

Sustainable Finance beyond Public Markets: Evidence from Green Loans

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Abstract:

Green loans have emerged as one of the fastest-growing segments of sustainable finance, yet systematic evidence on their economic and environmental implications remains limited. This study provides the first comprehensive global analysis of green loan markets using a matched sample of 2,868 green and conventional syndicated loans issued between 2017 and 2024. Employing endogenous treatment effect models to address borrowers' self-selection into green financing, we document a large and economically meaningful borrowing-cost advantage associated with green loan labels, with green loans priced approximately 123 basis points lower than comparable conventional loans on average. This pricing effect is not uniform across firms but is concentrated among borrowers with weaker ESG scores and higher leverage, while remaining insignificant for firms with stronger ESG performance. In contrast to findings from public green bond markets, green loan issuance does not generate detectable increases in investor attention, consistent with the private and relationship-based nature of loan markets. Importantly, green loan adoption is followed by substantive improvements in environmental outcomes, including reductions in emissions and waste and increases in ESG-related disclosure, alleviating concerns that green loans facilitate symbolic labeling or greenwashing. A direct comparison between green loans and green bonds further reveals systematic differences in instrument choice, indicating that green loans and green bonds serve complementary roles within sustainable debt markets. Overall, the results highlight the importance of private credit markets in sustainable finance and show that green loans expand access to environmentally linked financing for firms that may be less suited to issuing green bonds, while still delivering measurable environmental improvements.

Keywords: Lond Green Label; Loan Spread; Signaling Effect; Pro-environmental tastes

JEL classification: G12; G41; Q59

1. Introduction

The sustainable finance market has experienced unprecedented growth over the past decade, driven by heightened climate awareness and regulatory emphasis on environmental, social, and governance (ESG) objectives. Within this landscape, green loans have become one of the fastest-growing segments, with global issuance reaching \$950 billion in 2024, representing a 17% increase from the previous year¹. This rapid expansion reflects growing recognition that climate change is not only an environmental problem but also an economic one.

Despite this rapid expansion, academic understanding of green loan markets remains limited. Existing research on sustainable finance has largely concentrated on publicly traded instruments such as green bonds (e.g., Edmans and Kacperczyk, 2022; Flammer, 2021; Zerbib, 2019), while systematic evidence on private credit markets is scarce. This gap is particularly striking given that bank lending continues to represent the dominant source of external finance for non-financial firms worldwide. As a result, whether green loan labels affect borrowing costs, how such effects arise in private credit markets, and which firms benefit most from green loans remain largely open questions.

Green loans operate in institutional environments that differ fundamentally from green bonds. They are negotiated in private, relationship-based credit markets characterized by concentrated lenders, limited secondary trading, and intensive screening and monitoring. Pricing in these markets reflects contractual design and private information rather than investor visibility or trading demand. These features suggest that environmental labels may play a different economic role in loan markets than in publicly traded securities.

Most existing evidence on the pricing and market implications of environmental labels comes from the green bond market. Studies of green bonds document yield differentials, investor attention effects, and post-issuance environmental improvements, emphasizing the role of public market transparency and investor demand (e.g., Edmans and Kacperczyk, 2022; Flammer, 2021; Zerbib, 2019). Whether these insights extend to green loans, however, is not self-evident given the private nature of loan markets and the central role of bank monitoring. Meanwhile, research on green loans is limited, largely focused on China, and emphasizes regulatory credit policies and bank performance rather than borrower outcomes (e.g., Huang et al., 2023; Tian and Zhao, 2025; Zhang,

¹ For more information about the green loan market, please see: https://www.spglobal.com/_assets/documents/ratings/research/101593071.pdf.

2022). This narrow focus leaves fundamental questions about green loan economics unanswered in the broader global context.

A further challenge in sustainable finance concerns the quality and consistency of ESG information. Berg et al. (2022) document substantial disagreement across major ESG rating providers, driven primarily by differences in measurement rather than weighting or scope. Such ESG disagreement introduces noise into sustainability assessments and may be particularly consequential in private credit markets, where information asymmetries are already pronounced and lenders rely heavily on contractual verification rather than market signals.

