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The Influence of the Policy of Replacing Environmental Protection Fees with Taxes on Enterprise Green Innovation—Evidence from China's Heavily Polluting Industries

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Abstract: This paper analyzes the impact of the policy of replacing environmental protection "fees" with "taxes" on enterprise green innovation based on the Chinese A-share listed companies sample from 2015 to 2019. This paper tries to analyze the factors that may affect the level of green innovation of enterprises and the ability of enterprise green innovation (GI) under the background of the implementation of this policy. This paper adopts the difference-in-differences method (DID), takes 1 January 2018 as the time variable demarcation boundary and uses the heavily polluting industry as the dummy variable boundary, conducts group research on the experimental variables, and observes and analyzes the impact of heavily polluting industries and non-heavy pollution before and after the implementation of the policy. It is found that the policy significantly improves green innovation and the R&D efficiency of green innovation of enterprises in heavy pollution industries. Further research reveals that after the implementation of the policy, large enterprises and private enterprises, compared with SMEs and state-owned enterprises, lay more stress on improving green innovation technology. In the end, it examines the relationship between senior executives' academic research experience and enterprises' green innovation and finds that senior executives' academic research experience can not only promote green innovation, but also improve the R&D efficiency of green innovation. The research results of this paper provide a theoretical basis for decision makers and enterprise management in formulating rules and managing enterprises.

Keywords: the policy of replacing environmental protection fees with taxes; green innovation; senior executives' academic research experience; policy effect introduction

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1. Introduction

With the rapid development of China's economy, science, and technology, urbanization and industrialization have also accelerated. In the process of development, the ecological environment is inevitably destroyed. Against this backdrop, China urgently needs a win–win path of innovative and green development. Therefore, since the 13th Five-Year Plan, China has been promoting environmental protection and pollution control. The report to the 19th National Congress of the Communist Party of China (CPC) [1] points out that in the development concept "lucid waters and lush mountains are as valuable as mountains of gold and silver" must be established and put into practice, and innovative development must be pursued.

According to the report of the 19th National Congress of the CPC, "China will raise the standards for pollutant discharge, strengthen the responsibility of polluters, and improve systems for environmental credit evaluation, mandatory disclosure of information, severe punishment, and heavy fines. An environmental governance system is to be established in which the government plays the leading role, enterprises are the main participants, and social organizations and the public participate".

After a long and arduous exploration of environmental protection and taxation in China, the *Environmental Protection Tax Law of the People's Republic of China* came into force in China on 1 January 2018. The enactment of the environmental protection tax law is a major measure to implement the requirements of the third and fourth plenary sessions of the 18th CPC Central Committee, to "promote environmental protection by replacing fees with taxes" and to "protect the ecological environment with a strict legal system". It is of great significance to protect and improve the environment, reduce pollutant discharge, and promote ecological progress.

According to the principle of shifting the tax burden, the *Environmental Protection Tax Law* tries to realize the smooth transfer from the pollutant discharge fee system to the environmental protection tax system. The differences between the two systems are as follows. First of all, they are of different legal ranks.

Regulation on Pollution discharge Fee Collection, Usage, and Management is administrative regulation, and the fees collected according to the regulation belong to administrative charges. The Environmental Protection Tax Law is China's first tax law since the principle of statutory taxation was established in March 2015, and thus has the highest legal effect. The reform of "fees" to "taxes" reflects the authority of law and the rigidity of tax, and when the problems of arrears and omission of payment should arise, there is a law to abide by. Secondly, they are collected by different departments. According to the *Regulation on Pollutant discharge Fee Collection, Usage, and Management*, after the amount of pollutant discharge fees is determined, the environmental protection authorities responsible for the verification of pollutant discharge shall serve the pollutant discharge fee payment notice to the polluters. Polluters shall pay the pollution fee at the designated commercial bank within 7 days upon receiving the notice of payment. According to the *Environmental Protection Tax Law*, environmental protection tax shall be collected and administered by tax authorities in accordance with the relevant provisions of the *Law of the People's Republic of China on the Administration of Tax Collection* and monitored and administered by environmental protection authorities. The tax collection and management takes the following mode: The enterprise is responsible for declaration, the tax department for collection, and the environmental protection department for coordination; information is shared. When the pollutant discharge fee was collected by local environmental protection departments, there were such phenomena as "collection based on agreement" and "arbitrary reduction". After environmental protection "fees" are changed into "taxes'; they are to be evaluated by the environmental protection department and collected by the tax department, thus paying environmental protection "taxes' is implemented more effectively. Thirdly, in terms of preferential policies for emission reduction, with environmental protection tax, the grade of tax relief for enterprise emission reduction has been increased. Under the pollutant discharge fee system, only one tax break for emission reduction is provided, while with the *Environmental Protection Tax Law*, one more is added, making the latter more flexible. Fourthly, in terms of the purpose of promulgation, the *Regulation on Pollutant discharge Fee Collection, Usage, and Management* and the *Administrative Measures for the Collection of Pollutant Discharge Fee* are mainly to strengthen the collection of pollutant discharge fees, while the *Environmental Protection Tax Law* is a protection of China's environment and the regulation of environmental pollution of various enterprises. Finally, the standards are different. Environmental taxes use the standard of pollutant discharge fee as the floor and 10 times that as the ceiling. Twelve provinces (autonomous regions and municipalities directly under the central government) have raised their tax standards, while the rest keep the previous standard.

In short, environmental taxes are more strictly levied than pollution charges. Both pollutant discharge fee and environmental taxes are market-based environmental regulations. When enterprises emit high levels of pollution, environmental taxes are levied at a higher rate than pollutant discharge fee. When enterprises discharge less pollutants, tax relief is given to curb external environmental damage and discharges and prevent the discharge of pollutants, such as "industrial waste", from the source (Xu and Xie, 2016) [2]. The purpose of replacing environmental protection "fees" with "taxes" is not to obtain fiscal revenue, but to force enterprises with high pollution and high energy consumption to transform and upgrade.

Based on the above background, this paper attempts to study the impact of the implementation of environmental protection "fees" with "taxes" on enterprise green innovation, find out the factors that influence the capacity of green innovation and explore their relationship.

This paper may have research significance in the following aspects:

(1) Explore the linear relationship between replacing environmental protection "fees" with "taxes" and enterprises' green innovation.
(2) Identify the key factors influencing the changes of enterprises' green innovation after the implementation of the new policy.
(3) Put forward reasonable and effective suggestions for enterprises to cope with the implementation of new policies based on the research conclusions.

2. Literature Review and Hypothesis Development

2.1. Literature Review

This paper reviews the literature from the perspective of the impact of China's environmental policies on green innovation.

The first is the impact of environmental policy on technological innovation. Most of the existing literature focuses on testing the "Porter hypothesis" of environmental regulations. In the course of social development in the past, people paid too much attention to the development of industrial science and technology strength but ignored the basic living environments of people. Until the end of the 20th century, Porter and Vander (1995) [3] proposed the famous Porter hypothesis. Porter and Van der Linde believed that when an organization begins to regulate the environment and try to make better use of the resources in an environment, it will improve the quality of the products produced, and technological innovation may occur in this process. As for the test of the weak version of the Porter hypothesis, Requate and Unold (2001) [4] found that more and better environmental policies will promote enterprises to increase investment in technological innovation in order to use green technology innovation more quickly to ease the pressure of environmental policy. Zhao et al. (2022) [5] analyzed the A-share panel data of China's heavily polluting industries from 2011 to 2019. The results show that the environmental protection tax implemented in China has increased corporate innovation and brought long-term economic benefits to innovative companies. This verifies that Porter's hypothesis shows a strong version of the effect in China. Yang et al. (2012) [6], studied the data of enterprises in Taiwan from 1997 to 2003 and found that pollution control costs were positively correlated with R&D expenditures; that is, stronger environmental protection would lead to more R&D expenditures. Li and Nie (2009) [7] verified the practicability of the "Porter hypothesis" in China by using provincial panel data from 1999 to 2007. According to their findings, there is a significant positive correlation between environmental regulation and technological innovation. When environmental regulation increases by 1%, the number of invention patents increases by 0.17% and the number of utility model patents increases by 0.07%. Xie et al. (2014) [8] took listed companies among the A-share heavy pollution industry in the Shanghai and Shenzhen stock markets from 2008 to 2013 as research samples, empirically tested the impact of environmental regulation (represented by environmental input) on R&D investment, and found that environmental regulation has a positive effect on the R&D investment of listed companies in heavy polluting industries in China.

