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Exploration or Exploitation? Corporate Green Innovation Strategy for Carbon Emission Reduction-Evidence from Pilot Enterprises in China

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Abstract: Green innovation has become a key strategy for reducing emissions. However, existing research mainly examines this phenomenon through the resource and institutional perspectives, often ignoring the changes in corporate green innovation behavior under industry peer pressure. Therefore, this study draws on the policy framework of China's carbon trading pilot and uses a multi-period difference-in-difference (DID) fixed effects model to explore how carbon trading shapes enterprises' green innovation strategies. The survey used data from pilot enterprises from 2008 to 2019 and found that carbon trading policies are conducive to green innovation, and both exploratory green innovation and exploitative green innovation have been reflected. It is worth noting that under the influence of peer pressure, this positive effect is more prominent in exploratory green innovation. Furthermore, it was found that firms facing carbon pressure can skillfully find an equilibrium between exploratory green innovation and exploitative green innovation. The research results demonstrate the green innovation strategies and trade-offs of Chinese enterprises facing the impact of carbon trading policies, with the hope that the research conclusions will have certain theoretical reference significance for future corporate green transformation and increased investment in green innovation.

Keywords: carbon trading; green innovation; exploratory green innovation; exploitative green innovation; innovation equilibrium



Citation: Liu, S.; Li, Y. Exploration or Exploitation? Corporate Green Innovation Strategy for Carbon Emission Reduction-Evidence from Pilot Enterprises in China. *Sustainability* **2024**, *16*, 4486. <https://doi.org/10.3390/su16114486>

Academic Editors: Jianhua Zhu, Jiaoping Yang, Yanming Sun and Chaoan Lai

Received: 25 April 2024

Revised: 16 May 2024

Accepted: 23 May 2024

Published: 25 May 2024



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1. Introduction

To cope with global warming, controlling carbon dioxide emissions has become urgent. Currently, measures to control carbon emissions are divided into government-commanded, market-incentivized, and voluntary [1]. However, due to the obvious social externality of this behavior, the enthusiasm of enterprises is not high. Therefore, the market incentive type has gradually become an important way [2], i.e., the government takes the lead in controlling the regional carbon emission balance by decentralizing carbon emission quotas to enterprises and commercializing them in the market [3]. The success of the European Union's carbon trading market provides a practical reference for Chinese enterprises to explore the path of low-carbon development.

Then how can enterprises, as the main body of carbon trading, fulfill their carbon emission commitments? Green innovation becomes an important way [4–6]. For the relationship between carbon trading and enterprise green innovation, some scholars take Chinese state-owned enterprises as samples and present a structural equation model, pointing out that there is a cost-following effect of carbon trading [7], i.e., enterprises increase the cost of pollution management by updating equipment, introducing technologies, reducing production, etc., which is not favorable to enterprise green innovation; some scholars also use the difference-in-differences method, pointing out that carbon trading has a crowding-out effect on innovation investment, which inhibits enterprise green innovation [8,9]. However, some scholars hold different views on this. Some studies use the spatial Durbin model to

study the impact of green innovation on the region and surrounding areas, and propose that moderate environmental regulation can stimulate the green innovation ability of enterprises, i.e., through the optimization of processes and technological upgrading to offset the cost of compliance brought by the environmental governance. Also, some studies construct the logic chain of “environmental regulation–green innovation intention–green innovation behavior” and conclude that green innovation has an industrial agglomeration effect. There are even scholars who use the panel data and adopt the difference-in-difference (DDD) model, which concludes that carbon trading has a positive effect on the quality and quantity of innovation and so on [10–12]. It can be seen that the relationship between carbon trading and enterprise green innovation is complicated. Reviewing the previous studies, there are both administrative-based and market-based environmental regulations; both regional- and industry-level studies; and both spatial econometric modeling and panel data analyses, and the diversity of research topics and methodologies has confused the research conclusions. Based on this, this paper mainly focuses on the policy research of carbon trading on enterprises’ green innovation, and at the same time considers whether enterprises’ green innovation behavior is biased in the face of the impact of carbon trading.

The peer pressure effect suggests that firms will tend to adopt similar innovative activities with other firms to reduce the uncertainty and riskiness caused by individual uniqueness in the external environment [13]. With the improvement in China’s carbon trading market, more and more enterprises are included in the list of carbon trading; will there also be a peer pressure effect of green innovation among enterprises in different regions? Especially when the pilot enterprises are threatened by other competitors in the limited market environment, and the enterprises are in a constant innovation race to catch up with each other, will this learning–improvement–relearning pressure invariably affect the enterprises’ green innovation decisions? This paper argues that considering the impact of the peer group pressure on firms’ innovation decisions brought about by carbon trading policies can help to understand the innovation incentive role and effects of carbon markets more comprehensively.

The research goal of this article is to deepen the understanding of the impact of carbon trading on firms’ green innovation, especially to explore the role and effect of carbon trading on incentivizing green dual innovation. Therefore, to achieve this goal, the article proposes two specific research directions: refining the concept of green innovation and focusing on the impact of peer pressure on corporate green innovation.

The main research contributions of this paper include the following: First, it deepens the understanding of the impact of carbon trading on dual green innovation. Although existing studies have analyzed the impact of carbon trading policy on corporate decision-making [14] and clarified the incentive role of carbon trading policy in green innovation [15,16], they have not deeply explored the impact of different types of green innovation and its equilibrium. Therefore, this study refines the concept of green innovation, divides it into exploratory green innovation and exploitative green innovation, and investigates the impact of carbon trading on dual green innovation and its equilibrium, thus enriching the theoretical literature in this field. Second, existing studies on the relationship between carbon trading and innovation mainly focus on the resource perspective and stakeholder perspective [17,18], and rarely consider the impact of competitive pressure in the same industry. Trading policy as a market incentive mechanism, the participating subjects will unintentionally generate competitive pressure to reduce carbon emissions, which will affect the innovation decisions of firms. Therefore, it is of great research significance to understand the impact of peer pressure on green innovation in the industry, which can help to better understand the incentives and effects of innovation in the carbon trading market, and thus promote the development of the carbon trading market.

2. Theoretical Analysis and Hypothesis Formulation

2.1. Carbon Trading and Green Innovation

Green innovation is to improve or reduce environmental damage by optimizing production, manufacturing, and other links or the entire manufacturing process [19]. However, the relationship between carbon trading policies and green innovation is not clear at present. Some studies have pointed out that carbon trading policies internalize the cost of environmental pollution and increase corporate compliance costs [7]. Therefore, to obtain the legitimacy of carbon emissions, some companies would rather cut production and upgrade technology than invest in green innovation [8,9,20]. This is very common among non-state-owned enterprises and small-scale enterprises and is affected by factors such as corporate cash flow, future profitability, government subsidies, and supervision [21,22]. Also, some scholars argue that carbon trading may impose significant environmental governance pressure on pilot enterprises, potentially leading to resource misallocation and flow to the process innovation with terminal governance, thus crowding out the investment in green innovation [23–26], contributing to the cautious approach toward green innovation among Chinese enterprises. Coupled with the low level of technological innovation of Chinese enterprises [27], the uncertainty and risks of green innovation will force pilot enterprises to increase operating costs, so they are more cautious about green innovation. But Coase pointed out that as long as property rights are clear, market transactions can automatically achieve the optimal state of resource allocation and solve the problem of negative externalities. Therefore, scholars have proposed the “innovation offsets” effect to offset the cost of environmental compliance through “innovation offsets” to achieve a win–win situation for environmental protection and efficiency [28]. This coincides with the “Porter hypothesis”.

