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Study on the Influence of Green Bonds on Enterprise Green Innovation

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ABSTRACT

Green bond is a new financial instrument that balances economic benefits and environmental protection, and is crucial to accelerate the green transformation of enterprises. This paper takes enterprise issuing green bonds as a quasi-natural experiment, constructs a multi-point DID model to investigate how green bonds affect green innovation, and explores potential mechanisms. The findings indicate that: (1) Green bonds have the potential to greatly increase both the quantity and quality of green innovation within enterprises. (2) Mechanism test results show that green bonds mainly attract the attention of peers and intensify the research and development (R&D) competition by releasing green signals, and green innovation is promoted with R&D competition. (3) Heterogeneity test results show that the role of green bonds in promoting green innovation is more obvious in enterprises with high pollution and high ESG scores. In addition, belonging to the Green Finance Pilot Zones (GFPZ) will also affect the improvement of green bond issuance on green innovation. This study provides new insights for improving enterprises' green innovation and promoting China's green transformation.

KEYWORDS

Green bond; Green innovation; R&D competition; Multi-time point DID; Green transformation

1. INTRODUCTION

As a country with high carbon emissions, China's excessive carbon emissions are seriously affecting people's production and lives. According to the Paris Climate Agreement, China's carbon dioxide emissions per GDP unit should drop from 2005 levels by 60%–65% by 2030. Given the twin limitations on resources and the environment, China's green transformation path has garnered a lot of attention as the deadline draws near. To change the past extensive industrial model, the Chinese government emphasizes that increasing the potential for green innovation is essential to the change. By using less energy, green innovation can enhance the quality of the environment, improving production efficiency (Cheng et al., 2021). However, due to its high investment risk, long return cycle, it is challenging for conventional financial instruments to offer such low-yield and high-risk green innovation initiatives long-term, reliable financial backing (Lin and Ma, 2022), which requires the help of green finance (Yu et al., 2021). As a new financial instrument, green bonds have high efficiency of capital allocation, which can directly invest funds in green projects. By the end of 2022, China emerged as the global leader in the green bond issuing industry, with cumulative green bond issuance reaching 1.9 trillion yuan, up 22% year over year. In this context, the debate about how businesses intend to use the money from the green bonds-designated green projects or otherwise-to further the anticipated environmental advantages of their green innovation can offer workable solutions for advancing sustainable development and green transformation.

The existing literature mainly analyzes the government's role in promoting green innovation (Behera and Sethi, 2022), market (Sharma et al., 2021), digital finance (Lin and Ma, 2022), digital transformation (Tang et al., 2023; Lv and Wu, 2024) and other factors. Among them, academics have focused a great deal of attention on how environmental regulations affect green innovation, which is mainly discussed based on the cost constraint theory and Porter's hypothesis. According to cost constraint theory, environmental regulations would drive up the cost of businesses' pollution emission and have a crowding out impact on their R&D expenditures (Petroni et al., 2019; Wang et al., 2023). The Porter hypothesis maintains that environmental regulation can produce compensation benefits that exceed the cost and generate incentives, which are complementary to green innovation (Guo et al., 2023; Zhou et al., 2023; Zhang et al., 2023). Furthermore, some individuals think that the link between green innovation and environmental regulation is formed like a "U" (Liu et al., 2023; Zhang et al., 2023). However, few academics have looked at how green bonds affect green innovation. Identifying sustainable capital investments over the long term is the foundation for implementing green innovation initiatives (Yu et al., 2021). Most scholars mainly studied the potential economic benefits of green bonds. Through the environmental protection and resource allocation attributes of green bonds, they play a positive role in corporate capital cost (Zhang et al., 2021), corporate value (Jiang et al., 2022), total factor productivity (Li et al., 2023) and environmental quality (Chang et al., 2022). However, it is also possible for enterprises to issue green bonds for green washing (Xu et al., 2022). Enterprises achieve the purpose of "saying more than doing" through selective information disclosure, so they will not produce environmental benefits (Shi et al., 2023; Sinha et al., 2021).

In general, previous studies have provided theoretical basis and research results for green bonds and green innovation, but there are still certain limitations. First, the existing literature mainly uses environmental rating and carbon dioxide emission reduction as alternative indicators to evaluate the environmental benefits of green bonds, but the consequence of green bonds on green innovation receives less consideration. Second, only the positive pathways of effect are included in the present study of the environmental advantages of green bonds, and does not consider the negative impact brought by green washing. Third, although there have been studies on green bonds in the literature, the majority of them focus on financial limitations without taking into account how green bonds influence green innovation through the R&D competition mechanism.

This study takes the issuance of green bonds as a quasi-natural experiment to investigate the impact of green bonds on enterprises' green innovation and its potential mechanisms. First, we select A-share listed companies in Shanghai and Shenzhen of China from 2012 to 2022 as samples and construct a multi-point DID model to investigate how green bonds affect the quantity and quality of green innovation. Second, we analyze how green bonds affect enterprises' green innovation from the perspective of R&D competition. Finally, enterprises are classified by industry attribute (polluted vs. unpolluted) and ESG scores (high ESG scores vs. low ESG scores) to conduct a heterogeneity analysis. We then divided samples according to whether they belong to Green Finance Pilot Zones (GFPZ) to test whether there is heterogeneity in the promotion effect of green bonds.

The marginal contributions are as follows: (1) Using green innovation as a gauge for measuring environmental benefits, the consequences of green bonds on businesses' adoption of green innovation is investigated in this article, which also looks at the benefits and drawbacks of doing so within the same framework. When it comes to the impact of green bonds on issuers, it's important to take into account both the positive and negative effects of these bonds. (2) We analyze how green bonds affect green innovation from the standpoint of R&D competition. At present, the mechanism analysis of green bonds mainly starts from the resource effect, ignoring the R&D competition mechanism among peers triggered by green signals. Therefore, examining how green bonds affect enterprises' green innovation from the standpoint of R&D competition expands the way academics can examine how green bonds work, improves our understanding of their financial effects. (3) By examining the heterogeneity of ESG scores and GFPZ, this study illustrates how ESG scores and GFPZ positively

influence the role of green bonds in encouraging green innovation of enterprises, and provides new insights for enterprises to accelerate green transformation.

The remaining sections of the essay are structured as follows: Part 2 is the literature review. Part 3 is the theoretical analysis and hypothesis formulation. Part 4 is the data and empirical design. Part 5 is the results and analysis. Part 6 is the conclusions and discussion.

2. LITERATURE REVIEW

2.1. Studies on Green Bonds

Green bonds are issued by governments, businesses, financial institutions, and other organizations to generate funds for ecologically beneficial projects (Wang et al., 2020; Hyun et al., 2021), which is an important part of the green financial system. Since the green bond market has grown so quickly, academics have conducted in-depth research on it.