However, investment in green innovation and R&D alone cannot directly and accurately reveal innovation results. Moreover, due to the path-dependence effect of green technology innovation, R&D investment cannot define the innovation type. Therefore, scholars began to use patent data, which are more refined and microscopic, to intuitively and accurately measure how well enterprises are innovating (Calel and Dechezleprtre, 2016) [9]. As for whether environmental policies are able to induce green technology innovation, relevant research has gradually shifted from the medium and macro perspective to the micro perspective of enterprises.

Taking the SO_2 emission trading policy, which expanded the pilot scope in 2007, as a starting point, Qi et al. (2018) [10] found that the pilot emission trading policy significantly induced green technology innovation in polluting industries. Cui et al. (2018) [11] evaluated the effect of China's carbon emission trading pilot policy on innovation based on the patent application data of listed companies and found that the policy promoted low-carbon technological innovation at the enterprise level. Han and Sang (2018) [12] focused on the impact of environmental policies on enterprises' product portfolio behavior and product quality. To a certain extent, it reveals the micro mechanism of enterprise product conversion when facing environmental policies. In other words, companies are likely to devote more resources to making cleaner products and move away from polluting intensive ones. There is abundant verification of the strong version of the Porter hypothesis. However, due to the different measurement methods of environmental regulation and the difference of selected samples, the conclusions obtained in the existing literature are not consistent. Some studies have found that environmental policies boost productivity in specific industries (Han et al., 2017) [13], however, some scholars have come to the opposite conclusion that governments' strengthening of environmental regulations has a restraining effect on enterprises' green technology innovation (Tu and Chen, 2015) [14]. Some other studies have shown that there may be a non-linear relationship between environmental regulation and enterprise productivity (Zhang et al., 2011; Han and Hu, 2015; Yu D and Cui, 2019) [15–17]. Using the micro data of Chinese manufacturing enterprises from 2004 to 2005, Xu and Xie (2016) [2] tested the impact of sewage charge collection on enterprise productivity. It is found that there is a U-shaped relationship between the collection of pollutant discharge fees and enterprise productivity. Low intensity of collection of pollutant discharge fees hinders the improvement of enterprise productivity, while the collection of sewage charges over a certain intensity will drive the enterprise to improve productivity. As for the research on the impact of the change from environmental protection "fees" to "taxes" on enterprises' green innovation, there have been many studies since the emergence of the latter in 2018. Replacing fees with taxes is an important measure to promote ecological progress and sustainable development (Li and Yang, 2019) [18]. Yu et al. (2019) [19] found that environmental tax (all taxes and fees related to environmental protection) significantly promoted enterprises' green innovation at all stages. Wang and Qi (2016) [20] found that market-based environmental regulation tools had a spillover effect, while command-based environmental regulation tools were more suitable for technological innovation of energy conservation and emission reduction, and had a stronger effect on invention patents with a higher innovation degree.

Under the current research, green innovation is often associated with the environmental performance of enterprises and sustainable economic development. Through green innovation, enterprises transform the manufacturing process of products, improve the production process of products, and improve resource utilization to reduce the waste of environmental resources. The purpose of green innovation by enterprises is often to reduce pollution and waste of resources, in general, to reduce the negative impact of enterprises on the environment (Dangelico and Pujari, 2010; Woo et al. 2013) [21,22].

In terms of the correlation between corporate green innovation and environmental performance, Dangelico and Pontrandolfo (2010) [23], through their research on the world's green products, found that in China, green products and green technology innovations are mainly concentrated in manufacturing enterprises. Li et al. (2020) [24] used statistical surveys and methods of constructing SME structural equations to conduct research and analysis on energy-intensive enterprises in China and found that there was a significant positive correlation between green innovation behavior and environmental performance of enterprises. It promotes corporate financial performance and social performance, and enterprise green innovation has a positive impact on the sustainable development of enterprises. Sezen and Cankaya (2013) [25] analyzed the data of 53 large-scale manufacturing enterprises in Turkey based on questionnaires and found that green innovation in the manufacturing industry significantly improved the environmental performance and social performance of enterprises and had a positive impact on the sustainable development of enterprises. It can be seen that the green innovation of enterprises has significantly improved the environmental performance of enterprises and has a positive effect on the sustainability of enterprises (Singh et al., 2021; Ionescu, 2021) [26,27]. However, some scholars have also found that corporate green innovation has an adverse impact on the financial performance of enterprises (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013; Driessen et al., 2013) [28,29], because a large number of costs are incurred in the process of green innovation activities (Liu et al., 2011) [30]. In general, most of the existing studies on the relationship between corporate green innovation and corporate performance believe that corporate green innovation activities promote corporate environmental performance, but in terms of corporate green innovation and overall corporate performance levels, there is still a need for deeper research.

In the current research on sustainable economic development and corporate green innovation, it is found that in addition to the direct relationship between the two, there are many macro factors that will affect the sustainable development of the economy. Some countries are subject to economic sanctions, such as Iran, and companies in those countries may pay more attention to corporate green innovation, ensure strict compliance with international market norms, and promote sustainable economic development in their countries (Afshar Jahanshahi and Brem, 2019) [31]. How the economy can continue to develop during the "COVID-19" epidemic has also become an issue for scholars to discuss. Ionescu (2021) [32] used data from the NGFS and the UN to analyze it combined with the data fed back by the 6500 model respondents he was looking for, and found that during the "COVID-19" epidemic, green finance was used to promote the sustainable development of low-carbon energy and economy, and can actively and effectively optimize the environmental quality, but there are differences in the environmental quality of different economic development levels. Chapman (2021) [33] collects data from authoritative institutions, such as EIU, JLL, ICMA, etc., and combines the data compiled by his survey, analysis, and evaluation of how IoT in sustainable cities can optimize connected sensor networks through digital urban governance in environmentally sustainable cities, and found that sustainable cities are developed based on networked and integrated IoT systems and machine learning analysis. Economic sustainable development is a topic worthy of extensive discussion. This article discusses the relationship between economic sustainable development and corporate green innovation. Some scholars (Popp, 2002; Acemoglu et al., 2012) [34,35] put the technological progress of enterprises, environmental regulation, and sustainable economic development into an analytical framework and put forward the view that technological innovation is biased towards environmental technological innovation. Afterwards, some scholars conducted research on green innovation and sustainable economic growth of enterprises on this basis. Wang et al. (2016) [36] found that the efficiency of enterprise green innovation has a significant positive impact on green performance. Zhou et al. (2017) [37] established an economic growth model of endogenous biochemical and environmental policy under the goal of green growth, and conducted an in-depth exploration of the correlation between corporate green innovation and economic green growth. The key factor for sustainable growth is directional technological innovation under the regulation of environmental pollution, and green innovation has a positive effect on the green development of the economic system. Weng et al. (2015) [38] found that green innovation can promote the sustainable development of the surrounding environment. The empirical research results of many scholars (Rauscher, 2009; Moser et al., 2013; Zhou et al., 2017) [37,39,40] showed that corporate green innovation can not only drive the sustainable economic development of enterprises, but also promote the economic green and sustainable development of an entire industry. Ge et al., (2018) [41] found that green innovation strategies (GIS) can help companies gain the advantages of economic sustainability, but when using GIS, it is necessary to pay attention to environmental conditions and choose a green innovation strategy suitable for enterprise development. It can be seen that, whether it is the sustainability of individual enterprises, or the economy of an industry or an entire country, corporate green innovation can significantly promote the sustainable development of the economy.