Firstly, carbon trading has a cost-forcing effect [28]. The government allocates carbon emission credits to pilot enterprises, and pilot enterprises can freely buy and sell carbon emission credits in the carbon trading market [29]. This uses the price mechanism to internalize the external cost of environmental pollution [11,30]; that is, when a company exceeds its emission quota, it needs to make additional purchases. However, China’s carbon trading market is still in its preliminary stage [3], and market prices are highly volatile. This part of the funds is additional expenditure for enterprises [31]. In order to maintain profits, enterprises can only transfer environmental costs to consumers, resulting in an increase in product prices and a decrease in market competitiveness. Forced by the requirements of profitability, enterprises are more likely to increase investment in green innovation to fundamentally meet environmental compliance requirements.

Secondly, there is the incentive effect of innovation. Carbon trading encourages companies to sell additional carbon emission shares. The more remaining credits, the higher the additional benefits. This incentive policy encourages enterprises to increase investment in green innovation and continuously optimize production processes with the help of clean technology or energy-saving equipment [32], allowing enterprises to not only reduce carbon emissions but also obtain additional carbon benefits [1].

Finally, there is the signaling role. Enterprises participating in carbon trading show the public and investors a social image of actively participating in environmental governance. To increase consumer trust and loyalty [33–35], pilot enterprises will pay better attention to consumers’ green needs and increase green investment. Therefore, based on the above analysis, the following hypothesis is put forward:

H1. *Carbon trading policies promote green innovation among enterprises.*

2.2. Exploratory Green Innovation and Exploitative Green Innovation

According to the ambidextrous innovation theory, scholars define it as exploratory innovation and exploitative innovation [36,37]. Among them, exploratory innovation emphasizes the complete transformation of technology, aiming to develop new products, new technologies, and new markets, while exploitative innovation emphasizes small and

incremental innovation, that is, upgrading and reengineering based on original product technology. It can be seen that exploratory innovation requires companies to bear great uncertainty and invest a lot of money in research and development to achieve disruptive changes. On the contrary, exploitative innovation optimizes and upgrades based on original products or services, with less risk and immediate returns. It is more similar to design-based or process innovation and can quickly obtain short-term results [38–40].

In the short term, the impact of the implementation of carbon trading policies on pilot companies is not only reflected in the increase in environmental governance pressure and adjustments in resource allocation but also the changes in the green innovation direction preferences of corporate managers. First, the pressure on environmental governance has increased. The implementation of carbon trading policies has caused enterprises to face more stringent environmental regulatory requirements and policy cost pressures [31]. Pilot companies are forced by environmental regulatory requirements and must take measures to reduce carbon emissions as soon as possible to avoid regulatory penalties, which adds tremendous pressure to corporate managers [11,41]. Secondly, there is resource allocation adjustments. To meet the requirements for controlling carbon emissions as soon as possible, managers of pilot enterprises may adjust the allocation strategy of productive resources. More resources may be invested in exploitative green innovation focusing on end-of-pipe governance [37] to achieve the goals of rapidly reducing pollution emissions and improving energy efficiency. Finally, the preference for green innovation direction changes. Due to tight time and huge pressure, managers are more inclined to choose exploitative green innovation solutions that are relatively mature and easy to implement, such as waste treatment, energy conservation, and technological improvement. Therefore, based on the above analysis, the following hypothesis is put forward:

H2a. *Carbon trading policies promote firms' exploitative green innovation.*

Although companies may pursue exploitative green innovation in response to environmental regulatory requirements, this is not a long-term solution. In the long term, it is inevitable for the Chinese government to build a carbon trading market to achieve its goals of "carbon neutrality and carbon peaking." Therefore, for enterprises, only by establishing green technology advantages as soon as possible can they stabilize their position in the future carbon market. First of all, although exploratory innovation requires a large investment in scientific research funds in the early stage and is highly uncertain and risky, it is more innovative. This is because it requires enterprises to break through the existing knowledge base and create new green technologies, and this innovativeness can bring competitive advantages to enterprises [37,42]. Secondly, as environmental issues become more and more important, consumer demand for green products and services is also increasing [34,35]. Consumers will be pursuing environmental protection, sustainability, and social responsibility, which also puts forward new requirements for the green development of enterprises. Therefore, in the fierce market competition, companies have to carry out green innovation with technical barriers to ensure their long-term competitiveness in the market. Finally, the carbon trading policy has an innovation incentive effect [32] and promotes companies to sell remaining carbon emission credits. Obtaining unexpected income from selling remaining carbon emission credits will, to a certain extent, stimulate the enthusiasm of enterprises for green innovation and make corporate management more likely to develop green innovation with technical barriers. Therefore, based on this, the following hypothesis is put forward:

H2b. *Carbon trading policies promote firms' exploratory green innovation.*

It is worth mentioning that enterprises need to pay attention to the equilibrium between exploratory and exploitative innovation during the green innovation investment process [36,43,44]. This is because an excessive pursuit of exploration will lead to a waste of resources and low utilization efficiency; an excessive pursuit of utilization will lead to

short-sightedness and inertia of the organization, causing the enterprise to lose its growth vitality [45]. Therefore, it is extremely important to pursue an equilibrium between the two innovations. In this way, enterprises can reduce the uncertainty of investment projects and avoid risks; at the same time, it can alleviate the preemption of idle resources by different types of innovation to ensure that enterprise resources are fully utilized and form a competitive advantage [44,46]. In particular, when companies face the impact of carbon trading policies, whether companies develop new carbon emission reduction technologies, add carbon emission reduction functions based on existing technologies, or carry out both requires further discussion. Therefore, based on this, the following hypothesis is put forward:

H3. *Under the pressure of carbon trading, enterprises maintain a relative balance between exploratory green innovation and utilization-oriented green innovation.*

2.3. Peer Pressure and Green Innovation

The traditional strategic perspective believes that an enterprise's competitive advantage is durable [47], but the dynamic competition theory believes that its advantages are short-lived and changing. To maintain competitive advantages among enterprises, it is not limited to simple imitation, but also the process of continuous optimization and innovation [48]. This is similar to the Red Queen theory [49] proposed by Barnett and Hansen, which emphasizes the co-evolution between organizations; that is, organizations must constantly compete and learn to achieve the survival of the fittest. In other words, enterprises do not exist alone. In the market competition environment, the reciprocal interaction between enterprises determines their survival status [50,51]. Therefore, when the target enterprise is subject to peer pressure from competitors, the enterprise will continuously improve its survivability through search learning. At the same time, it will react to competitors, causing optimization learning among competitors to form a virtuous cycle [13]. From an individual perspective, when the target company ignores peer pressure from competitors or fails to respond on time, the company's viability will be significantly reduced, eventually leading to the company being eliminated [52].

The same applies to the impact of carbon trading policies on corporate green innovation. In a market with limited resources, pilot firms in the same industry will pay close attention to the behavioral decisions of other competitors to make quick strategic responses and maintain their market position to maintain their competitive advantage [52,53]. However, most of the existing studies believe that carbon trading policies have a certain bias on the impact of corporate green innovation [17]. However, according to the concept of synergistic organizational evolution, in this competitive relationship, every successful enterprise is continuously learning to improve organizational viability [13]. Therefore, when the target firm chooses to avoid or abandon its innovation strategy, it will soon be forced out of the market by the pressure from competitors. Similarly, when enterprises are subjected to the external shock of carbon trading policy, their behavioral decisions will be influenced by peer pressure from other enterprises in the same industry [50,54]. To capture the market and build defense barriers, these pilot enterprises will actively participate in the innovation race, when the enterprises may not only stick to the short-term benefits of low-quality innovations such as process modification but also focus on exploratory green innovations, to form green technological barriers against the threat of competitors, so based on the above analysis, the following hypothesis is proposed:

H4. *Peer pressure plays a positive moderating role between carbon trading and green innovation.*

3. Methodology of Research

3.1. Sample Selection

Carbon trading policy provides a good natural experimental background for studying the differences in corporate green innovation. The Chinese government has carried out

carbon trading pilot programs in eight provinces and cities, including Beijing, Shanghai, Tianjin, Chongqing, Hubei, Guangdong, and Shenzhen, since 2011. Based on the data availability of listed companies, first, this paper organizes the data of all listed companies in the pilot region from 2008 to 2019. Second, the enterprises participating in carbon trading are identified, and the data of these enterprises come from the relevant pilot lists published by each government. Finally, the missing data are obtained by consulting relevant information to supplement.

