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Corporate Green Bonds

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Research Background and Theory

Research Background

- A recent trend in corporate financing is the issuance of corporate green bonds, with proceeds used to fund environmentally and climate-friendly projects such as renewable energy, green buildings, or resource conservation. In recent years, corporate green bonds have become increasingly popular, with Morgan Stanley calling this evolution the "green bond boom." Before 2013, corporate green bonds were essentially non-existent. Corporate green bond issuance surged from approximately $5 billion in 2013 to $95.7 billion in 2018.
- Despite their growing popularity, green bonds impose restrictions on companies' investment policies and require third-party verification to ensure proceeds are used for projects that generate environmental benefits, which creates additional administrative and compliance costs. The study investigates why companies issue green bonds.

Theoretical Framework

Signaling Theory

Investors lack sufficient information to assess companies' environmental commitments.

By issuing green bonds, companies commit substantial capital to green projects, and through third-party assurance, send a credible signal of environmental commitment.

Greenwashing

“Greenwashing" refers to the practice of making unsubstantiated or misleading claims about a company's environmental commitments.

Due to their high costs, green bonds will not be used for "greenwashing." The green bond market relies on private governance mechanisms with strict certification standards.

Cost of Capital

If green bond investors are willing to accept lower yields to address climate change, this in turn signals a positive stock market reaction, as equity holders will benefit from green bonds as a cheaper source of debt financing.

02

Dataset Construction

Corporate Green Bonds Dataset

- **Data source:** All corporate bonds with the "Green Bond Indicator" field marked as "Yes" in the Bloomberg Fixed Income Database, excluding bonds where the issuer's BICS (Bloomberg Industry Classification System) is "Government."

Year	# Bonds	$ Amount (billion)
2013	16	5.0
2014	76	15.4
2015	222	28.7
2016	156	68.7
2017	323	87.8
2018	396	95.7
Total	1189	301.2

Two tables show the number and total share of corporate green bonds issued each year from 2013-2018, as well as the number of corporate green bonds by industry according to BICS classification. Corporate green bonds are more common in environmentally driven industries such as utilities, energy, and transportation.

Industry	# Bonds	$ Amount (billion)
Financials	554	151.0
Banking	322	117.3
Real estate	178	22.0
Others	54	11.7
Industrials	635	150.3
Utilities	112	53.1
Power generation	149	34.7
Renewable energy	223	14.9
Transportation and logistics	25	13.8
Waste and environment services and equipment	28	8.5
Forest and paper products manufacturing	10	3.7
Automobiles manufacturing	8	3.5
Travel and lodging	15	3.4
Communications equipment	2	2.5
Food and beverage	3	1.3
Containers and packaging	2	1.0
Consumer products	4	0.7
Electrical equipment manufacturing	4	0.6
Others	50	8.7
Total	1189	301.2

Corporate Green Bonds Dataset

Country	# Bonds	$ Amount (billion)
China	190	75.1
Netherlands	46	33.2
United States	194	31.5
France	157	30.8
Germany	57	19.4
Mexico	9	12.2
Sweden	140	11.6
United Kingdom	25	10.8
Luxembourg	20	8.9
Spain	17	7.6
Hong Kong	31	7.4
Japan	37	6.7
Australia	15	5.4
Italy	10	4.6
Norway	20	4.4
India	17	4.2
Brazil	6	3.4
Canada	10	3.4
Denmark	4	2.1
Austria	5	1.7
South Korea	5	1.7
United Arab Emirates	3	1.6
Taiwan	21	1.6
Singapore	10	1.2
Others	140	10.9
Total	1189	301.2

	All (1)	Private (2)	Public (3)
# Green bonds	1189	624	565
# Green bond issuer-days	775	391	384
# Green bond issuer-years	526	301	225
# Green bond issuers	400	231	169
Amount (in $M)	253.4	245.5	262.0
	(421.0)	(329.5)	(503.3)
Certified (1/0)	0.656	0.684	0.625
	(0.475)	(0.465)	(0.485)
Maturity (years)	7.7	7.4	8.1
	(29.5)	(5.5)	(42.3)
Fixed-rate bond (1/0)	0.753	0.732	0.775
	(0.432)	(0.443)	(0.418)
Coupon (for fixed-rate bonds)	0.037	0.038	0.036
	(0.022)	(0.022)	(0.022)
Credit rating			
S&P rating (median)	A–	BBB+	A–
Moody's rating (median)	A3	A3	A2
Bloomberg's composite rating (median)	A–	BBB+	A–

Two tables show the number and total share of corporate green bonds issued by country from 2013-2018, as well as summary statistics for green bonds issued by public and private companies. Green bonds are especially popular in China, the United States, and Europe.