Nowadays, China is faced with serious pollution problems, and environmental protection is a top priority. Therefore, the reform of environmental protection "fees" to "taxes" is an inevitable outcome. Tax is mandatory, forcing enterprises to learn environmental protection management technology, optimize resource allocation, and control the amount of pollution. Furthermore, it is conducive to fair competition among enterprises. The reform is not only a response to the country's call for environmental protection, but also a further performance of China's environmental responsibility.

Whether it is environmental protection "fees" or environmental protection "taxes", they are both market-based environmental regulations. After the change of environmental protection "fees" into "taxes", the principle of "more emissions, more taxes, less emissions and less taxes" has achieved remarkable results in the control of Chinese enterprises' pollution emissions and forced enterprises to make a change. Thus, what impact will the change from environmental protection "fees" into "taxes" have on enterprises' green innovation, especially those in heavily polluting industries? This paper makes an investigation and analysis based on the data about China.

2.2. Research Hypothesis

At the beginning of 2018, China promulgated the *Environmental Protection Law*, a tax law to promote ecological progress. According to the law, companies are required to handle pollution in four major categories, but construction and traffic noise are not yet included. It can be seen that the purpose of implementing the tax law is to reduce the pollution and emissions of enterprises and better protect the environment.

Perino and Requate (2012) [42] found that strict environmental policies to a certain extent promote the use of new technologies by enterprises, promote the dissemination of environmental protection technologies, and at the same time greatly enhance the importance of enterprises in the research and development of environmental protection technologies, making enterprises focus more on green innovation and enhance the green innovation capability of enterprises. Rubashkina et al. (2015) [43] took European manufacturing enterprises from 1997 to 2009 as the research object, conducted research on the strong and weak versions of the Porter Hypothesis and used the number of patent outputs to measure the innovation level of enterprises, and found that environmental regulation promotes the innovation of enterprises and significantly improves the innovation level of enterprises. In China, 2003, the Chinese government began to levy sewage charges on companies. Zhao and Sun (2016) [44] conducted a study on the applicability of Porter's hypothesis in China using the relevant data of pollution-intensive enterprises in China from 2007 to 2012 as a research sample. The study found that environmental regulation has a weak effect on the technological innovation of enterprises. However, Yang et al. (2019) [45] used panel data from 30 provinces in China from 2009 to 2016 to analyze the impact of environmental regulation on corporate innovation. They found that formal environmental regulation has effectively enhanced the technological innovation of enterprises. However, informal environmental regulation generally can positively drive enterprise technology innovation. It can be seen that with the continuous improvement of the environmental protection system by the government, Chinese enterprises have gradually increased their emphasis on technological innovation. In 2018, with the advent of environmental protection tax, a series of fees originally collected by the environmental protection authorities, mainly pollutant discharge fees, have been transferred to the tax bureau as taxes. At this point, underpayment or omission of payment due to improper measurement and other reasons becomes a tightly regulated measure of tax and the environmental costs of enterprises are raised. In particular, in order to reduce costs and gain greater profits, enterprises in heavily polluting industries that used to pay a lot of environmental protection fees are likely to emphasize green innovation and increase investment in green innovation in products, so as to reduce long-term costs.

Based on the above analysis, H1 is proposed: The policy of replacing environmental protection "fees" with "taxes" has significantly promoted the green innovation of enterprises in heavily polluting industries.

The R&D innovation efficiency of an enterprise reflects the level of the enterprise's full use of innovation resources. Under the current situation of saturation of most product markets, it has a profound impact on the formation of an enterprise's competitiveness (Gao et al., 2017) [46]. Tariq et al. (2017) [47] pointed out that the technological innovation environment of enterprises has a significant influence on the efficiency of R&D innovation of enterprises. Fan et al. (2020) [48] found that there is an inverted U-shaped relationship between environmental regulation and the efficiency of enterprise R&D innovation. Moderate environmental regulation policies will improve the efficiency of enterprise R&D innovation, but too strict environmental regulation policies will affect the efficiency of enterprise R&D innovation, producing an inhibitory effect. When enterprises conduct research and innovation, they need to pay attention to the environmental impact of technological innovation and achieve green economic development. After China implemented the policy of Replacing Environmental Protection Fees with Taxes in 2018, companies have to face a living environment with significant environmental protection tax burdens, this pressure is even more apparent from heavily polluting companies. The need for innovation appears more urgent. After implementing this policy, enterprises in heavily polluting industries will face the pressure of substantial environmental protection taxes in a short period. Therefore, these companies often take many countermeasures to improve their green R&D innovation efficiency so that the company can have more green innovation output at the same time, which not only can compare with other companies in the same industry in a short time. The environmental protection tax has an advantage in taxation, which relieves the tax pressure on the enterprise itself. It can also effectively reduce the operating cost of the enterprise for a long time.

Based on the above analysis, H2 is proposed: The policy of replacing environmental protection "fees" with "taxes" has significantly promoted R&D efficiency of green innovation of enterprises in heavily polluting industries.

Enterprises of different sizes have obvious differences in capital, labor force and R&D capacity, which determines that the implementation effects of environmental protection "fees" to "taxes" policies will be different for enterprises of different sizes. Wei (2022) [49] selected the data of 28 enterprises in China's manufacturing industry at that time as research objects. The analysis results show that large enterprises and small technology-based enterprises are more conducive to enterprises' technological innovation. Zhou et al. (2014) [50] conducted an empirical study on the data of China's A-share listed companies at the micro level from 2007 to 2010, and found that there is a significant inverted U-shaped relationship between the size of enterprises and the technological innovation of listed companies; that is, a certain degree of enterprise size is more beneficial for listed companies to engage in technological innovation activities, but once the enterprise size is too large, it will inhibit the innovation activities of enterprises. Most small and medium-sized enterprises may attach importance to the management of enterprise funds and expenses, and put more energy into investment and project research, and ignore the development of enterprise innovation. However, in general, large enterprises have sufficient capital and complete internal management systems. In this case, senior management will always consider the long-term development of the enterprise before making major decisions. In order to cope with the huge tax burden, large enterprises tend to adopt innovation to reduce energy consumption and reduce costs. After the implementation of environmental protection "fees" to "taxes", large enterprises may focus on the R&D of green innovation technology, reducing pollution emissions while relieving the pressure brought by environmental protection tax.

Based on the above analysis, H3 is proposed: Compared with small and medium-sized enterprises, the implementation of environmental protection "fees" to "taxes" has a more significant and positive effect on large enterprises.

Scholars generally believe that state-owned enterprises are more conducive to enterprises' innovation activities (Bai, 2021; Zeng, 2003) [51,52]. Based on the perspective of resource dependence, Xu (2015) [53] believes that enterprises need to obtain a large amount of funds from the external environment to conduct technological research and innovation, and the qualifications of state-owned enterprises are relative to non-state-owned enterprises. However, some scholars also believe that the nature of property rights of state-owned enterprises will bring adverse effects on enterprises, which will have a negative impact on the innovation activities of enterprises. Li and Xia (2008); Zhang et al. (2003); Ning et al. (2018) [54–56] found that the R&D efficiency of Chinese state-owned enterprises is significantly lower than that of non-state-owned enterprises. Ma and Lu (2019) [57] used Poisson regression analysis to examine internal control and how the relationship between enterprise innovation is very small. The study found that the higher the quality of the internal control of the enterprise, the better the innovation performance of the enterprise, especially in non-state-owned enterprises. In state-owned enterprises there are phenomena, such as low resource utilization, insufficient incentives for corporate executives, loose internal control, and defects in operational efficiency, which have a negative impact on corporate innovation activities (Clarke, 2003) [58]. In China, most state-owned enterprises have established R&D teams, which are responsible for the technological innovation of the whole enterprise. Private enterprises, on the contrary, focus on manufacturing one or several products and pay little attention to product technology innovation. However, the clear nature of property rights determines that these non-state-owned enterprises must pursue profit maximization and enterprise sustainable development as the fundamental goal, which is consistent with the goal of enterprise innovation. Therefore, after the implementation of environmental protection "fees" to "taxes", in order to relieve the pressure of environmental protection tax, private enterprises will strengthen their investment in green innovation and improve the degree of green innovation, so as to reduce costs or pollution emissions.