The relevant variables are from the CSMAR database. Among them, the green patent data are from the website of the State Intellectual Property Office (SIPO). At the same time, according to the “Green List of International Patent Classification” introduced by the World Intellectual Property Organization (WIPO) in 2010, the patent classification number is used to determine whether the patents applied by listed companies belong to green patents [55]. Finally, Stata/MP 14.0 software was used to process and statistically analyze the data as follows: (1) deleting the residual data; (2) excluding the data of financial and insurance industries; (3) Winsorizing the data to reduce the influence of extreme values. Finally, the data from 264 pilot enterprises were obtained.

3.2. Definition of Variables

Green innovation: The mainstream research methods mostly use the number of patent applications as a measure of green innovation [56]. Therefore, this paper firstly recognizes the level of green patents based on the classification number of patents according to WIPO’s definition of green patents. Secondly, for the classification of exploratory and exploitative innovations, it is usually considered that the technological impact is in the period of 5 years [57]. Therefore, drawing on the method of other scholars to take the first four digits of the IPC classification number of the patent as a guideline, assuming that the patent classification number of the patent applied by the enterprise in the current year was repeated in the period of the previous five years, then it is defined as exploitative innovation, or else it is defined as exploratory innovation [58,59]. In addition, drawing on other scholars’ studies [60], exploratory green innovation is multiplied by exploitative innovation to measure the innovation equilibrium indicator.

Peer pressure: Peer pressure among enterprises is affected by the intensity of industry competition [60]. This article refers to previous research and uses the Lerner index to mitigate the corresponding competitive intensity [61].

Control variables: Referring to previous studies [11], firm size, capital structure, equity concentration, years of operation, and growth capacity are included. The following is in general terms: (1) Firm Size—the larger the firm’s asset size, the stronger its economic strength, and the more capital it has to engage in green innovation activities; (2) Liability—the higher the firm’s debt-to-asset ratios, the more it hinders the firm from investing in green innovation; (3) Firm Age—the longer the firm has been established, the higher the firm’s own ability to control its innovation risks; (4) Growth Ability—the higher the growth ability, the faster the asset accumulation speed and the stronger the risk resistance ability; (5) Nature of Equity—with a different nature of equity, corporate innovation decisions have differences; (6) Equity Concentration—this involves using the proportion of shares held by the first largest shareholder; (7) Percentage of Independent Directors—independent directors can provide reasonable advice for corporate innovation decisions; (8) Capital Intensity—this represents the enterprise risk level and cost of capital, which affects the enterprise’s green innovation investment; (9) Profitability—the larger the value, the stronger the profitability, and the more conducive to the enterprise to increase green innovation investment; (10) Board Activity—the number of board of directors’ meetings is taken as a logarithmic number. At the same time, to reduce the impact of industry and the economic cycle on corporate green innovation, the industry and year of the enterprise control the specific description of Table 1.

Table 1. Description of variables.

| Variable Name | Definition |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Green Innovation | Logarithmic number of corporate green patent applications |
| Exploratory Innovation | Logarithmic number of green patents with patent classification numbers not repeated in the previous 5 years |
| Exploitative Innovation | Logarithmic number of green patents with patent classification number repeating in the previous 5 years |
| Innovation Equilibrium | The logarithm of exploratory green innovation \times the logarithm of exploitative green innovation |
| Peer Pressure | Operating income of individual company/total operating income of the industry \times cumulative Lerner index of individual stocks |
| Firm Size | Logarithmic total assets of enterprises |
| Liability | Total Liabilities/Total Assets \times 100% |
| Firm Age | Logarithmic number of years of establishment |
| Growth Ability | Total Assets Growth Rate |
| Nature of Equity | State-owned enterprises are assigned a value of 1, and non-state-owned enterprises are assigned a value of 0 |
| Percentage of Independent Directors | Proportion of independent directors to the number of directors |
| Equity Concentration | The shareholding ratio of the top 1 shareholder |
| Capital Intensity | Total Assets/Gross Sales \times 100 |
| Profitability | Net Profit/Total Assets \times 100 |
| Board Activity | Logarithmic number of board meetings |

3.3. Design of the Model

The difference-in-differences (DID) method is commonly used to estimate the causal effect of a treatment or policy intervention. This is because the DID method can effectively control time invariance and unobserved heterogeneity, which can reduce the endogeneity of the results. Therefore, this method is used in this paper to analyze the impact of carbon trading on corporate green innovation [62]. First, refer to Hu et al. (2020) and other scholars' studies to set up the treatment and control groups: the treatment group is set as the pilot enterprises in the eight carbon pilot regions, defining $Treat_i = 1$, while the non-pilot enterprises in the pilot regions are set as the control group, with $Treat_i = 0$.

In addition, it is necessary to consider that carbon trading will not have much impact on the control group sample and to ensure that the treatment group and the control group have as many similar characteristics as possible. Therefore, to reduce the bias caused by sample selection, this article first conducts Propensity Score Matching (PSM) on the data year by year and uses the matched samples for empirical evidence. Finally, 120 pilot enterprises were selected as the treatment group and 144 non-pilot enterprises were selected as the control group.

Second, determine the implementation time of carbon trading policy in each region. Due to the different policy unfolding times in each pilot region, referring to other and other scholars' research, set the launch time of the pilot carbon market in Beijing, Shanghai, Shenzhen, Guangdong, and Tianjin to be 2013, and when the enterprises are in these five cities and in 2013 and later, $Time = 1$. The start of the pilot carbon market in Hubei and Chongqing is in 2014, and when the enterprises are in these two cities and in 2014 and later, $Time = 1$, while the start of the carbon market in Fujian is in 2016, and when the enterprises are in the region and in 2016 and later, $Time = 1$; other than that, $Time = 0$. Finally, based on the above settings, the model is constructed:

$$Innovation_{it} = \alpha_0 + \alpha_1 Time_{it} \times Treat_i + \alpha_i \sum Control_{it} + \partial_i + \gamma_t + \epsilon_{it} \quad (1)$$

where

Innovation_{it} represents the green innovation strategy of firm *i* in year *t*, Innovation_{it} includes exploratory innovation and exploitative innovation, Time_{it} × Treat_i is a multi-period difference variable, Time_{it} represents the time of policy implementation, Treat_i is the treatment variable, Control_{it} represents the control variable, γ_t represents the year fixed effect, and ∂_i represents the individual fixed effect. Model (1) tests the impact of carbon trading on corporate green innovation.

4. Data Analysis

4.1. Descriptive Statistics

The descriptive statistics of each variable are shown in Table 2: among them, the mean value of innovation is 0.264, the maximum value is 3.807, the mean value of exploratory innovation is 0.119, and the mean value of exploitative innovation is 0.237, which indicates that the overall level of green innovation technology of enterprises in the pilot region is not high. Enterprises are more inclined to exploitative green innovation and pay less attention to exploratory green innovation, which still has more room for improvement.

