Financial Innovation

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Does the issuance of green bonds nudge environmental responsibility engagements? Evidence from the Chinese green bond market

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Abstract

Policymakers and managers have increasingly adopted green bonds as a direct financing tool to address environmental degradation and climate change in emerging economies; however, the increasing green washing sentiments in the green bond market raise questions on whether green bonds can nudge polluting businesses to achieve green transformation. Therefore, this study joins the controversial debate by investigating the impact of green bond issuance on corporate environmental responsibilities and the potential impact mechanisms and economic consequences. Using the data of Chinese listed enterprises from 2011 to 2020 and the staggered issuance of green bonds as plausibly exogenous shocks, we determine that the enterprises in the experimental group that issued green bonds increased their environmental performance compared to their counterparts. Furthermore, this positive link is maintains after a series of robustness tests. Moreover, we identify that green bond issuance plausibly enhances environmental responsibility engagements through two governance channels, namely, internal management and external supervision. This beneficial effect appears more pronounced for subsamples of firms in low-polluting industries, without environmental subsidies and with higher managerial abilities. Furthermore, economic consequences indicate that the issuance of green bonds primarily motivates speculative shareholder benefits, as evidenced by short-term increases in stock yields but with limited impact on the short-run financial performance. Overall, these findings offer new evidence supporting that green financing tools could play a helpful hand toward environmental sustainability.

Keywords: Green bonds, Environmental responsibility, Internal management, External supervision, Staggered difference-in-difference

JEL Classification: G21, G32, O16, Q01, Q55

Introduction

Industrialization has significantly improved human development and productivity growth regarding economic well-being and brought unprecedented natural disasters. “Resource curses,” “pollution paradises,” and “global warming” have become critical international concerns since the middle of the last century (Auty 2002; Walter and Ugelow 1979; Watson 1999). As the second largest economy in the world, China's fossil energy consumption and greenhouse gas emissions have always been at the forefront globally (Solaymani 2019). The Chinese government initially proposed the dual-carbon goals of "emission peak and carbon neutrality" at the 75th United Nations General Assembly in September 2020 to proactively address environmental damage and climate risk with international communities, opening a new chapter toward a green and low-carbon society. As the basic unit of macroeconomic and mesoindustry development, enterprises play a vital role in energy conservation and emission reduction. China has implemented a strict environmental target responsibility system since the 11th Five-Year Plan (Liu et al. 2021) to meet the environmental governance and emission reduction targets at the national and regional levels. Furthermore, local governments often set some environmental responsibility indicators (e.g., the qualified rate of pollutant discharge and the operation rate of environmental protection facilities), which are assigned to microenterprises within the jurisdiction; however, it is currently difficult to determine whether firms have committed or are committing to environmental responsibility to supplement the government's effort toward the dual-carbon goals. Therefore, exploring the issues surrounding corporate environmental responsibilities in China is significant.

Environmental responsibility refers to enterprises paying attention to the shareholders' interest, society's common interests, and the relationship between people and the environment (Holtbrügge and Dögl 2012). Environmental externalities, information asymmetry, and financial frictions in incomplete markets make polluting or dirty enterprises less motivated to comply with environmental and social duties (Cai and Ye 2020). Policymakers have increasingly introduced green bonds with short issuance processes to resolve these market failures and low financing costs to combat environmental degradation and climate change directly. For instance, the People's Bank of China, the National Development and Reform Commission, and the China Securities Regulatory Commission jointly released the latest "*Catalogue of Green Bond Support Projects*" in 2021, officially unifying green bond standards to channel more funds toward green production activities.

From the capital allocation perspective, green bonds could substantially ease green financial constraints and offer preferential support for businesses to engage in environmentally friendly initiatives, such as adopting renewable energy production, developing low-carbon technologies, and investing in pollution governance (Huang et al. 2022; Mbanyele et al. 2022). Moreover, the government certification function of green bonds could produce a signal effect, drawing increasing attention of external stakeholders (e.g., institutional investors, securities analysts, and news media) to enterprise business activities and pressuring them to fulfill their environmental responsibilities accordingly (Flammer et al. 2021). Conversely, managerial opportunism theory suggests that green bond issuance could provide alternative arbitrage tools for corporations facing severe environmental regulatory constraints (Cao et al. 2021). Studies on corporate greenwashing have increasingly shown that professional managers under pressure to perform tend to issue green bonds to obtain public funds at a lower cost of capital but cannot fulfill their commitments to invest in green projects afterward (Bhutta et al. 2022). The environmental performance of Chinese enterprises is not optimistic, and their commitment to environmental responsibility is still in a passive state of concept and action. A “greenwashing” phenomenon of using policies and capital to seek private interests has arisen in the green bond market. For example, the recent event where green bonds provided insufficient support for green low-carbon buildings in the real estate industry has aroused extensive discussion. Some construction developers failed to continuously disclose the data on carbon reduction, pollutant emissions, energy consumption, and other data of buildings to financial institutions, failing to meet the standards and requirements of green and low-carbon buildings, and were suspected of “pseudogreen” and “greenwashing.” Additionally, some recent studies have documented that listed enterprises are inclined to issue green bonds strategically when their stock prices fall. This action can improve the enterprise’s image in the capital market, alleviating investors’ pessimism and hedging downside risks (Chopra and Mehta 2022; Dong et al. 2022a, b; Tang and Zhang 2020). Thus, whether green bond issuance can nudge enterprises to engage in environmental activities remains an empirical puzzle that requires further investigation.

This study bridges this research gap by investigating the real impact of green bond issuance on environmental responsibility; however, one major endogeneity challenge must be addressed to identify the positive effect of green bonds on environmental responsibility. Enterprises with better environmental responsibility performance are more likely to receive government approval to issue green bonds. We first assemble a microsample of Chinese A-share listed enterprises during 2011–2020 to overcome this concern. Subsequently, we employ the staggered issuance of green bonds as a plausibly exogenous shock and evaluate the average treatment effect of green bond issuance on environmental responsibility using a time-varying difference-in-difference approach. We determine that the enterprises in the treatment group that issued green bonds achieve a higher level of environmental responsibility than their counterparts, and this positive correlation holds after a battery of robustness and endogeneity checks. Moreover, we identify strong support for two governance channels underlying the beneficial effect of green bond issuance on environmental responsibility, namely, internal management and external supervision. Furthermore, this positive effect appears more prominent for firms in low-polluting industries, without environmental subsidies and with higher managerial abilities. We also determine that green bonds with high ratings and green project clauses play a fundamental role in promoting environmental responsibility. Further economic analysis suggests that investors positively react to green bond issuance, which has an insignificant impact on enterprise financial performance.

Our study significantly contributes to the existing literature in three ways. First, it adds to a strand of literature on corporate decisions and market responses to the issuance of green bonds. A growing body of studies has solely focused on exploring the motivation behind green bond issuance (Cao et al. 2021; Lin and Su 2022; Liu et al. 2022) and the actual impacts of green bond issuance on various economic or financial variables such as debt-financing costs (Zhang et al. 2021), return on equity (Tan et al. 2022), fossil energy prices (Kanamura 2020), investor attention (Pham and Cepni 2022), stock liquidity (Lebelle et al. 2022; Tang and Zhang 2020), and stock price crash risks (Dong et al. 2022a, b). However, the social welfare outcomes of green bond issuance remain largely overlooked. Unlike these studies, this study investigates, for the first time, the positive relationship between green bond issuance and environmental responsibility, using the staggered difference-in-difference approach as the identification strategy. Moreover, we utilized the newly developed Goodman-Bacon decomposition technique (Callaway and Sant' Anna 2021) for robustness checks to achieve convincing results.

Second, our study enriches and expands the growing literature on the determinants of corporate environmental responsibilities. Most prior literature investigated whether and how firm-, manager-, and institution-specific characteristics influence corporate environmental responsibilities such as ownership structure (Dong et al. 2022a, b), political connections (Zhang 2017), educational background (Oh et al. 2019), board gender diversity (Wang et al. 2021), international trade (Bárcena-Ruiz and Sagasta 2022), and anticorruption campaign (Chen et al. 2022). Unlike these studies, we offer fresh insights by examining the role of green bond issuance in advancing corporate sustainability. Furthermore, unlike existing studies in this field explaining how the financing mechanism impacts corporate environmental responsibilities, we uncover two alternative governance channels (i.e., internal management and external supervision) through which green bond issuance could enhance environmental responsibility engagements.

Third, our study contributes to the extant literature by joining the ongoing debate on whether China's green finance can achieve a win–win situation for the economy and the environment. Previous research on the enterprise level mainly focused on the impact of green financial policies in China. Research on green credit policy (Hu et al. 2021; Yao et al. 2021; Cui et al. 2022), green financial reform and innovation experimental zone (Huang and Zhang 2021; Zhang et al. 2022), and emission trading system (Tang et al. 2020; Yu et al. 2022) is increasing; meanwhile, the research on whether green bonds achieve a win–win situation remain relatively scarce in the Chinese context. Green bonds have emerged as a promising tool to unlock green finance and provide funding for environmental projects worldwide (Kochetygova & Jauhari 2014; Gilchrist et al. 2021); thus, we directly study the economics of green bond issuance and the subsequent impact of this green financing tool on a microlevel using Chinese enterprises. Furthermore, our study provides empirical evidence and guidance for constructing and further developing China's green financial system.

The remainder of this study is arranged as follows. Sect. "Institutional background for green bonds in China" introduces the institutional background of green bonds in China, followed by the theoretical analysis and the development of hypotheses in Sect. "Theoretical analysis and hypotheses development". Sect. "Research design" presents the data, variables, and econometric specification, followed by the empirical analysis in Sect. "Empirical analysis". Sect. "Further discussions" presents further discussions, followed by the concluding remarks and enlightenment in Sect. "Conclusions, policy implications, and limitations".

Institutional background for green bonds in China

Green bonds originated due to increasing investor concerns about worldwide climate change and environmental issues. In 2007, the European Investment Bank issued the world's first Climate Awareness Bonds, commonly recognized as the first green bonds (Bhutta et al. 2022). With the international consensus on the definition of green bonds and active promotion by the Climate Bonds Initiative (CBI), the global green bond market has rapidly expanded and taken shape. Globally, annual green bond issuances have

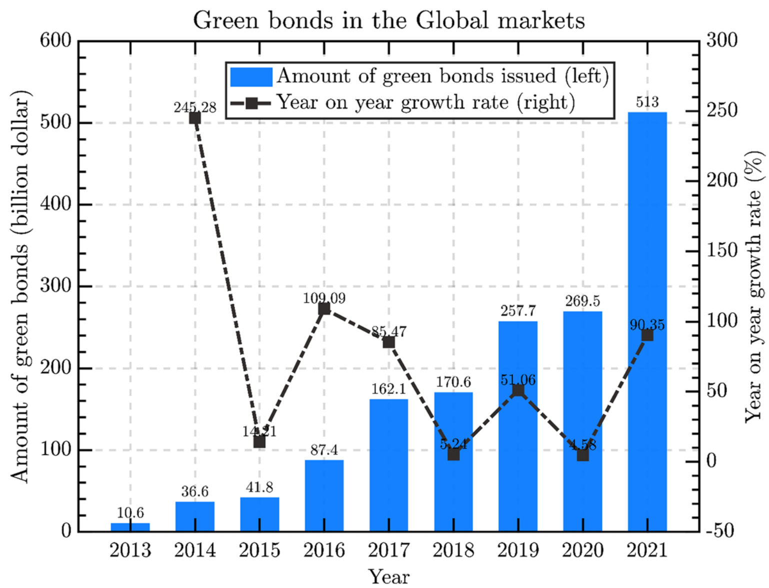

Fig. 1 Green bonds in the Global markets

increased rapidly from 11 billion United States dollars (USD) in 2013 to 513 billion USD in 2021. This growth is visible in Fig. 1, which shows the annual trend of global issuance from 2013 to 2021. The global green bond market has become a bright spot in the capital market. Issuing entities are spread across 73 countries or economies on 6 continents. In 2021, the top three issuers of green bonds were the United States, China, and Germany, with 83.5 billion USD, 68.2 billion USD, and 63.3 billion USD, respectively.

The Chinese government has actively promoted the development of a green bonds market in the past few years. In December 2015, the National Development and Reform Commission issued the *Guidelines for the Issuance of Green Bonds*,[1] officially opening the door to a green bonds market in China. This action enabled the convergence of China's green bond support scope and relevant standards in the international market. The Chinese government has since formulated policies to regulate and support green bond issuance (see Fig. 2), while relevant policies provide listed enterprises a comparative advantage in obtaining funds using green bonds. On the one hand, the approval time for the issuance of green bonds is shorter, the government has a unique green channel for review, and the enterprise can flexibly choose the issuance window as per the market situation. On the other hand, green bonds have certain advantages in their issuance as the local government policies provide issuing support.[2]

With the continuous promulgation of supportive policies, China's green bonds market has rapidly grown over the past few years. By the end of 2021, according to the official statistics of CBI, China's current cumulative issuance of green bonds will reach 2 trillion USD, ranking second worldwide. By sorting and analyzing the information on

[1] https://www.ndrc.gov.cn/xxgk/zcfb/tz/201601/t20160108_963561.html?code=&state=123

[2] For example, Shanghai Clearing House reduced the issuance registration rate and interest payment service rate of green bonds by 50%. Similarly, for enterprises issuing green bonds, the Guangzhou government will give a one-time subsidy of no more than 1 million CNY at 10% of the issuance cost.