Against this background, this study provides the first comprehensive global analysis of green loan markets. Using a matched sample of green and conventional syndicated loans issued between 2017 and 2024, we examine three interrelated questions: First, do green loan labels reduce firms' borrowing costs once self-selection into green financing is taken into account? Second, do green loans generate investor attention effects comparable to those documented for green bonds, or does the private nature of loan markets fundamentally alter these dynamics? Third, how do firms choose between green loans and green bonds, and what does this choice reveal about segmentation and complementarity within sustainable debt markets?

Our empirical analysis yields several novel findings. We document a large and economically meaningful borrowing-cost advantage associated with green loan labels. This effect is not uniform across firms, but is concentrated among borrowers with weaker ESG scores or tighter financial conditions. In contrast to green bonds, green loan issuance does not generate detectable increases in investor attention. Importantly, green loan adoption is followed by measurable improvements in environmental outcomes, indicating that green loans are not merely symbolic instruments.

By jointly examining pricing, environmental outcomes, and firms' financing choices, this study highlights a clear segmentation between green loan and green bond markets. Green loans appear to provide a complementary financing channel for firms that are less likely to rely on public green bond issuance, while still delivering meaningful environmental improvements. These findings contribute to the broader sustainable finance literature by demonstrating that private credit markets play a distinct and essential role in supporting the corporate transition toward sustainability.

The remainder of the paper proceeds as follows. Section 2 develops the theoretical framework and hypotheses. Section 3 describes the data and empirical methodology.

Section 4 presents the empirical results. Section 5 discusses the implications of these findings, and Section 6 concludes.

2. Theoretical background and hypothesis development

The pricing and market implications of green loans can be examined through two established theoretical perspectives in the sustainable finance literature, namely signaling theory (Riley, 1979) and taste-based theories of investor preferences (e.g., Du et al., 2017; Fama and French, 2007). These mechanisms have been widely discussed in the context of green bonds and other publicly traded securities (e.g., Lyon and Maxwell, 2011; Lyon and Montgomery, 2015).

The extent to which these theoretical insights carry over to green loan markets, however, is not self-evident. Green loans operate in private, relationship-based credit markets, where lenders rely more heavily on screening, monitoring, and contractual enforcement than on secondary market trading and dispersed investor demand. As emphasized in the corporate finance literature, relationship lending and private monitoring play a central role in loan pricing and contract design (e.g., Bharath et al., 2007; Sufi, 2007). These institutional features suggest that the mechanisms through which green loan labels affect borrowing costs may differ from those documented for green bonds.

Building on these considerations, this section outlines the theoretical channels through which green loan labels may influence borrowing costs and motivates the empirical analysis that follows. Rather than presuming which mechanism dominates a priori, we use the empirical evidence to assess the relevance of alternative explanations.

2.1 Signaling theory and information asymmetries

Signaling theory suggests that firms can convey private information about their quality through observable actions that are costly to imitate by lower-quality firms (Riley, 1979). In corporate finance, financing choices themselves can function as such signals, particularly when they involve contractual commitments, disclosure requirements, or external verification that impose real economic or organizational costs on borrowers. Because these costs are not easily borne by firms with weaker fundamentals or lower commitment, such signals can credibly separate higher-quality firms from lower-quality ones.

In the context of sustainable finance, environmental labels have therefore been interpreted as signals of firms' environmental commitment, managerial quality, and long-

term strategic orientation sustainability (e.g., Lyon and Maxwell, 2011; Lyon and Montgomery, 2015). Obtaining and maintaining an environmental label typically requires firms to allocate resources to eligible projects, comply with reporting and verification standards, and expose themselves to reputational risks in the event of non-compliance. These features imply that environmental labels are not merely symbolic, but may convey economically meaningful information to external stakeholders.