Table 2. Descriptive statistics.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|-------------------------------------|------|--------|-----------|--------|--------|
| Green Innovation | 2761 | 0.264 | 0.729 | 0 | 3.807 |
| Exploratory Innovation | 2761 | 0.119 | 0.360 | 0 | 1.792 |
| Exploitative Innovation | 2761 | 0.237 | 0.706 | 0 | 3.761 |
| Peer Pressure | 2761 | 0.026 | 0.053 | 0 | 0.404 |
| Firm Size | 2761 | 22.541 | 1.662 | 19.076 | 27.686 |
| Liability | 2761 | 0.459 | 0.214 | 0.048 | 0.955 |
| Firm Age | 2761 | 2.700 | 0.464 | 0.693 | 3.434 |
| Growth Ability | 2761 | 0.182 | 0.387 | −0.363 | 2.531 |
| Nature of Equity | 2761 | 0.568 | 0.495 | 0 | 1 |
| Percentage of Independent Directors | 2761 | 0.383 | 0.062 | 0.3 | 0.6 |
| Equity Concentration | 2761 | 0.367 | 0.161 | 0.084 | 0.789 |
| Capital Intensity | 2761 | 2.523 | 2.324 | 0.43 | 15.47 |
| Profitability | 2761 | 0.037 | 0.055 | −0.192 | 0.213 |
| Board Activity | 2761 | 2.249 | 0.397 | 1.386 | 3.296 |

The mean value of peer pressure is 0.026 and the standard deviation is only 0.053, which shows that the peer pressure suffered by the enterprises is basically equal. For other variables, 56.8% of the pilot firms are state-owned enterprise samples, with an average debt-to-asset ratio as high as 45.9%, a mean asset growth rate of 18.2%, and a net asset profit of only 3.7%. In addition, the proportion of shares held by the first largest shareholder is 36.7%, and the proportion of independent directors is 38.3%, with a small overall standard deviation, suggesting that there is not much difference between the pilot firms.

4.2. Correlation Analysis of Key Variables

Table 3 presents the results of the Pearson correlation analysis. Notably, the correlation coefficients of all variables, excluding the green innovation indicators, are below 0.4, indicating a weak covariance between these variables. Of particular interest is the positive influence of peer pressure on corporate green innovation, as evidenced in both exploitative and exploratory innovation. However, it is essential to acknowledge the inherent limitations of a correlation analysis, necessitating further validation and robustness checks to substantiate these findings.

Table 3. Correlation coefficients of variables.

| | Green Innovation | Exploratory Innovation | Exploitative Innovation | Peer Pressure | Firm Size | Liability | Firm Age |
|-------------------------------------|------------------|------------------------|-------------------------------------|----------------------|-------------------|---------------|----------------|
| Green Innovation | 1.000 | | | | | | |
| Exploratory Innovation | 0.857 *** | 1.000 | | | | | |
| Exploitative Innovation | 0.984 *** | 0.793 *** | 1.000 | | | | |
| Peer Pressure | 0.233 *** | 0.227 *** | 0.218 *** | 1.000 | | | |
| Firm Size | 0.160 *** | 0.150 *** | 0.162 *** | 0.127 *** | 1.000 | | |
| Liability | 0.105 *** | 0.079 *** | 0.108 *** | 0.027 | 0.431 *** | 1.000 | |
| Firm Age | 0.003 | 0.002 | 0.008 | 0.176 *** | 0.043 ** | 0.144 *** | 1.000 |
| Growth Ability | −0.005 | −0.001 | −0.004 | −0.077 *** | −0.073 *** | −0.124 *** | −0.231 *** |
| Nature of Equity | −0.111 *** | −0.075 *** | −0.110 *** | −0.036 * | 0.393 *** | 0.268 *** | 0.194 *** |
| Percentage of Independent Directors | 0.006 | 0.009 | 0.010 | −0.023 | 0.183 *** | 0.068 *** | −0.206 *** |
| Equity Concentration | 0.045 ** | 0.052 *** | 0.043 ** | 0.010 | 0.312 *** | −0.001 | −0.238 *** |
| Capital Intensity | −0.1388 *** | −0.114 *** | −0.131 *** | −0.033 * | −0.071 *** | −0.112 *** | 0.083 *** |
| Profitability | −0.019 | 0.005 | −0.020 | 0.011 | −0.030 | −0.336 *** | −0.108 *** |
| Board Activity | 0.053 *** | 0.036 * | 0.057 *** | 0.051 *** | 0.181 *** | 0.235 *** | 0.060 *** |
| | Growth Ability | Nature of Equity | Percentage of Independent Directors | Equity Concentration | Capital Intensity | Profitability | Board Activity |
| Growth Ability | 1.000 | | | | | | |
| Nature of Equity | −0.197 *** | 1.000 | | | | | |
| Percentage of Independent Directors | 0.043 ** | −0.105 *** | 1.000 | | | | |
| Equity Concentration | −0.008 | 0.334 *** | 0.091*** | 1.000 | | | |
| Capital Intensity | 0.068 *** | −0.117 *** | −0.030 | −0.124 *** | 1.000 | | |
| Profitability | 0.190 *** | −0.043 ** | −0.011 | 0.143 *** | −0.119 *** | 1.000 | |
| Board Activity | 0.022 | −0.031 | 0.065 *** | −0.175 *** | 0.051 *** | −0.119 *** | 1.000 |

Note: Regression coefficients in the table; *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

4.3. Benchmark Regression

Columns (1)–(3) of Table 4 show the impact of carbon trading policy on pilot enterprises' green innovation strategy and dual innovation based on the inclusion of control variables with firm and year fixed effect controls, respectively. As shown in Table 4, column (1), the coefficients of the multi-period difference variables are significantly positive at the 1% level, indicating that China's carbon trading policy has a positive impact on pilot enterprises' green innovation, which is consistent with Hypothesis 1.

In order to further study the impact on the dual innovation of enterprises, we continue to regress the exploratory green innovation and exploitative green innovation separately on this basis, and the specific results are shown in columns (2) and (3). The coefficient of exploitative green innovation is 0.152, which is significantly positively correlated at the 1% level; the coefficient of exploratory green innovation is significantly positively correlated only at the 10% level. It indicates that carbon trading promotes enterprises' green innovation, but in a short period, to accomplish the effect of carbon emission reduction and avoid regulatory penalties, enterprises pay more attention to exploitative green in-

novation compared with exploratory green innovation, which is basically consistent with Hypotheses H2a and H2b.

Table 4. Benchmark regression and moderating effect results.

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|-----------------------------------------------------------------|----------------------|------------------------|-------------------------|---------------------|------------------------|-------------------------|------------------------|
| | Green Innovation | Exploratory Innovation | Exploitative Innovation | Green Innovation | Exploratory Innovation | Exploitative Innovation | Innovation Equilibrium |
| Time _{it} × Treat _i × Pressure _i | | | | 0.970 (0.589) | 0.936 ** (0.415) | 0.917 (0.567) | |
| Peer Pressure _i | | | | −0.120 (0.158) | −0.097 (0.088) | −0.124 (0.158) | |
| Time _{it} × Treat _i | 0.143 *** (0.046) | 0.050 * (0.026) | 0.152 *** (0.047) | 0.045 (0.071) | −0.045 (0.047) | 0.060 (0.067) | 0.141 ** (0.069) |
| Firm Size | 0.067 ** (0.027) | 0.025 * (0.014) | 0.064 ** (0.027) | 0.067 ** (0.027) | 0.025 * (0.014) | 0.065 ** (0.027) | 0.072 ** (0.035) |
| Liability | −0.103 (0.103) | −0.036 (0.061) | −0.096 (0.100) | −0.102 (0.101) | −0.035 (0.060) | −0.094 (0.098) | −0.116 (0.169) |
| Firm Age | 0.020 (0.075) | −0.023 (0.046) | 0.041 (0.074) | 0.018 (0.074) | −0.025 (0.046) | 0.039 (0.074) | 0.000 (0.125) |
| Growth Ability | −0.006 (0.013) | −0.002 (0.011) | 0.001 (0.012) | −0.006 (0.013) | −0.002 (0.011) | −0.000 (0.012) | 0.022 (0.025) |
| Nature of Equity | −0.013 (0.031) | 0.018 (0.035) | −0.027 (0.043) | −0.004 (0.030) | 0.026 (0.036) | −0.019 (0.042) | −0.013 (0.037) |
| Percentage of Independent Directors | −0.226 (0.218) | −0.138 (0.129) | −0.143 (0.222) | −0.202 (0.216) | −0.116 (0.128) | −0.121 (0.221) | −0.046 (0.291) |
| Equity Concentration | −0.137 (0.219) | −0.067 (0.119) | −0.104 (0.205) | −0.149 (0.222) | −0.080 (0.120) | −0.115 (0.208) | −0.308 (0.320) |
| Capital Intensity | −0.002 (0.004) | 0.002 (0.002) | −0.002 (0.004) | −0.001 (0.004) | 0.002 (0.002) | −0.002 (0.004) | −0.000 (0.005) |
| Profitability | 0.149 (0.197) | 0.192 * (0.113) | 0.144 (0.195) | 0.137 (0.199) | 0.179 (0.113) | 0.133 (0.196) | 0.412 * (0.239) |
| Board Activity | 0.024 (0.023) | 0.011 (0.016) | 0.016 (0.023) | 0.025 (0.023) | 0.012 (0.016) | 0.017 (0.023) | −0.027 (0.038) |
| Year | | | | Control | | | |
| Industry | | | | Control | | | |
| Observations | 2761 | 2761 | 2761 | 2761 | 2761 | 2761 | 2761 |
| R-squared | 0.045 | 0.018 | 0.050 | 0.049 | 0.024 | 0.053 | 0.024 |