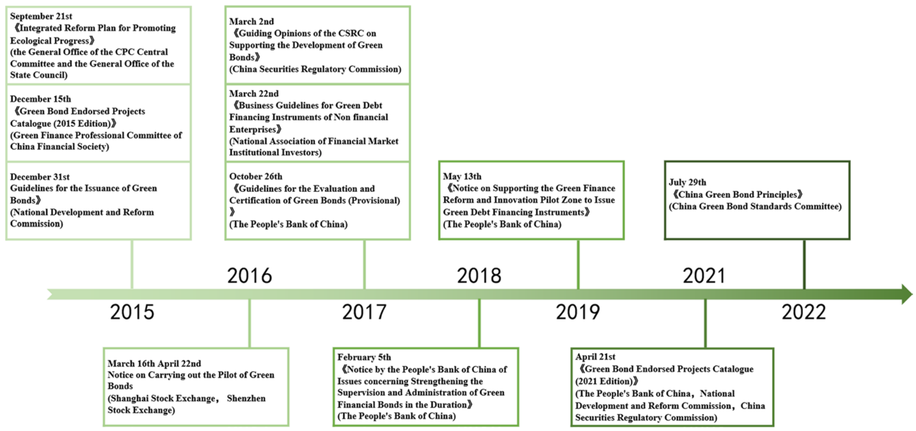

Fig. 2 Green bonds related policies in China

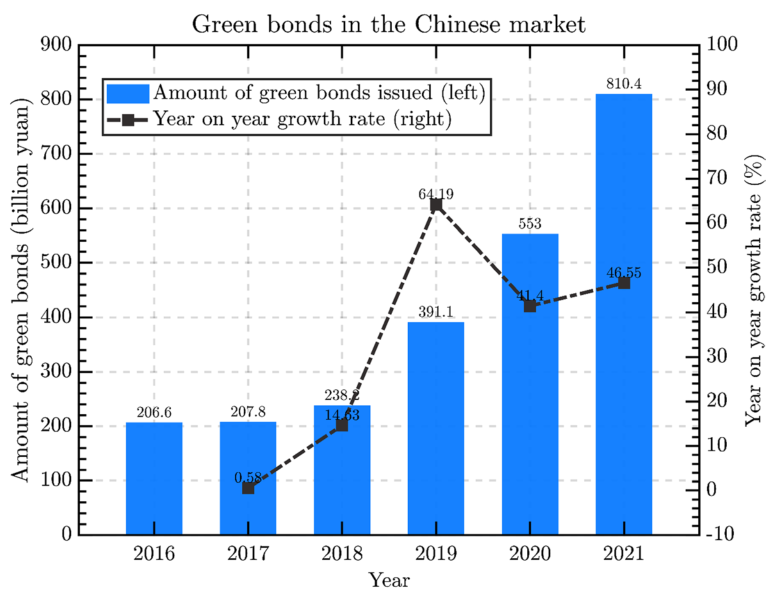

Fig. 3 Green bonds in the Chinese market

green bonds from the *Wind Database*,[3] we find that the amount of green bonds issued in China has grown from 206.6 billion Chinese Yuan (CNY) in 2016 to 810.4 billion CNY in 2021, with a rapid annual growth rate of 33.47% (see Fig. 3). Furthermore, we counted the total number and amount of green bonds issued by enterprises in all provinces of China from 2016 to 2021. Figure 4 shows that the top five provinces in terms of green bond issuance amount are Beijing, Guangdong, Shandong, Fujian, and Hubei, indicating that green bonds are used more in economically developed regions. Furthermore, we compiled statistics on the industry of listed enterprises issuing green bonds. Enterprises in the financial, manufacturing, electricity, heat, gas, and water production and supply industries have contributed a larger share in issuing green bonds, suggesting that green

[3] https://www.wind.com.cn/

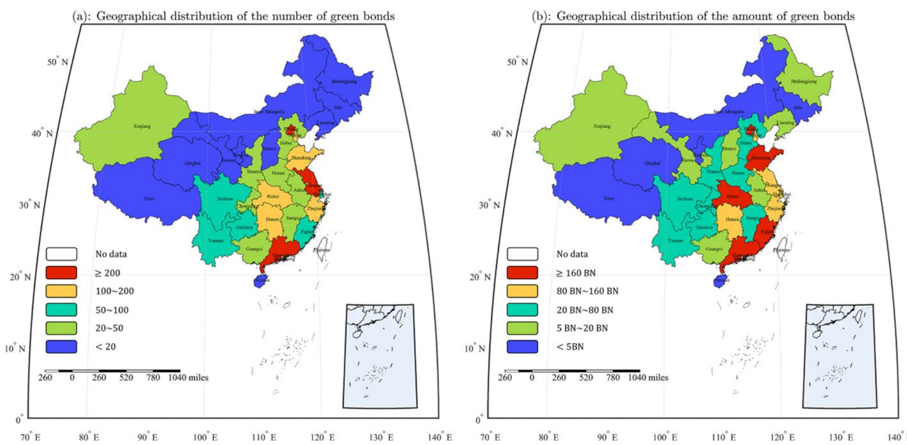

Fig. 4 Geographical distribution of green bonds in China

bonds primarily help the green transformation of traditional energy-intensive sectors. The corresponding names and classification codes of industry distribution by the Chinese Securities Regulatory Commission are in Table 15 in the Appendix. Overall, in light of several bright macrostatistics, China's green bonds market shows signs of promising growth.

Theoretical analysis and hypotheses development

As a critical direct financing tool supporting sustainability for microenterprises, green bonds motivate enterprises to undertake environmental responsibility while shaping a green image and reducing financing costs. Green bonds should accept the legal system of general bond supervision and the unique legal system of green bonds. Enterprises that have obtained green bond funds are expected to invest in abatement activities and the production of green products and take measures such as green technological innovation to address environmental problems. To ensure accountability and credibility, the third parties carry out green audits and dynamic credit ratings to prevent enterprises from diverting green funds for environmental responsibility to other uses unrelated to environmental protection.[4]

In addition to the aforementioned formal regulations, green bonds issuers may have to comply with more informal ones. Environmental protection has become a stable social norm that is widely recognized for advocating the development of a green economy (Luo et al. 2013; Cai and Ye 2020; Pástor et al. 2021). When an enterprise issues green bonds for energy-saving or environment-friendly projects, it will attract consumers, investors, financial analysts, and social media, resulting in better oversight of the enterprise from a broader range of stakeholders and public opinion (Banga 2019; Tang and Zhang 2020). Thus, the enterprise will be exposed to increased institutional pressures. Generally, institutional pressure refers to the binding effect of social rules, norms, mentality, and other factors in the external environment (Yiu and Makino 2002). The pressure of public

[4] Guidelines for Establishing the Green Financial System. Retrieved from: http://www.pbc.gov.cn/english/130721/3133045/index.html
China Eyes Clean Development via Green Finance. Retrieved from: http://www.chinadaily.com.cn/a/201805/22/WS5b03dff2a3103f6866ee9e40.html

opinion can be considered as an implicit contract between enterprises and stakeholders or an informal agreement on codes of conduct and norms requiring enterprises to meet stakeholder demands (DiMaggio and Powell 1983; Suchman 1995).

Consequently, enterprises can obtain recognition from stakeholders by undertaking environmental responsibility. As the government, consumers, green preference investors, and other stakeholders hold the required socioeconomic resources, enterprises must meet their requirements for environmental protection after issuing green bonds (Deschryver and De 2020). The cognitive legitimacy proposed by Scott et al. (2000) is an integral part of organizational legitimacy, emphasizing whether a new thing conforms to the public's cognition and expectation in a specific institutional environment. An enterprise failing to respond to stakeholders' requirements on the legitimacy of cognition may lose the support of stakeholders and be unable to obtain funds and technology, thus falling into the predicament of survival and unsustainable development. Given this, we infer those enterprises should improve their environmental responsibility engagements to qualify for the legitimacy of this recognition. Upon issuing green bonds, enterprises will be motivated to engage in more environmental responsibility activities to meet the environmental requirements of stakeholders and secure legitimate living space in a fiercely competitive environment. Thus, we develop the following hypothesis.

Hypothesis 1 The issuance of green bonds can nudge environmental responsibility engagements.

Existing studies have indicated that several economic mechanisms affect enterprises' willingness to undertake environmental responsibility, such as the financing channel (Lioui and Sharma 2012; Huang et al. 2023) and the information channel (Godfrey 2009; Alam and Islam 2021). Unlike these studies, we argue that enterprises will take environmental responsibility as an investment opportunity and change their level of environmental responsibility when facing more external pressure and legitimacy requirements. Specifically, our analysis narrows down to the governance channel. We propose two plausible economic channels that potentially explain how green bond issuance improves the level of environmental responsibility: internal management and external supervision. According to the source of corporate governance, the control system of enterprises is divided into internal and external control. External control includes legal and regulatory constraints, government intervention, external auditing, and media supervision. Internal and external control are both necessary to ensure enterprises' sustainable development. Regarding research on media supervision, scholars believe that the media, as "information carriers" and "corporate supervisors," have played a positive role in exerting public opinion supervision and improving governance capabilities (Fang et al. 2009; Chen et al. 2013). The research on internal control still mainly focuses on promoting corporate performance and the impact on corporate value through internal control (Black et al. 2006). Below, we propose the critical role that managers play in internal control. This senior executive actively constrains the environmental behavior of the enterprise, which differs from the external supervision mechanism of media supervision, and can form an effective internal and external linkage with it to promote the assumption of corporate environmental responsibility.

Theoretically, an enterprise's decision to undertake environmental responsibility depends on whether such engagement can result in actual performance benefits, meaning that environmental responsibility can enhance the enterprise's value (Christmann and Taylor 2001). Currently, there are two main disputes about the impact of environmental responsibility on enterprise value.

On the one hand, the benefits balance and manager opportunism hypotheses believe that corporate social responsibility (CSR) negatively affects enterprise value (McWilliams and Siegel 2000; Friedman 2007). The benefits balance hypothesis holds that the enterprise's resources are limited and cannot balance the benefits among all stakeholders (Reynolds et al. 2006; İyigün, 2015). Moreover, the agency theory indicates that enterprise managers may pursue personal goals and act in ways that harm the interests of shareholders and other stakeholders. For instance, when the enterprise performs well financially, managers may extract funds through pet projects in the guise of environmental responsibility spending to meet their private interests. Similarly, managers may cover up their inadequate performance when businesses perform poorly by increasing environmental responsibility expenditure. These managerial opportunistic behaviors will eventually negatively impact enterprise value (Ullmann et al. 1985; Hemingway et al. 2004; Barnea and Rubin 2010).

Various scholars believe that CSR can positively affect enterprise value. According to the stakeholder theory, enterprises exist within social, economic, and political environments (Parmar et al. 2010). Furthermore, demands of stakeholders for enterprises to fulfill CSR are increasing, and enterprises are continuously adjusting their operations to meet these requirements and obtain stakeholder support (Oeyono et al. 2011). Based on social identity theory and signal theory (Hu et al. 2020; Zhang et al. 2020), engaging in CSR can establish a positive corporate image (Servaes and Tamayo 2013), reduce operational risks and transaction costs (Lee and Faff 2009; Yang et al. 2020), improve enterprise value (Yoon and Chung 2018), and signal to the public that the enterprise is committed to environmental responsibility.

The above arguments highlight the critical role of internal managers in undertaking environmental responsibility. As the core microgroup responsible for corporate operations and management, the senior management team is crucial in formulating and implementing strategic decisions (Hambrick et al. 1984; Li et al. 2017). Their attention to environmental issues and cognitive attitude are important internal factors influencing enterprises to engage in environmental responsibility. Managers can effectively allocate limited resources and balance the allocation of enterprise resources between productive inputs (e.g., production and operation) and nonproductive inputs (e.g., environmental and social responsibility). When managers devote more attention to environmental issues, they can effectively improve environmental responsibility and promote the positive impact of environmental responsibility on corporate financial performance.

Nonetheless, it can be challenging for managers to allocate sufficient attention to environmental concerns within their organizations. As the significant operations group in enterprises, senior management teams' attention is limited and considered a scarce enterprise resource. Moreover, due to the industry spillovers and positive externalities of undertaking environmentally beneficial behaviors, enterprise managers are often inclined to pay limited attention to environmental responsibility. This reluctance occurs due to the principal–agent problem and information asymmetry wherein managers invest resources in projects that can quickly obtain benefits and have low opportunity costs under external pressure (Shleifer 1990; Denis 2019; Atanassov 2013). However, compared to productive investments that produce direct and fast economic benefits to enterprises, environmental responsibility is a nonproductive investment with more extended investment periods and higher opportunity costs. Therefore, short-sighted managers tend to focus on other projects with immediate benefits, leading to underinvestment in environmental responsibility.