Research on green bonds currently primarily focuses on the following topics. The effects of liquidity risk (Febi et al., 2018), environmental preference (Zerbib, 2019), investor attention (Pham et al., 2020), and other factors on green bond spreads (Boutabba and Rannou, 2022), whether there is a green premium in green bonds (Karpf and Mandel, 2018; Dorfleitner et al., 2022), and the link between the green bond market and other markets (Ferrer et al., 2021; Elsayed et al., 2022). In addition, several academics have explored the economic and environmental consequences caused by green bonds, and the primary perspectives fall into two groups: favorable consequences and unfavorable consequences. There are academics who lend credence to the notion that green bonds have advantages. Zhang et al. (2021) discovered that green bonds alleviated information asymmetry, enhanced stock liquidity. Jiang et al. (2022) observed that green bonds can boost business value, but this positive effect is not sustainable because green investment erodes corporate profits. Zhao et al. (2022) analyzed the economic benefits brought by green bonds from a macro perspective and held that the main funding source for energy-saving initiatives is green bonds, which can boost green economic recovery by roughly 17% annually and foster 4.9% annual economic development. Chang et al. (2022) used quantile regression to find that among the top ten countries supporting green finance, and the link between green bonds and environmental quality is not linear, and green bonds have a beneficial influence on a certain quantile. Li et al. (2023) constructed a multi-time point DID model to demonstrate that issuing green bonds can enhance the total factor productivity from the perspectives of realistic requirements, intrinsic motivation and green signal, and the effect is obvious. However, green bonds will also cause negative effects. Enterprises can use green bonds to carry out green washing to cover up their social responsibilities. Sinha et al. (2021) used quantile-to-quantile regression and found that green bond financing would have a progressive negative impact on environmental and social responsibility. Shi et al. (2023) found that enterprises would distort the investment in green activities through the money obtained by green bonds, which would have an inhibitory effect on green projects. Xu et al. (2022) pointed out that there was green washing in China's green bond market due to the overpricing of green bonds.

2.2. Studies on Green Innovation

Green innovation is the process of offering unique, environmentally friendly goods to businesses in order to increase their competitiveness and production efficiency (Kunapatarawong and Martinez-Ros, 2016; Wang et al., 2021), which can lower the cost of emission reduction, and create a situation where environmental preservation and economic growth are mutually beneficial. At present, the influence of environmental regulations on green innovation has been the subject of several studies, primarily categorized into two types: “conflicting” and “complementary”. The majority of academics who endorse the “conflict” perspective between the environmental regulations and green innovation rely on strict environmental regulations. Kneller and Manderson (2012) examined how environmental

laws affected British manufacturing companies' technological innovation, and the conclusion is that there is a phenomenon known as crowding out among them. Li and Wu (2017) conducted research on command-and-control environmental regulation, and discovered that while regulations promote enterprises' technology import and improvement, they would not conducive to enterprises' original innovation. Petroni et al. (2019) found that the payment of pollutant discharge fees increased the financial burden and squeezed out green innovation resources. Wang et al. (2023) discovered that businesses did not redirect their investments in green innovation into other forms of innovation, and that required environmental protection rules significantly hampered green innovation. The other view is that environmental regulation and green innovation complement each other, and economy and environment cannot be discussed separately, and adequate environmental regulation can compel firms to innovate green and produce "compensatory benefits" that surpass the cost of environmental control (Porter and Linde, 1995). Peng et al. (2021) constructed a theoretical framework indicating that environmental regulation encourages green innovation willingness, which in turn encourages innovation behavior. The empirical results demonstrate that controlled environmental legislation has a greater impact on green innovation willingness than incentive kind. Farooq (2024) used listed enterprises from 10 Asian economies as samples to examine the relationship between environmental regulation and capital investment. The results support Porter's hypothesis. Guo et al. (2023) merged data from listed businesses in high-pollution sectors with data from city-level environmental rules, and discovered that the more stringent the environmental legislation, the more it encourages businesses to advance green innovation. Zhou (2023) found that companies with greater environmental regulatory pressure could convert the regulatory pressure into incentives and were more likely to implement green innovation. Liu (2023) found environmental rules and green innovation have a non-linear connection, with command and market-based regulations having a "U" shaped impact and voluntary regulations having an inverted "U" shaped impact.

2.3. Studies on the Effect of the Green Bonds on Enterprises' Green Innovation

At present, the effect of green bonds on enterprises' green innovation has not been extensively explored by academics. Lee et al. (2023) used the data of 277 cities in China to construct a spatial econometric model, and observed that green bonds may encourage urban green space and innovation by boosting economic growth and increasing disposable income, but have negative spillover effects on surrounding cities. Ren et al. (2023) studied that green bonds promoted enterprises' green innovation through the functions of financing constraint, investment incentive, and green regulation. Environmental protection is one of the features of green bonds, which may be seen of as an expansion of environmental control (Cui et al., 2022; Shi et al., 2022). Analyzing this issue's study from the standpoint of how China's green financing policy affects green innovation is also possible. Currently, there are many studies on Carbon Emission Trading Pilot (CETP), Green Credit Policy (GCP), Green Finance Pilot Zones (GFPZ). Hu et al. (2020) discovered that cutting back on government support for CETP can encourage innovation and lower the cost of compliance, which will tangentially improve quantity and quality. Zhang et al. (2021) conducted a quasi-natural experiment on the issuance of GCP on investment, financing, and environmental quality in high-pollution and energy-consuming enterprises. The findings demonstrate that the "two high" companies' short-term financing activity is encouraged, but has a long-term punishment effect, and the policy can improve the environmental quality. Zhang (2023) explored the policy effect of GFPZ, and found that while the policy's "incentive effect" on green enterprise innovation was not significant, the "compulsory effect" on green innovation of polluting enterprises was.

In summary, the current research on green bonds and green innovation has been analyzed from different perspectives. The impact of green bonds, including their promotion effect on enterprise value, cost of capital, financial performance, total factor productivity, and other economic repercussions, as well as their inhibitory effect on green bleaching risk, are given more emphasis in the study on green bonds. When looking at green innovation from the standpoint of traditional

environmental legislation, the study is more extensive. However, the government-led environmental protection policy will greatly weaken the enthusiasm of enterprises. Few academics have investigated their link. Most of them have carried out it from the perspective of financing constraints, debt costs, and investor incentives, ignoring the green signals released by green bonds in triggering R&D competition among peers. Although the above studies have made progress in the field of sustainable development, there are still limitations. Therefore, to make up for the deficiency, this paper links green bonds with enterprises' green innovation, discusses the relationship between them and the influencing mechanism, and enriches the relevant content of research in this field.