Based on the above analysis, hypothesis H4 is proposed: Compared with state-owned enterprises, the implementation of environmental protection "fees" to "taxes" policy promotes private enterprises to improve green innovation.

The research of Harel et al. (2020) [59] found that the executive team of a company can improve the performance of the company by affecting the level of innovation investment of the company. Liu et al. (2017) [60] found through their research that the innovation decisions made by corporate executives with overseas study and overseas employment experience are conducive to the application of corporate innovation patents. In recent years, scholar-executives have become an important phenomenon in corporate governance practice. It has become the focus of academic circles whether this kind of senior management talent with both academic ability and management skills are really able to promote enterprise innovation and then the implementation of the national strategy of macro innovation. A lot of literature studies come to the conclusion that corporate executives with academic experience are better than ordinary corporate executives and principals in corporate management. The research (Zhou et al., 2017) [61] shows that senior executives' academic experience reduces the cost of financing corporate debt by about 6.4%. From the perspective of its mechanism, the academic experience of senior executives improves the operating ability of enterprises from different aspects by reducing earnings management and improving accounting conservatism. In the research (Sheng et al., 2021) [62], it is found that enterprises that have senior executives with academic experience invest more in innovation, and this effect is mainly achieved by reducing the asymmetry of enterprise information. In addition, for executives with academic experience, the higher they are educated, the more significant the promotion effect on enterprise innovation. For small-scale enterprises, more frequent communication between superiors and subordinates helps strengthen the incentive effect of senior executives' academic experience on enterprise innovation, thus improving the innovation strength of enterprises. Moreover, they explore the relationship between executives' academic experience and the quality of enterprise innovation. It is found that senior executives' academic experience can not only improve the quantity of innovation, but also positively promote the quality of innovation.

Corporate executives with academic research experience and social responsibility may cherish the implementation of the tax law more than ordinary executives after the environmental protection "fees" are replaced by "taxes". Therefore, they will vigorously promote the green transformation and upgrading within their enterprises, enabling their enterprises to improve their reputation and adapt to the implementation of environmental tax more quickly.

Based on the above analysis, hypothesis H5 is proposed: The effect is even more pronounced when senior executives have an academic background.

3. Research Design

3.1. Sample Selection and Data Sources

In this paper, panel data and patent data of A-share listed companies in Shanghai and Shenzhen stock markets from 2005 to 2019 are selected. Data about patents of listed companies are from the China National Intellectual Property Administration, while other data about companies are from the China Stock Market & Accounting Research Database (CSMAR http://cndata1.csmar.com/ (accessed on 13 August 2021)) and financial data and analysis tool service provider (Wind http://www.wind.com.cn (accessed on 13 August 2021)). Incomplete and unreasonable data are filtered out during data screening. Green innovation in the financial industry is difficult, and green innovation is mainly concentrated in some heavily polluting manufacturing industries, so the sample data of the financial industry are excluded. According to the *Guidelines for Environmental Information Disclosure of Listed Companies* published by the Ministry of Environmental Protection on 14 September 2010, a total of 16 industries, namely thermal power, iron and steel, cement, electrolytic aluminum, coal, metallurgy, chemicals, petrochemicals, building materials, paper making, brewing, pharmaceutical, fermentation, textiles, tanning and mining, are considered to be heavily polluting industries. Eighteen subsectors, including cultural communication and information technology, are classified as light pollution industries.

3.2. Variable Definitions

3.2.1. Explanatory Variables

In this paper, the DID model is used in the experimental study, and the explanatory variable is Treated*Period (T*P for short). In terms of grouping, samples are grouped according to whether they belong to the heavy pollution industry or not. Heavy pollution industries were the experimental group, and other industries, such as light pollution, were the control group. When assigning industry dummy variables, the heavily polluting industries are assigned a value of 1, and the non-heavy polluting industries are assigned a value of 0. On 1 January 2018, China officially implemented the *Environmental Protection Tax Law* for heavily polluting industries. Therefore, in the experimental group samples, the year 2018 was adopted as the basis for grouping. When assigning a value to the time dummy variable, if the time of the sample is before 2018, the value is 0, and if the time of the sample is after 2018, the value is 1. After the implementation of the environmental protection tax in 2018, T*P is 1, while in the control group, T*P is always 0.

3.2.2. Explained Variables

The explained variables in this paper are level of green innovation and the R&D efficiency of green innovation.

Enterprise Green Innovation (GI): Innovation is a phased process, including the initial stage of investment in R&D all the way to the final authorization of innovation patents by the state. Therefore, in experiments, the number of patents is used to measure the innovation ability of enterprises. A green innovation patent consists of green invention patent and green utility model patent. In the patent application process, many are not approved because they are similar to others' inventions, repeated, or not practical. Innovations that duplicate existing inventions of others or cannot bring benefits to the enterprise shall not be counted as innovations of the enterprise. Therefore, in this paper, only the patents approved and authorized by the state are selected to measure the level of green innovation of enterprises.

The R&D efficiency of green innovation: the ratio of green patent output to R&D investment.

3.2.3. Grouping Variables

Grouping variables in this experiment include the nature of enterprise property rights (Soe), enterprise size (Size) and academic experience of senior executives (Ac).

Nature of Enterprise Property rights (Soe): Many studies have found that the difference in the nature of enterprise property rights has a profound impact on enterprises' innovation motivation and allocation of innovative resources (Gao,2013; Bouriaud,2007) [63,64]. In this paper, the property rights of enterprises include state-owned enterprises and non-state-owned enterprises. Dummy variables are used to value it, where the value of state-owned enterprises is 1 and that of non-state-owned enterprises is 0.

Enterprise Size (Size): Schumpeter wrote in his theory of Economic Development (1912): Different entrepreneurs and different enterprise scales have different promoting effects on new industries. Many other scholars also believe that enterprise size is an important factor affecting enterprise green innovation. In this paper, the enterprise size is measured by the logarithm of the total assets of the enterprise at the end of the year. In this paper, the selection of the criteria for the classification of large and medium-sized enterprises and small and medium-sized enterprises in the enterprise scale draws on the research method of Zhang and Lu (2022) [65]. Use the median as the boundary to divide the size of the enterprise into large enterprises and small and medium enterprises.

Academic Experience of Corporate Executives (Ac): In 2015, The State Council issued *Opinions on Accelerating Implementation of Innovation-Driven Development Strategy through Strengthening Institutional Reforms*, stressing the importance of giving full play to the innovative role of universities and research institutions. Therefore, many university teachers and researchers with academic experience become senior executives in enterprises. Research by many scholars has shown that executives with academic experience run enterprises better. Theoretically, the academic experience of executives means that the executives of the company have a higher level of education. The company executives have undergone rigorous academic training and have a broader vision than ordinary people, as well as state-of-the-art expertise for analysis and judgment. At the same time, corporate executives with educational experience will have more abundant and powerful academic resources to support the corporate research team, which is more conducive to corporate innovation (Zhao et al., 2019) [66]. In this quasi-natural experiment, the division of the academic experience of corporate executives is based on whether there are executive members of the corporate executive team that have conducted academic research in scientific research institutions or research institutes in domestic and foreign universities or various national industry societies and industries. If the members of the executive team of the company have obtained a master's degree or above in China or other countries or have participated in academic and scientific research exchange conferences, behave with scientific solid research analysis capabilities, or have apparent experience in academic research exchanges, the company's executives are considered to have academic research experience. In this paper, dummy variables are used to assign values to the academic experience of senior executives of enterprises, where those who have academic experience are marked as 1, and those who have no scientific research experience are marked as 0 (see Table 1 for the detailed definition of variables). The data related to the academic experience of corporate executives used in this paper all come from the character series feature database in the CSMAR database. For the situation where the data of executive members in the executive team of some companies are missing, this paper has read the departmental corporate annual reports and used search engines—supplementary data queries.

