy guidance with market spontaneous regulation. From a macro level perspective, the government sets quotas for carbon emission rights of enterprises based on certain standards, making the total carbon emissions controllable. From a micro level, enterprises can publicly trade in the carbon trading market according to their own needs, and the price is transparent, determined by market supply and demand, The carbon trading pilot policy organically combines macroeconomic regulation and market allocation, and the punishment and incentive mechanism of environmental regulation can effectively transmit and directly affect individual enterprises. The combination of government environmental regulations and carbon trading pilot policies, the greater the role of environmental regulations, the stronger the punishment of pollution behavior in the carbon trading market, and the incentive for enterprises to engage in green innovation.

This article divides the median of environmental regulation intensity and sets the dummy variable Strpub. When the environmental regulation intensity is less than the average, Strpub takes 1, otherwise it takes 0. This article adds the interaction term composed of environmental regulation Strpub and carbon trading pilot policies (Ets) to the benchmark regression model for triple differentiation. The regression results of columns (1) and (2) in Table 7 indicate that carbon trading pilot policies can strengthen the role of environmental regulation, limit carbon emissions behavior of enterprises, and guide enterprises to engage in green innovation.

Table 7. Mechanism Verification.

Variables	Environmental regulation		CFR	
	Inv	Inv	Inv	Inv
Ets	0.0361*	0.0356*	0.0580**	0.0575**
	(0.0112)	(0.0109)	(0.0268)	(0.0265)
Strpub	0.0590**	0.0589**	——	——
	(0.0270)	(0.0272)		
CFR	——	——	0.0143**	0.0142**
			(0.0091)	(0.0090)
Ets×Strpub	0.1054**	0.1935***	——	——
	(0.0427)	(0.0570)		
Ets×CFR	——	——	0.0355	0.0581**
			. (0.0254)	(0.0254)
Control variable	Yes	Yes	Yes	Yes
Constant	-2.6102***	-2.4989***	-1.8353***	-1.4685***
	(0.6090)	(0.6356)	(0.2708)	(0.2580)
Fixed year effect	Yes	Yes	Yes	Yes
Corporate fixed effects	No	Yes	No	Yes
Observations	9209	9209	25687	25687
R-squared	0.0967	0.1005	0.070	0.0752
Number of code	1103	1103	2891	2891

4.4.2. Corporate Cash Flow

There is a close correlation between the cash flow situation of enterprises and research and development activities. When carbon trading pilot policies can improve the cash flow situation of enterprises, carbon trading policies can have a positive incentive effect on green innovation of enterprises. Although carbon trading pilot policies may increase financial pressure on enterprises in the short term, and enterprises need to invest more funds in green innovation, from a long-term perspective, Enterprises can benefit from green innovation, thereby improving their cash flow. Innovation can maximize profits in the long term. Therefore, this article examines the mechanism by which corporate cash flow affects corporate innovation. When the carbon quota of a company exceeds its demand, the company can sell excess carbon emission quotas in the carbon trading market, which can generate certain profits after being sold in the open market. Therefore, the company's cash flow increases, making it more willing to actively engage in green innovation. This article divides the median of corporate cash flow ratios and sets the dummy variable CFR. When environmental regulation is less than the average, CFR is taken as 1, otherwise it is taken as 0. This article adds the interaction term composed of cash flow ratio CFR and carbon trading pilot policies (Ets) to the benchmark regression model for triple differentiation. As shown in columns (3) and (4) of Table 7, it indicates that the carbon trading pilot policy can improve the cash flow of enterprises, enhance the income expectation of enterprise innovation, and guide the growth of long-term innovation ability of enterprises.

4.5. Heterogeneity Analysis

After the implementation of the carbon trading pilot policy, the differences in the response of enterprises themselves determine the different effects of the policy. Due to the impact of the equity concentration and technology intensity of enterprises on innovation behavior choices and behavioral effects, it cannot be ignored. Based on this, this article analyzes the heterogeneity of the role of carbon trading pilot policy in promoting green innovation of enterprises from the characteristics of enterprise equity concentration and technology intensity.

