The Enhancement Effect of Green Bond Issuance on Greenwashing Risk - Research Based on Difference-in-Differences Model

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Abstract. Green bonds, as an important component of the financial market, can help companies raise funds for green projects while potentially increasing greenwashing risks. Using data from 305 A-share listed companies (2014-2023), this study employs DID method and GONE theory to explore how green bond issuance affects greenwashing risk. Results show that green bond issuance positively correlates with greenwashing risk, especially when corruption costs are low, supervision is weak, exposure probability is small, and management control is high. The effect is more pronounced in high-pollution industries and state-owned enterprises with low external financing dependence.

Keywords: green bonds; greenwashing risk; green regulation

1 Introduction

In May 2021, China released the Catalogue of Green Bond Support Projects (2021) to standardize its green bond market. By 2023, China had issued 481 green bonds worth 839.864 billion yuan, becoming a global leader in this sector. However, the regulatory system has weaknesses in areas like review processes and fund supervision, increasing greenwashing risks. While existing research focuses on green bonds' benefits and premium effects [1,2], with studies showing premiums are influenced by corporate debt and media attention [3,4], and third-party authentication [5,6], this paper examines their potential risks. Using a multi-period DID model, we analyze 305 A-share listed companies to study green bonds' impact on greenwashing risk. The study expands GONE theory application and employs DDD model to examine heterogeneity across industries, financing dependence, and corporate nature, ultimately providing targeted recommendations for market development.

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2 Theoretical and hypothesis

2.1 Theoretical Model Analysis

The GONE theory system examines the four dimensions of fraud causes: greed factors, opportunity factors, need factors, and exposure factors, which has a natural fit with analyzing corporate greenwashing behavior [7]. Combining the investor communication decision-making model, this paper analyzes how green bond issuance affects greenwashing risk. Green bonds mainly influence corporate behavior through information asymmetry and incentive structures: investors find it difficult to verify the use of funds and environmental benefits, while companies may utilize imperfect information disclosure for selective disclosure; meanwhile, the financing advantages brought by green labels and lower violation costs, along with management's short-term interest orientation, may lead companies to pursue superficial environmental protection [8]. Let x represent the bond issuance status (issued/not issued), and the corporate value be v(θ,x). When issuing bonds (x=issue), the corporate value v=θi; otherwise, v=θn, where θi>θn. Management's decision-making considers both economic benefits and social image, affected by regulatory demands and exposure risks (Figure 1).

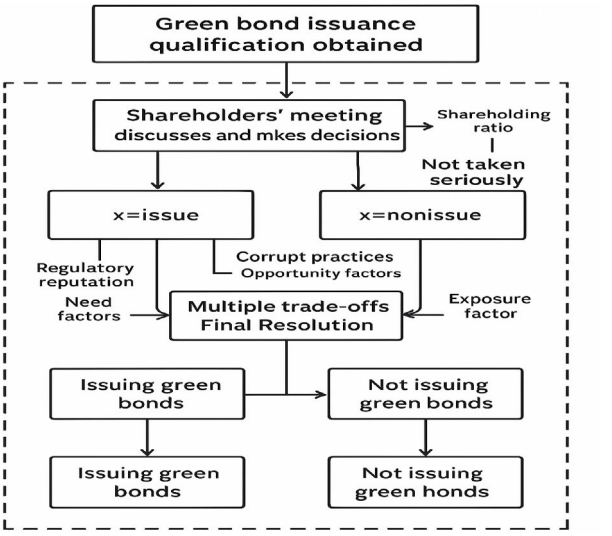

Fig. 1. Decision Process for Issuing Corporate Green Bonds

Using management's shareholding ratio G(0,1) as a proxy variable for greed factors, management's benefits (U) are represented as:

$$U = \begin{cases} G \times \theta_n, x = \text{nonissue} \\ G \times \theta_i + \beta, x = \text{issue} \end{cases} \quad (1)$$

where G is management's shareholding ratio, and β represents the excess returns brought by green reputation. Adding regulatory avoidance costs (s) and exposure probability (e), the utility function becomes:

$$U = \begin{cases} G \times (1 - s) \times \theta_n + \omega, x = \text{nonissue} \\ G \times \theta_i + \beta, x = \text{issue} \end{cases} \quad (2)$$