Green loan contracts possess several features that enhance their role as certification-based signals. Similar to green bonds, green loans restrict the use of proceeds to environmentally eligible projects and typically require third-party verification and periodic reporting. These design features limit managerial discretion over capital allocation and strengthen monitoring by lenders, thereby mitigating information asymmetry between borrowers and creditors. Prior studies show that external assurance and structured non-financial disclosure can improve financing conditions by enhancing transparency and credibility (e.g., Cheng et al., 2014; Dhaliwal et al., 2012). From a governance perspective, such restrictions can also reduce agency problems by aligning investment behavior with predefined environmental objectives (Jensen, 1986).

Importantly, certification-based signals derive their economic relevance from their ability to mitigate information asymmetries between borrowers and lenders. In credit markets characterized by private information and limited transparency, externally verified commitments and contractual restrictions can enhance the credibility of borrowers' claims and facilitate more efficient pricing. From this perspective, green loan certification can serve as a mechanism through which lenders obtain additional information about borrowers' project quality and governance, consistent with broader insights from the corporate finance literature on information asymmetry and financing conditions (Frank and Goyal, 2009).

Taken together, these arguments suggest that green loan labels can function as economically meaningful signals in private credit markets. By embedding verification, disclosure, and monitoring mechanisms into loan contracts, green loan certification may influence borrowing costs relative to otherwise comparable conventional loans.

[H1a]: Green loan labels are associated with lower borrowing costs relative to comparable conventional loans.

2.2 Investor preferences and taste-based theories

Investor preference theories, formalized by Fama and French (2007) and extended to ESG contexts by (Pástor et al., 2021), provide an alternative interpretation of the pricing effects associated with green financial instruments. In these frameworks, some investors derive utility from holding assets that align with their values and are therefore willing to accept lower expected returns. In sustainable finance, such taste-based demand may generate price premia for green securities even in the absence of differences in cash-flow risk or information content.

Applying taste-based theories to loan markets requires consideration of the institutional features of financial intermediation. Unlike public bond markets, where securities are directly purchased by a broad set of investors, loan markets are intermediated by banks that originate, hold, and distribute credit exposures. As a result, any influence of investor preferences on loan pricing is transmitted indirectly through financial intermediaries rather than through direct market demand.

One potential channel through which taste-based preferences may affect green loan pricing operates via banks' own lending behavior. Banks may attach intrinsic value to expanding green loan portfolios due to regulatory considerations, reputational concerns, or strategic objectives related to sustainability and climate risk management². In such cases, lending terms offered to green borrowers could reflect banks' preferences in addition to conventional risk and return considerations.

A second channel arises from banks' expectations about downstream investor demand. If banks anticipate demand for green loan participations or securitized loan exposures from investors with sustainability-oriented preferences, this expectation may influence pricing decisions at origination. Through this mechanism, taste-based preferences in end-investor markets can be reflected in primary loan pricing even in the presence of intermediation.

Taken together, taste-based theories provide a plausible counter-argument to a purely information-based interpretation of green loan pricing. Whether observed differences in borrowing costs are driven by preference-based demand, certification-based signaling, or a combination of both mechanisms is ultimately an empirical question.

² For more information about the Basel Committee's report to Climate-related risk drivers and their transmission, please see: <https://www.bis.org/bcbs/publ/d516.pdf>.

[H1b]: Differences in borrowing costs between green loans and conventional loans may reflect investor or intermediary preferences for environmentally aligned assets.

2.3 Green loan label and investor attention

The institutional differences between loan and bond markets have important implications for investor attention effects. Green bond literature documents significant increases in investor attention following issuance, reflected in trading volumes, analyst coverage, and institutional ownership changes (e.g., Flammer, 2021; Tang and Zhang, 2020). These attention effects stem from the public nature of bond markets and the signaling value of green labels to dispersed investors.

Loan markets operate differently due to their private, relationship-based structure. Initial loan syndication involves a limited number of sophisticated institutional lenders who conduct extensive due diligence and maintain ongoing relationships with borrowers. Secondary loan trading is limited, with most loans held to maturity by originating banks or sold in private transactions to specialized loan investors.