4.5.1. Strengthen the Role of Environmental Regulation

Due to differences in interests between major shareholders and minority shareholders, as well as the fact that major shareholders have control over the company's discourse, the cost of misappropriating company resources is relatively low. Major shareholders transfer company resources in order to maximize their own interests, resulting in profit losses for minority shareholders. This article classifies the first largest shareholder with a shareholding ratio greater than the median as equity intensive enterprises, while the second largest shareholder with a shareholding ratio greater than the median is equity dispersed enterprises, and conducts group regression. Columns (1) and (2) of Table 8 show the heterogeneity regression results of equity intensive and equity dispersed enterprises, respectively. The results indicate that the carbon trading pilot policy has significantly improved the green innovation level of equity dispersed enterprises, but has no significant impact on the green innovation of equity intensive enterprises. On the one hand, the cost of the tunneling effect of major shareholders is relatively low, while the risk and cost of green innovation are relatively high, and the risk return rate is significantly better than that of enterprise green innovation. On the other hand, in the long run, green innovation is beneficial for the stable operation and sustainable development of enterprises. In the process of equity financing for listed companies, major shareholders use stock price fluctuations to cash out at high levels and earn profits from stock price differences, The expected returns of this behavior are much higher than the company's internal rate of return, which can also lead to the company's neglect of green innovation.

4.5.2. Heterogeneity of Technology Intensity

The technological intensity of enterprises affects their production mode and carbon emissions, therefore, the role of carbon trading pilot policies in selecting innovative behavior varies among enterprises with different intensities. This article is based on the Organization for Economic Cooperation and Development (OECD), divides manufacturing enterprises into technology intensive enterprises and non technology intensive enterprises, and regresses them separately. Columns (3) and (4) of Table 8 show the regression results of heterogeneity in technology intensity. This indicates that the carbon trading pilot policy has significantly promoted green innovation in non technology intensive enterprises, but the promotion effect on green innovation in technology intensive enterprises is not significant. On the one hand, technology-intensive enterprises include sub industries such as transportation, instrumentation, and pharmaceuticals. These enterprises have low carbon emissions, and their competitiveness is mainly reflected in technological innovation and intellectual property innovation. The correlation between green innovation capabilities and economic output is poor, and these enterprises focus more on technological innovation in economic benefits. Therefore, the impact of carbon trading pilot policies on technology-intensive enterprises is not significant. On the other hand, the technological innovation benefits of technology-intensive enterprises in terms of knowledge are higher than those of green innovation. These enterprises have a larger scale of technological innovation, already equipped with relevant technical facilities and personnel, and there is a scale effect. The average fixed cost of sustained technological innovation for enterprises decreases with innovation investment. When the total amount of innovation investment remains constant, from the perspective of cost-benefit, enterprises can maximize their economic benefits by purchasing carbon rights. Therefore, the effect of carbon trading pilot policies on technological innovation enterprises is not significant. On the contrary, non-technical enterprises have higher carbon emissions, lower costs of green innovation, and smaller losses of crowding out effects on technological innovation, resulting in greater profits. Therefore, the carbon trading pilot policy has a more significant impact on non-technical intensive enterprises.

Table 8. Heterogeneity Analysis Results.

Variables	Equity intensity		Technology intensity	
	(1)	**(2)**	**(3)**	**(4)**
	Equity intensive	**Equity dispersed**	**Tall technology intensity**	**Low technology intensity**
Ets	0.0099	0.0801***	0.0165	0.1042***
	(0.0342)	(0.0366)	(0.0429)	(0.0364)
Control variable	Yes	Yes	Yes	Yes
Constant	-1.2676***	-1.3930***	-1.4025***	-1.4776***
	(0.391)	(0.323)	(0.3838)	(0.3664)
Fixed year effect	Yes	Yes	Yes	Yes
Corporate fixed effects	Yes	Yes	Yes	Yes
Observations	13372	11854	13176	12161
R-squared	0.5961	0.6491	0.6042	0.5468
Adjust R-squared	0.5325	0.5935	0.5550	0.4930
Number of code	1585	284	1426	1261