The issuance of green bonds can relax financial constraints and incentivize managers to invest in environmental activities, increasing their attention to environmental issues. Green bonds incentivize managers to become increasingly proactive in addressing environmental problems. According to the attention allocation theory, managers are more likely to form a positive attitude toward environmental issues and promote forward-looking environmental strategies when they believe the institutional environment can support environmental management practices (Roxas and Coetzer 2012). Furthermore, the benefits of environmental protection with more financial support outweigh its costs, effectively alleviating managers' short-sighted behavior. Thus, managers move beyond the minimum environmental regulation requirements (e.g., terminal governance) and actively allocate their attention to front-end production (e.g., cleaner energy use). Moreover, some mandatory binding terms require green bond issuers to use funds only for green projects and products, encouraging enterprise managers to become more environmentally conscious; therefore, issuing green bonds can help enterprise managers pay more attention to environmental concerns.

Furthermore, issuing green bonds can improve the internal governance of enterprises through stakeholders. Green bonds can help stakeholders better identify the pollution attributes of enterprises. Environmental resource allocation requirements will be externally imposed on managers when these stakeholders include the level of environmental responsibility in their scope of evaluating managerial performance. This situation reduces the managers' unwillingness to invest funds in environmental projects. Under mixed pressure from stakeholders, managers could regard the stakeholders' attention to green as a market opportunity. To the extent that managers improve the governance of internal environmental issues by allocating more attention to environmental responsibility in response to consumers' demand for environmental protection and investors' green investment preferences. Accordingly, this study develops the following hypothesis.

Hypothesis 2 Green bond issuance can raise managers' internal attention on corporate environmental issues, thus improving the level of enterprises undertaking environmental responsibility.

External supervision is another crucial factor influencing enterprises to engage in environmental responsibility activities. The rapid development of the internet over the past few decades has led to people being increasingly enthusiastic about going "green." In addition to increasing the number of investors and consumers who prefer green products, the public and media are also paying increasing attention to environmental issues. Dyck et al. (2010) reported that the formal regulatory system accounted for only 7% and the auditor for 10% in exposing corporate fraud. In contrast, the informal system played a more significant role, with the media alone accounting for approximately 13%. Therefore, as an external force, the media has become a supervisory tool to compensate for the lack of an effective legal system in most emerging capital markets and may be significant in driving enterprises to commit to environmental responsibility (Dyck et al. 2008).

Prior studies have suggested that the media is more prominent in increasing public awareness about environmental issues (Sampei and Aoyagi-Usui 2009). As information intermediaries, the media heavily influence concerns about environmental violations. For example, Xu et al. (2016) found that after environmental violations, firms with greater media coverage experienced substantial losses in value than their counterparts with less media attention.

Increasing media attention can help alleviate the problem of "greenwashing" that may occur after enterprises issue green bonds. Suchman (1995) argued that the media could play an active role in public dialogue on the legitimacy requirements. Specifically, if the enterprise disregards environmental issues after obtaining green bond funds, the media could supervise the enterprise through public coverage. Previous studies have shown that media attention can improve enterprises' environmental responsibility performance. For example, Aerts and Cormier (2009) verified the relationship between public opinion supervision and enterprise environmental communication from the content of media reports. Similarly, Kuo and Chen (2013) showed that the public mainly learned about the environmental system and implementation of enterprises through environmental news.

Moreover, as the primary source of information from the outside world, the media profoundly impacts the enterprise's image. Enterprises voluntarily disclosing environmental information can help improve their social image and fulfill their environmental responsibility commitment. In this way, the media can effectively play a supervisory role in curbing enterprises' "greenwashing" tendencies for financing purposes, thus bringing environmental responsibility up to standard through more prudent and pragmatic disclosure.

Generally, firms attract substantial media attention after issuing green bonds (Tang and Zhang 2020). When enterprises issue green bonds, they can obtain the "eyeball effect" and "halo effect," meaning they gain economic benefits by attracting public attention and establishing a green image that makes the enterprise more favored. Increased media coverage after issuing green bonds can encourage better environmental performance in several ways.

On the one hand, enterprises are subject to intense external supervision from the media after issuing green bonds. As the public receives more information through media such as newspapers, television, radio, and the internet, they can indirectly pressure enterprises through public opinion. According to the legitimacy theory, media attention, as an independent third-party supervisory entity, can encourage enterprises to undertake environmental responsibility in response to legitimacy requirements from the public.

On the other hand, enterprises can establish a positive green image by issuing green bonds. The impression management theory suggests that media reports can play a role in self-praise and self-promotion. Furthermore, CSR performance can offer enterprises with positive signals related to reputation (Fombrun and Shanley 1990). Aerts and Cormier (2009) demonstrated that the number of post-media reports related to enterprise environmental information could significantly affect environmental information disclosure more than pre-reports. After enterprises issue green bonds, environmental responsibility can be used to build and maintain a positive reputation (Linthicum et al. 2010). To preserve the enterprise's reputation and image and obtain increasingly valuable resources, the enterprise will strive to meet the green expectations and requirements of stakeholders, take the initiative to undertake environmental responsibility and improve its environmental responsibility level. Therefore, we propose the following hypothesis.

Hypothesis 3 The issuance of green bonds can raise the external attention of the media on corporate environmental issues, thus improving the level of enterprises undertaking environmental responsibility.

Research design

Construction of the econometric model

To encourage listed enterprises to issue green bonds on their own, two major Chinese stock exchanges in Shanghai and Shenzhen successively issued the *Notice on Launching the Pilot of Green Corporate Bonds*[5] in 2016 (hereafter denoted by 2016 Pilot Notice), which provides a desirable quasi-natural experiment for us to examine the positive link of green bonds issuance. The timing of the issuance of green bonds by listed enterprises is different, similar to the gradual implementation of the policy pilots in batches. In the spirit of Beck et al. (2010) and Berger et al. (2014), we examine the real impact of the issuance of green bonds on environmental responsibility by building the two-way fixed effects (TWFE) staggered difference-in-difference (SDID) model:

$$ER_{i,t} = \beta_0 + \beta_1 Green_i \times Time_{i,t} + \gamma \boldsymbol{X}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where i represents the individual enterprise, and t represents the year. The explained variable, $ER_{i,t}$ represents the score of environmental responsibility (see Sect. "Environmental responsibilities (ER)" in particular). We focus on the estimation coefficients (β_1) of the core explanatory variables $Green_i \times Time_{i,t}$, which capture the real impact of green bond issuance on enterprises' commitment to environmental responsibility. Specifically, enterprises that have issued green bonds during the sample period are regarded as the experimental group. If the enterprise i belongs to the experimental group, $Green_i$ equals 1; otherwise, it equals 0. When the enterprises i have issued green bonds in time t and beyond, $Time_{i,t}$ equals 1; otherwise, it equals 0.

We attempt to control for the multi-dimensional fixed effects to address the endogeneity concern resulting from the omitted variable biases. Following Beck et al. (2010), this paper adopts the TWFE model that controls for time and individual fixed effects. μ_i represents enterprise-level fixed effect, and λ_t denotes the year-level fixed effect. $\boldsymbol{X}_{i,t}$ represents a battery of control variables (see Sect. "Control variables" in particular). We do not include additional variables $Green_i$ and $Time_{i,t}$; however, we add $Green_i \times Time_{i,t}$ as

[5] http://www.sse.com.cn/lawandrules/sserules/listing/bond/c/c_20160316_4058800.shtml http://www.szse.cn/lawrules/rule/allrules/bussiness/t20160422_565143.html

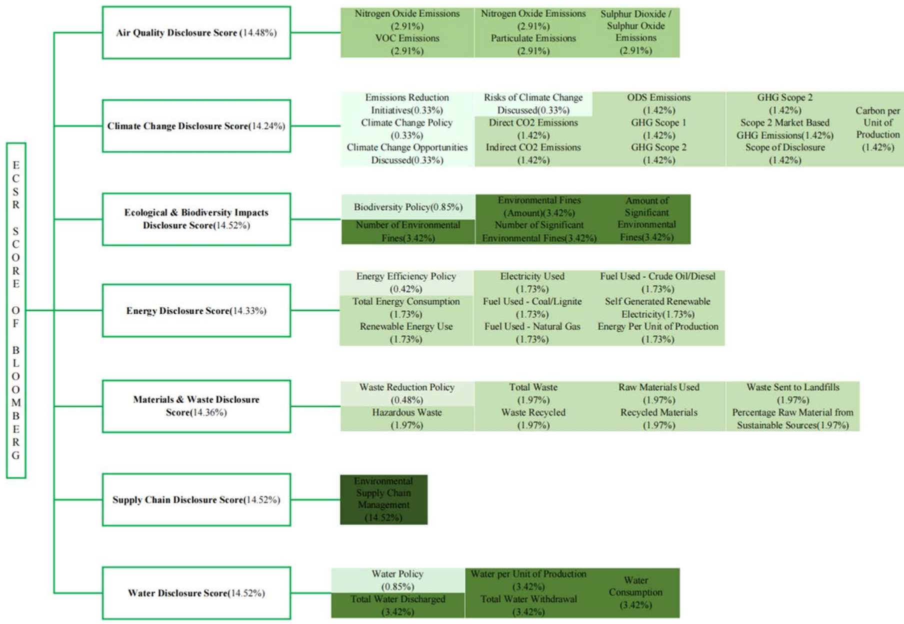

Fig. 5 Environmental Responsibility Score of Bloomberg

core explanatory variables to avoid multicollinearity problems. Furthermore, the standard errors in all specifications are clustered at the enterprise-level to reduce the impact of potential heteroscedasticity and sequence correlation.

Variable selection

Environmental responsibilities (ER)

Referring to the research of previous scholars, we regard environmental responsibilities (ER) as a concept of enterprises' extra effort in integrating environmental concerns into their business operations and their interaction with their stakeholders. It is viewed as a firm's contribution to sustainable development by balancing and improving environmental impacts without damaging economic performance (Zenisek 1979; Williamson et al. 2006; Enderle et al. 2012). Enterprise-level ER is mainly measured using external third-party scores. Considering the relevant data, we refer to Nollet et al. (2016) and use the environmental score in Bloomberg's ESG Disclosure Index to measure ER. The data is based on public enterprise materials and covers a wide range of data through Bloomberg's quantitative model to reduce noise, standardize data, and deal with scale deviation. In terms of the environmental score, the following topics are included: (1) air quality; (2) climate change; (3) ecological and biodiversity impacts; (4) energy; (5) materials and waste; (6) supply chain; (7) water. Figure 5 provides more detailed proportions and indicators covered by this indicator.

Control variables

To exclude the influence of other enterprise variables, we also select the following variables as control variables in our empirical model following Hu et al. (2021) and

Table 1 Variable definitions

Variable	Definition
ER	The single environment score in Bloomberg's corporate social responsibility score
S	The single social score in Bloomberg's corporate social responsibility score
G	The single governance score in Bloomberg's corporate social responsibility score
H-ER	The environmental responsibility score in the Huazheng ESG evaluation system
Environmental penalty	Dummy variable. Whether the enterprises receive environmental penalties based on third-party statistics constitutes. If there is yes, it will be 1; if there is no, it will be 0
Terminal governance	Dummy variable. Whether the enterprises adopt the measures to reduce the three wastes. If there is yes, it will be 1; if there is no, it will be 0
Front-end governance	Dummy variable. Whether the enterprises use renewable energy or adopt policies and measures of the circular economy. If there is yes, it will be 1; if there is no, it will be 0
Employee behavior	Dummy variable. whether the enterprises have green office policies or measures. If there is yes, it will be 1; if there is no, it will be 0
Green × Time	Core explanatory variables. It represents the interactive item of issuing green bonds and time dummy variable
Post × Treat	It represents the interactive item between polluting enterprises and policy time affected by the Environmental Protection Law of the People's Republic of China 2014
Green × Time × Cer	It represents the triple differential variable of green bonds, time, and third-party ratings
Green × Time × Clause	It represents the triple differential variable of green bonds, time, and green project clauses
Size	Natural logarithm of annual total assets
Lev	Total liabilities at the end of the year/total assets at the end of the year
Growth	Operating income of the current year/operating income of the previous year—1
ROA	Net profit/average balance of total assets
ROE	Net profit/average balance of shareholders' equity
Cashflow	Net cash flow from operating activities/operating income
Board	The natural logarithm of the number of directors
Tobin Q	Market value/total assets at the end of the year
Attention	Count variable. Statistics on the frequency of environmental words in annual reports and corporate environmental and social responsibility reports
Posnews	Count variable. Number of positive reports from mainstream media on enterprises
Neunews	Count variable. Number of neutral reports from mainstream media on enterprises
Negnews	Count variable. Number of negative reports from mainstream media on enterprises

This table reports the construction method of variables

Dong et al. (2022a, b). (1) Enterprise scale (Size) is measured as the natural logarithm of the total enterprise assets. (2) Enterprise debt (Lev) is the ratio of total liabilities to total assets. (3) Enterprise growth (Growth) is measured as the annual growth rate of operating income. (4) Enterprise return on asset (ROA) is measured as the net income divided by total assets. (5) Enterprise return on equity (ROE) is the net income divided by the average balance of shareholders' equity. (6) Enterprise cash holdings (Cashflow) are measured as the net cash flow ratio from operating activities to operating income. (7) Enterprise board size (Board) is measured as the natural logarithm of the number of directors. Table 1 reports the specific definitions for these variables.