3. THEORETICAL ANALYSIS AND HYPOTHESIS FORMULATION

3.1. The Positive Effect of Green Bonds on Enterprises' Green Innovation

The first question we need to address is whether green bonds can actually promote green innovation. As a new financing tool, green bond can provide long-term financial support for enterprises' green innovation projects and promote green innovation. On the other hand, bond issuers may change the use of green funds and invest in non-green projects, which may not promote green innovation. So we start the analysis with the positive and negative impacts of green bonds separately.

First, we consider the positive impact of green bonds. Social responsibility theory holds that in addition to seeking economic returns, companies should also actively fulfill their social and environmental responsibilities. From the perspective of financing attributes, as a direct financing method, green bonds have greater advantages compared with traditional credit financing. Because green bonds have comparatively lengthy maturities, they are more suited for generating steady, long-term capital, improving maturity mismatch behavior of businesses, and optimizing the debt maturity structure (Wang and Chu, 2022). From the perspective of green attributes, the funds raised by green bonds are mainly used for environmental protection projects, which helps enterprises obtain positive environmental benefits (Tang and Zhang, 2020), lessen the potential environmental hazards for stakeholders, and satisfy the demands of various stakeholders, and reflect the social responsibility voluntarily undertaken by enterprises. When stakeholders see businesses acting in this way, it's easy to win their approval, increase their external financing, raise more funds for enterprises' technological innovation, and promote enterprises' green innovation. Therefore, the following hypothesis is proposed:

Hypothesis 1: Green bonds by enterprises can promote their green innovation.

Enterprises issuing green bonds can increase competition for R&D. According to the signal transmission theory, the issuance of green bonds by enterprises sends a signal to their peers that enterprises assume social responsibility by investing in green projects, supporting sustainable growth and environmental protection. When industry leaders issue green bonds, they are incentivized to take full advantage of their first-mover advantage, continuously increase their R&D investment, and improve the level of green innovation of their enterprises in order to maintain continuous competitive advantage and monopoly rents (Flammer, 2015; Huang et al., 2022; Wang et al., 2022). However, after the profitability "setback", enterprises in the same industry will quickly respond to the R&D practices of competitors, increase R&D investment by issuing green bonds, and further seize the green innovation resources in the market to catch up with the leaders. Under competitive pressure, the two groups of firms repeatedly play dynamic games (Li et al., 2023). In this way, green bonds can stimulate R&D competition among peer companies. Therefore, the following hypothesis is proposed:

Hypothesis 1a: Green bonds will enhance enterprises' green innovation by enhancing R&D competition.

3.2. The Negative Effect of Green Bonds on Enterprises' Green Innovation

Second, we consider the negative impact of green bonds. Neoclassical economic theory holds that firms seek to maximize profits. However, in the process of pursuing profit maximization, enterprises issuing green bonds can fulfill their environmental and social responsibilities will greatly increase the cost. In this process, enterprises can selectively disclose selectively disclose environmental information through green washing, or use qualitative disclosure methods such as oral description to cover up quantitative disclosure methods such as digital description, and exaggerate their environmental responsibilities. Misleading the public about actual environmental performance (Lyon and Maxwell, 2011; Lyon et al., 2013; Marquis et al., 2016), in order to earn green revenue. However, green innovation is an important embodiment of green investment and environmental protection ability of enterprises (Xing et al., 2021). When enterprises issue green bonds for the purpose of green bleaching, the degree of green investment of enterprises will be distorted and the development of green innovation of enterprises will be hindered. Therefore, the following hypothesis is proposed:

Hypothesis 2: Green bonds will hinder enterprises' green innovation.

4. DATA AND EMPIRICAL DESIGN

4.1. Variable Definition

4.1.1. Green Innovation

Green innovation (TGP_{it}/Gin_{it}). The explained variable is the level of enterprise green innovation. We divide the explained variables into quantity of green innovation (TGP_{it}) and quality of green innovation (Gin_{it}). Referring to previous studies (Lin and Ma, 2022), we measured the total number of green patent applications for TGP_{it} and the number of green invention patent applications for Gin_{it}. First, this paper obtains the patent application information of sample enterprises from the CNRDS database, and then further screens out the green invention patents. Second, to avoid the influence of zero and negative values, we add 1 to the variables TGP_{it} and Gin_{it} respectively and then take logarithms.

4.1.2. Green Bond

Green bond ($Gbond_{it}$). The variable is composed of the interaction term of $Treat_i$ and $Post_t$, i.e. $Gbond_{it} = Treat_i \times Post_t$. In other words, if the enterprise has issued green bonds, then $Treat_i = 1$, otherwise $Treat_i = 0$. The year after the enterprise issues green bonds, $Post_t = 1$, otherwise $Post_t = 0$. $Gbond_{it}$ is the core explanatory variable of this paper, which is expressed as the $Gbond_{it} = 1$ in the current year and subsequent years when the enterprise issues green bonds for the first time from 2012 to 2022, otherwise it is 0. In addition, to eliminate the impact of issuance times, we only retain the green bonds first issued by the enterprise in the current year.

4.1.3. Control Variables

Referring to the existing literature (Li et al., 2023), the following variables affecting enterprises' green innovation are selected as control variables: Enterprise size (Size), asset-liability ratio (Lev), net profit margin of total assets (ROA), proportion of fixed assets (Fixed), growth rate of operating income (Growth), number of directors (Board), company establishment years (Firm Age), the greatest shareholder's ownership ratio (Top1), and Dual position (Dual). For specific definitions, please refer to the variable definition table.

Table 1. Variable definition table.

Variable Symbol	Variable Name	Variable Definition
Explained Variables		
TGP	Quantity of green technology innovations	The total number of green patent applications plus one, for logarithmic values
Gin	Quality of green technology innovation	The total number of green invention patent applications submitted by enterprises plus one, using logarithmic notation
Explanatory Variables		
Gbond	Issuance of Green Bonds	Takes the value of 1 in the year in which the enterprises first issues a green bond in 2012-2022 and in subsequent years, and 0 otherwise.
Control Variables		
Size	Enterprise size	Natural logarithm of total assets for the year
Lev	Asset-liability ratio	Ratio of total liabilities to total assets
ROA	Net profit margin of total assets	Net profit/average balance of total assets
Fixed	Proportion of fixed assets	Net fixed assets to total assets
Growth	Growth rate of operating income	(Current year's operating income/previous year's operating income)-1
Board	Number of directors	The number of board members is taken as a natural logarithm
Firm Age	Company establishment years	Ln (current year-year of incorporation+1)
Top1	Shareholding ratio of the largest shareholder	Number of shares held by the largest shareholder/total number of shares
Dual	Dual position	The chairman and general manager are the same person as 1, otherwise it is 0.

Note: The variables used in this work are listed in this table along with their definitions.