5. Conclusion and Inspiration

5.1. Conclusion

The results show that: (1) The pilot policy of carbon trading has significantly promoted the green innovation of enterprises and improved the scientific and technological innovation of enterprises. This conclusion is still valid after a series of robustness tests and endogenous treatment, such as placebo test, excluding the implementation of pilot policies for innovative cities and the interference of economic crisis. (2) The mechanism test shows that the carbon trading pilot policy can significantly promote the green innovation of enterprises by strengthening the effect of environmental regulation and improving the cash flow of enterprises. (3) Heterogeneity analysis shows that the technology-intensive situation and the degree of equity dispersion of enterprises can affect the effect of enterprise innovation. In view of the above conclusions, this paper puts forward some suggestions from improving the carbon trading system, exploring the multi-dimensional path of carbon trading pilot to promote enterprise innovation, and improving the adaptability, flexibility and implementation intensity of policies. The research in this paper provides policy enlightenment for further improving the carbon trading market, enhancing the effect of the carbon trading system, giving full play to the carbon market to promote green innovation of enterprises and realizing low-carbon development, which is of reference significance for the construction and improvement of the national carbon market and promoting the perfection of the national energy conservation and emission reduction policy planning.

5.2. Inspiration

This article takes the carbon trading pilot policy as a quasi natural experiment, providing empirical theory for promoting the improvement of the national environmental regulatory system and market. The research conclusion of this article contains the following policy recommendations:

1) Promote the construction of a carbon trading mechanism and leverage the resource allocation function of the carbon market. Due to the significant promotion of green innovation by enterprises through carbon trading pilot policies, on the one hand, it is necessary to accelerate the promotion of carbon trading pilot projects, build a comprehensive carbon trading market, establish carbon markets in various provinces, cities, and industries, expand carbon trading pilot areas, explore the inclusion of coal, construction, and other industries in the pilot scope, lower the threshold for carbon trading pilot projects, and strengthen the establishment of derivative instrument markets such as options and futures for carbon rights, Realize cross period trading in the carbon trading market and build a multi-level carbon trading market. On the other hand, promoting the unity of carbon markets between provinces and cities, narrowing the gap in carbon markets, and making the entry barriers and carbon rights prices consistent across different carbon markets.

2) Explore multidimensional paths for carbon trading to promote enterprise innovation, and optimize the implementation effect of policies. Firstly, we need to strengthen environmental regulations, improve the legal supervision system, establish a sound punishment mechanism, combine environmental regulations with the carbon trading market, avoid insufficient supervision of carbon trading pilot projects, combine environmental supervision laws with carbon trading mechanisms, fully leverage the role of environmental regulations in promoting enterprise innovation, and expand the credibility of carbon trading pilot policies. The second is to strengthen the signaling effect of carbon trading pilot policies on enterprises and deepen the carbon trading market. Strengthen the promotion of carbon trading policies to optimize the overall strength of enterprises, leverage the role of carbon trading pilot policies in effectively improving enterprise cash flow and expanding market competitiveness, fully promote the advantages of carbon trading systems, encourage green innovation of enterprises, and establish a good incentive mechanism.

3) Fully consider the heterogeneity of enterprises and adjust carbon trading policies reasonably. According to the characteristics of industry enterprises, carbon trading rules should be reasonably set. Based on the results of heterogeneity, the carbon trading system should strengthen the transformation supervision of state-owned enterprises, accelerate the speed of strategic adjustment of enterprises, and optimize the implementation effect of carbon trading policies on them. It can increase the adaptability of carbon trading systems to other systems, stimulate green innovation in technology intensive enterprises and equity dispersed enterprises, and thus achieve the transformation and transition of small enterprises.

Funding: This research was funded by the Guizhou University of Finance and Economics Student Science Research Project "Research on the Driving Effect and Implementation Path of Transfer Payment System to Improve the Efficiency of Public Service Supply for People's Livelihood", grant number 2022ZXSY012.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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(Executive Editor: Wang-jing Xu)