Note: Regression coefficients in the table; *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

Next, based on model (1), we examine how the carbon trading policy affects the equilibrium between exploratory green innovation and exploitative green innovation in enterprises. The empirical results are shown in column (7) of Table 4. The results show that the regression coefficient is 0.141 and is significant at the 5% level. It shows that carbon trading has a significant promoting effect on enterprises to balance exploratory green innovation and exploitative green innovation. That is to say, companies facing the impact of carbon trading policies need to take into account both short-term and long-term innovation and development, not only to quickly fulfill the commitment of emission control and reduction but also to establish a competitive advantage for future green development. Therefore, managers are encouraged to focus on both exploratory green innovation and exploitative green innovation and to pay more attention to both types of innovations.

In addition, this article uses the Variance Inflation Factor (VIF) to test whether the model has multicollinearity problems. The final result of VIF is 1.95, which is much smaller than 10, so there is no multicollinearity problem (results are limited to space and not shown).

4.4. Moderating Effects Test

To further verify the role of peer pressure in the relationship between carbon trading and corporate green innovation, based on model (1), the following regression model is constructed to verify the moderating effect of the peer effect:

$$\text{Innovation}_{it} = \beta_0 + \beta_1 \text{Time}_{it} \times \text{Treat}_i + \beta_2 \text{Pressure}_i + \beta_3 \text{Time}_{it} \times \text{Treat}_i \times \text{Pressure}_i + \beta_i \sum \text{Control}_{it} + \partial_i + \gamma_t + \epsilon_{it} \quad (2)$$

Among them, Innovation_{it} represents the green innovation strategy of enterprise i in year t , Innovation_{it} includes exploratory innovation and exploitative innovation, i represents the enterprise, t represents the year, $\text{Time}_{it} \times \text{Treat}_i$ is the intersection of time variables and treatment variables, Control_{it} represents the control variable, and γ_t represents year fixed effects and ∂_i represents individual fixed effects. The regression results are shown in Table 4.

In Table 4, columns (4)–(6) test the impact of carbon trading policy on firms' green innovation and dual green innovation under peer pressure. According to the empirical results, it can be seen that the coefficients of the cohort pressure cross-terms are all positive. Among them, exploratory green innovation is significant at a 5% level, but the coefficients of green innovation and exploitative green innovation are not significant. It indicates that under the pressure of peer group effects, carbon trading policy plays a significant positive role in the exploratory green innovation of enterprises, but has little effect on the exploitative green innovation and overall green innovation of enterprises, which is basically consistent with hypothesis H4.

4.5. Tests for Parallel Trends and Dynamic Effects

The basic requirement of multi-period DID as an effective means of policy evaluation is that the experimental and control groups satisfy the parallel trend assumption, i.e., the change trends of the experimental and control groups are consistent before the government carries out the carbon trading policy. Therefore, this paper is inspired by the previous work to construct the interaction term between the year and treatment variable by taking the first 4 years of carbon trading policy as the benchmark of comparison [63]. In addition, considering the problem of multicollinearity, the variables in the year before the implementation of the policy are excluded from existing studies. If the model satisfies the parallel trend assumption, then the coefficient of the interaction term before the implementation of the carbon trading policy is not significant, while there is a significant difference after the implementation of the carbon trading policy.

The results of the parallel trend hypothesis test are shown in Figure 1 below, where none of the coefficients of the interaction terms are significant in the first five years of policy implementation. However, it is worth noting that the exploratory green innovation passed the significance test at the 5% level in 2015, while the exploitative green innovation also passed the significance test at the 10% level in 2015. This suggests that the green innovations in the experimental and control groups satisfy the parallel trend hypothesis, but due to information asymmetry, resulting in a lag in the market response, managers often begin to launch green innovation actions only after receiving policy warnings, resulting in a later policy effect. In the long run, the coefficients of the cross-terms are all significantly positive after the enactment of the carbon trading policy, which indicates that the carbon trading policy has a long-term impact on the green innovation behavior of enterprises.

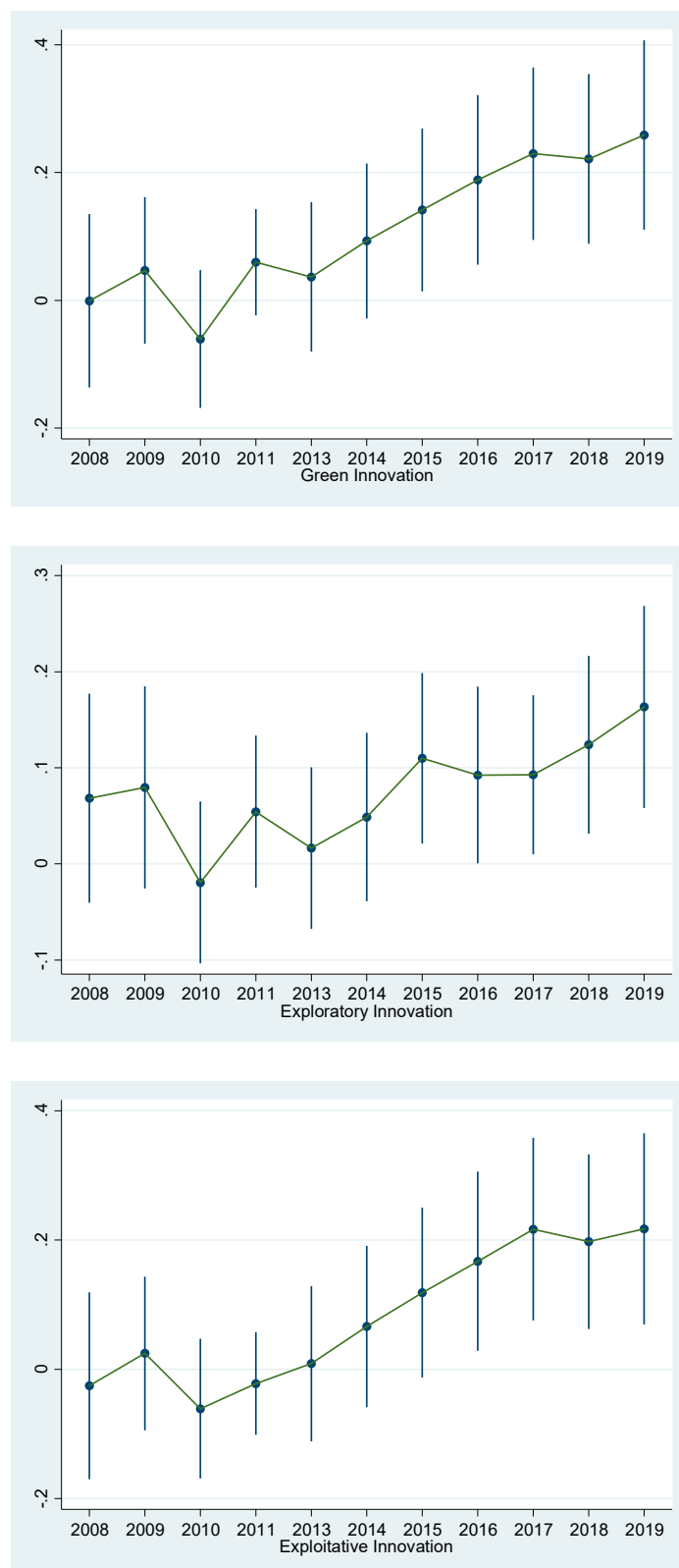


Figure 1. Parallel trend test results.