Table 2 Summary statistics of the main variables

Variables	Observations	Mean	Median	SD	Min	Max
ER	8493	11.020	9.302	8.049	0.775	65.630
Green	8493	0.020	0.000	0.138	0.000	1.000
Time	8493	0.580	1.000	0.493	0.000	1.000
Green × Time	8493	0.007	0.000	0.081	0.000	1.000
Size	8493	23.210	23.103	1.368	19.450	28.640
Lev	8493	0.484	0.495	0.199	0.009	1.165
ROA	8493	0.045	0.037	0.069	-0.775	0.675
ROE	8493	0.074	0.082	0.200	-7.213	1.611
Cashflow	8493	0.109	0.095	0.273	-7.860	8.808
Growth	8493	0.205	0.091	1.786	-0.953	84.990
Board	8493	9.076	9.000	1.910	3.000	18.000

This table reports the summary statistics of the main variables for all of the firm-year observations in the sample. It summarizes the observed values, average values, median values, standard deviations, and maximum and minimum values from 1058 sample enterprises from 2011 to 2020

Sample selection and data source

To ensure time comparability before and after the 2016 Pilot Notice, we selected Chinese A-share listed enterprises from 2011 to 2020 as the research sample.[6] The financial data of listed enterprises sources are from the *China Stock Market and Accounting Research (CSMAR) Database*, and we primarily process the data as follows. (1) We exclude ST and * ST enterprises in the sample period, (2) we exclude financial industry observations, and (3) we exclude listed enterprises whose financial data or other indicators are seriously missing. The corporate ER data comes from environmental scores in Bloomberg's ESG Disclosure Index. Using stock identifiers, we manually collated the original green bond data from the *Wind Database* and obtained the corresponding issuers of listed enterprises in China. We initially complied a microsample of 86 listed enterprises during the study period, of which 28 are financial listed enterprises, and 18 are overseas listed enterprises. Using the above screening criteria and excluding ineffective enterprises, we eventually retained the data of 22 listed enterprises as the experimental group. We also selected other A-share listed enterprises that have never issued green bonds from 2016 to 2020 as the control group. We obtained 8,493 enterprise-year observations in our research sample. Table 2 reports the descriptive statistics of the main variables used in the study. Among them, the scores of environmental responsibilities vary significantly, from 0.775 to 65.630, with a standard deviation of 8.049.

Empirical analysis

Baseline results

This study adopts the DID approach to identify the effect of green bond issuance on the ER of listed enterprises. Table 3 reports the estimation results of model (1). Columns (1)–(2) are the benchmark regressions without control variables, in which

[6] We chose this sample interval as follows: (1) Environmental responsibility data for many companies after 2020 are either unavailable or incomplete. (2) The COVID-19 caused a global pandemic after 2020, resulting in many outliers in the data. Therefore, we end our sample in 2020 in our main analysis. We use alternative data that ends in 2021 as a robustness check.

Table 3 Estimation results of baseline regression

	(1) ER	(2) ER	(3) ER	(4) ER
Green × Time	9.8808***	7.1552***	6.9238***	7.056***
	(2.0810)	(2.6119)	(2.0189)	(2.6015)
Size			2.6956***	1.0726***
			(0.0852)	(0.3124)
Lev			− 5.7161***	− 0.4330
			(0.4909)	(1.1128)
ROA			1.0271	2.0957
			(1.4971)	(1.7307)
ROE			− 1.4530***	0.0519
			(0.4377)	(0.5363)
Cashflow			− 0.0327	− 0.0956
			(0.2442)	(0.1958)
Growth			− 0.0767***	0.0009
			(0.0238)	(0.0139)
Board			− 0.0764*	− 0.0966
			(0.0404)	(0.1055)
Constant	10.9526***	8.2869***	− 48.0572***	− 15.051**
	(0.0864)	(0.2409)	(0.1674)	(6.8336)
Firm fixed effects	NO	YES	NO	YES
Year fixed effects	NO	YES	NO	YES
R-squared	0.0099	0.1833	0.1674	0.1887
Observations	8493	8493	8493	8493

This table reports the results of panel regressions. The sample includes firm-year observations for 1058 enterprises during 2011 to 2020. All of the variables are as defined in the Table 1. The robust standard error clustered at the firm level is shown in parentheses

*Denotes 10% significance level; **Denotes 5% significance level; ***Denotes 1% significance level

Column (2) adds both the individual and time-fixed effects. Columns (3)–(4) are the benchmark regression after adding control variables, in which Column (4) adds the TWFE. Columns (1)–(4) show that the coefficients for *Green* × *Time* are positive and significant at 1% levels. The results are also economically significant. For instance, Column (4) shows that issuing green bonds contributes to a 7.056 increase in ER Scores. Thus, enterprises' issuance of green bonds can improve their ER. As a result, Hypothesis 1 in this study is initially supported. Specifically, enterprise green bond has the advantages of an extended debt repayment cycle, high requirements for information disclosure, strong risk diversification, and more restrictions on using funds (Flammer 2021); thus, green bonds can better support the development of green industries and projects. Green bonds can help enterprises obtain funds directly from the capital market, alleviate information asymmetry by transmitting signals, establish a positive green reputation for enterprises, attract the attention and recognition of external investors, obtain a large amount of low-cost capital, and face more external supervision. Furthermore, managers will pay more attention to enterprise ER for using funds. These factors ultimately promote enterprises to take on more ER.

Table 3 also reports the regression results for the control variables. Looking at enterprise size, we can see that the "Size" coefficient is significantly positive. This result is consistent with the notion that larger enterprises spend more resources on ER due to their size advantages, including easy access to capital at low costs. Other variables like ROA, ROE, and Growth are positively associated with ER. The results are consistent with the existing evidence in the literature that profitable and growth firms invest more in CSR activities (Mbanyele and Muchenje 2022). In contrast, the leverage, cash flow, and board coefficients enter the regressions with negative signs.

Robustness checks

To ensure the accuracy of the baseline results, we conducted a host of robustness checks using parallel trend and dynamic effect tests, placebo tests, Goodman-Bacon decomposition, propensity score matching (PSM)-DID, instrumental variable regression, and an alternative dependent variable. We also controlled industry time trends, eliminating other policy interference and extending the sample period and size.

Parallel trend and dynamic effect test

The DID model must meet the parallel trend assumption; that is, the ER level of the enterprises in the experimental group and the enterprises in the control group should follow the same trend before the issuance of green bonds. Furthermore, model (1) is only a static analysis, and we cannot know the dynamic impact of the issuance of green bonds on ER; therefore, we further test the dynamic effect of green bond issuance on ER. In the SDID methodology, different individuals use different time points to implement policies, and the parallel trend and dynamic test are complex; however, the basic idea is still the same as in the event study methodology. Our study refers to Beck et al. (2010) to use the staggered DID method to centralize the policy time (i.e., the time of each period minus the time of their policy implementation). We establish the dynamic model in the following way:

$$ER_{i,t} = \alpha + \sum_{\tau=-6}^{6} \beta_\tau Green_i \times Time_{i,t-\tau} + \gamma X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{2}$$

where $Green \times Time$ is a dummy variable. If the enterprise issued green bonds in the $t-\tau$ period, the value is 1; otherwise, it is 0. For example, when $\tau = 2$, the dummy variable indicates that the enterprise issued green bonds in the second period, which measures the effect of the second year after the issuance of green bonds.

Figure 6a shows the inspection results. Before the issuance of green bonds, the coefficient was not different from 0 at the 5% level, indicating no significant difference in the ER level in the experimental and control groups. Thus, the pre-treatment parallel trend test is valid. However, significant differences exist between the experimental and control groups after the issuance of green bonds, indicating that the dynamic effect test results are valid. Overall, we can conclude that the issuance of green bonds promotes ER with a lasting effect.

Mixed Placebo test

We conducted a placebo test to exclude the influence caused by other random factors. The single-period DID model usually adopts the method of changing the policy time or

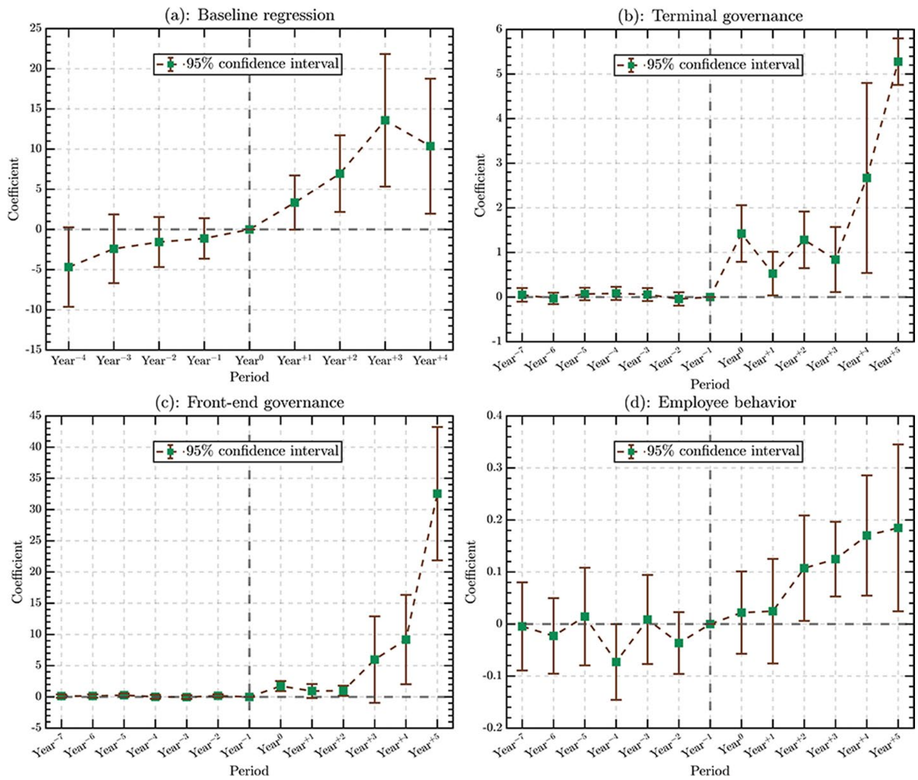

Fig. 6 Results of the parallel trend test

the experimental group to perform placebo tests; however, the policy time point of our experimental group is not the same. To resolve this issue, we randomly select the experimental group and change the time point of green bond issuance to construct a pseudo-experimental group and a pseudopolicy time point, following Chen and Xie (2022). We randomly repeated the processes 1000 times to conduct the mixed placebo test. Figure 7 (a) shows that the estimated results of the pseudopolicy time point and the pseudoexperimental group are insignificant, while our benchmark regression result becomes an obvious outlier. Thus, the placebo test further excludes the influence of other random factors, confirming that this paper's baseline estimated results are not accidental.

Goodman-Bacon decomposition

The years in which enterprises issue green bonds vary, allowing us to use a TWFE staggered DID technique in the benchmark regression; thus, our experimental group can be divided into the experimental group affected by the policy earlier and the experimental group affected by the policy later. Due to this situation, our model results may have deviations beyond the traditional DID model. Recently, many articles have begun to pay attention to these problems and provide solutions (Borusyak and Jarravel 2021; Goodman-Bacon 2021; De Chaisemartin and D'Haulfoeuille 2022; Sun and Abraham 2021). We first draw the processing state diagram of the enterprises in the experimental group.

Figure 8 shows that the Y coordinate is the code of the listed enterprise. Dark blue represents the time when the experimental group enterprises issued green bonds.