The final probability of management issuing green bonds (w*) is:

$$w^* = \frac{(G+n) \times E[\theta_i - e \times \theta_n] - O_s + \beta}{1 - G - n} \quad (3)$$

This model indicates that the probability of green bond issuance increases with management's shareholding ratio (G) and reputation demand (n), and decreases with corruption costs (O) and exposure risk (e). This theoretical framework explains how green bond issuance increases greenwashing risk through management incentives, regulatory arbitrage, and information asymmetry, providing a basis for subsequent empirical research.

2.2 Empirical Hypothesis

While green bonds can enhance corporate environmental performance and social credibility, China's regulatory framework hasn't kept pace with market growth, particularly regarding project approval and fund usage. This regulatory gap may incentivize companies to use green bonds for greenwashing.

Hypothesis 1: Corporate green bond issuance significantly increases greenwashing risk.

Theoretical analysis shows management can obtain excess returns (β) through green bonds. When external supervision (government regulation, media oversight) and internal controls (audits, governance) are weak, the cost of corrupt operations decreases, encouraging greenwashing behavior for short-term benefits.

Hypothesis 2: Weak supervision mechanisms and lower corruption opportunity costs increase greenwashing risk.

Hypothesis 3: Higher environmental penalties and reputation pressure increase greenwashing risk as companies seek to avoid costs (θi-θn) through deceptive prctices.

Hypothesis 4: Lower exposure probability (e) of greenwashing behavior increases its risk, as limited detection encourages selective environmental disclosure.

Hypothesis 5: Higher management control ratios (G) and expected returns (β) increase greenwashing risk, as management with stronger control tends to prioritize short-term gains through green bond misuse.

3 Research Design

3.1 Model construction and variable interpretation

This paper employs a difference-in-differences (DID) model to examine the impact of green bond issuance on greenwashing risk. Following Beck et al. [9], the model specification is:

$$Greenwashing_{i,t} = \alpha_0 + \alpha_1 Treat_i \times Post_t + \alpha_2 Control_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (4)$$

where $Greenwashing_{i,t}$ represents firm i's greenwashing risk level in period t; $Treat_i$ is a dummy variable equal to 1 for firms issuing green bonds and 0 otherwise; $Post_t$ is a policy timing dummy equal to 1 after issuance and 0 before; $Control_{i,t}$ represents control variables; μ_i and γ_t are firm and time fixed effects; and $\varepsilon_{i,t}$ is the error term. To address potential endogeneity, we employ multiple strategies: using PSM to select control groups based on firm size, industry, and financial characteristics; including additional controls for corporate governance, environmental performance history, and external regulatory pressure; and adopting a multi-period DID model to control for time trends. Table 1 presents variable definitions and measurements.

Table 1. Variable Definitions and Descriptions

type of variable	variable symbol	variable-definition
explained variable	Green washing	Drift green risk
Core interpretation variable	bond*, after	DID interaction terms
Mechanism test variable	G	Administrative expense rate
	O	The largest shareholder shareholding ratio
	N	Whether it is a key pollution monitoring unit
	E	The number of fund embezzlement processing cases handled by the CSRC
controlled variable	Size	The log value of the total assets of the enterprise
	Lev	Total liabilities / total assets
	liquid	Current assets / current liabilities
	lncash	(Monetary funds + negotiable securities) / current liabilities
	TobinQ	(Stock market value + net debt) / present value of assets

The study examines A-share listed companies from 2014-2023, using green bond issuance data from Wind database, financial data from CSMAR database, and environmental violation data from annual reports and environmental protection authorities. Sample selection excludes financial industry firms, ST and *ST companies, and observations with missing data. Continuous variables are winsorized at 1% and 99% levels. The final balanced panel dataset includes 305 companies.

Descriptive statistics show a mean greenwashing risk of 0.342 with a standard deviation of 0.156, indicating substantial variation across firms. For control variables, the

average debt ratio is 0.486 and current ratio is 1.623, suggesting sound overall financial conditions. The average largest shareholder ownership is 34.2%, indicating concentrated ownership structures among sample firms.