This market structure suggests that green loan labels may not generate the same investor attention effects observed for green bonds. The limited number of loan market participants reduces the scope for attention-driven demand increases. The relationship-based nature of lending means that banks already possess substantial private information about borrowers, potentially reducing the information value of green labels.

However, green loans might still affect investor attention through different mechanisms. Bank lenders may increase monitoring intensity for green loans due to reputational risks associated with environmental lending. Green loan borrowers might receive enhanced coverage from ESG-focused analysts or rating agencies. Media attention to corporate environmental initiatives could increase following green loan announcements.

Accordingly, the competing predictions about investor attention effects lead to alternative hypotheses:

[H2a]: Green loans do not generate significant investor attention effects due to the private nature of loan markets.

[H2b]: Green loans increase investor attention through enhanced monitoring and ESG coverage mechanisms.

3. Data and method

3.1 Data and sample construction

We construct a comprehensive global dataset of green and conventional loans from multiple sources to ensure data quality and completeness. Our primary loan data comes from Refinitiv's DealScan database, which began systematically reporting green loan information in 2017. DealScan provides detailed information on loan terms, borrower characteristics, and syndicate structure covering global syndicated loans.

To identify green loans, we rely on DealScan's green loan indicator, which is based on loan documentation and public announcements by borrowers and lead arrangers. We supplement this with manual verification using borrower press releases, regulatory filings, and third-party green finance databases to ensure accurate classification. Our green loan sample includes loans explicitly labeled as "green," "environmental," or "sustainability-linked" where proceeds are restricted to environmental projects or pricing is contingent on environmental performance metrics.

We obtain borrower-level financial data from Refinitiv's Worldscope database, which provides standardized accounting information for publicly traded companies globally. This includes income statement, balance sheet, and cash flow data necessary to construct control variables and assess borrower financial health. We match loan and firm data using multiple identifiers including borrower names, ticker symbols, and unique firm identifiers.

Environmental performance data comes from Bloomberg's ESG database, which provides comprehensive coverage of corporate sustainability metrics including greenhouse gas emissions, waste generation, water usage, and ESG disclosure scores. Bloomberg's coverage expanded substantially during our sample period, yielding progressively richer environmental data for loan borrowers.

For investor attention measures, we use Bloomberg's news and analyst coverage data, supplemented with institutional ownership information from Thomson Reuters. These sources allow us to construct measures of media attention, analyst coverage intensity, and institutional investor interest around loan announcement and activation dates.

Since the number of conventional loans is far greater than that of green loans, we develop a novel matching approach using the Random Similarity Forest, which enable us to control more factors than the propensity score matching (PSM) method. Table 1 reports the matching results. While significant structural differences exist between the conventional and green loans prior to matching, Panel B shows no significant differences in loan-, market-, and -borrower level characteristics after matching.

Table 1. T-test to loans before and after matching.*Panel A: Green loans and conventional loans pre-match*

	Mean (Non-green)	Mean (Green)	Diff.	T-Stat.
Yrs2Maturity	1.65	2.14	0.49	27.11
ln(Amount)	21.23	21.93	0.70	15.23
MarketLed	0.58	0.05	-0.53	-91.40
ln(Asset)	16.52	18.78	2.26	51.83
ln(Equity)	15.33	17.68	2.35	54.72
ln(Revenue)	15.75	17.61	1.86	45.73
ln(MarketCap)	16.30	18.07	1.77	43.12
Obs.	72,447	1,434		

Panel B: Green loans and conventional loans post-match

	Mean (Non-green)	Mean (Green)	Diff.	T-Stat.
Yrs2Maturity	2.10	2.14	0.04	1.54
ln(Amount)	21.85	21.93	0.08	1.24
MarketLed	0.06	0.05	-0.01	-1.59
ln(Asset)	18.85	18.78	-0.07	-1.10
ln(Equity)	17.72	17.68	-0.05	-0.82
ln(Revenue)	17.65	17.61	-0.04	-0.69
ln(MarketCap)	18.15	18.07	-0.08	-1.37
Obs.	1,434	1,434		

Note: This table reports t test results before and after a random similarity forest plus nearest neighbors 1:1 matching approach. To examine the impact of green loan label on loan spread, we not only control loan-, market-, and -borrower level variables reported in Panels A and B, but also control the loan active year, loan base rate, and borrower industry.