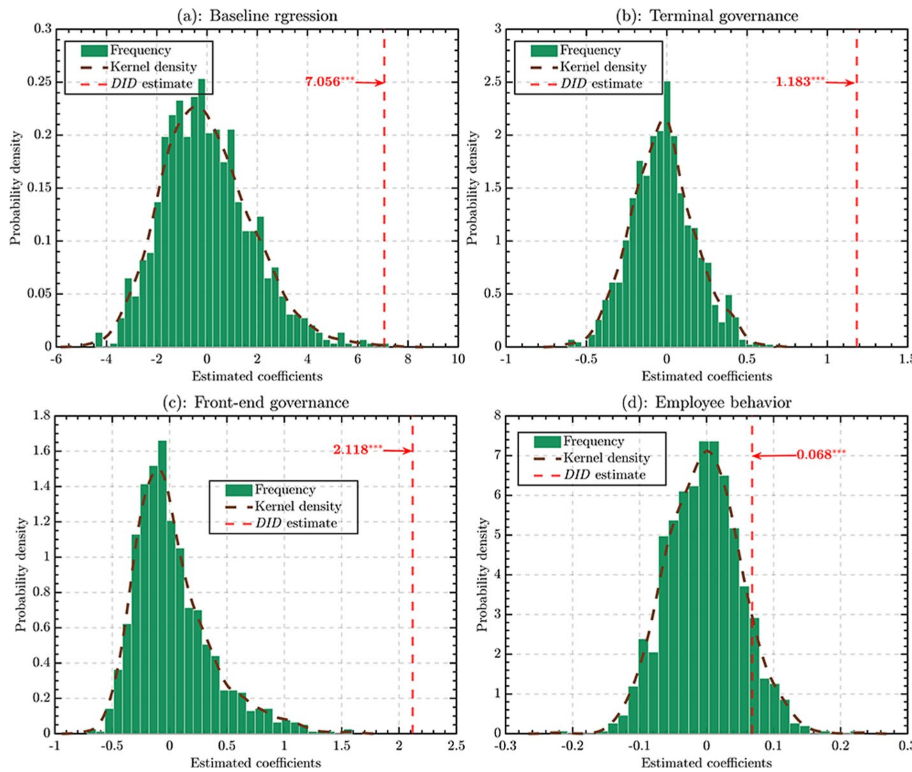

Fig. 7 Results of the placebo test

Light blue represents when the experimental group enterprises have not issued green bonds. We then divide the enterprises of the original experimental group into two types: (1) early processing, such as enterprise 2202, and (2) late processing, such as enterprise 301. Furthermore, other enterprises not shown in the processing status cloud belong to (3) control groups that have never been processed during the entire sample period. Furthermore, according to Goodman-Bacon (2021), we divide the estimation results of our study into the following three parts:

$$\beta_1 = \begin{cases} \beta_{11} : \textit{Earlier Group Treatment vs. Later Group Control} \\ \beta_{12} : \textit{Later Group Treatment vs. Earlier Group Control} \\ \beta_{13} : \textit{Treatment vs. Never Treated} \end{cases} . \tag{3}$$

Among them are the estimated coefficients of a *2 × 2 DID* of the team; however, the second kind of treatment effect (β_{12}) is a bad influence and brings errors to our results. The results in Fig. 9 show that β_{12} accounted for only 0.48% of the total *TWFE* treatment effects, which are shown in the circle, while β_{13} accounted for as much as 99.34%, shown in the triangle. Our results are robust, and there is no error in the multi-time point processing effect. Estimating the impact of green bond issuance on ER is feasible using the TWFE staggered DID method. This outcome means that in the benchmark regression, the results are reliable.

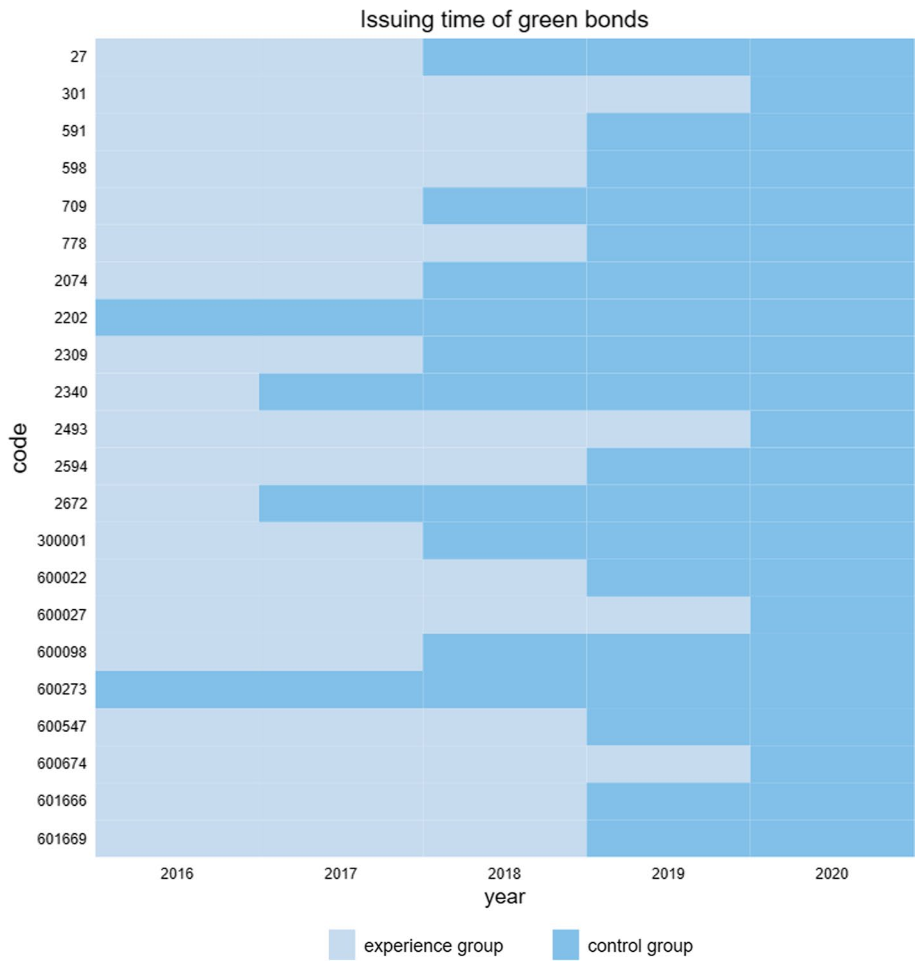

Fig. 8 The processing state diagram of the enterprises in the experimental group

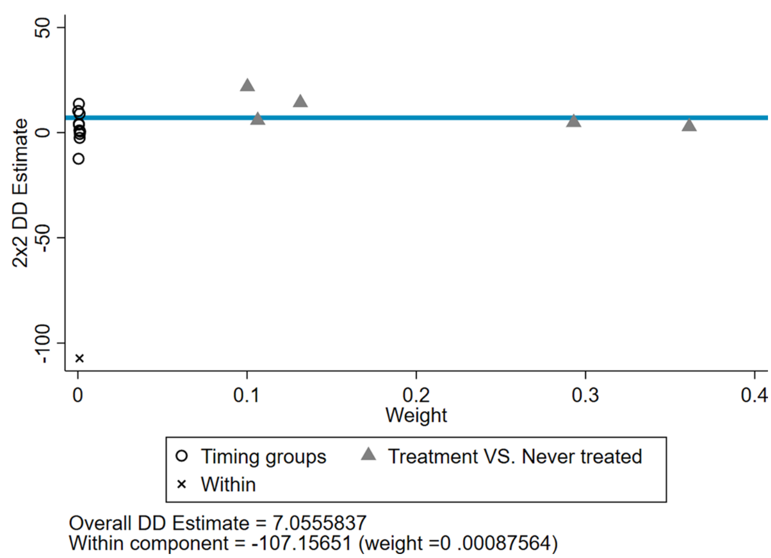

Fig. 9 Results of Goodman-Bacon decomposition

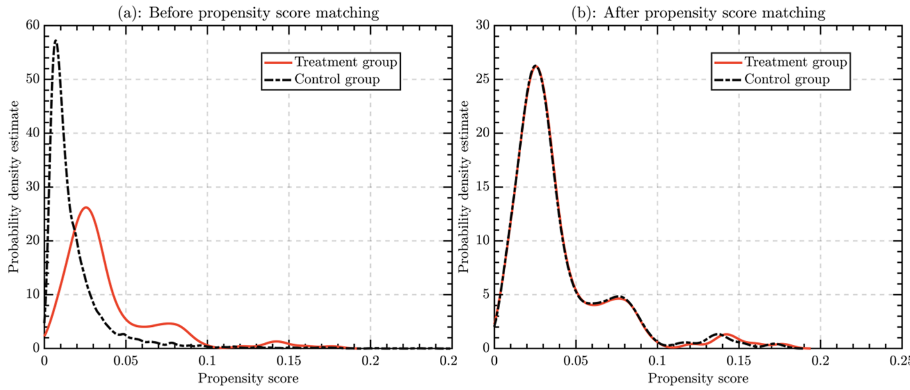

Fig. 10 Nuclear density before and after PSM matching

Propensity score matching (PSM)-DID

Our research may face doubt concerning the randomness of enterprises issuing green bonds, and enterprises undertaking ER are more likely to issue green bonds. This non-randomness of policy choice may cause a slight sample selection bias. We refer to Böckerman and Ilmakunnas (2009) and Heyman et al. (2007) to eliminate this interference and use the propensity-matching approach to control sample selection errors. The 22 enterprises that have issued green bonds in the sample period are used as the experimental group, and the control variables in the basic regression are used as the covariates. We then use the 1:2 nearest caliper matching with replacement matching year by year. After re-matching, the mean difference between the experimental group and the control group for all variables is not significant at the level of 10%; that is, the samples of the treatment group and the control group are balanced. Furthermore, we use the nuclear density map to check whether there are differences between the two groups' tendency scores before and after matching. Figure 10 shows that the deviation of the nuclear density curve between the two groups before matching is relatively large, while the nuclear density curve after matching is the same, so the matching effect is good. Therefore, PSM has produced the treatment effect of reducing the sample selectivity deviation yearly.

Columns (5)–(6) in Table 4 present the DID results using matched samples with non-empty weights and samples meeting the common support assumption. These results are consistent with the benchmark regression results, showing that the benchmark regression result remains stable after considering the selection deviation.

Instrumental variable regression

The issuance of green bonds in China is mainly a government-led model. The local government encourages enterprises to issue green bonds by formulating green development implementation plans and promulgating relevant regulations. This paper refers to Chen et al. (2018) practice of building government environmental governance policies. We manually collect the number of policies and regulations on green bonds issued by prefecture-level city governments as the local government's support for the issuance of green bonds (Policy). We provide a detailed description of these policies in Table 16 in the Appendix. Theoretically, the local government's support for issuing green bonds will

Table 4 Robustness checks: PSM-DID & Huazheng ESG & Environmental penalty & Control industry time trend

	(5) weight	(6) on_support	(7) H-ER	(8) Environmental penalty	(9) ER
Green × Time	4.2704*	6.3037**	1.3796*	-0.0213**	6.7716**
	(2.3977)	(2.5975)	(0.7165)	(0.0087)	(2.6710)
Constant	− 7.4398	− 24.1428**	50.0321***	0.0023	− 9.0713
	(75.2552)	(11.2294)	(2.5217)	(0.1078)	(10.9419)
Control variables	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES
R-squared	0.0898	0.1311	0.0833	0.0067	0.0035
Observations	489	5773	32,909	7286	8493

This table reports the results of robustness checks. For columns 5, through the 1:2 nearest caller matching, we obtain a new sample that is successfully matched and recorded as weight (Use samples with non-empty weights). This sample includes firm-year observations for 259 enterprises during 2011 to 2020. For columns 6, through the 1:2 nearest caller matching, we also re select samples that meet the common support hypothesis for regression. This sample excludes the interference of common factors that are missing from the model. This sample includes firm-year observations for 968 enterprises during 2011 to 2020. For columns 7, we use Huazheng environmental responsibility to replace the explanatory variables in our research for regression. This index covers almost the entire Chinese A-share listed companies. Therefore, there are many observation samples for this regression. This sample includes firm-year observations for 4227 enterprises during 2011 to 2020. For columns 8, we use environmental penalty as a substitute for the explained variable for regression. This sample includes firm-year observations for 1140 enterprises during 2011 to 2020. For columns 9, the time trend of the benchmark regression sample is controlled. This sample includes firm-year observations for 1058 enterprises during 2011 to 2020. All of the variables are as defined in the Table 1. The robust standard error clustered at the firm level is shown in parentheses

*Denotes 10% significance level; **Denotes 5% significance level; ***Denotes 1% significance level

significantly affect whether enterprises issue green bonds, but this variable is unrelated to ER. Furthermore, the government's policy on green bond issues is quasi-exogenous and will not be affected by ER, so the local government's support for green bond issuance (Policy) meets the requirements as an instrumental variable. Therefore, we use the staggered introduction of prefecture-level city government policies on green bonds as the instrumental variable (IV) for enterprises to issue green bonds and use the two-stage least squares (2SLS) estimation method to conduct the endogeneity test.

Columns (11) and (12) in Table 5 present the results of the instrumental variable regressions, where Column (11) indicates that the support of local governments for green bonds is significantly positively correlated with the issuance of green bonds. The results in Column (12) indicate that the corporate issuance of green bonds is significantly and positively related to the level of ER, which supports the previous conjecture. Furthermore, the statistical results of the under-identification and weak-identification tests show that the IV we choose is strongly effective. Finally, the estimated coefficients of the IV-2SLS approach suggest that the main findings in the baseline regression remain sound after controlling for possible endogeneity issues.

Alternative variable

According to the information disclosure of listed enterprises, we can learn about the measures taken and efforts made by the enterprises for environmental protection. We use other ER evaluation indicators for robustness checks to avoid the deviation caused by the accuracy of *Bloomberg*'s ESG data. ESG evaluation institutions in China, such as *Huazheng, Shangdao Ronglv,* and *Wind*, have gradually strengthened their coverage of

Table 5 Robustness check: instrumental variable regression

	(10) **ER**	**(11)** **First stage** **Green × Time**	**(12)** **Second stage** **ER**
Policy		0.0033***	
		(0.0008)	
Green × Time	7.2789**		39.5387**
	(2.8828)		(16.8196)
Kleibergen-Paap rk LM			17.925
P-value			0.0000
Kleibergen-Paap rk Wald F			18.241
Stock-Yogo bias critical value			16.38 (10%)
Control variables	YES	YES	YES
Firm fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
R-squared	0.2716		0.3161
Observations	9330	9264	9264

This table reports the results of instrumental variable regression. For columns 10–12, this sample is consistent with the baseline regression including firm-year observations for 1374 enterprises during 2011 to 2021. A total of 7892 green bond policies issued by 256 Prefecture-level cities were manually sorted out. The robust standard error is shown in parentheses

**Denotes 5% significance level; ***Denotes 1% significance level

A-share enterprises and become mainstream ESG evaluation institutions. However, the ER score in the *Shangdao Ronglv* is missing and cannot be used effectively. Moreover, the ESG data of *Wind* has been counted since 2018, which does not apply to our study. Furthermore, some scholars have adopted the *Hexun* CSR scoring system; however, the data is missing, and no single score of environmental social responsibility has been disclosed in recent years.