Table 1. Definition of variables.

Name	Type	Description
Enterprise Green Innovation (GI)	Explained variable	Number of green patents granted to enterprises
R&D efficiency of enterprises (Effection)	Explained variable	Ratio of green patent output to R&D investment
Experimental grouping variable (Treat)	Explained variable	The value is 1 for heavy pollution industry and 0 for non-heavy pollution industry
Time grouping variable (Period)	Explained variable	0 before 2018 and 1 after 2018
Enterprise Size	Grouping variable	Logarithm of an enterprise's total assets at the end of the year
Nature of Property Rights (Soe)	Grouping variable	1 for state-owned enterprises and 0 for non-state-owned enterprises
Academic experience of corporate executives (Ac)	Grouping variable	1 for academic experience and 0 for no academic experience
Tobinq	Control variable	Ratio of market value to replacement cost
Asset-liability ratio (Levage).	Control variable	Ratio of total liabilities to total assets
Enterprise age (Age)	Control variable	Time of listing
R&D investment (RD)	Control variable	Logarithm of corporate R&D spending plus one
ROA	Control variable	Ratio of net profit to total assets at the end of the period
Cap_inten	Control variable	Ratio of total assets to operating revenue
Top1	Control variable	Shareholding ratio of the largest shareholder to the total share capital
Indep	Control variable	Ratio of the number of independent directors to the total number of directors

3.2.4. Control Variables

Considering that other factors of large enterprises may influence this experiment, some factors affecting the economic characteristics of some enterprises are selected as control variables. There are 11 control variables in this experiment: ① Enterprise age (Age). The age of an enterprise is the survival time of the enterprise in this competitive market. The older an enterprise is, the more mature it is, the more experience it has in survival and development, and the less likely it is to be eliminated. Li et al. (2020) and Lukason et al. (2014) [67,68] found in their studies that the more mature the enterprise is, the more innovative it is. In this paper, the length of time an enterprise has been listed is considered the age of the enterprise. ② R&D investment (RD). R&D investment is directly related to the green innovation ability of an enterprise. The amount of R&D investment of an enterprise will directly affect whether there will be green innovation output. ③ Tobinq. Tobin Q is the ratio of an enterprise's market value to its replacement cost. Dang et al. (2019); Liu and Zhang (2017) [69,70] found that the higher the value is, the greater the wealth and innovation capacity of an enterprise in the society. ④ Asset-liability ratio (Levage). Asset-liability ratio reflects the liabilities of enterprises. It is generally believed that a moderate amount of debt will enable companies to spend more money on green innovation R&D. ⑤ Other variables related to corporate performance and corporate internal governance structure: return on total assets (Roa), capital intensity (cap_inten), shareholding ratio of the largest shareholder (Top1), proportion of independent directors (Independent). Among them, the Roa is the ratio of an enterprise's net profit to total assets, capital intensity is the ratio of an enterprise's total assets to its operating income, the shareholding ratio of the largest shareholder is the proportion of the share of the largest shareholder to the total shares, and the proportion of independent directors refers to the proportion of independent directors in the total number of directors. (See Table 1 for detailed definitions of variables).

3.3. Model Design

After a policy is implemented, scholars often pay attention to the effect of the policy implementation and whether it has played a role in promoting or inhibiting the specific research object after the implementation of the policy. The traditional method to evaluate the policy effect is mainly by setting a dummy variable for the occurrence or not of the policy and then performing regression. In comparison, the difference-in-differences model (DID) is more scientific and can eliminate the influence of endogenous factors, making a more accurate assessment of policy effects. DID is generally used to evaluate the effect of random experiments or natural experiments, such as the effect of policy adjustments and changes in laws and regulations, and the effect of experiments usually takes a period of time to appear, so using DID to conduct quasi-natural experiments requires data from several years before and after the experiment, to evaluate the change of the explained variable before and after the experiment.

The difference-in-differences method usually sets an experimental group and a control group, and also sets two different periods as controls, usually based on the time point of policy implementation or policy change. The premise of using the difference-in-differences method is that the experimental group and the control group must have a common trend before the implementation of the policy, that is, a parallel trend test is carried out in a quasi-natural experiment, and the policy effect finally evaluated in the experiment needs to be deducted from the pre-implementation experiment difference between the group and the control group.

In this experiment, the difference-in-differences (DID) model is adopted to evaluate the impact of the change of environmental protection fees to taxes on enterprise green innovation. The model designed is as follows:

$$GI_{it} = β0 + β1\ Treat_i + β2\ Period_t + β3\ Treat_i \times Period_t + Controls + ε_{it}$$

GI_{it} represents the level of green innovation of enterprises, and $Treat_i$ is the dummy variable of experimental group. It is measured by whether it falls into the category of heavy polluting industry; the value is 1 for heavy pollution industries and 0 for non-heavy pollution industries. $Period_t$ is a time-grouped dummy variable; the cut-off point is 2018, the year the tax was implemented; the value is 0 before 2018 and 1 after 2018. Controls and ε IT are the control variables and error terms in this experiment respectively. In this experiment, the key concern is whether the value of β3 of $Treat_i \times Period_t$ is significantly positive. If this coefficient is significantly positive, it means that the change of environmental protection fees to taxes has promoted the green innovation of enterprises.

3.4. Descriptive Statistics

3.4.1. Descriptive Statistics

The descriptive statistics of the main variables are shown in Table 2. As can be seen, among the 25,408 samples selected, the average value of enterprises' level of green innovation is only 0.257. It indicates that the selected listed companies have not carried out green innovation or have low green innovation ability. In order to eliminate the effect of heteroscedasticity, some variables were logarithmic in this experiment. In descriptive statistics, the standard deviation of difference of enterprises' green innovation ability is 0.613, indicating that there are differences among enterprises' green innovation abilities. The rest of the statistics are within normal range.

3.4.2. Analysis

In this experiment, 25,408 experimental samples were divided into light pollution industry companies, cleaner production industry companies and heavy pollution industry companies according to whether the company was a company in a heavily polluting industry. Among them, companies with unclear industry categories and incomplete information on green innovation were excluded. A total of 6929 enterprises in heavily polluting industries were taken as the experimental group, and 18,412 enterprises in lightly polluting and non-polluting industries were taken as the control group. In Table 3, there are 18,412 samples in the control group and 6929 samples in the experimental group. It is found that the mean of green innovation ability of enterprises with light pollution and no pollution is 0.267, while the mean of green innovation ability of enterprises with heavy pollution is only 0.232. It can be seen that the green innovation capacity of heavily polluting enterprises is still backward compared with other industries, and the enterprises as a whole have low green innovation abilities. In terms of the R&D input of green innovation in heavy pollution industries, the standard deviation of difference is 8.152, suggesting that different heavy pollution enterprises attach different degrees of importance to green innovation, and many enterprises still lack awareness of green innovation.

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
GI	25,408	0.257	0.613	0	2.639
Treat × Period	25,341	0.07	0.255	0	1
Size	25,407	22.057	1.264	19.859	25.494
Top1	25,408	0.346	0.147	0.102	0.692
Soe	25,408	0.344	0.475	0	1
Roa	25,408	0.045	0.062	−0.166	0.196
Independent	25,408	0.371	0.048	0.333	0.5
Levage	25,408	0.431	0.203	0.07	0.864
Cap-inten	25,408	2.265	1.685	0.47	9.091
Tobinq	25,408	2.588	1.797	0.904	9.385
Age	25,408	16.294	5.89	4.92	29
RD	25,408	13.08	8.009	0	21.049
AC	25,408	0.95	0.218	0	1

Table 3. Descriptive statistics based on samples.