4.2. Data Sources

We divides the control group and the experimental group based on whether the listed companies issued green bonds. It does this by choosing a sample of A-share listed companies in Shanghai and Shenzhen of China, that issued between 2012 and 2022. The development of green bonds in China's capital market began in 2016. To ensure sufficient samples, this paper chose 2012 as the starting point. In addition, a sample of financial firms is excluded. After the above processing, 39 enterprises issued 47 green bonds, and 491 listed enterprises issued 980 ordinary bonds, for a total of 5460 observed values. This paper's data on green bonds is sourced from the Wind and CSMAR database, and the information on green patents held by firms is sourced from the CNRDS database. Continuous variables are winsorized at the 1% and 99% quantiles.

4.3. Empirical Design

In order to test the impact of green bonds on enterprises' green innovation, the DID Model (1) is constructed as follows:

$$TGP_{it}/Gin_{it} = \beta_0 + \beta_1 Gbond_{it} + \beta_2 Controls_{it} + \sum Firm_i + \sum Year_t + \varepsilon_{it} \quad (1)$$

where i and t represent the enterprise and the year. TGP_{it} represents the quantity of green innovations in enterprise i in year t. Gin_{it} represents the quality of green innovation in enterprise i in year t. $Gbond_{it}$ represents a dummy variable. When enterprise i issues green bonds in year t, the $Gbond_{it} = 1$, otherwise $Gbond_{it} = 0$. $Controls_{it}$ represents control variables, and the specific control variables are selected in Table 1. $Firm_i$ represents the firm fixed effect. $Year_t$ represents the year fixed effect. ε_{it} is the standard error of the Model (1), we chose robust standard error.

5. RESULTS AND ANALYSIS

5.1. Descriptive Statistics and Correlation Test

5.1.1. Descriptive Statistics

According to the descriptive statistics table, the variances of the quantity and quality of green innovation are 1.514 and 1.316 respectively, and the mean values are 1.399 and 1.006 respectively, showing that businesses usually have low levels of green innovation and that there is a wide variation in the green innovation levels of various businesses. During the study period, 2.4% of the firms issued green bonds, as shown by the average value of 0.024. The descriptive statistics of the control variables are similar to the existing literature on green innovation, which is controlled within a reasonable range.

Table 2. Descriptive statistics table.

Variables	N	mean	p25	p50	p75	sd	min	max
TGP	5460	1.399	0	1.099	2.398	1.514	0	5.919
Gin	5460	1.006	0	0.693	1.792	1.316	0	5.451
Gbond	5460	0.024	0	0	0	0.154	0	1
Size	5460	23.64	22.63	23.53	24.52	1.415	20.63	27.43
Lev	5460	0.539	0.422	0.55	0.67	0.175	0.114	0.919
Fixed	5460	0.228	0.059	0.184	0.357	0.195	0.001	0.753
ROA	5460	0.035	0.014	0.031	0.056	0.046	0.176	0.188
Growth	5454	0.154	0.023	0.1	0.252	0.343	0.551	2.099
Board	5458	2.183	2.079	2.197	2.197	0.199	1.609	2.708
Dual	5460	0.187	0	0	0	0.39	0	1
Top1	5459	0.369	0.245	0.353	0.49	0.162	0.081	0.764
Firm Age	5460	2.967	2.773	3.045	3.178	0.325	1.946	3.555

Note: This table provides the basic statistical information of the variables used in this paper.

5.1.2. Correlation Test

Table 3 shows the correlation test of variables. It can be seen from the above table that except the correlation coefficient between the explained variables is greater than 0.5, the coefficients of other variables are all less than 0.5, indicating that there is no multicollinearity among the variables. Among them, the correlation coefficients between the independent variable Gbond, TGP and Gin are all

statistically significant, suggesting a potential promotion impact of green bonds on enterprises' green innovation.

Table 3. Correlation test of variables.

Variables	TGP	Gin	Gbond	Size	Lev	Fixed	ROA
TGP	1						
Gin	0.947***	1					
Gbond	0.163***	0.142***	1				
Size	0.476***	0.473***	0.090***	1			
Lev	0.173***	0.148***	0.044***	0.509***	1		
Fixed	0.113***	0.066***	0.079***	0.103***	-0.056***	1	
ROA	0.004	0.004	-0.029**	-0.046***	-0.388***	0.015	1
Growth	0.012	0.01	-0.01	0.006	0.026*	-0.046***	0.261***
Board	0.090***	0.093***	-0.009	0.228***	0.097***	0.178***	0.024*
Dual	-0.033**	-0.014	0.01	-0.125***	-0.085***	-0.071***	0.015
Top1	0.070***	0.070***	0	0.265***	0.104***	0.148***	0.072***
Firm Age	0.02	0.022	0.058***	0.202***	0.135***	-0.039***	-0.088***
	Growth	Board	Dual	Top1	Firm Age		
Growth	1						
Board	-0.035***	1					
Dual	0.040***	-0.189***	1				
Top1	-0.013	0.057***	-0.130***	1			
Firm Age	-0.060***	0.062***	-0.061***	-0.125***	1		

Note: This table provides the matrix of correlation coefficients for the main variables used in this paper.

5.2. Empirical Results

5.2.1. Effect of the Green Bond on Enterprises' Green Innovation

All regression results are shown in Table 4, the coefficients of all Gbond are positive. As the environmental benefit of enterprises, when green innovation is positive, it indicates that the resource allocation and green signal effect of green bonds play a dominant role (Flammer, 2021). From the regression results of Table 4's column (1) and column (2) without adding control variables, the regression coefficients of explanatory variables are significantly positive. The regression results in column (3) further show that after adding the results of control variables, the regression coefficient of green bonds is 0.359, which is significant at the level of 1%, that is, the number of green innovations of enterprises increased by 35.9% on average. Table 4's column (4) displays the estimation results for green bond issuance on green innovation patents, with a coefficient of 0.291, demonstrating that the quantity of green innovation is more promoted by businesses issuing green bonds than the quality of green innovation. As a result, green bonds significantly encourages their own green innovation, which verifies **Hypothesis 1**.

Table 4. Baseline regression results.