Therefore, our study uses the ER score in the *Huazheng* ESG evaluation system as the replacement variable for the explained variable. Column (7) in Table 4 presents the regression results, which are consistent with those obtained from the benchmark regression.[7]

The previous analysis shows that Bloomberg's ESG data, Huazheng, and other ER evaluation indicators often rely on firms' self-reported data. To better measure the true commitment of corporations to the environment and address these concerns, we use an indicator that does not involve enterprise self-information disclosure and repeat the test. We use the environmental penalty data published by a third party (the competent department of environmental protection under the State Council in conjunction with relevant departments) in China as an alternative variable to measure ER. This data is from the China Research Data Service (CNRDS) Database. Column (8) of Table 4 shows the corresponding regression results. Based on these results, we can conclude that the issuance of green bonds significantly reduces the environmental penalty imposed on

[7] Huazheng's ESG rating covers 3 first-level indicators, 14 s-level indicators, 26 third-level indicators, and more than 130 bottom-level data indicators. Compared with the overseas market, it incorporates more indicators suitable for the current development stage in China, such as the quality of information disclosure, CSRC punishment, and targeted poverty alleviationThe bottom indicators are aggregated from bottom to top according to the industry weight matrix to obtain the enterprise's ESG score and the final AAA—C rating of nine grades.

enterprises. This test further confirms that the issuance of green bonds enhances enterprises' ER from an objective perspective.

Controlling industry time trends

The ER undertaken by enterprises may be affected by some unobserved industry-specific trends before the issuance of bonds. ER in different industries may have different time trends. We added the industry-specific time trends to the benchmark regression model to avoid results bias caused by this situation. Construction variable $\mathrm{Ln_i} \times \mathrm{t}$. Here, $\mathrm{Ln_i}$ is the industry classification dummy variable divided by the Ministry of Environmental Protection of China to disclose environmental protection information in 2010. If the sample industry belongs to i, the value is 1; otherwise, it is 0. Furthermore, t represents the year variable. Column (9) in Table 4 shows the specific regression results. The results are still significant at the 1% level, indicating that our conclusions are not different due to the existence of industry-specific time trend items.

Eliminating other policy interference

This section discusses other policies that may affect ER during our sample period. First, we exclude the impact of the *Environmental Protection Law of the People's Republic of China 2014*. Considering that this policy may force enterprises to improve their environmental scores, we add a dummy variable $Post \times Treat$ to the benchmark regression equation:

$$ER_{i,t} = \beta_0 + \beta_1 Green_i \times Time_{i,t} + \beta_2 Post \times Treat + \gamma \boldsymbol{X}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}. \tag{4}$$

When the year is 2014 or later, the value of Post is 1; otherwise, it is 0. When the enterprise belongs to a polluting enterprise affected by the environmental protection law, the value of Treat is 1; otherwise, it is 0. Column (13) in Table 6 shows that when the impact of this policy is added, the estimated coefficient of the core explanatory variable $Green \times Time$ is still significant. In addition to this policy impact, green bonds issued by enterprises after the *Guidelines for the Issuance of Green Bonds* in 2016 still have an incremental effect on promoting ER.

Second, we consider the impact of the *green finance pilot zone*. Establishing and developing the *green finance pilot zone* can be important in promoting the dual-carbon goal. On June 14, 2017, China selected eight regions in five provinces, namely, Zhejiang, Jiangxi, Guangdong, Guizhou, and Xinjiang, to build *green finance reform and innovation pilot zones*.[8] We excluded these eight regions during our sample period. Column (14) in Table 6 shows that the estimation coefficient of the core explanatory variable is still significantly positive. In 2019, the scope of the *green finance reform pilot zone* was further expanded, and Lanzhou New Area in Gansu Province was approved as the ninth green finance reform and innovation pilot zone. We further excluded the samples from this region, and the regression results still meet expectations, as shown in Column (15) in Table 6. Therefore, the above results exclude the interference of other policies on our main findings, verifying the robustness of the benchmark regression results.

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[8] See the overall plan of the green finance reform and innovation pilot zones, 2017. Available at: http://www.gov.cn/xinwen/2017-06/27/content_5205752.htm.

Table 6 Robustness checks: Eliminate other policies interference & Extend sample period and sample size

	(13) Exclusion of environmental law (2014)	(14) Exclusion of reform pilot zone (2017)	(15) Exclusion of reform pilot zone (2019)	(16) Terminal governance	(17) Front-end governance	(18) Employee behavior
Green × Time	6.9575***	5.8877**	5.9001**	1.1834***	2.1175***	0.0684**
	(2.6164)	(2.5432)	(2.5402)	(0.2586)	(0.5523)	(0.2586)
Post × Treat	1.2291***					
	(0.4645)					
Constant	− 16.8811**	− 14.7468***	− 14.2719**	− 1.6053	− 3.9866***	0.5579
	(6.8179)	(6.6159)	(6.5545)	(1.0496)	(1.4114)	(0.3756)
Control variables	YES	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
R-squared	0.1912	0.1884	0.1870	0.2185	0.0934	0.0547
Observations	8493	8166	8063	12,110	12,110	12,110

This table reports the results of robustness checks: For columns 13, this sample is consistent with the baseline regression including firm-year observations for 1058 enterprises during 2011 to 2020. For columns 14, this sample excludes the sample of enterprises located in the green finance reform pilot zone promulgated in 2017 (a total of 41 companies). Finally, this sample includes firm-year observations for 1017 enterprises during 2011 to 2020. For columns 15, based on columns 14, we further exclude the sample of enterprises in the newly announced green finance reform pilot zone in 2019 (a total of 16 companies). This sample includes firm-year observations for 1001 enterprises during 2011 to 2020. For columns 16–18, the data comes from the CESG Database of China Research Data Service Platform (CNRDS). This sample includes firm-year observations for 4242 enterprises during 2010 to 2021. The robust standard error is shown in parentheses

**Denotes 5% significance level; ***Denotes 1% significance level

Extending the sample period and size

The benchmark regression in our study uses a small sample size due to data availability issues; however, we try to find ways to expand the sample period and size using the data of A-share listed enterprises from 2010 to 2021. We leveraged the advantages of the *CESG* in *CNRDS* Database and manually supplemented missing data using the annual reports of listed enterprises.

This approach includes three measurement indicators. First, terminal governance measures whether enterprises adopt policies or technologies to reduce the emission of waste gas, wastewater, waste residue, and greenhouse gases. If yes, it is 1; if no, it is 0. The second is front-end governance, which evaluates whether enterprises use renewable energy or adopt policies and measures of the circular economy. If yes, it is 1; if no, it is 0. Finally, employee behavior determines whether the enterprises have green office policies or measures. If yes, it is 1; if no, it is 0. Sixty-eight nonfinancial A-share listed enterprises issued green bonds in this sample interval. Excluding the missing samples and ST and *ST, 61 enterprises entered the experimental group, and 4,181 enterprises entered the control group. See Table 6 for the regression results, which are consistent with the conclusions obtained from the benchmark regression.

The regression results show that the issuance of green bonds has promoted the commitment to ER from three dimensions. The listed enterprises in the experimental group have significantly undertaken more ER regarding terminal governance, front-end governance, and employee behavior than those in the control group. Furthermore, this result remains valid after a series of robustness tests, including parallel trend and dynamic effect tests, placebo tests, tendency-matching scores, and controlling industry time trends. See the robustness test and placebo test in Fig. 6s (b)–(d) and 7 (b)–(d), respectively.

Mechanism test

The benchmark regression results show that the issuance of green bonds positively affects ER. Next, we establish the models to test the mechanism following the method of Baron and Kenny (1986) to test the role of enterprises' internal and external attention in promoting ER through green bonds. It can be expressed as follows:

$$Ln(\mu) = \alpha_1 + \sum_{j=1}^{p} \delta_j Green_i \times Time_{i,t,j} \tag{5}$$

$$ER_{i,t} = \alpha_2 + \beta_2 Green_i \times Time_{i,t} + \gamma_2 X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{6}$$

$$ER_{i,t} = \alpha_3 + \beta_3 Green_i \times Time_{i,t} + \vartheta Attention_{i,t} + \gamma_3 X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}. \tag{7}$$

Model (5) uses Poisson distribution, referring to Long and Freese (2006), because our study's internal and external attention measures are count variables. Therefore, the first step adopts Poisson estimation, μ, is the mean of $\text{Attention}_{i,t}$. At this time, the probability distribution of the connection function $\text{Ln}(\mu)$ is a Poisson distribution. The intermediary variables, $\text{Attention}_{i,t}$, include the concern of internal enterprise managers for environmental issues and the concern of external media for enterprises. The settings of other variables are consistent with those in the benchmark regression.

Managers' attention

Currently, most scholars measure managers' attention using questionnaires and textual analysis. The annual reports of listed enterprises provide a good data source to analyze the managers' concerns about environmental issues; therefore, we refer to the environmental lexicon constructed by Chen et al. (2018). The selected keywords of environmental concern are environment (Huan Jing), energy consumption (Neng Hao), pollution (Wu Ran), emission reduction (Jian Pai), and environmental protection (Huan Bao). We then used Python for text analysis and extracted the frequency of corresponding keywords from the management discussion and analysis of the annual report of listed enterprises and the CSR report. The settings of other variables are consistent with those in the benchmark regression.

The regression results in Column (19) in Table 7 show that issuing green bonds can increase managerial attention on environmental issues. Column (20) shows that issuing green bonds can promote commitment to ER. Finally, Column (21) shows that the managers' attention significantly plays a regulatory role in green bonds promoting ER; thus, research Hypothesis 2 is supported.

We provide additional evidence showing the role of governance in internal environmental issues. Managers' attention can promote the management of pollutant emissions (terminal governance) and employees' green work behavior (employee behavior);

Table 7 Mechanism test: Managers' attention

	(19) Attention	(20) ER	(21) ER	(22) Terminal governance	(23) Front-end governance	(24) Employee behavior
Green × Time	1.0540*	4.29120*	3.7813	0.9976***	1.6038***	0.0218
	(0.0315)	(2.2768)	(2.4402)	(0.3833)	(0.5633)	(0.0591)
Attention			0.0578***	0.0037***	0.0016	0.0024***
			(0.0100)	(0.0013)	(0.0015)	(0.0004)
Constant		− 20.5674**	− 19.0722*	0.0363	− 1.8958	0.7517
		(10.0504)	(9.7328)	(0.7917)	(1.2897)	(0.4690)
control variables	YES	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Log likelihood	− 22,940.634					
R-squared		0.1305	0.2751	0.2331	0.0897	0.0404
Observations	5356	5409	5409	7430	7430	7430

This table reports the results of one of the mechanism tests. For columns 19–21, we use the data after matching the original sample with the manager's attention as a sample. This sample includes firm-year observations for 791 enterprises during 2010 to 2021. Column 19 uses the Poisson estimate. -22,940.634 is the logarithmic likelihood value of the regression. For columns 22–24, we use the samples in Table 6 for matching. This sample includes firm-year observations for 1238 enterprises during 2010 to 2021. All of the variables are as defined in the Table 1. The robust standard error is shown in parentheses

*Denotes 10% significance level; **Denotes 5% significance level; ***Denotes 1% significance level

however, it has no significant effect on cleaner production or the circular economy of enterprises (front-end governance). The results can be seen in Columns (22)–(24) in Table 7.

Medias' attention

Regarding external media attention, the *CNRDS Database* provides us with information about enterprises' external media attention. We used data that measures three different media sentiments to conduct our regression: positive news (Posnews), neutral news (Neunews), and negative news (Negnews). Online media attention includes news reports from more than 400 important online media in China, the most important of which is the news reports from 20 mainstream online financial media (i.e., *Hexun, Sina Finance, Dongfang Fortune, Tencent Finance, Netease Finance, Phoenix Finance,* and *the China Economic Network*). For example, Posnews represents the total positive news about the enterprise.

The regression results in Columns (25) and (26) in Table 8 indicate that the issuance of green bonds can significantly promote the attention of external media to enterprises. Column (28) shows that issuing green bonds can promote the commitment to ER. Moreover, Columns (29)–(31) show that the media's positive and neutral reports play a regulatory role in green bonds promoting ER; however, the negative reports do not play a regulatory role. We also use Pingdingshan Tian'an Coal Industry Co., Ltd.—the first Chinese coal enterprise to issue green bonds—to verify our findings. The company received extensive positive reports from Henan Province and the media.[9] As a result, research Hypothesis 3 is supported.