Firm-Level Dataset

Data sources:

- Accounting data comes from S&P Compustat, using both Compustat North America (including data for U.S. and Canadian companies) and Compustat Global (including all other publicly traded companies).
- Stock market data comes from the daily stock files of Compustat North America and Compustat Global.
- ESG data comes from Thomson Reuters' ASSET4.
- Environmental materiality (i.e., the financial importance of the natural environment to company operations) data comes from SASB.

Variable construction:

- Size is the natural logarithm of total assets' book value (in USD).
- Return on assets (ROA) is the ratio of operating income before depreciation to total assets' book value.
- Tobin's Q is the ratio of the market value of total assets (book value of total assets plus market value of common equity minus book value of common equity) to the book value of total assets.
- Leverage is the ratio of debt (long-term debt plus debt in current liabilities) to total assets' book value.

Firm-Level Dataset

	N	Green bond issuers (1)	(Nongreen) bond issuers in same country, industry, and year (2)	(Nongreen) bond issuers in same country and year but different industries (3)	p-value (diff. in means) (4)
Log(assets)	225	10.470 (2.460)	8.942 (1.003)	–	0.000***
Return on assets	225	0.056 (0.040)	0.059 (0.029)	–	0.378
Tobin's Q	225	1.179 (0.404)	1.196 (0.311)	–	0.704
Leverage	225	0.331 (0.178)	0.355 (0.108)	–	0.138
Environment rating (ASSET4)	157	80.097 (19.659)	62.315 (17.058)	–	0.000***
Social rating (ASSET4)	157	74.370 (25.282)	58.334 (18.698)	–	0.000***
Governance rating (ASSET4)	157	60.498 (29.313)	47.630 (23.456)	–	0.008***
Environment materiality (SASB, industry level)	225	1.742 (1.715)	–	1.298 (0.815)	0.000***

The table records statistics from the year before green bond issuance, comparing green bond issuers with other bond issuers. Column 2 shows that green bond issuers are on average larger than other bond issuers, and the two are similar in profitability (ROA), firm value (Tobin's Q), and capital structure (leverage). Column 3 indicates that green bond issuers are more likely to operate in industries where the environment has financial importance to company operations.

03

Stock Market Reaction

Research Methodology

- **The study uses event study methodology to assess the stock market's reaction to corporate green bond issuance announcements.** In addition to the baseline event window [-5, 10], to observe whether stock prices rise before and after the event window, the study also considers time intervals before the event window [-20, -11] and [-10, -6] and time intervals after the event window and . For each company i, abnormal returns are calculated using the market model. The market model coefficients α and β are estimated using OLS based on 200 trading days before the first event window (corresponding to the interval [-220, -21]) using daily returns.

$$R_{it} = \alpha_i + \beta_i \times R_{mt} + \varepsilon_{it}, \quad \hat{R}_{it} = \hat{\alpha}_i + \hat{\beta}_i \times R_{mt}.$$

- Abnormal returns within the event window are calculated as $AR_{it} = R_{it} - R_{it}^{hat}$, and cumulative abnormal returns (CARs) for each event window are reported.

Event Study Results, Heterogeneity Analysis

Event time	CAR	Std. err.
[−20, −11]	−0.129	0.157
[−10, −6]	0.051	0.245
[−5, 10]	0.489**	0.241
[11, 20]	−0.029	0.218
[21, 60]	−0.122	0.645

The table above reports the average cumulative abnormal returns before and after green bond issuance announcements over different event windows, covering all 384 issuance-day observations.

The average CAR for the event window [-5, 10] is 0.49%, significant at the 5% level. CARs for all other intervals before and after this event window are small and insignificant, suggesting that the results are not driven by unrelated trends near the event date. The positive CARs indicate that the stock market reacts positively to green bond issuances.

	CAR [−5, 10]	Std. err.
Panel A. Certified vs. noncertified		
Certified green bonds ($N = 192$)	0.710**	0.292
Noncertified green bonds ($N = 192$)	0.268	0.535
Panel B. First-time issue vs. seasoned issue		
First-time green bond issue ($N = 169$)	0.798**	0.322
Seasoned green bond issue ($N = 215$)	0.246	0.512
Panel C. Financial materiality of the environment		
SASB score above median ($N = 172$)	0.699***	0.143
SASB score below median ($N = 212$)	0.318	0.303

The table above reports the average CAR[-5,10] for different subsamples.

Panel A indicates that the stock market reaction is larger and more significant for certified green bonds, and smaller for non-certified bonds.

Panel B shows that abnormal returns are larger and more significant for first-time green bond issuances, and smaller for non-first-time issuances.

Panel C shows that abnormal returns are only significant in industries where the natural environment is financially important to company operations.