Variables	(1)	(2)	(3)	(4)
	TGP	Gin	TGP	Gin
Gbond	0.406***	0.324***	0.359***	0.291***
	(0.087)	(0.078)	(0.086)	(0.077)
Size			0.248***	0.178***
			(0.030)	(0.027)
Lev			0.205	0.079
			(0.140)	(0.126)
Fixed			-0.205	-0.312**
			(0.160)	(0.143)
ROA			0.738**	0.248
			(0.312)	(0.279)
Growth			0.035	0.048
			(0.032)	(0.029)
Board			-0.134	0.021
			(0.102)	(0.091)
Dual			0.041	0.063*
			(0.038)	(0.034)
Top1			-0.066	-0.026
			(0.186)	(0.167)
Firm Age			-0.337*	0.048
			(0.203)	(0.182)
Cons	0.835***	0.559***	-3.717***	-3.677***
	(0.033)	(0.030)	(0.882)	(0.790)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
R^2	0.230	0.185	0.249	0.198
adj.R^2	0.148	0.097	0.166	0.111
N	5460	5460	5452	5452

Note: This table reports the baseline results of green bonds on enterprises' green innovation. All the regressions include firm fixed effect, time fixed effect. The figures in parentheses are robust standard errors,** and,**** represent the significance level of 10%, 5% and 1%, respectively. The following table is the same.

5.3. Robustness Test

5.3.1. Parallel Trend Test

In this paper, the enterprises that have issued green bonds are taken as the treatment group, and the enterprises that have not issued green bonds are taken as the control group, and the multi-time point DID model is used for research. The DID model hypothesizes that there is no significant difference

between the treatment group and the control group before the policy shock, but there is a significant difference after the policy shock, that is, after the issuance of green bonds, the treatment group's level of green innovation differs significantly from that of the control group. Thus, to carry out the parallel trend test and further investigate the dynamic characteristics of the effect of enterprises issuing green bonds, based on the research of Beck et al. (2010), and the findings are shown in Figure 1 and Figure 2. Before the green bonds being issued, there was no significant difference in the two explained variables of enterprises' green innovation between the two groups, which satisfies the hypothesis of parallel trend. After the issuance of green bonds, the green innovation of the treatment group is significantly higher than that of the control group, and the regression coefficient is significantly greater than 0, indicating that the issuance of green bonds has a significant promotion effect on enterprises' green innovation, but the promotion effect declines over time.

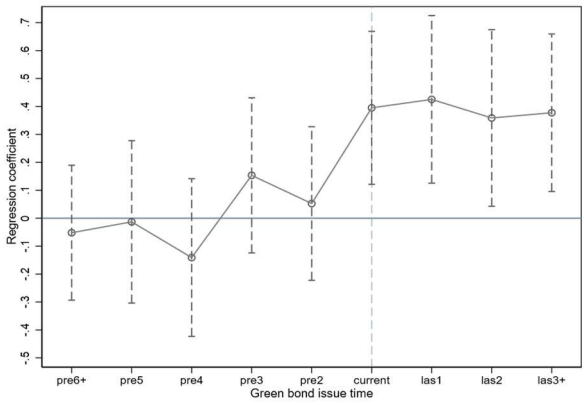

Figure 1. Parallel trend test for TGP.

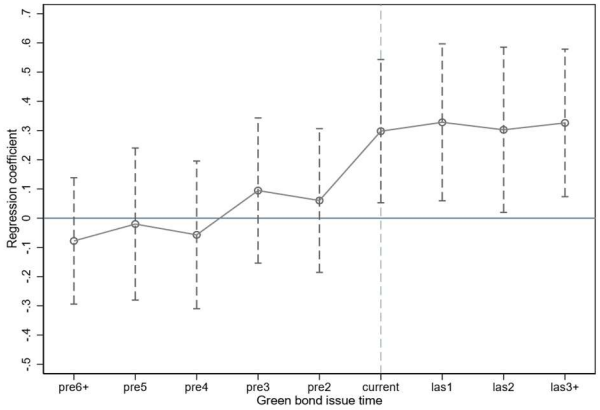

Figure 2. Parallel trend test for Gin.

5.3.2. Change the Explained Variable

The variables that were described will be replaced as follows: the number of green patents the enterprise has acquired represents the quantity of green innovation, and the number of green invention patents the enterprise has obtained represents the quality of green innovation. The treatment methodology remains the same. The regression results are shown in Table 5. The strength of the aforementioned results is demonstrated by the regression coefficients, which are all significant at the 1% level both before and after the addition of control variables. The coefficients for the quantity of green innovation are also much higher than those for the quality of green innovation.

Table 5. Robustness test results: Change the explained variable.

Variables	(1)	(2)	(3)	(4)
	TGP_hd	Gin_hd	TGP_hd	Gin_hd
Gbond	0.550***	0.284***	0.492***	0.255***
	(0.079)	(0.060)	(0.078)	(0.060)
Size			0.271***	0.131***
			(0.027)	(0.021)
Lev			0.072	-0.117
			(0.127)	(0.097)
Fixed			0.219	0.075
			(0.144)	(0.111)
ROA			0.485*	0.096
			(0.282)	(0.216)
Growth			-0.008	-0.010
			(0.029)	(0.022)
Board			-0.294***	-0.103
			(0.092)	(0.071)
Dual			0.005	0.011
			(0.034)	(0.026)
Top1			-0.161	-0.034
			(0.168)	(0.129)
Firm Age			-0.090	0.151
			(0.183)	(0.141)
Cons	0.629***	0.297***	-4.725***	-2.824***
	(0.030)	(0.023)	(0.796)	(0.611)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
R^2	0.250	0.116	0.270	0.125
adj.R^2	0.169	0.021	0.190	0.029
N	5460	5460	5452	5452

Note: This table reports the regression results of the robustness test by changing the explained variables. Others are consistent with Table 4.

5.3.3. Lagged Regression Model

The robustness test takes into account the fact that green innovation output takes time to erupt to demonstrate the research's robustness. The explained variables are, accordingly, delayed by one and two periods to confirm this finding. Table 6 displays the regression findings. Columns (1) and (2) represent the regression of the lag by one period, and the coefficients are clearly positive. Columns (3) and (4) are the regression results lagged by two periods, and the explained variables are significant. Whether lagged one period or lagged two periods, the regression coefficients of the quantity of green

innovation are greater than those of the quality of green innovation. The outcomes above align with the findings of the empirical results.

Table 6. Robustness test results: Lagged regression model.

Variables	(1)	(2)	(3)	(4)
	TGP_{t+1}	Gin_{t+1}	TGP_{t+2}	Gin_{t+2}
Gbond	0.327***	0.275***	0.221**	0.180**
	(0.089)	(0.079)	(0.093)	(0.082)
Size	0.303***	0.223***	0.326***	0.234***
	(0.033)	(0.030)	(0.038)	(0.034)
Lev	0.118	0.033	-0.298*	-0.290*
	(0.154)	(0.137)	(0.171)	(0.151)
Fixed	0.004	-0.097	0.098	0.041
	(0.175)	(0.156)	(0.194)	(0.171)
ROA	0.375	0.078	-0.322	-0.522*
	(0.326)	(0.291)	(0.341)	(0.300)
Growth	-0.068**	-0.046	-0.037	-0.027
	(0.034)	(0.030)	(0.035)	(0.031)
Board	-0.269**	-0.147	-0.246**	-0.220**
	(0.109)	(0.097)	(0.118)	(0.104)
Dual	0.003	0.000	-0.017	0.006
	(0.040)	(0.035)	(0.042)	(0.037)
Top1	0.051	0.043	-0.119	-0.161
	(0.205)	(0.183)	(0.237)	(0.209)
Firm Age	-0.327	0.028	-0.336	0.051
	(0.232)	(0.207)	(0.278)	(0.245)
Cons	-4.750***	-4.352***	-5.060***	-4.322***
	(1.001)	(0.893)	(1.188)	(1.047)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
R^2	0.273	0.218	0.258	0.208
adj.R^2	0.185	0.123	0.156	0.100
N	4940	4940	4422	4422

Note: This table reports the regression results of the robustness test by considering the lag of green innovation. Others are consistent with Table 4.