Treat: 0					
	N	**Mean**	**sd**	**Min**	**Max**
Lngi	18,412	0.267	0.626	0	2.639
Size	18,412	21.994	1.235	19.859	25.494
Top1	18,412	0.34	0.146	0.102	0.692
Soe	18,412	0.33	0.47	0	1
Roa	18,412	0.046	0.063	−0.166	0.196
Independent	18,412	0.372	0.049	0.333	0.5
Lev	18,412	0.427	0.207	0.07	0.864
Cap	18,412	2.354	1.751	0.47	9.091
Tobinq	18,412	2.721	1.875	0.904	9.385
Age	18,412	16.344	5.942	4.92	29
lnrd	18,412	13.292	7.95	0	21.049
ac	18,412	0.949	0.221	0	1
Treat: 1					
Lngi	6929	0.232	0.579	0	2.639
Size	6928	22.22	1.326	19.859	25.494
Top1	6929	0.362	0.148	0.102	0.692
Soe	6929	0.383	0.486	0	1
Roa	6929	0.045	0.06	−0.166	0.196
Independent	6929	0.367	0.045	0.333	0.5
Lev	6929	0.442	0.194	0.07	0.864
Cap	6929	2.017	1.447	0.47	9.091
Tobinq	6929	2.246	1.523	0.904	9.385
Age	6929	16.118	5.737	4.92	29
lnrd	6929	12.488	8.152	0	21.049
Ac	6929	0.954	0.209	0	1

4. Analysis of Empirical Results

4.1. Correlation Coefficient Matrix

Pearson correlation coefficient matrix is adopted for analysis. The correlation coefficient results are shown in Table 4. Green innovation is positively correlated with both green R&D investment (p = 0.202, $p < 0.001$) and enterprise size (p = 0.236, $p < 0.001$). In Table 4, it can be seen that the grouping variables selected in this paper, such as Size, Ac, and most of the control variables, such as Top1, Indep, Cap-inten, Tobinq, and RD, are all related to the enterprise green innovation level (GI) at a significant level of 0.01. All these have laid a good statistical foundation for further research.

Table 4. Correlation coefficient analysis matrix.

	lngi	Size	Top1	Soe	Roa	Indep	lev	Cap	Tobinq	Age	Lnrd	Ac
Lngi	1											
Size	0.236 ***	1										
Top1	0.035 ***	0.158 ***	1									
Soe	0.011 *	0.318 ***	0.220 ***	1								
Roa	0.014 **	−0.00300	0.145 ***	−0.104 ***	1							
Indep	0.024 ***	0.023 ***	0.040 ***	−0.081 ***	−0.015 **	1						
Lev	0.088 ***	0.394 ***	0.013 **	0.291 ***	−0.409 ***	−0.022 ***	1					
Cap	−0.058 ***	−0.040 ***	−0.103 ***	−0.050 ***	−0.209 ***	0.035 ***	−0.112 ***	1				
Tobinq	−0.085 ***	−0.421 ***	−0.028 ***	−0.230 ***	0.302 ***	0.069 ***	−0.325 ***	0.053 ***	1			
Age	−0.012 *	0.234 ***	−0.154 ***	0.072 ***	−0.116 ***	0.027 ***	0.122 ***	0.075 ***	−0.102 ***	1		
RD	0.202 ***	0.175 ***	−0.061 ***	−0.260 ***	0.090 ***	0.094 ***	−0.198 ***	−0.080 ***	0.041 ***	0.158 ***	1	
Ac	0.054 ***	0.054 ***	0.019 ***	0.031 ***	0.013 **	−0.027 ***	−0.013 **	−0.033 ***	−0.014 **	0.001	0.089 ***	1

t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.2. Parallel Trend Test

Figure 1 Parallel trend test is the premise of the DID. Only the results obtained using DID that pass the parallel trend test are reliable. Before the implementation of replacing environmental protection "fees" with "taxes" in 2018, the coefficient is generally at a low level, and the experimental group and the control group had the same trend of change. However, since the policy was implemented in 2018, the coefficient has increased significantly. This indicates that the implementation of the policy has a significant impact on the innovation of enterprises in heavy pollution industries, resulting in an obvious difference between the experimental group and the control group, which proves that the subsequent regression results make sense.

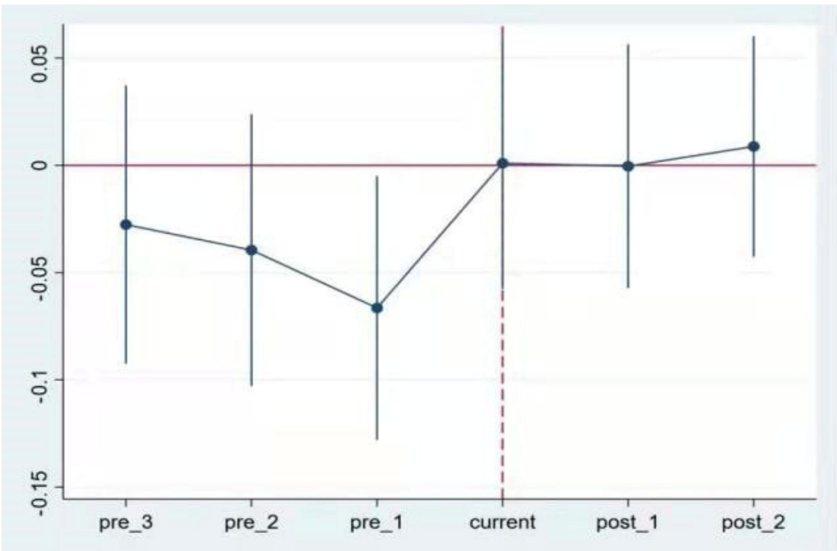

Figure 1. Results of parallel trend test.

4.3. Analysis of Regression Results

Table 5 shows the regression results of panel data of the change from environmental protection "fees" to "taxes" and enterprises' green innovation ability, and the dependent variable is Lngi (enterprises' green innovation capacity). Column (1) of regression results does not include post dynamic effect, and the dummy variable of the policy is positively correlated with the level of green innovation of enterprises at the significance level of 1%, so H1 is supported. When DID is 1, that is, after the policy takes effect, enterprises' level of green innovation increases by 0.048% on average below the significance level of 1%. Column (2) suggests that after a series of control variables are added, the interaction term Treat × Period has a coefficient of 0.05, significant at the 1% level. After the implementation of the policy, regardless of whether the post dynamic effect is considered, the implementation of the policy significantly promotes the level of green innovation of enterprises at the level of 1%, indicating that the implementation of environmental protection "fees" to "taxes" has an incentive effect on the green innovation of most enterprises. Moreover, it confirms H1 that this system promotes enterprises to improve their green innovation ability and embrace technological transformation and upgrading.

Table 5. Regression results of environmental protection "fees" to "taxes" policy on enterprises' green innovation ability.

	(1)	(2)	(3)	(4)
VARIABLES	lngi	lngi	eff	eff
Treat × Period	0.048 ***	0.050 ***	0.003 ***	0.003 ***
	(4.33)	(4.49)	(5.96)	(6.11)
Post_1		0.017 **		0.000
		(2.19)		(0.64)
Post_2		0.023 ***		0.001 **
		(2.67)		(2.25)
Size	0.006	0.006	−0.001	−0.001
	(0.50)	(0.48)	(−1.45)	(−1.45)
Top1	−0.076 *	−0.076 *	−0.004 *	−0.004 *
	(−1.74)	(−1.74)	(−1.78)	(−1.77)
Soe	−0.016 *	−0.016*	−0.001 **	−0.001 **
	(−1.79)	(−1.78)	(−1.98)	(−1.97)
Roa	−0.179 ***	−0.178 ***	−0.009 ***	−0.009 ***
	(−3.84)	(−3.83)	(−3.09)	(−3.08)
Independent	0.091	0.091	0.003	0.003
	(1.26)	(1.26)	(0.77)	(0.77)
Lev	0.093 *	0.093 *	0.006 **	0.006 **
	(1.85)	(1.85)	(2.05)	(2.04)
Cap	−0.004 **	−0.004 **	−0.000	−0.000
	(−2.08)	(−2.06)	(−0.41)	(−0.40)
Tobinq	−0.018 ***	−0.018 ***	−0.001 ***	−0.001 ***
	(−3.90)	(−3.90)	(−4.15)	(−4.15)
Age	−0.093 ***	−0.093 ***	−0.005 ***	−0.005 ***
	(−3.38)	(−3.38)	(−3.52)	(−3.52)
lnrd	0.005 ***	0.005 ***	0.001 ***	0.001 ***
	(3.65)	(3.67)	(17.42)	(17.41)
Ac	0.017	0.017	0.001	0.001
	(1.16)	(1.15)	(0.97)	(0.97)
Constant	1.943 ***	1.947 ***	0.126 ***	0.126 ***
	(2.70)	(2.70)	(3.34)	(3.34)
Observations	25,340	25,340	25,340	25,340
R-squared	0.0646	0.0646	0.0957	0.0957
Number of groups	2658	2658	2658	2658
company	yes	yes	yes	yes
year	yes	yes	yes	yes
F	218	446.4	20,037	15,317