4.6. Robustness Tests

4.6.1. Control the Time Variability of Carbon Trading Policies

In the benchmark regression, carbon trading has been gradually carried out on pilot projects since 2013. Considering that the policy may have signal warnings and cumulative

learning effects, the regions that will carry out carbon trading pilots in the future can adapt to this mechanism in advance. Therefore, the samples of enterprises in the Hubei, Chongqing, and Fujian regions were screened out, and there was a significant gap in the green innovation level of enterprises in the five pilot areas of Beijing, Shanghai, Shenzhen, Guangdong, and Tianjin. The empirical results are shown in Table 5, columns (1)–(3), and the coefficients $\text{Time}_{it} \times \text{Treat}_i$ are positive, although the coefficients of green exploratory innovation are not significant; considering the impact of the exploratory innovation input cycle, its output effect has a lag, which is negligible, so it is basically consistent with the results of Hypotheses H1 and H2b mentioned above. The coefficient on exploratory green innovation in columns (4)–(6) is significantly positive. It indicates that firms pay more attention to exploratory green innovation under peer pressure, which is consistent with hypothesis H4 and results are robust.

Table 5. Results of robustness test (1).

| Variables | (1) Green Innovation | (2) Exploratory Innovation | (3) Exploitative Innovation | (4) Green Innovation | (5) Exploratory Innovation | (6) Exploitative Innovation |
|-------------------------------------------------------------------|----------------------------|----------------------------------|-----------------------------------|----------------------------|----------------------------------|-----------------------------------|
| $\text{Time}_{it} \times \text{Treat}_i \times \text{Pressure}_i$ | | | | 0.867 (0.601) | 0.941 ** (0.421) | 0.811 (0.577) |
| Pressure_i | | | | −0.155 (0.185) | −0.137 (0.101) | −0.124 (0.183) |
| $\text{Time}_{it} \times \text{Treat}_i$ | 0.118 ** (0.049) | 0.024 (0.027) | 0.137 *** (0.049) | 0.032 (0.074) | −0.071 (0.046) | 0.056 (0.071) |
| Firm Size | 0.079 ** (0.036) | 0.032 (0.019) | 0.072 ** (0.035) | 0.081 ** (0.036) | 0.034 * (0.019) | 0.073 ** (0.036) |
| Liability | 0.001 (0.126) | 0.011 (0.073) | −0.012 (0.123) | −0.002 (0.125) | 0.008 (0.072) | −0.015 (0.122) |
| Firm Age | 0.000 (0.079) | −0.022 (0.049) | 0.021 (0.079) | −0.002 (0.079) | −0.025 (0.049) | 0.019 (0.079) |
| Growth Ability | −0.002 (0.015) | 0.001 (0.014) | 0.004 (0.013) | −0.003 (0.016) | 0.000 (0.014) | 0.003 (0.014) |
| Nature of Equity | −0.007 (0.025) | −0.011 (0.011) | −0.002 (0.025) | −0.003 (0.025) | −0.007 (0.017) | 0.002 (0.024) |
| Percentage of Independent Directors | −0.437 * (0.231) | −0.266 ** (0.135) | −0.364 (0.228) | −0.414 * (0.229) | −0.240 * (0.135) | −0.342 (0.227) |
| Equity Concentration | −0.194 (0.299) | −0.140 (0.161) | −0.150 (0.280) | −0.206 (0.304) | −0.154 (0.163) | −0.162 (0.285) |
| Capital Intensity | 0.000 (0.005) | 0.003 (0.003) | −0.000 (0.004) | 0.000 (0.005) | 0.003 (0.003) | 0.000 (0.004) |
| Profitability | 0.186 (0.238) | 0.257 * (0.141) | 0.229 (0.234) | 0.172 (0.241) | 0.240 * (0.141) | 0.214 (0.236) |
| Board Activity | 0.034 (0.024) | 0.014 (0.019) | 0.032 (0.024) | 0.035 (0.024) | 0.015 (0.019) | 0.032 (0.024) |
| Observations | 2353 | 2353 | 2353 | 2353 | 2353 | 2353 |
| R-squared | 0.045 | 0.018 | 0.050 | 0.048 | 0.024 | 0.053 |
| Year fixed effects | | | | control | | |
| Corporate fixed effects | | | | control | | |

Note: Regression coefficients in the table; *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

4.6.2. Exclude the Impact of the SO₂ Emissions Trading Pilot Policy

Since 2007, the Chinese government has approved 11 provinces and municipalities, including Hubei, Chongqing, and Zhejiang, to conduct pilot SO₂ emissions trading. The mechanism is similar to carbon trading, i.e., to control SO₂ emissions through market incentives. To avoid the impact of this policy on this study, this paper excludes the enterprises located in the SO₂ emissions trading pilot areas and regresses the sample again. The empirical results are shown in columns (1)–(3) of Table 6, which show that the coefficients $\text{Time}_{it} \times \text{Treat}_i$ are all positive, and the coefficients are positive for exploratory green innovations, but not significant, taking into account the impact of exploratory green innovations' large inputs and long cycles, and their output effects have a certain lag, and thus can be ignored. Therefore, the experimental results of H1 and H2b are still robust. The results of hypothesis H4 are verified in columns (4)–(6), and the coefficients of the cross-terms of all three are significantly positive under the influence of peer pressure, which again proves the robustness of the empirical results.

Table 6. Results of robustness test (2).

| Variables | (1) Green Innovation | (2) Exploratory Innovation | (3) Exploitative Innovation | (4) Green Innovation | (5) Exploratory Innovation | (6) Exploitative Innovation |
|-------------------------------------------------------------------|----------------------------|----------------------------------|-----------------------------------|----------------------------|----------------------------------|-----------------------------------|
| $\text{Time}_{it} \times \text{Treat}_i \times \text{Pressure}_i$ | | | | 1.113 * (0.639) | 1.068 ** (0.437) | 1.077 * (0.622) |
| Peer Pressure _i | | | | −0.117 (0.177) | −0.117 (0.097) | −0.103 (0.176) |
| $\text{Time}_{it} \times \text{Treat}_i$ | 0.132 *** (0.048) | 0.033 (0.027) | 0.147 *** (0.049) | 0.020 (0.074) | −0.074 (0.047) | 0.039 (0.072) |
| Firm Size | 0.072 ** (0.033) | 0.029 (0.018) | 0.066 ** (0.033) | 0.073 ** (0.033) | 0.030 * (0.018) | 0.067 ** (0.033) |
| Liability | −0.017 (0.117) | −0.002 (0.068) | −0.023 (0.114) | −0.017 (0.115) | −0.003 (0.067) | −0.024 (0.112) |
| Firm Age | −0.004 (0.078) | −0.028 (0.048) | 0.019 (0.077) | −0.008 (0.077) | −0.031 (0.048) | 0.015 (0.077) |
| Growth Ability | −0.002 (0.014) | 0.002 (0.012) | 0.002 (0.012) | −0.002 (0.014) | 0.001 (0.013) | 0.002 (0.013) |
| Nature of Equity | −0.030 (0.036) | −0.018 (0.016) | −0.023 (0.035) | −0.024 (0.035) | −0.012 (0.020) | −0.017 (0.034) |
| Percentage of Independent Directors | −0.427 * (0.228) | −0.259 * (0.133) | −0.355 (0.225) | −0.397* (0.225) | −0.231 * (0.132) | −0.326 (0.224) |
| Equity Concentration | −0.156 (0.278) | −0.114 (0.151) | −0.122 (0.260) | −0.176 (0.283) | −0.134 (0.153) | −0.142 (0.266) |
| Capital Intensity | 0.002 (0.004) | 0.003 (0.002) | 0.001 (0.004) | 0.002 (0.004) | 0.003 (0.002) | 0.002 (0.004) |
| Profitability | 0.168 (0.222) | 0.243 * (0.130) | 0.195 (0.218) | 0.150 (0.225) | 0.226 * (0.130) | 0.177 (0.221) |
| Board Activity | 0.030 (0.023) | 0.015 (0.018) | 0.025 (0.023) | 0.031 (0.024) | 0.015 (0.018) | 0.025 (0.023) |
| Observations | 2455 | 2455 | 2455 | 2455 | 2455 | 2455 |
| R-squared | 0.047 | 0.019 | 0.051 | 0.052 | 0.026 | 0.056 |
| Year fixed effects | | | | control | | |
| Corporate fixed effects | | | | control | | |