5.3.4. Placebo Test

To test that the impact of enterprises' green bond issuance on green innovation is not caused by other random factors, the placebo test is used to identify the contingency of the effect of green bond issuance. In this research, 1000 samples were randomly chosen and regression was done according

to Model (1). The outcomes of the placebo test were shown in Figure 3 and Figure 4. The mean regression coefficient of 1000 random samples is close to 0, which is much smaller than the baseline regression coefficient. The distribution of estimated coefficients is close to normal distribution, and most of the P values are greater than 0.1, which is not significant at the level of 10%. It demonstrates that the influence of enterprises issuing green bonds on green innovation is not caused by random variables, and the above conclusions are robust.

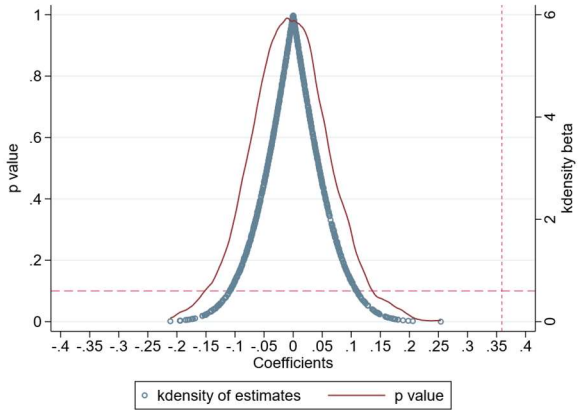

Figure 3. Placebo test for TGP.

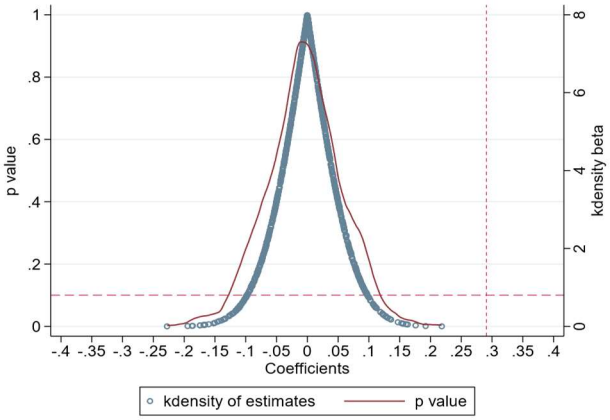

Figure 4. Placebo test for Gin.

5.3.5. PSM-DID Test

Considering that it is not random for companies to issue green bonds in response to unforeseen events, it is possible that enterprises with good efficiency, large scale, and high technical level will be more likely to pass the approval to issue bonds, so the above model may have the problem of sample self-selection. However, considering that it is difficult to find an instrumental variable to represent green bonds, Flammer (2021) uses the PSM method to match the control group for the treatment group to verify the robustness of the results. Specifically, the kernel matching method is used to match the control variables of the baseline regression such as enterprise size (Size), asset-liability ratio (Lev), and net profit margin of total assets (ROA) at the company level as covariates. After eliminating a small number of samples that are not matched, the multi-time point DID model is used for regression. The results are shown in column (1) and column (2) of Table 7. The regression coefficients of the two explained variables are significant, demonstrating that there are no sample selection issues with the original model, and that the conclusions are reliable.

Table 7. Robustness test results: PSM-DID test.

Variables	(1)	(2)
	TGP	Gin
Gbond	0.365***	0.290***
	(0.087)	(0.078)
Size	0.240***	0.169***
	(0.031)	(0.028)
Lev	0.189	0.034
	(0.150)	(0.135)
Fixed	-0.218	-0.344**
	(0.164)	(0.147)
ROA	0.678**	0.160
	(0.342)	(0.309)
Growth	0.050	0.059*
	(0.033)	(0.030)
Board	-0.080	0.049
	(0.108)	(0.097)
Dual	0.027	0.056
	(0.040)	(0.036)
Top1	0.008	0.019
	(0.192)	(0.173)
Firm Age	-0.258	0.167
	(0.212)	(0.190)
Cons	-3.884***	-3.864***
	(0.917)	(0.825)
Year	Yes	Yes
Firm	Yes	Yes
R^2	0.255	0.202
adj.R^2	0.169	0.110
N	5150	5135

Note: This table reports the regression results of the robustness test by PSM-DID. Others are consistent with Table 4.

5.4. Mechanism Test

The empirical evidence that green bond issuance promotes enterprises' green innovation is obtained above. Based on theoretical analysis, the mechanism is revealed from the perspective of R&D competition. When enterprises issue green bonds to release green signals, enterprises in the same industry consider that issuing green bonds will form a good reputation, indicating that enterprises are making efforts to undertake social responsibilities and attract the attention of environmental investors (Lins et al., 2017), and enterprises in the same industry will increase their competitive advantages by

issuing green bonds. Consequently, a dominant industry will continue to boost investment in R&D and encourage green innovation when it issues green bonds in order to maintain its monopolistic position. However, under budgetary constraints, the comparatively backward businesses in the same industry would optimize resource allocation, boost R&D investment, and develop their capacity for green innovation in order to strengthen their competitive edge. The ratio of R&D investment to the greatest R&D investment in the same industry serves as a proxy for the intensity of R&D rivalry (Huang et al., 2022). The following model are used for mechanism verification:

$$M_{it} = \theta_0 + \theta_1 Gbond_{it} + \theta_2 Controls_{it} + \sum Firm_i + \sum Year_t + \varepsilon_{it} \quad (2)$$

Where M_{it} is the mechanism variable measuring R&D competition (RDC) and the remaining variables remain unchanged from the baseline model.

Table 8. Mechanism test.