Robustness Tests

		CAR[−5, 10]	Std. err.
1.	Global market model based on MSCI World Index	0.481**	0.230
2.	Global three-factor model of Fama and French	0.511**	0.252
3.	Industry-adjusted CARs	0.496**	0.221
4.	Cross-sectional correlation	0.489**	0.244
5.	Precision-weighted CARs	0.530**	0.217
6.	Excluding financials	0.569***	0.170
7.	Excluding confounding events	0.527**	0.256
8.	Median CARs	0.336**	0.128
9.	Excluding countries with green bond subsidies	0.452**	0.226

The left table shows the results of calculating CAR [-5, 10] using alternative methods, which include but are not limited to:

- Replacing country-specific market indices with the MSCI All Country World Stock Index
- Fama-French three-factor model
- Industry-adjusted returns (subtracting the average return of all stocks in the same country and same two-digit SIC industry on a given trading day)
- Brown and Warner (1980, 1985) "crude dependence adjustment" (CDA) for calculating standard errors

Results remain significant after adjustment using alternative methods.

04

Corporate Performance

Research Methodology

- The study uses PSM-DID methodology, treating 225 publicly traded companies that issued green bonds as the treatment group and constructing matched companies as the control group to ensure the two groups are highly similar before green bond issuance. Subsequently, using all companies' annual observation data from 2010-2018, a difference-in-differences test is conducted.

$$y_{it} = \alpha_i + \alpha_c \times \alpha_t + \alpha_s \times \alpha_t + \beta \times \text{Green bond}_{it} + \varepsilon_{it}$$

- Here, i denotes company, t refers to year, c stands for country, and s represents the two-digit SIC industry. y is the relevant variable (such as CO_2 emissions or institutional ownership). α_i is the firm fixed effect, $\alpha_c * \alpha_t$ is the country fixed effect, and $\alpha_s * \alpha_t$ is the industry fixed effect. Green Bond is a dummy variable equal to 1 if firm i has issued a green bond in year t, and 0 otherwise.

Research Variables

- Environmental performance: The first measure is ASSET4's environmental rating. The second measure is the ratio of ASSET4's carbon dioxide emissions (in tons) divided by the book value of assets.
- Ownership structure: Long-term investor ownership (duration) refers to the percentage of shares held by institutional investors whose holding period exceeds the median of all investors. Long-term investor ownership (churn rate) refers to the percentage of shares held by institutional investors whose churn rate is below the median of all investors. Green investor ownership refers to the percentage of shares held by "green" institutional investors.

PSM Results

- The table below shows descriptive statistics for matched and unmatched characteristics using Mahalanobis distance matching for 14 features. ASSET4's ESG rating applies to 157 of the 225 companies. For companies not covered by ASSET4, matching is based on the other 4 characteristics (i.e., 8 matching variables).

		Obs.	Mean	Median	Std. dev.	*p*-value (diff. in means)	*p*-value (diff. in medians)
Panel A. Matching characteristics							
Log(assets)	Green bond	225	10.470	10.065	2.460	0.781	0.688
	Matched control	225	10.359	9.891	2.106		
Return on assets	Green bond	225	0.056	0.056	0.040	0.666	0.529
	Matched control	225	0.054	0.053	0.040		
Tobin's Q	Green bond	225	1.179	1.037	0.404	0.870	0.901
	Matched control	225	1.186	1.033	0.369		
Leverage	Green bond	225	0.331	0.321	0.178	0.909	0.929
	Matched control	225	0.333	0.318	0.179		
Environment rating (ASSET4)	Green bond	157	80.10	90.25	19.66	0.385	0.714
	Matched control	157	78.13	89.13	22.68		
Social rating (ASSET4)	Green bond	157	74.37	85.98	25.28	0.820	0.564
	Matched control	157	73.80	82.94	23.31		
Governance rating (ASSET4)	Green bond	157	60.50	68.09	29.31	0.458	0.305
	Matched control	157	58.00	65.08	28.69		
Δ Log(assets)	Green bond	225	0.045	0.030	0.071	0.884	0.319
	Matched control	225	0.043	0.044	0.065		
Δ Return on assets	Green bond	225	0.002	0.001	0.013	0.222	0.383
	Matched control	225	0.003	0.002	0.011		
Δ Tobin's Q	Green bond	225	0.023	0.010	0.076	0.901	0.409
	Matched control	225	0.022	0.014	0.068		
Δ Leverage	Green bond	225	0.006	0.004	0.028	0.662	0.144
	Matched control	225	0.007	0.008	0.021		
Δ Environment rating (ASSET4)	Green bond	157	3.83	0.87	10.46	0.648	0.308
	Matched control	157	3.32	1.17	8.10		
Δ Social rating (ASSET4)	Green bond	157	3.93	1.68	9.67	0.647	0.320
	Matched control	157	3.46	2.01	6.44		
Δ Governance rating (ASSET4)	Green bond	157	2.09	1.51	7.35	0.625	0.935
	Matched control	157	1.68	1.55	8.73		
Panel B. Other characteristics							
CO_2 emissions	Green bond	132	101.14	13.66	184.63	0.931	0.953
	Matched control	132	98.23	13.67	186.69		
Institutional ownership	Green bond	34	0.405	0.381	0.419	0.731	0.935
	Matched control	34	0.422	0.386	0.427		
Ownership by long-term investors (duration)	Green bond	34	0.191	0.112	0.252	0.826	0.705
	Matched control	34	0.193	0.105	0.236		
Ownership by long-term investors (churn rate)	Green bond	34	0.176	0.087	0.253	0.625	0.634
	Matched control	34	0.170	0.085	0.244		
Ownership by green investors	Green bond	34	0.038	0.015	0.043	0.802	0.923
	Matched control	34	0.037	0.015	0.048		
Δ CO_2 emissions	Green bond	132	−0.35	−0.01	7.98	0.652	0.940
	Matched control	132	−0.82	−0.01	7.35		
Δ Institutional ownership	Green bond	34	0.005	0.003	0.116	0.836	0.970
	Matched control	34	0.004	0.003	0.129		
Δ Ownership by long-term investors (duration)	Green bond	34	0.001	0.002	0.033	0.843	0.592
	Matched control	34	0.002	0.003	0.036		
Δ Ownership by long-term investors (churn rate)	Green bond	34	0.003	0.002	0.031	0.778	0.726
	Matched control	34	0.002	0.002	0.027		
Δ Ownership by green investors	Green bond	34	0.006	0.004	0.041	0.574	0.911
	Matched control	34	0.005	0.004	0.034		