[9] http://epaper.pdsxww.com/pdsrb/html/2018-11/14/content_197077.htm
https://baijiahao.baidu.com/s?id=1729365235363701956&wfr=spider&for=pc

Table 8 Mechanism test: medias' attention

	(25) Posnews	(26) Neunews	(27) Negnews	(28) ER	(29) ER	(30) ER	(31) ER
Green × Time	1.3610***	1.4069***	1.0410	7.0412***	6.9881***	7.0832***	7.0254***
	(0.0372)	(0.0538)	(0.1076)	(0.5636)	(0.5767)	(0.5453)	(0.5665)
posnews					0.0053**		
					(0.0021)		
neunews						0.0071*	
						(0.0035)	
negnews							− 0.0025
							(0.0050)
Constant				− 13.9132*	− 12.0466	− 12.3328*	− 14.4548*
				(7.4585)	(6.9943)	(6.8939)	(7.0256)
control variables	YES	YES	YES	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES
Log likelihood	− 232,783.7	− 171,644.3	− 134,989.4				
R-squared				0.1892	0.1919	0.1912	0.1893
Observations	8412	8412	8412	8412	8412	8412	8412

This table reports the results of one of the mechanism tests. We use the data after matching the original sample with the medias' attention as a sample. This sample includes firm-year observations for 1057 enterprises during 2011 to 2020. Columns 25–27 use the Poisson estimate in which the logarithmic likelihood value of the regression is reported. All of the variables are as defined in the Table 1. The robust standard error is shown in parentheses

*Denotes 10% significance level; **Denotes 5% significance level; ***Denotes 1% significance level

Further discussions

We confirmed the positive relationship between green bond issuance and ER using the SDID approach and a host of robustness checks in the above empirical analysis. Furthermore, this study investigates whether green bonds have heterogeneous impacts on ER in different enterprises and industries and the economic impact on enterprise value.

Heterogeneity analysis

Manager's ability

We tested the economic channel of corporate governance on enterprises' commitment to ER; thus, a topic of interest is whether some ability traits of managers play a moderating effect. The upper echelons theory suggests that senior executives' education background or academic experience can impact corporate decision-making (Bantel and Jackson 1989; Wally and Baum 1994; Wiersema and Bantel 1992; Graham and Harvey 2002). Managers must be able to identify stakeholders' legitimacy; only then can they make correct decisions related to CSR (Shafer et al. 2007; He et al. 2015). Furthermore, managers' educational backgrounds are largely related to their ability to observe events (Üsdiken 1992). Prior studies indicated that the higher the education level of enterprise executives, the more likely they are to judge the policy orientation based on rigorous professional knowledge and, thus, assume greater social responsibility (He et al. 2015; Francis et al. 2015).

Therefore, to examine whether the impact of green bond issuance on ER is heterogeneous with managers' ability, we first calculated the average education level of all managerial members within the enterprise as the proxy for the manager's ability. We then

Table 9 Heterogeneity analysis: manager's ability

	(32)	(33)	(34)	(35)
	High education level		Low education level	
	ER	ER	ER	ER
Green × Time	8.5201**	8.4046**	0.5043	0.4491
	(3.4461)	(3.4220)	(0.8051)	(0.8395)
Constant	8.3094***	− 17.0934*	9.0977***	− 16.5660
	(0.3383)	(9.5994)	(0.7766)	(28.7900)
Control variables	NO	YES	NO	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
R-squared	0.0506	0.1499	0.050	0.1498
Observations	4642	4642	1343	1343

This table presents variants of the regressions in Table 3, dividing the sample into two parts that distinguish between sub sample with high managers' abilities and sub sample with relatively low managers' abilities. This sample includes firm-year observations during 2011 to 2020. All of the variables are as defined in the Table 1. The robust standard error is shown in parentheses

*Denotes 10% significance level; **Denotes 5% significance level; ***Denotes 1% significance level

divided the total sample into two subgroups according to the average value (i.e., one group with a relatively high education level and the other with a relatively low education level).

We regress green bond issuance on ER on these two subgroups, and Table 9 shows the estimation results. The coefficients of $Green \times Time$ in Columns (32)–(33) are 8.5201 and 8.4046, respectively, at the 5% significance level. The coefficients of $Green \times Time$ in Columns (34)–(35) are insignificant, which validates our previous ideas. In the subsample with high education levels, the issuance of green bonds has a more pronounced impact on ER. This finding uncovers a manager's positive role in promoting ER through green bond issuance, showing that enterprises with strong executive ability can better identify policy changes and the external environment. When enterprises issue green bonds, they will better identify their legitimacy requirements in the face of more stakeholders' participation; thus, managers' ability to handle and analyze problems can boost ER engagements.

Pollution attribute

As shown in the institutional background in Sect. "Institutional background for green bonds in China" above, China's green bonds have prominent characteristics of industry bias. Therefore, another topic of interest is whether the impact of green bond issuance on ER shows industry heterogeneity. The results of sub-sample regression are also important for our research by dividing high-polluting industries and low-polluting industries. Referring to Pan et al. (2019) and Huang et al. (2022), we select 15 types of heavily polluting industries required by the *Ministry of Environmental Protection of China to disclose environmental protection information in 2010*. These include (1) coal mining and washing; (2) oil and gas extraction; (3) ferrous metal mining and dressing; (4) nonferrous metal mining and dressing; (5) textile; (6) leather, fur, feathers and their products and footwear; (7) paper and

Table 10 Heterogeneity analysis: Pollution attribute

	(36)	(37)	(38)	(39)
	Low-polluting industry		High-polluting industry	
	ER	ER	ER	ER
Green × Time	9.1000**	8.9881**	4.6984	4.7429
	(3.9438)	(3.8786)	(3.2722)	(3.2776)
Constant	7.8335***	− 23.3013***	9.2949***	− 12.3474
	(0.2887)	(7.7116)	(0.4631)	(15.1591)
Control variables	NO	YES	NO	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
R-squared	0.0382	0.1320	0.0621	0.1655
Observations	6025	6025	2468	2468

This table presents variants of the regressions in Table 3, dividing the sample into two parts that distinguish between subsample with heavy pollution and subsample with light pollution. This sample includes firm-year observations during 2011 to 2020. All of the variables are as defined in the Table 1. The robust standard error is shown in parentheses

**Denotes 5% significance level; ***Denotes 1% significance level

paper products; (8) petroleum processing, coking and nuclear fuel processing; (9) chemical raw materials and chemical products; (10) chemical fiber; (11) rubber and plastic products; (12) nonmetallic mineral products; (13) ferrous metal smelting and rolling processing; (14) nonferrous metal smelting and rolling processing; (15) and electricity and heat production and supply. Combining the three-level industry code matching, we divided 13 enterprises in the experimental group into high-polluting industries and the remaining 9 enterprises into low-polluting industries.

We then run the baseline regression on these two subsamples, and the estimation results are shown in Table 10. The coefficients of $Green \times Time$ in Column (36)–(37) are 9.1000 and 8.9881, respectively, at the 5% significance level. The coefficients of $Green \times Time$ in Columns (38)–(39) are insignificant. The issuance of green bonds can significantly promote the ER of enterprises in low-polluting industries but not in high-polluting industries. On the one hand, the high-polluting industries are subject to more external supervision and information disclosure requirements. Therefore, issuing green bonds, as an exogenous impact, may bring relatively little external attention and supervision of public opinion. As a result, the attention of internal managers and external media of the enterprise has not been significantly increased, and the enterprise has no sufficient motivation to improve ER to meet the legitimacy requirements of external pressure. On the other hand, it is more difficult for high-polluting industries to stop using traditional polluting processes and technologies and carry out green innovation. These challenges lower the efficiency of resource optimization and allocation, making enterprises less likely to give up productive investment and turn to nonproductive investment; ultimately, they do not improve ER.

Table 11 Heterogeneity analysis: Environmental subsidies

	(40)	(41)	(42)	(43)
	Without environmental subsidies		With environmental subsidies	
	ER	ER	ER	ER
Green × Time	11.0134**	10.9406**	1.7440	1.4030
	(5.4382)	(5.3730)	(1.7691)	(0.426)
Constant	8.0625***	− 9.9072	9.0246***	− 25.9398
	(0.3010)	(7.1551)	(0.4630)	(16.1027)
Control variables	NO	YES	NO	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
R-squared	0.1733	0.1806	0.1563	0.1654
Observations	5620	5620	2873	2873

This table presents variants of the regressions in Table 3, dividing the sample into two parts that distinguish between sub sample with environmental subsidies and sub sample without environmental subsidies. This sample includes firm-year observations during 2011 to 2020. All of the variables are as defined in the Table 1. The robust standard error is shown in parentheses

**Denotes 5% significance level; ***Denotes 1% significance level

Environmental subsidies

Enterprises may be unable to effectively implement environmental investment due to their own awareness or financial constraints. The government is objectively required to take measures to provide financial subsidies to help enterprises address relevant environmental issues and promote the improvement of environmental equipment and processes. Currently, the main forms of environmental subsidies include cash incentives, tax incentives, preferential interest rates for financing environmental projects, or direct investment in environmental protection. Before the emergence of green bonds, China had environmental subsidies. Therefore, we must determine if green bond issuance is a substitute for making up for environmental subsidies. This section examines whether private green finance complements or substitutes government green finance in improving corporate environmental performance. To investigate this argument, we take advantage of the availability of green bonds as a private climate financing mechanism and government environmental subsidies as a public climate finance tool. Both types of green finance can encourage an improvement in environmental performance; however, the literature is unclear whether firms with access to both forms of funding perform better. If the issuance of green finance is more effective for firms with green subsidies, green bond finance complements government green subsidies; however, if the results are only significant for firms without subsidies, then it means that green bonds can act as a substitute for government green funding.

Based on the details of government subsidies extracted from the enterprises' annual reports, we manually collate the number of environmental subsidies received each year according to keywords related to environmental protection and measure it using the relative level of environmental subsidies after scale adjustment. We then divide our sample into two sub-categories: firms with and without environmental subsidies.

Table 12 Heterogeneity analysis: Environmental rating & Green project clauses

	(44) ER	(45) ER	(46) ER	(47) ER
Green × Time × Cer	2.7587**	2.7296**		
	(1.3303)	(1.3260)		
Green × Time × Clause			6.2282**	5.7782*
			(3.0586)	(3.0700)
Constant	8.2919***	− 15.4469**	8.2791***	− 15.1040**
	(0.2406)	(6.8304)	(0.2424)	(6.8584)
Control variables	NO	YES	NO	YES
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
R-squared	0.1815	0.1870	0.1755	0.1802
Observations	8493	8493	8493	8493

This table presents variants of the regressions in Table 3, interacting green bond with dummy variables that examine the impact of the different rating by independent third parties and green project clauses on environmental responsibility. This sample includes firm-year observations during 2011 to 2020. All of the variables are as defined in the Table 1. The robust standard error is shown in parentheses

*Denotes 10% significance level; **Denotes 5% significance level; ***Denotes 1% significance level

The sub-sample regression results are shown in Table 11. The coefficients of our main variable for firms with no environmental subsidies in Columns (40)–(41) are 11.0134 and 10.9406, respectively, at the 5% significance level. In contrast, the coefficients for firms with environmental subsidies in Columns (42)–(43) are insignificant. Comparing the results for firms with and without environmental subsidies, the impact of green bonds on enterprise environmental performance is more pronounced for firms without environmental subsidies and insignificant for firms with environmental subsidies. The results suggest that green bond finance can substitute for government climate finance in promoting enterprise environmental performance.

Environmental rating

Considering that third-party certification of green bonds may convey additional information, we redesign the baseline regression to examine the role of bond certification. Companies may strategically issue green bonds as a form of green washing to attract investors but fail to deliver on their promise to reduce greenhouse gas emissions (Flood 2022). Thus, to explore this possibility, we create a variable that indicates whether the green bond is certified by independent third parties and its respective rating. The specific model is as follows:

$$ER_{i,t} = \beta_0 + \beta_1 Green_i \times Time_{i,t} \times Cer_{i,t} + \gamma \boldsymbol{X}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{8}$$

where, $Cer_{i,t}$ represents the rating of green bond i by third parties in time t. If the green bond has no third-party rating, the value is 0. If the rating is AA -, the value is 1. If it is AA, the value is 2. If it is AA +, the value is 3. If it is AAA, the value is 4. The definitions of other variables are consistent with the previous text.

Table 12 shows that the coefficients of the explanatory variable of the triple difference in Columns (44)–(45) are significantly positive, indicating that the higher the enterprise's green bond rating, the stronger its commitment to ER. The results are consistent with our expectations that high-rated bonds are more credible and reflect a strong commitment to improving corporate environmental performance.

Green project clauses

To further illustrate the efficacy of green bond issuance, we employ this heterogeneity test to examine the incorporation of green project clauses. Many green bonds incorporate clauses that restrict funding usage to green projects, as issuing these bonds requires auditing for proper utilization; however, the absence of specific usage limitations in general green bonds might increase the risk of greenwashing. Thus, to explore this possibility, we create a dummy variable that indicates whether the green bond has strict green project recognition clauses for regulating the use of fundraising funds. The specific model is as follows:

$$ER_{i,t} = \beta_0 + \beta_1 Green_i \times Time_{i,t} \times Clause_{i,t} + \gamma \boldsymbol{X}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{9}$$

where $Clause_{i,t}$ represents whether green bond i has strict green project recognition clauses in time t. If the green bond has the green project recognition clauses, the value is 1; otherwise, the value is 0. The definitions of other variables are consistent with the previous text.