Variables	(1)	(2)
	RDC	RDC
Gbond	0.040***	0.034**
	(0.015)	(0.015)
Size		0.070***
		(0.006)
Lev		-0.117***
		(0.027)
Fixed		-0.002
		(0.032)
ROA		0.039
		(0.055)
Growth		0.019***
		(0.007)
Board		-0.047**
		(0.019)
Dual		0.001
		(0.007)
Top1		0.083**
		(0.036)
Firm Age		0.221***
		(0.037)
Cons	0.063***	-1.996***
	(0.007)	(0.163)
Year	Yes	Yes
Firm	Yes	Yes
R^2	0.241	0.284
adj.R^2	0.143	0.190
N	4307	4302

Note: This table reports the mechanism results. Others are consistent with Table 4.

The mechanism test's regression findings are listed in Table 8. Column (1) shows the effect of R&D competition on the explained variable without the control variables, the coefficient of the Gbond is 0.04, which is significant at the level of 1%. Column (2) shows the effect of R&D competition on the explained variable after the addition of the control variables, the coefficient of the Gbond is 0.034, which is positively significant at the level of 5%. Therefore, it can be seen that green bonds can intensify R&D competition and promote green innovation, which verifies Hypothesis 1a.

5.5. Heterogeneity Analysis

5.5.1. Heterogeneity of Industry Attributes

Table 9. Heterogeneity analysis of industry attributes.

Variables	(1)	(2)	(3)	(4)
	TGP	TGP	Gin	Gin
	Polluted=1	Polluted=0	Polluted=1	Polluted=0
Gbond	0.393***	0.360***	0.358***	0.271***
	(0.135)	(0.113)	(0.117)	(0.102)
Size	0.337***	0.176***	0.258***	0.099***
	(0.055)	(0.039)	(0.048)	(0.035)
Lev	0.446*	0.146	0.432**	-0.070
	(0.251)	(0.171)	(0.219)	(0.155)
Fixed	-0.218	-0.213	-0.080	-0.395**
	(0.263)	(0.210)	(0.229)	(0.190)
ROA	2.107***	-0.018	1.724***	-0.395
	(0.509)	(0.403)	(0.445)	(0.364)
Growth	-0.063	0.061	-0.020	0.062*
	(0.061)	(0.038)	(0.054)	(0.035)
Board	-0.393**	0.010	-0.108	0.091
	(0.177)	(0.126)	(0.154)	(0.114)
Dual	-0.001	0.062	0.115*	0.049
	(0.070)	(0.045)	(0.061)	(0.041)
Top1	0.895***	-0.544**	0.938***	-0.489**
	(0.340)	(0.226)	(0.297)	(0.204)
Firm Age	-2.467***	0.295	-1.817***	0.556***
	(0.420)	(0.231)	(0.367)	(0.209)
Cons	-0.008	-3.868***	-0.927	-3.117***
	(1.642)	(1.112)	(1.434)	(1.006)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
R^2	0.287	0.236	0.216	0.205
adj.R^2	0.199	0.148	0.120	0.113
N	1880	3572	1880	3572

Note: The effect of green bonds on the green innovation of both polluted and unpolluted businesses is seen in this table. Others are consistent with Table 4.

Green bonds can guide capital flow to resource-saving and environment-friendly enterprises so that such enterprises face fewer external financing constraints, while for polluted enterprises, financing

costs have risen significantly. Under such circumstances, will polluted enterprises issue green bonds to attract investors and financial institutions and promote their green innovation? We believe that although the enterprise itself is a polluted industry, the issuance of green bonds shows that it is committed to green projects, is striving to assume social responsibility, and urgently needs to achieve the purpose of energy conservation and emission reduction through green innovation. Therefore, the issuance of green bonds to polluted enterprises plays a more significant role in promoting green innovation. To analyze the heterogeneous impact of industry attributes, this paper divides the samples into polluted enterprises and unpolluted enterprises for testing, where polluted=1, otherwise polluted=0. Table 9's columns (1) and (3) display the regression analysis of polluted enterprises. It can be seen that issuing green bonds has a great promotional effect on the technological innovation of polluted enterprises. The regression findings for unpolluted enterprises are listed in columns (2) and (4), and it is evident that the promotion impact of issuing green bonds on unpolluted enterprises is less than that on polluted enterprises.

5.5.2. Heterogeneity of ESG Scores

Table 10. Heterogeneity analysis of ESG scores.

	(1)	(2)	(3)	(4)
Variables	TGP	TGP	Gin	Gin
	ESG=1	ESG=0	ESG=1	ESG=0
Gbond	0.564***	0.096	0.532***	-0.008
	(0.114)	(0.145)	(0.104)	(0.125)
Size	0.236***	0.271***	0.108**	0.242***
	(0.050)	(0.043)	(0.046)	(0.037)
Lev	-0.055	0.242	-0.080	0.110
	(0.230)	(0.195)	(0.210)	(0.168)
Fixed	-0.228	-0.208	-0.518**	-0.171
	(0.264)	(0.221)	(0.241)	(0.191)
ROA	0.405	0.653	0.192	-0.051
	(0.512)	(0.432)	(0.467)	(0.373)
Growth	-0.058	0.115**	-0.040	0.107***
	(0.049)	(0.046)	(0.045)	(0.040)
Board	-0.060	-0.088	0.083	0.043
	(0.140)	(0.161)	(0.128)	(0.140)
Dual	0.011	-0.014	0.035	0.031
	(0.054)	(0.058)	(0.050)	(0.050)
Top1	0.401	-0.471*	0.223	-0.132
	(0.284)	(0.277)	(0.259)	(0.240)
Firm Age	-0.250	-0.339	0.123	0.088
	(0.304)	(0.321)	(0.277)	(0.278)
Cons	-3.772***	-4.339***	-2.277*	-5.380***
	(1.377)	(1.331)	(1.256)	(1.150)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
R^2	0.274	0.228	0.226	0.182
adj.R^2	0.127	0.055	0.069	-0.000
N	2796	2656	2796	2656

Note: This table reports the impact of green bonds on enterprises' green innovation of ESG scores. Others are consistent with Table 4.

At present, China's green bond market lacks a sound supervision and governance mechanism for the use of funds, so investors' expected environmental benefits from green bonds may come from the ESG level of enterprises themselves. The higher ESG scores, the more likely it is to take the initiative to assume environmental responsibility and invest green funds in agreed green projects to achieve the expected environmental benefits. Therefore, we divided the sample into two groups with high ESG scores and low ESG scores. When an indicator variable's ESG scores is greater than the sample's median ESG scores, it is the group with high ESG scores, then ESG=1, otherwise ESG=0. The regression results are shown in **Table 10**, in which columns (1) and (3) show the regression results of the enterprises with ESG=1, and the regression coefficients are all positive. For ESG=0, the regression results are displayed in columns (2) and (4). The results indicate that none of the green innovation promotion effects of the samples with lower ESG scores are significant. These findings confirm that green bonds issued by enterprises with high ESG scores have a more significant impact on green innovation.