4 Empirical results and analysis

4.1 Descriptive statistical analysis

Descriptive statistics of the main variables are shown in Table 2, where the entire sample with a minimum risk index of-0.801, a maximum value of 0.580, a mean value of 0.003 and a standard deviation of 0.142. The standard deviation of the enterprise green bond issuance record and each control scalar is also large, indicating that there are obvious differences in the distribution of each panel data among the sample enterprises, which is conducive to exploring the correlation relationship between each variable and the explained variable.

Table 2. Descriptive statistics for the main variables

variable name	sample capacity	least value	crest value	average value	standard error
greenwashing	2081	-0.801	0.580	0.003	0.142
bond	2081	0.000	1.000	0.083	0.276
size	2081	19.980	28.636	23.415	1.340
lev	2081	0.086	0.954	0.486	0.512
liquid	2081	0.085	28.508	1.962	2.236
incash	2081	0.002	26.369	0.655	1.414
TobinQ	2081	0.450	17.206	1.967	1.563

4.2 Robustness test

To verify the reliability of our findings, we conduct the following robustness tests. First, we perform parallel trends tests. Using 2016 as the baseline, we construct relative time dummies for event study analysis. Results show no significant differences between treatment and control groups pre-implementation ($t=-3$: $\beta=-0.015$, $p>0.1$; $t=-2$: $\beta=-0.008$, $p>0.1$; $t=-1$: $\beta=-0.012$, $p>0.1$), satisfying the parallel trends assumption. Post-implementation dynamic effects are significantly negative ($t=0$: $\beta=-0.045$, $p<0.05$; $t=1$: $\beta=-0.063$, $p<0.01$), further supporting our main conclusions. See Figure 2 for details.

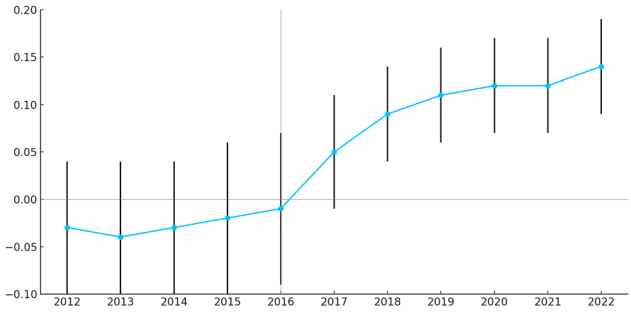

Fig. 2. DID parallel trend test plot

Second, to reduce potential bias from single indicators, we employ multiple alternative measures: environmental information disclosure quality index based on completeness, timeliness, and reliability; environmental violation records including frequency and fines; and a comprehensive environmental performance index using standardized weighted averages of multiple environmental indicators [10]. Regression results using these alternative measures remain consistent with our main findings, showing green bond issuance significantly reduces greenwashing behavior. Third, to address sample selection bias, we use propensity score matching to select control groups. Matching variables include firm size, industry, leverage ratio, and ROA. Balance tests show good equilibrium between treatment and control groups before and after matching (Diff=0.009, $p>0.05$), indicating high matching quality [11]. DID estimates using matched samples remain significant (β=-0.052, $p<0.01$), supporting the robustness of our main conclusions. See Table 3 for matching results.

Table 3. PSM Balance Test Results

Variables	Pre-matching Means		Diff	Post-matching Means		Diff
	Treat-ment	Control	t-value	Treat-ment	Control	t-value
Size	22.86	22.43	2.15**	22.81	22.76	0.42
Lev	0.486	0.472	1.86*	0.483	0.479	0.38
ROA	0.052	0.048	1.92*	0.051	0.05	0.29
TobinQ	1.842	1.795	1.74*	1.836	1.828	0.35