Note: Regression coefficients in the table; *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

4.6.3. Exclude the Impact of Low-Carbon Pilot Cities

In addition to the carbon trading pilot policy, the Chinese government also successively proposed the pilot work of low-carbon cities in 2010, 2012, and 2017. This policy requires each pilot region to accelerate the R&D and promotion of low-carbon technology innovation in order to accelerate the green development of cities. Therefore, to eliminate the bias brought by low-carbon cities, this paper treats low-carbon cities as dummy variables, i.e., if city n is selected as a low-carbon city pilot in year t , assign a value of 1, and otherwise 0. Since Xiamen is on the list of the first batch of low-carbon pilot cities, the policy will produce some early warnings on the transformation of the entire Fujian Province's low-carbon economy, and therefore Fujian Province was set to be controlled in 2010, and regressed again. The final empirical evidence is shown in Table 7, in which the $\text{Time}_{it} \times \text{Treat}_i$ coefficients are all significantly positive at a certain level, which is basically consistent with H1 and H2. The coefficients of the cross-terms of exploratory green innovations in columns (4)–(6) are significantly positive, indicating that firms pay more attention to exploratory green innovations under the cohort pressure, which is consistent with the results of H4, and once again proves that the conclusions are robust.

Table 7. Results of robustness test (3).

| Variables | (1) Green Innovation | (2) Exploratory Innovation | (3) Exploitative Innovation | (4) Green Innovation | (5) Exploratory Innovation | (6) Exploitative Innovation |
|-------------------------------------------------------------------|----------------------------|----------------------------------|-----------------------------------|----------------------------|----------------------------------|-----------------------------------|
| $\text{Time}_{it} \times \text{Treat}_i \times \text{Pressure}_i$ | | | | 0.969 (0.589) | 0.936 ** (0.415) | 0.916 (0.567) |
| Peer Pressure _{<i>i</i>} | | | | −0.120 (0.157) | −0.097 (0.087) | −0.125 (0.158) |
| $\text{Time}_{it} \times \text{Treat}_i$ | 0.143 *** (0.046) | 0.050 * (0.026) | 0.152 *** (0.047) | 0.045 (0.071) | −0.045 (0.047) | 0.060 (0.067) |
| Firm Size | 0.067 ** (0.027) | 0.025 * (0.014) | 0.065 ** (0.027) | 0.068** (0.027) | 0.025* (0.014) | 0.065 ** (0.027) |
| Liability | −0.104 (0.103) | −0.037 (0.061) | −0.097 (0.100) | −0.103 (0.101) | −0.035 (0.060) | −0.095 (0.098) |
| Firm Age | 0.019 (0.075) | −0.024 (0.046) | 0.041 (0.074) | 0.017 (0.074) | −0.025 (0.046) | 0.039 (0.074) |
| Growth Ability | −0.006 (0.013) | −0.002 (0.011) | 0.000 (0.012) | −0.007 (0.013) | −0.002 (0.011) | −0.000 (0.012) |
| Nature of Equity | −0.013 (0.031) | 0.018 (0.036) | −0.027 (0.043) | −0.005 (0.030) | 0.025 (0.036) | −0.019 (0.042) |
| Percentage of Independent Directors | −0.223 (0.218) | −0.136 (0.129) | −0.140 (0.221) | −0.199 (0.215) | −0.114 (0.128) | −0.117 (0.220) |
| Equity Concentration | −0.137 (0.219) | −0.068 (0.119) | −0.104 (0.205) | −0.150 (0.222) | −0.080 (0.121) | −0.115 (0.208) |
| Capital Intensity | −0.002 (0.004) | 0.002 (0.002) | −0.002 (0.004) | −0.001 (0.004) | 0.002 (0.002) | −0.002 (0.004) |
| Profitability | 0.147 (0.197) | 0.191 * (0.113) | 0.142 (0.195) | 0.134 (0.199) | 0.177 (0.113) | 0.131 (0.196) |
| Board Activity | 0.024 (0.023) | 0.011 (0.016) | 0.016 (0.023) | 0.025 (0.023) | 0.012 (0.016) | 0.017 (0.023) |
| City * year fixed effects | 0.024 (0.024) | 0.014 (0.018) | 0.022 (0.023) | 0.024 (0.024) | 0.014 (0.017) | 0.022 (0.023) |
| Observations | 2761 | 2761 | 2761 | 2761 | 2761 | 2761 |
| R-squared | 0.046 | 0.018 | 0.050 | 0.049 | 0.024 | 0.053 |
| Year fixed effects | | | | control | | |
| Corporate fixed effects | | | | control | | |

Note: Regression coefficients in the table; *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

4.6.4. Replace the Peer Pressure Variable

Considering that the intensity of industry competition is an important reason for inducing peer pressure, this paper further verifies the robustness of the empirical results by introducing the Helfinda index to replace the Lerner index. The empirical results are shown in Table 8. The $\text{Time}_{it} \times \text{Treat}_i$ coefficients in models (1)–(3) are all significantly positive, which is consistent with the empirical results of H1 and H2. In columns (4) to (6), the coefficients of the three cross-terms are all positive, but only exploratory green innovation passes the significance test, which is basically consistent with the previous empirical results.

Table 8. Results of Robustness Test (4)-HHI.

| Variables | (1) Green Innovation | (2) Exploratory Innovation | (3) Exploitative Innovation | (4) Green Innovation | (5) Exploratory Innovation | (6) Exploitative Innovation |
|-------------------------------------------------------------------|----------------------------|----------------------------------|-----------------------------------|----------------------------|----------------------------------|-----------------------------------|
| $\text{Time}_{it} \times \text{Treat}_i \times \text{Pressure}_i$ | | | | 0.970 (0.589) | 0.936 ** (0.415) | 0.917 (0.567) |
| Peer Pressure _i | | | | −0.120 (0.158) | −0.097 (0.088) | −0.124 (0.158) |
| $\text{Time}_{it} \times \text{Treat}_i$ | 0.143 *** (0.046) | 0.050 * (0.026) | 0.152 *** (0.047) | 0.045 (0.071) | −0.045 (0.047) | 0.060 (0.067) |
| Firm Size | 0.067 ** (0.027) | 0.025 * (0.014) | 0.064 ** (0.027) | 0.067 ** (0.027) | 0.025 * (0.014) | 0.065 ** (0.027) |
| Liability | −0.103 (0.103) | −0.036 (0.061) | −0.096 (0.100) | −0.102 (0.101) | −0.035 (0.060) | −0.094 (0.098) |
| Firm Age | 0.020 (0.075) | −0.023 (0.046) | 0.041 (0.074) | 0.018 (0.074) | −0.025 (0.046) | 0.039 (0.074) |
| Growth Ability | −0.006 (0.013) | −0.002 (0.011) | 0.001 (0.012) | −0.006 (0.013) | −0.002 (0.011) | −0.000 (0.012) |
| Nature of Equity | −0.013 (0.031) | 0.018 (0.035) | −0.027 (0.043) | −0.004 (0.030) | 0.026 (0.036) | −0.019 (0.042) |
| Percentage of Independent Directors | −0.226 (0.218) | −0.138 (0.129) | −0.143 (0.222) | −0.202 (0.216) | −0.116 (0.128) | −0.121 (0.221) |
| Equity Concentration | −0.137 (0.219) | −0.067 (0.119) | −0.104 (0.205) | −0.149 (0.222) | −0.080 (0.120) | −0.115 (0.208) |
| Capital Intensity | −0.002 (0.004) | 0.002 (0.002) | −0.002 (0.004) | −0.001 (0.004) | 0.002 (0.002) | −0.002 (0.004) |
| Profitability | 0.149 (0.197) | 0.192 * (0.113) | 0.144 (0.195) | 0.137 (0.199) | 0.179 (0.113) | 0.133 (0.196) |
| Board Activity | 0.024 (0.023) | 0.011 (0.016) | 0.016 (0.023) | 0.025 (0.023) | 0.012 (0.016) | 0.017 (0.023) |
| Observations | 2761 | 2761 | 2761 | 2761 | 2761 | 2761 |
| R-squared | 0.045 | 0.018 | 0.050 | 0.049 | 0.024 | 0.053 |
| Year fixed effects | | | | control | | |
| Corporate fixed effects | | | | control | | |