5.5.3. Heterogeneity of Green Finance Pilot Zones

Table 11. Heterogeneity analysis of green finance pilot zones.

	(1)	(2)	(3)	(4)
Variables	TGP	TGP	Gin	Gin
	GFPZ=1	GFPZ=0	GFPZ=1	GFPZ=0
Gbond	0.967***	0.094	0.691***	0.138
	(0.146)	(0.107)	(0.130)	(0.096)
Size	0.278***	0.221***	0.197***	0.160***
	(0.059)	(0.035)	(0.052)	(0.032)
Lev	-0.025	0.296*	-0.009	0.119
	(0.236)	(0.177)	(0.209)	(0.159)
Fixed	-0.187	-0.309	-0.276	-0.438**
	(0.285)	(0.193)	(0.253)	(0.173)
ROA	-0.385	1.374***	-0.902*	0.927***
	(0.527)	(0.386)	(0.468)	(0.347)
Growth	0.103*	-0.017	0.078	0.016
	(0.056)	(0.040)	(0.050)	(0.036)
Board	-0.254	-0.030	-0.163	0.166
	(0.182)	(0.123)	(0.162)	(0.110)
Dual	0.057	0.035	0.096*	0.039
	(0.062)	(0.047)	(0.055)	(0.043)
Top1	-0.597*	0.287	-0.391	0.278
	(0.308)	(0.234)	(0.273)	(0.211)
Firm Age	-0.971***	0.016	-0.593**	0.455*
	(0.316)	(0.265)	(0.281)	(0.238)
Cons	-2.203	-4.415***	-1.889	-4.779***
	(1.572)	(1.100)	(1.395)	(0.990)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
R^2	0.291	0.234	0.230	0.189
adj.R^2	0.206	0.147	0.137	0.097
N	1875	3577	1875	3577

Note: This table reports the impact of green bonds on enterprises' green innovation of GFPZ. Others are consistent with Table 4.

After an enterprise issues green bonds, in addition to the bonds themselves, which can supplement the funds of the enterprise, external stakeholders of the enterprise may also give certain support to the green bond issuer due to environmental preference or positive confidence in the operation of the green bond issuer. If the issuer's region is supported by policies, it can obtain more external support through the spillover effect, hence favorably influencing the connection between the issuer's technical innovation and the issuing of green bonds. The provinces of Guangdong, Guizhou, Xinjiang, Zhejiang, Sichuan, and Jiangxi were chosen in 2017 as the experimental regions of green finance pilot zones (GFPZ) in order to investigate a new model of green development in the regional economy. Because of politics backing, green bonds will play a more promotional role for enterprises situated in the GFPZ. Therefore, this study takes the GFPZ proposed in 2017 as the basis for the division, and divides the sample enterprises according to whether the region they are located in is GFPZ. When the location of the enterprises is GFPZ, then GFPZ=1, otherwise GFPZ=0, so as to test whether and how regional policy support affects the relationship between the issuance of green bonds by enterprises and their green innovation.

The regression results show that when the sample enterprises are located in the GFPZ, the coefficients of explanatory variables are all positive, and green innovation quantity has a higher coefficient than green innovation quality. When the GFPZ=0, the regression coefficients of explanatory variables are not significant. It can be seen that the promotion effect of issuing green bonds on enterprise technological innovation is more obvious in the GFPZ, which once again proves the rationality of the theoretical logic derivation above.

6. CONCLUSION AND DISCUSSION

6.1. Conclusion

This paper selects A-share listed companies in Shanghai and Shenzhen of China from 2012 to 2022 as samples, constructs a multi-point DID model to investigate how green bonds affect green innovation and explores potential mechanisms. The main conclusions are as follows: (1) Green bonds indeed improve enterprises' green innovation. Following a further division of green innovation produced by enterprises into two categories-quantity and quality, green bonds boost both of these, indicating that green bonds, can provide continuous capital investment for traditional technology transformation and green project development. (2) After the mechanism test, we find that green bonds will cause R&D competition among peer enterprises, and green innovation is significantly enhanced by R&D competition. (3) The green bonds has significant differences in the effect on green innovation of enterprises with different industry attributes. According to our research, green bonds have a greater role in promoting green innovation in polluted enterprises, indicating that polluted enterprises have a stronger motivation to achieve the purpose of transformation through green innovation. (4) The green bonds has significant differences in the effect on green innovation of enterprises with ESG scores. According to our research, green bonds promote green innovation more for enterprises with high ESG scores, which may be because the motivation for enterprises with low ESG scores is not environmental benefits. (5) The GFPZ will also affect the improvement of green bond issuance on green innovation. According to our research, when the sample enterprises is located in GFPZ, green bonds can promote green innovation more. This may be because in the sub-sample located in GFPZ, GFPZ provides institutional guarantee for the micro-impact of green bonds, which is reflected in the greater incentive effect of green bonds on green innovation.

6.2. Discussion

Based on the above research conclusions, this paper puts forward the following policy recommendations: (1) Enterprises should grasp the policy dividend and actively issue green bonds. The results show that green bonds have an innovation incentive effect and have a positive impact on

the quantity and quality of green technology innovation. Therefore, in the context of sustainable development, national policies are increasingly inclined to green enterprises. Enterprises should grasp the policy dividend, make full use of green bonds, a market-oriented means, to improve their own green innovation level, and then accelerate the promotion of green transformation. (2) Further promote the improvement of information disclosure system in the issuance of green bonds by enterprises. The research results show that green bonds can promote green innovation of enterprises and generate environmental benefits by investing funds in green projects, indicating that there is no green washing phenomenon in China's green bond market for the time being. However, in order to prevent the occurrence of green washing, in terms of green bond information disclosure, the management system for the use of green bond funds should be further strictly controlled, and enterprises should be encouraged to replace qualitative disclosure with quantitative information disclosure, so as to form an open and transparent fund management system and better play the green innovation role of green bonds. (3) The government should implement relevant incentive policies to guide various market players to participate in the construction of the green bond market. It is found that the industry attributes of enterprises, ESG scores, and GFPZ will all affect the effect of green bond issuance. Enterprises with high ESG scores and GFPZ will be given full play as examples, and differentiated incentive policies will be adopted for enterprises with different internal and external characteristics.

However, this study may have some limitations as follows. This research focuses on China's green bond market and studies the influence and mechanism of green bonds on firms' green innovation, which provides quantitative evidence for the micro effects of green bonds, but also has the limitation of a small research sample. China's green bond market began to emerge in 2016, and at first it was dominated by green financial bonds, but for the research samples of green corporate bonds and green enterprise bonds in this paper, it only began to emerge gradually in 2018, and there are fewer green bond issuing entities. Despite using ordinary bond issuing companies as a control group in this paper's analysis, it still can't solve the problem of less samples.

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