Table 12 shows that the coefficients of the explanatory variable of the triple difference in Columns (46)–(47) are significantly positive, indicating that the precise clauses within green bonds could alleviate concerns regarding firms' potentially endogenous greenwashing decisions.

Economic consequences analysis

Market reaction: Stock yield fluctuation

We have shown in economic mechanisms that enterprises can get more external attention from stakeholders after issuing green bonds; thus, our first concern is whether the issuance of green bonds can benefit shareholders in the stock market. To answer this question, we utilize the event study method to examine the impact of green bond issuance on the stock yield of listed enterprises.

Following Dasgupta et al. (2006), we measure the cumulative abnormal return (CAR) as the proxy variable for the enterprise value in the stock market. Specifically, we choose the date of the first green bond issuance by the listed enterprise as the event date. Furthermore, the event window period is from the trading day of the event to the 1–6 trading day after the event to test the short-term dynamic effect of CAR. Meanwhile, we select the relevant data of 200 trading days preceding the event as the estimation period, i.e., (−200, −40). We use a market model (10) to calculate the excess stock return, and the daily market return and individual stock return data are from the *CSMAR Database*.

$$R_{it} = \alpha_i + \beta_i R_{mt} + e_{it} \tag{10}$$

where subscript i represents the listed enterprise in our study, and t represents the daily time interval from the event day. R_{it} represents the actual stock return of stock i on day

Table 13 Economic consequence analysis: CAR significance test

Event window t	(48) CAR	(49) T-test	(50) *P* value	(51) Std. Err
(0,1)	0.0084**	2.3325	0.0297	0.0036
(0,2)	0.0079**	2.3633	0.0278	0.0033
(0,3)	0.0102**	2.1034	0.0477	0.0049
(0,4)	0.0118*	2.0234	0.0559	0.0058
(0,5)	0.0120*	1.9283	0.0674	0.0062
(0,6)	0.0103	1.4635	0.1581	0.0071

This table reports the average cumulative abnormal return (CAR) for different time windows around the announcement of green bond issues. The sample consists of N = 22 green bond issuance events

*Denotes 10% significance level; ** Denotes 5% significance level

t. R_{mt} represents the corresponding market return on day t. After obtaining the estimated coefficients of $\widehat{\alpha}_i$ and $\widehat{\beta}_i$, we can calculate the excess stock return as follows:

$$AR_{it} = R_{it} - \left(\hat{\alpha}_i + \hat{\beta}_i R_{mt}\right). \tag{11}$$

Then, the CAR of stock i in the event window of (t_1, t_2) is summed up by the excess stock return obtained in model (12):

$$CAR_i(t_1, t_2) = \sum_{t_1}^{t_2} AR_{it} \tag{12}$$

where t_1 and t_2 are the left and right ends of the previously defined event window.

Finally, we must test whether the CAR of each stock is statistically different from zero to judge whether the issuance of green bonds significantly impacts the stock return of listed enterprises.

Table 13 reports the significance test of CAR, showing that the CAR of treatment stocks under the market model is significantly greater than 0, at least at the 10% statistical level, within the five trading days following the issuance of green bonds. The economic effect is also sizable. On average, the issuance of green bonds produces about 1% excess returns for shareholders; however, the reaction period is relatively short, and the CAR turns statistically insignificant on the sixth trading day after the issuance of green bonds. These findings indicate a short-term "green preference" in the capital market, and the issuance of green bonds can timely signal to investors that enterprises attach great importance to green development. Our results also support previous findings (Tang and Zhang 2020; Flammer 2021) that issuing green bonds can be a profitable shock event for speculative investors in the stock market.

Financial performance: Tobin Q value, ROA and ROE

In addition to the short-term market reaction, we are also concerned whether enterprises' financial value or performance can be enhanced after the issuance of green bonds. To examine this economic consequence, we refer to common practice and select

Table 14 Economic consequence analysis: Tobin Q value, ROA and ROE

	(52) Tobin Q	(53) ROA	(54) ROE
Green × Time	0.0943	− 0.0029	− 0.0032
	(0.0588)	(0.0024)	(0.0069)
Constant	10.3774***	0.1002	− 0.5454***
	(1.7134)	(0.0308)	(0.1634)
Control variables	YES	YES	YES
Firm fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
R-squared	0.1517	0.5935	0.5227
Observations	8353	8353	8353

This table reports the economic consequence analysis. We use the data after matching the original sample with the Tobin Q value as a sample. This sample includes firm-year observations during 2011 to 2020. All of the variables are as defined in the Table 1. The robust standard error is shown in parentheses

***Denotes 1% significance level

the three proxy variables, namely, Tobin Q value, ROE, and ROA. Table 14 reports the estimation results, and the coefficients of $Green \times Time$ in Columns (52)–(54) are statistically insignificant, suggesting that green bond issuance have no evident impact on the enterprises' financial value or performance. The reason may be that ER initiatives are nonproductive investments and have limited impact on improving short-term enterprise's financial performance.

Combining the economic outcome analysis in this subsection with the results presented in Sect. "Market reaction: stock yield fluctuation" shows that green bond issuance primarily motivates speculative shareholder benefits, as evidenced by short-term increases in stock yields; however, it has little impact on the short-run financial performance. As one of the most important microentities in the real economy, listed enterprises are expected to actively engage in ER investments through energy conservation and emission reduction projects to help meet China's dual-carbon goals (Du et al. 2014; Saeed et al. 2021). Moreover, we anticipate improvements in corporate financial performance and the quality of corporate environmental management. Unfortunately, the issuance of green bonds has not yet achieved a "win–win" outcome for both financial and environmental performance in China. As a result, the issuance of green bonds by enterprises will be more likely to address the "urgent need" for enterprise financing than to serve as "icing on the cake" for the financial performance of enterprises; these findings follow existing studies (Tang and Zhang 2020; Maltais et al. 2020; Yeow and Ng 2021).

Conclusions, policy implications, and limitations

This study takes the A-share listed enterprises in China from 2011 to 2020 as the subject and examines the impact, mechanism, and heterogeneity of corporate green bond issuance on ER. We use the SDID method, and our empirical results indicate that Chinese enterprises' issuance of green bonds can encourage enterprises to improve ER. The results remain stable after conducting several robustness tests, including the parallel trend test, placebo test, control of industry time trends, PSM-DID, and the Goodman-Bacon decomposition. This outcome shows that the purpose of issuing green bonds is to obtain project financing, pursue sustainable development, and promote the green development of enterprises. We examine several potential channels contributing to this incentive effect and argue that green bonds enhance ER by strengthening internal management and external supervision. Moreover, this effect is more pronounced for industries with low pollution levels, without environmental subsidies and with higher managerial abilities. At the same time, we examine the promoting effect of green bond environmental rating and green project clauses on ER. Finally, we discuss whether green financing tools can achieve a "win–win" outcome for enterprises and the environment. The results show that the issuance of green bonds can bring enterprises excess returns on short-term stock returns; however, it has no significant impact on other financial performance indicators of enterprises.

Developing countries like China face serious environmental problems. We provide suggestions for enterprises, the public, and the government to promote the coordinated development of the environment, society, and governance. First, the reward and punishment mechanism for managers in green governance must be improved. Based on our empirical results, the more attention an enterprise pays to ER or the better the executives can comprehend and adhere to new policies, the more likely they are to comply with green bonds' requirements and proactively undertake ER. The relevant departments must provide customized guidance and education for managers based on their enterprises' specific needs and cultivate senior executives' awareness to achieve coordinated economic, social, and environmental development through CSR. Policy guidance is needed to increase the cost of pollution activities, encouraging managers to pay more attention to environmental problems in production. Enterprises and senior executives can better understand the implementation standards and specific forms of green finance policies through policy interpretation and business publicity and participate in environmental governance to understand the policy objectives.

Second, the media should continue playing a guiding role in strengthening long-term and continuous supervision over the heavily polluting enterprises' environmental pollution behavior. Media pressure can give heavy polluting enterprises certain external regulations, increase pollution costs, and urge them to improve environmental behavior (Li et al. 2017). We believe that the professionalism and independence of the media should be given full play to make it a critical weapon to expose the pollution behavior of enterprises so that stakeholders can better understand the state of the enterprise. Thus, the media should fulfill its role as a continuous watchdog and promote social accountability by exposing the pollution behavior of enterprises.

Third, governments, especially in developing countries, should further support and regulate the development of China's green bonds. Green-friendly enterprises are not created overnight and require a long-term process from concept to behavior inertia. The government must guide enterprises to participate actively in environmental protection associations and green management training. At the same time, it should also formulate incentive policies for green bonds to encourage enterprises to implement ER actively. The government can increase support and subsidies for green innovation through green bond financing, contribute to mitigating global climate change and building a green home, and ensure the green signals positively spill over into enterprises' production and management processes.

This study may have some limitations. First, due to data availability, we use the data of Chinese A-share listed enterprises for research, which is remains limited by information disclosure and statistical data. We expect that the National Bureau of Statistics will release data for more detailed research. Moreover, our empirical research is based on a microlevel data sample of public enterprises, which may produce biased estimation results for the economic impact analysis. Future research could investigate the policy performance at a macrolevel by using data at the city or industry level. Moreover, we utilized the staggered difference-in-differences method and conducted multiple robustness tests to mitigate potential endogeneity issues; however, we acknowledge the inherent challenges in empirical execution. Future research may find it worthwhile to explore other selective measurement methods to address potential endogeneity concerns.

Appendix

See Tables 15 and 16.

Table 15 Industry distribution of listed enterprises issuing green bonds

industry classification	Code	Quantity	Proportion (%)
Finance industry	J	30	26.32
Manufacturing industry	C	28	24.56
Electricity, heat, gas and water production and supply industry	D	25	21.93
Water conservancy, environment and public facilities management industry	N	11	9.65
Real estate industry	K	6	5.26
Construction industry	E	5	4.39
Mining industry	B	4	3.51
Leasing and business services industry	L	2	1.75
Retail and storage industry	F	1	0.88
Transportation, storage and post industry	G	1	0.88

More detailed official notices are provided here. Available at: https://www.ndrc.gov.cn/xxgk/zcfb/tz/201601/t20160108_963561.html?code=&state=123

Table 16 Details of local government green bond policies

Encouragement type	Policy tools	Policy description
Policy signals	Special documents	Release special documents to encourage green bonds (or green finance)
	Special working group	Establish a special working group to encourage green bonds (or green finance)
	Green bond pilot	Fully or partially carry out green bond pilot projects
Convenience measures	Green channel	Opening a green channel for green bonds, priority given to processing
	Project	Establish a database of green bond issuance projects and strengthen the reserve of qualified projects
	Green debt alliance	Invite issuers, investors, regulatory agencies, intermediaries, evaluation agencies, etc. to jointly launch a green bond alliance
	Forum training or docking meeting	Hold green bond forums, training or project docking meetings
	Stimulate financing demand	Promote the green transformation of local economy and stimulate the demand for green financing
Financial incentives	Cost sharing	Share issuance costs by providing issuance subsidies, guarantee subsidies, bond discounts, and other means
	Credit enhancement	Enhance credit through guarantee funds, debt loan portfolios, special construction fund portfolios, and other means
	Tax break	Provide tax incentives for issuers, investors, etc. within the framework of central policies
	Guiding investment	Encourage investors within and outside the jurisdiction to invest in green bonds
Recognition	Commendation organization	Commending the issuer and participating institutions
	Media coverage	Organize media coverage on green bonds and green bond projects
	Include in review	Include green bonds in other routine work reviews and evaluations

More detailed incentive measures are provided here. Available at: https://www.climatebonds.net/files/reports/chinalocalgovt-01-11april17-ch-a3.pdf

Abbreviations

USD	United States dollars
CNY	Chinese Yuan
CSR	Corporate social responsibility
TWFE	Two-way fixed effects
ER	Environmental responsibilities
CNRDS	The China Research Data Service
CAR	Cumulative abnormal return

Acknowledgements
Not applicable

Author contributions
Y L: Conceptualization, Writing-original draft, Methodology, Software, Formal analysis; H H: Conceptualization, Writing-review and editing, Formal analysis; W M: Writing-review and editing, Formal analysis; F W: Project administration, Funding acquisition; H L: Review, Validation, Data curation.

Funding
This work was supported by the National Social Science Fund of China (Grant No. 22BJY188); the National Natural Science Foundation of China (Grant Nos. 71934001, 71573159, 41771568, 71533004, 71974001); the National Key Research and Development Program of China (Grant No. 2016YFA0602500); the Strategic Priority Research Program of Chinese Academy of Sciences (Grant No. XDA23070400); the Natural Science Foundation of Shandong Province (Grant No.

ZR2021MG011); the Social Science Foundation of Shandong Province (Grant Nos. 21CJJJ09, 2020-NDJJ-07); the Major Project of Humanities and Social Sciences Research of Shandong University (Grant No. 19RWZD05).

Availability of data and materials

The authors confirm that data will be made available on reasonable request.

Declarations

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Received: 3 January 2023 Accepted: 4 January 2024
Published online: 01 March 2024

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