t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6 is the regression results of the fixed panel effect of replacing environmental protection "fees" with "taxes" on enterprise green innovation R&D efficiency. The dependent variable is Effection (enterprise green innovation R&D efficiency)—The efficiency is measured by the ratio of the enterprise's green R&D patent output to the enterprise's green R&D investment. Column (1) is the analysis when only fixed effect of time and industry are included after the implementation of the policy without taking into consideration control variables. From Column (1), it can be seen that after the implementation of the policy in 2018, the coefficient of the interaction term Treat × Period is 0.003, which is significant below the significance level of 1%. After adding a series of control variables, as shown in Column (2), the coefficient of the interaction term Treat × Period is 0.003, which is still significant below the significance level of 1%. Therefore, the conclusion is that whether control variables are included or not, the policy promotes the R&D efficiency of green innovation at the significance level of 1%. H2, that the implementation of the policy significantly promotes the R&D efficiency of enterprises' green innovation, is confirmed.

Table 6. Regression results of changing environmental protection "fees" to "taxes" on green R&D efficiency of enterprises.

	(1)	**(2)**
VARIABLES	eff	eff
Treat × Period	0.003 ***	0.003 ***
	(5.96)	(6.11)
Post_1		0.000
		(0.64)
Post_2		0.001 **
		(2.25)
Constant	0.126 ***	0.126 ***
	(3.34)	(3.34)
Observations	25,340	25,340
R-squared	0.0957	0.0957
Number of groups	2658	2658
company	yes	yes
year	yes	yes
F	20,037	15,317

t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$.

4.4. Heterogeneity Analysis

4.4.1. Heterogeneity of Enterprise Size

The results of replacing environmental protection "fees" with "taxes" varies with the size of enterprises. The median of enterprise sizes is used as the classification basis, those above the median are regarded as large enterprises, and those below the median are regarded as small and medium enterprises. Subsample regression is performed according to the experimental model. The regression results are shown in Table 7. After a series of control variables and fixed effects of industry and time are included, the coefficient of the DID multiplier in the sample of large enterprises is 0.077, and the coefficient of the DID multiplier in the sample of small and medium enterprises is 0.041. For large enterprises, the policy significantly promotes the improvement of green innovation abilities of large enterprises at the significance level of 1%. Compared with large enterprises, the policy has promoted the green innovation of small and medium-sized enterprises at the significance level of 10%, but the intensity is far less than that of large enterprises. The above analysis confirms H3 that, compared with small and medium-sized enterprises, the implementation of the policy has a more significant and positive effect on large enterprises.

4.4.2. Heterogeneity of the Nature of Property Rights

The policy of replacing environmental protection "fees" with "taxes" has different effects on enterprises with different types of property rights. In this experiment, there are state-owned enterprises and non-state-owned enterprises according to the nature of property rights. The value of state-owned enterprises is 1, and the value of non-state-owned enterprises is 0. Subsample regression was conducted after a series of control variables, time and industry fixed effects are taken into consideration, and the regression results are shown in Table 8. In the sample of state-owned enterprises, the coefficient of DID interaction term is 0.039, while that of non-state-owned enterprises is 0.05. It can be seen that the policy of replacing environmental protection "fees" with "taxes" has a stronger effect on non-state-owned enterprises than on state-owned enterprises. In this experiment sample, private enterprises account for the vast majority of non-state-owned enterprises, which confirms H4, that is, the policy plays a greater role in promoting the green innovation ability of private enterprises.

Table 7. Heterogeneity of enterprise size.

	Large Enterprises	**Small and Medium-Sized Enterprises**
VARIABLES	lngi	lngi
Treat × Period	0.077 ***	0.041 *
	(4.28)	(1.69)
Size	0.034	0.024 **
	(1.26)	(2.10)
Constant	2.167 *	0.708
	(1.76)	(1.23)
Observations	12,662	12,678
R-squared	0.0988	0.0230
Number of groups	1775	2136
company	yes	yes
year	yes	yes
F	3726	1332

t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8. Heterogeneity of property rights of enterprises.

	State-Owned Enterprises (Soes)	**Non-State-Owned Enterprise**
VARIABLES	lngi	lngi
Treat × Period	0.039	0.050
	(0.78)	(1.61)
Constant	1.204	2.144 ***
	(1.48)	(2.73)
Observations	8725	16,615
R-squared	0.0892	0.0544
Number of groups	805	2138
company	yes	yes
year	yes	yes
F	5862	1630

t-statistics in parentheses. *** $p < 0.01$.

4.4.3. The Heterogeneity of the Academic Experience of Senior Executives

Corporate executives with different academic experience tend to take different measures to deal with the policy of replacing environmental protection "fees" with "taxes" in environmental protection. In the sample, if the senior executive has academic or scientific research experience, the value is 1; otherwise, the value is 0. In this experiment, interaction terms are included to examine whether senior executives' academic experience positively promotes the correlation between policies and enterprises' level of green innovation. As shown in Table 9, the interaction term between DID and Ac is significant at 0.01. This indicates that the promotion effect of corporate executives with academic research experience on enterprise green innovation ability is greater than that of corporate executives without academic research experience. Thus, H5 is verified. After the implementation of the policy, corporate executives with academic research experience are more likely to take effective countermeasures to significantly improve the green innovation ability of enterprises, so as to reduce corporate tax burden.

Table 9. Heterogeneity of senior executives' academic experience.

VARIABLES	lngi	lngi
Treat × Period	0.048 ***	0.002
	(4.32)	(0.11)
DID_Ac		0.048 ***
		(2.90)
Ac		0.013
		(0.85)
Constant	1.958 ***	1.948 ***
	(2.75)	(2.70)
Observations	25,340	25,340
R-squared	0.0645	0.0646
Number of groups	2658	2658
company	yes	yes
year	yes	yes
F	9309	16,216

t-statistics in parentheses. *** $p < 0.01$.

4.5. PSM Regression Analysis

In quasi-natural experiments based on DID, besides independent variables, control variables may also have a significant impact on experimental results. In this experiment, in order to confirm that it is mainly the policy of replacing environmental protection "fees" with "taxes", rather than other control variables, that affects enterprises' green innovation, this paper uses PSM regression analysis to alleviate the endogenous problems caused by observable variables.

The regression analysis results are shown in Table 10. The deviation of difference of all control variables before and after matching are similar, and the *p* values of all variables are greater than 0.1, showing no significant difference. It can be proved that in this experiment, the control variables are not the main factors affecting the change of enterprises' green innovation.

Table 10. Analysis of PSM regression results (before and after matching).