Note: Regression coefficients are shown in the table; *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

5. Conclusions and Recommendations

5.1. Conclusions and Discussion

Taking the 2013 carbon trading pilot as the research background, this paper explores how carbon trading will affect the green innovation of Chinese enterprises. By adopting the multi-period DID method, the following conclusions are drawn from the samples of carbon trading pilot enterprises from 2008 to 2019: carbon trading is indeed conducive to corporate green innovation, which not only shows in exploitative green innovation, but also has an obvious promotion effect on corporate exploratory green innovation, and the two maintain a relatively balanced situation. Meanwhile, peer pressure has a significant positive moderating effect on carbon trading and exploratory green innovation, but not on exploitative green innovation.

It is easy to understand that the problem of global warming has become more and more serious in recent years, and more countries have participated in global governance. China naturally assumes important environmental governance responsibilities. Therefore, to achieve low-carbon development, the Chinese government continues to implement various policies to encourage innovation to mobilize the enthusiasm of enterprises for green innovation. In addition, affected by the innovation incentive effect, pilot companies can fulfill their low-carbon emission commitments through green technology innovation. They can not only freely buy and sell carbon emission credits in the carbon trading market and obtain additional income, but they can also show a positive social image to stakeholders such as investors and the public, increase customer loyalty, and stabilize their market position, which is beneficial to corporate development.

In a short period, the pilot enterprises, when facing the impact of carbon trading, have difficulty adapting to the harsh regulatory environment for a while. Therefore, to meet the current requirements of controlling carbon emissions as soon as possible and to avoid being penalized by the regulation, the enterprises will pay more attention to the short and quick exploitative green innovations, such as the waste treatment, the improvement in the efficiency of the energy use, and the improvement in the clean technology, and other measures.

However, in the long run, building a carbon market is a general trend, and China's carbon trading system will be continuously improved in the future. Therefore, managers will show forward-looking awareness of green innovation, although exploratory green innovation requires radical technological change, high risk and uncertainty, and higher requirements for knowledge, talent, and capital investment of the enterprise; the enterprise is only limited to the exploitation of a green innovation company that may end up with the ability to trap [45]. Especially a low-threshold, low-technology approach will soon be imitated and copied to catch up with the pilot companies, and ultimately lose a competitive advantage. Therefore, investing in core technology and building barriers to green innovation is the long-term way [64], so the carbon trading policy can also have a certain incentive effect on the exploratory green innovation of enterprises. Therefore, in the face of the impact of carbon trading policy, enterprises pay attention to the exploitative green innovation to meet the requirements of controlling carbon emissions but also take into account the exploratory green innovation to form technological barriers, and push managers to pay more attention to both types of innovation.

Finally, enterprises are not independent individuals, but dynamic competition and synergistic development among enterprises. When facing the impact of carbon trading policies, green innovation among competitors in the same industry is a two-way influence. Following the principle of "action–feedback–action", enterprises are forced to participate in the atmosphere of the innovation competition. At this time, managers will change the enterprise's green innovation decision, reduce the focus on exploitative green innovation, try to break through the "patent bubble" trap [65], and turn to exploratory green innovation to ensure the value, scarcity, and difficulty of the imitation of technology, and form a sustainable green first-mover advantage. Therefore, under the pressure of a cohort, enterprises will pay more attention to exploratory green innovation.

5.2. Research Recommendations

Policy recommendations:

Continuously improve the carbon trading mechanism and mobilize the enthusiasm of enterprises for green innovation. Carbon trading policy does have a positive incentive effect on corporate green innovation. Therefore, as an effective means of environmental governance, it should gradually include more high-polluting and high-energy-consuming industries, give full play to the main role of the market incentive mechanism, and mobilize corporate enthusiasm for green innovation. Promote regional green development to achieve the goal of “carbon peaking and carbon neutrality” faster. In addition, refine the criteria for identifying green innovation and break the patent bubble. At present, to fulfill their commitment to reduce carbon emissions within this year, some enterprises tend to adopt short and quick exploitation innovations, and the economic spillover effect is not obvious. Therefore, while playing the role of the carbon market, the government can consider optimizing the green innovation patent identification criteria and refining the incentive policy for exploitative green innovations and exploratory innovations, to reduce the patent bubble.

Managerial recommendations:

Managers must be forward-looking and alert to dynamic competition. As a future development trend of the carbon trading market, it is difficult for any company to be immune, especially as companies in the same industry are always in dynamic competition, and it is difficult to maintain long-term competitive advantages only by imitation, optimization, and other methods. At the same time, managers should have a sense of urgency, focus on exploratory innovation investment, and form technical barriers to seize the initiative in market competition.

5.3. Limitations and Future Prospects

The shortcomings of this study include the following: First, carbon emissions trading policy belongs to the national level, but this article focuses on corporate innovation behavior and belongs to the micro-level. Therefore, this study uses key enterprises in the pilot area as a sample. Although the sample is representative, it may deviate from the reality to a certain extent. With the improvement in the carbon market system, future research can further study the impact mechanism of carbon emission trading policies on corporate green innovation using national carbon market samples. Second, the impact of carbon trading policies on corporate green innovation behavior is complex and may be influenced by other factors, which are not discussed because of space. In the future, we can continue to explore the deep-seated mechanism of carbon policies in corporate green innovation behavior, thereby providing a theoretical basis for the improvement in the carbon market system. Third, the research focuses on the impact of corporate green innovation behavior and does not translate it into the actual effect of controlling carbon emissions. Future research can explore this aspect in depth.

Author Contributions: Conceptualization, S.L. and Y.L.; Methodology, S.L.; Software, S.L.; Writing—original draft preparation, S.L.; Writing—review and editing, S.L.; Visualization, Y.L. Funding acquisition, Y.L. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by Humanities and Social Sciences Research Project of the Ministry of Education (Grant number 20YJA630039).

Institutional Review Board Statement: An ethical approval does not apply to this article.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original data presented in the study are openly available in the CSMAR database.

Acknowledgments: The conceptualization and design of the study were collaboratively developed by all authors. The initial draft of the manuscript was composed by Shanshan Liu, with subsequent versions receiving insightful feedback from all contributors. We thank Yugang Li for his comments on the manuscript. In addition, we are grateful to Jintao Zhang for his valuable suggestions, and his patience. Finally, we are very grateful to our English major friend Kelly for carefully revising and polishing our article and helping us improve our English writing skills.

Conflicts of Interest: The authors declare no conflict of interest.

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