DID Results

	Environmental performance			
	Environment rating		CO_2 emissions	
	(1)	(2)	(3)	(4)
Green bond	6.118**		−10.898***	
	(2.438)		(4.101)	
Green bond (pre-issue year)		1.333		1.083
		(2.502)		(4.229)
Green bond (short-term, 1 year)		4.079		−7.667
		(2.663)		(4.879)
Green bond (long-term, 2+ years)		7.034**		−12.977**
		(3.286)		(5.325)
Firm fixed effects	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes
Observations	1466	1466	1196	1196
R-squared	0.88	0.88	0.90	0.90

The left table shows environmental performance results before and after green bond issuance, indicating that after issuing green bonds, especially after at least two years, companies' environmental performance significantly improves. This finding is consistent with the signaling argument—corporate green bonds indeed lead to improved environmental performance.

			Long-term investors				Green investors	
	Institutional ownership		Ownership by long-term investors (duration)		Ownership by long-term investors (churn rate)		Ownership by green investors	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Green bond	0.011		0.017**		0.014**		0.025**	
	(0.010)		(0.007)		(0.006)		(0.011)	
Green bond (pre-issue year)		−0.001		0.001		0.000		0.002
		(0.010)		(0.006)		(0.004)		(0.008)
Green bond (short-term, 1 year)		0.010		0.011		0.004		0.014
		(0.011)		(0.008)		(0.007)		(0.012)
Green bond (long-term, 2+ years)		0.011		0.022**		0.018**		0.029**
		(0.013)		(0.009)		(0.007)		(0.013)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	361	361	361	361	361	361	361	361
R-squared	0.80	0.80	0.62	0.62	0.56	0.56	0.70	0.70

The left table shows equity structure before and after green bond issuance, indicating that green bond issuance helps companies attract investor clientele who value long-term horizons and are sensitive to the natural environment.

DID Results and Research Conclusions

	Environment rating	CO_2 emissions	Institutional ownership	Ownership by long-term investors (duration)	Ownership by long-term investors (churn rate)	Ownership by green investors
	(1)	(2)	(3)	(4)	(5)	(6)
Green bond × certified	7.656***	−14.392***	0.012	0.020**	0.018**	0.034***
	(2.737)	(5.154)	(0.013)	(0.010)	(0.008)	(0.014)
Green bond × noncertified	2.224	−2.051	0.010	0.012	0.007	0.015
	(2.445)	(4.476)	(0.011)	(0.009)	(0.008)	(0.012)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	–	–	–	–
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1466	1196	361	361	361	361
R-squared	0.88	0.90	0.80	0.62	0.56	0.70

The left table shows that almost all estimates for certified green bonds are large and significant, while estimates for non-certified green bonds are small and insignificant. Certification requires higher costs and therefore indicates a stronger commitment to the natural environment.

- The stock market's reaction to green bond issuance announcements is positive. The reaction is stronger for green bonds certified by independent third parties and for first-time issuers.
- With green bond issuance, companies' environmental performance (i.e., higher environmental ratings and lower carbon emissions) improves, and holdings by long-term and green investors increase.
- The findings support signaling theory; the notions that companies use green bonds as a "greenwashing" tool and the cost-of-capital argument do not hold.