Variable	Matched	Treated	Control	%bias	ǀbiasǀ	*t*	*p* > ǀ*t*ǀ	V(C)
Size	Before	22.22	21.99	17.60	12.71	0	1.15 *	
	After	22.21	22.22	−0.400	97.90	−0.220	0.829	1.07 *
Top1	Before	0.362	0.340	15.10	10.73	0	1.020	
	After	0.361	0.362	−0.100	99.30	−0.0600	0.953	0.970
Soe	Before	0.383	0.330	11.10	7.920	0		
	After	0.381	0.384	−0.600	94.50	−0.350	0.726	
Roa	Before	0.0448	0.0458	−1.600	−1.130	0.259	0.91 *	
	After	0.0447	0.0453	−1	35.20	−0.640	0.519	1.12 *
Independent	Before	0.367	0.372	−11.60	−8.100	0	0.86 *	
	After	0.367	0.367	−1	91.20	−0.620	0.538	0.94 *
Lev	Before	0.442	0.427	7.600	5.300	0	0.88*	
	After	0.442	0.449	−3.700	51.60	−2.180	0.0290	0.92 *
Cap	Before	2.016	2.354	−21	−14.31	0	0.68 *	
	After	2.019	1.997	1.400	93.40	0.900	0.368	1
Tobinq	Before	2.245	2.721	−27.80	−18.88	0	0.66 *	
	After	2.248	2.239	0.500	98.20	0.340	0.733	1.13 *
Age	Before	16.12	16.34	−3.900	−2.730	0.00600	0.93 *	
	After	16.13	16.21	−1.400	64.10	−0.820	0.415	0.92*
Inrd	Before	12.49	13.29	−10	−7.130	0	1.05 *	
	After	12.52	12.43	1.100	89.50	0.600	0.549	0.93 *
Ac	Before	0.954	0.949	2.600	1.850	0.0640		
	After	0.954	0.959	−2.400	10.80	−1.460	0.144	

t-statistics in parentheses. * $p < 0.1$.

When performing multiple regression analysis, regression analysis is usually performed on all samples uniformly. However, each research sample often has multiple attributes. Generally, multiple regression analysis methods will ignore the influence of the remaining attributes of the samples in the analysis process on the final results of the experiment. The propensity score matching analysis (PSM) effectively avoids this problem. The PSM regression analysis method is based on the idea of matching estimation. By setting a control group without external influencing factors, the matching analysis is carried out with the experimental group. If the results before and after matching are consistent, it can be determined that the experimental property changes of the samples are mainly influenced by exogenous factors rather than endogenous factors. In this experiment, kernel density is adopted to visually reveal whether there are differences in propensity score values between the two groups before and after matching. As shown in Figure 2, the deviation of difference of the two kernel density curves is large before and after matching. However, after matching, the two curves are basically consistent, the gap between the mean values of the treat group and the control group is significantly reduced, and thus the interference with different control variables is eliminated. It is proved once again that the change of control variables in this experiment has no significant impact on the change of enterprises' levels of green innovation.

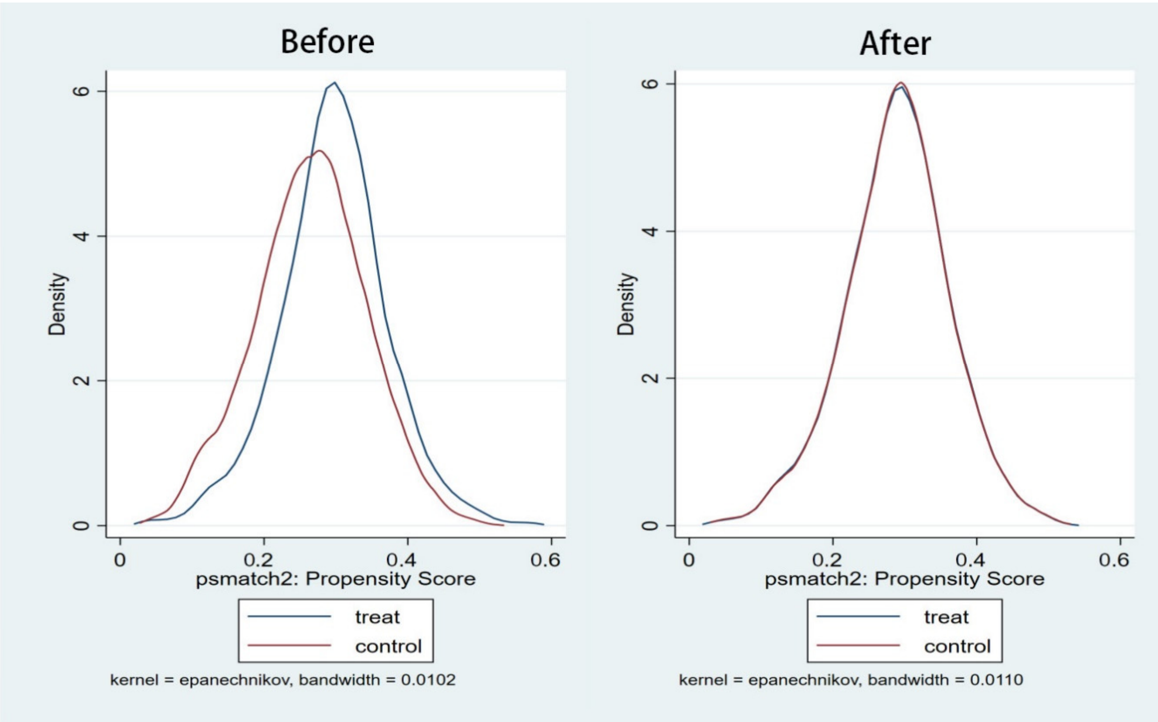

Figure 2. Kernel density comparison before and after PSM.

5. Conclusions and Implications

Based on Porter's hypothesis, this paper combines the discussion of the impact of environmental regulation on corporate innovation and the relationship between enterprise green innovation activities, corporate environmental performance, and economic sustainable development; it has conducted research on the impact of policies on corporate green innovation. The study found that the Chinese government has improved the level of corporate green innovation and the efficiency of corporate green R&D innovation by replacing the environmental protection "fee" with a "tax" policy, thereby effectively promoting green innovation activities. Further research through heterogeneity analysis found that the replacement of this policy has significant differences in the effect of the implementation of the policy on enterprises of different scales and different property rights. As well as private enterprises, due to the high R&D cost of green innovation and the limitations of R&D funds of small and medium-sized enterprises, the effect of this policy on green innovation activities of small and medium-sized enterprises is significantly lower than that of large enterprises. State-owned enterprises have government support, sufficient and stable R&D and innovation capital investment, and high-level scientific research and innovation teams, and continue to carry out green innovation in the daily business operation process. The effect of state-owned enterprise innovation activities is not obvious. This study also found that when the executives of the enterprise have academic research experience, the replacement of the policy in this type of enterprise has a significantly better effect on the green innovation of enterprises than in enterprises whose executives do not have academic research experience. Based on the above conclusions, the following revelations are drawn:

(1) The policy of replacing environmental protection "fees" with "taxes" significantly promotes enterprises' green innovation abilities. Governments at all levels need to vigorously implement the policy, strictly implement the continuous modification of the policy, and constantly spur enterprises on green innovation. These efforts can not only help enterprises reduce the environmental tax burden, but also play a role in the adoption of innovative technologies to protect the ecological environment and promote the continuous development of enterprises.
(2) When implementing the policy of replacing environmental protection "fees" with "taxes", full consideration should be given to its impact on enterprises of different industries and sizes. It is not desirable to introduce it with equal force to all enterprises. Preferential policies should be given to enterprises that have been committed to green development and green innovation R&D, so as to encourage enterprises to commit to green innovation while protecting the environment.
(3) It is suggested that after each policy change, enterprises should organize their management to learn about the change, quickly understand the new policy, actively and timely respond to policy changes, analyze the current situation, and make reasonable and effective adjustments to minimize the adverse impact of policy changes in the short term.
(4) Capable enterprises should encourage more members of their senior management team to cooperate with research institutes, industry associations, industry societies, and other scientific research institutions on weekdays to engage in more academic research, enhance the awareness of forecasting national policy trends, expand the horizons of corporate executives and cultivate the analytical and predictive awareness of corporate executives, and let business executives lead enterprises to adapt to the new change in a timely manner. Enterprises also need to designate commissioners to estimate policies and respond to policy changes. Only with a thorough understanding of every policy change can enterprises stay in the forefront of the industry after every major adjustment of policies.

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