Note: *, **, *** indicate significance at 10%, 5%, and 1% levels

Fourth, we examine result robustness under different time windows: reducing sample period to 2 years pre/post implementation (-2 to +2 years); extending to 3 years (-3 to +3 years); and using asymmetric windows (-2 to +3 years). Estimates across different time intervals consistently show significant negative effects (β ranging from -0.043 to -0.067, $p<0.05$), with similar coefficient magnitudes, indicating findings are robust to time window selection. Finally, we conduct additional tests: excluding firms with major asset restructuring during the sample period; controlling for industry×year fixed effects; clustering standard errors at provincial level; and considering macroeconomic cycles and environmental policy changes [12]. These tests maintain our main conclusions, further supporting the reliability of our findings. In summary, through multiple

robustness tests, our conclusions demonstrate strong stability. Whether using different measures, adjusting sample selection methods, or varying time windows, the inhibitory effect of green bond issuance on corporate greenwashing behavior remains robustly supported. These results provide reliable empirical foundation for our policy implications.

4.3 Mechanism test results

We examine four mechanisms affecting green bond issuance and greenwashing risk. Following Li et al. [13], results show stronger greenwashing effects with lower corruption costs (coefficient=0.026, $p<0.05$). Using key pollution monitoring status [14], monitored units show stronger greenwashing effects (coefficient=0.071, $p<0.01$), suggesting regulation drives apparent rather than genuine green transformation. Following Deng and Wei [15], lower exposure probability groups show significant positive effects (coefficient=0.180, $p<0.01$). Higher management shareholding shows stronger greenwashing effects (coefficient=0.147, $p<0.01$). Regulation/reputation needs and exposure probability mechanisms prove most significant ($p<0.01$) compared to other factors.

5 For further analysis

This paper will analyze the heterogeneity from the three dimensions of industry category, external capital demand of enterprises and enterprise nature, and deeply discuss the differentiated impact of issuing green bonds by enterprises on green bleaching risk under different conditions.

5.1 Industry categories

Using a triple difference (DDD) model, we analyze green bond issuance effects across industries. Results show significant positive correlations in manufacturing (0.075, $p<0.01$), power (0.100, $p<0.01$), construction (0.067, $p<0.05$), and mining (0.114, $p<0.01$) sectors. These high-pollution industries face strict environmental regulations, driving them to use green bonds as transformation tools. In contrast, low-pollution sectors like water conservancy and wholesale/retail show no significant correlation, suggesting high-pollution industries are more likely to use green bonds strategically.

5.2 External capital needs of enterprises

Analysis of firms' external financing dependence reveals positive correlations between green bond issuance and greenwashing risk across all groups, with low-dependency firms showing stronger significance ($p<0.01$) than high-dependency firms ($p<0.05$). This suggests firms less reliant on external financing may issue green bonds primarily for reputational advantages rather than genuine financing needs, increasing greenwashing risk.

5.3 Nature of enterprises

Analysis of ownership structure reveals significant positive correlation between green bond issuance and greenwashing risk in state-owned enterprises (SOEs), while non-SOEs show no significant correlation, as shown in Table 4. SOEs demonstrate higher greenwashing risk due to heightened environmental protection expectations and closer policy alignment. Their understanding of regulatory frameworks makes them more adept at leveraging green bonds compared to non-SOEs.

Table 4. Test of heterogeneity of enterprise nature

variable	Greenwashing	
	state-owned enterprise	Non-state-owned enterprises
bond*after	0.139** (0.043)	-0.008 (0.180)
Whether to control	yes	yes
Constant	0.997** (0.355)	0.834** (0.237)
individual	Yes	Yes
Year	Yes	Yes
R-squared	0.331	0.180

6 Conclusion and recommendations

Using A-share listed companies from 2014-2023, this paper employs difference-in-differences method to examine green bond issuance's impact on corporate greenwashing behavior. Results show that green bond issuance significantly reduces greenwashing risk by 5.2 percentage points through three channels: information transparency, reputation constraints, and external supervision. These effects are more pronounced in state-owned enterprises, high-pollution industries, and larger enterprises. We recommend: improving market institutional framework through unified certification standards and enhanced disclosure requirements; strengthening post-issuance supervision via fund tracking and environmental benefit assessment; establishing incentive mechanisms linking environmental performance to financing costs; and promoting market innovation through product diversification. This research provides new evidence for understanding green bonds' governance effects.

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