Table 2 reports descriptive statistics of the key variables in our matched sample. Our final sample consists of 2,868 loan observations, evenly split between green (1,434) and conventional (1,434) loans after matching. The mean loan spread is 122.4 basis points with substantial variation (standard deviation of 99.0 basis points), ranging from 22.5 to 550 basis points. This variation offers ample cross-sectional dispersion for identifying the effects of green labeling on borrowing costs.

Table 2. Summary statistics.

Variable	Obs.	Mean	Std.Dev.	Min	Max
Green	2,868	0.500	0.500	0.000	1.000
LoanSpread	2,868	122.436	99.001	22.500	550.000
MarketLed	2,868	0.053	0.223	0.000	1.000
ln(Amount)	2,868	21.889	1.735	17.808	25.328
NumCovenant	2,868	0.252	0.764	0.000	8.000
Yrs2Maturity	2,868	5.744	2.385	2.000	15.000
LIBOR	2,868	0.101	0.302	0.000	1.000
BBSY	2,868	0.065	0.246	0.000	1.000
Euribor	2,868	0.064	0.245	0.000	1.000
Taibor	2,868	0.131	0.338	0.000	1.000
TermSOFR	2,868	0.191	0.393	0.000	1.000
Tibor	2,868	0.200	0.400	0.000	1.000
Collateral	2,868	0.149	0.356	0.000	1.000
ln(Asset)	2,868	18.812	1.651	11.955	22.882
ln(Cash)	2,868	15.718	1.513	8.235	20.214
ROE	2,868	10.332	8.220	-72.920	40.240
QuickRatio	2,868	1.024	0.323	0.220	3.100
Financials	2,868	0.112	0.316	0.000	1.000
Utilities	2,868	0.059	0.235	0.000	1.000
ClimateChange	2,868	5.035	0.162	4.518	5.135
COP26	2,868	0.646	0.478	0.000	1.000

Loan characteristics show substantial variation across our sample. The average loan amount is approximately \$3.6 billion ($\ln(\text{Amount}) = 21.889$), with maturity averaging 5.7 years. Market-led loans represent 5.3% of our sample, reflecting the predominance of relationship-based lending in our matched sample. The number of financial covenants averages 0.25, indicating relatively light covenant structures consistent with higher-quality borrowers.

Borrower characteristics reveal substantial firm-level heterogeneity. Average firm size ($\ln(\text{Asset}) = 18.812$) corresponds to approximately \$150 million in total assets, reflecting the diverse range of firms accessing syndicated loan markets from mid-cap to large multinational corporations. This size distribution is consistent with prior syndicated loan studies (e.g., Roberts, 2015; Sufi, 2007). Return on equity averages 10.3% with significant dispersion (standard deviation 8.22%), indicating considerable variation in firm profitability across our sample, similar to patterns documented in corporate finance literature (Frank and Goyal, 2009). The quick ratio averages 1.02, suggesting adequate short-term liquidity across sample firms, though the moderate level indicates that many borrowers face meaningful liquidity constraints that could influence their financing choices (Almeida et al., 2004).

The sample spans various base rate environments, with Tibor (20.0%) and Term SOFR (19.1%) being the most common benchmark rates. The climate change index averages 5.035, capturing moderate policy attention to environmental issues over our sample period. The COP26 indicator shows that 64.6% of our sample loans were originated after the November 2021 climate conference, reflecting the acceleration of green loan activity following this watershed event in global climate policy³.

Table 3 presents the Pearson correlation coefficients between the main variables. The correlation matrix reveals several important relationships consistent with our theoretical expectations. Green labeling is negatively correlated with loan spreads (-0.176^{***}), providing initial univariate patterns consistent with differences in borrowing costs between green and conventional loans. Green loans are also positively correlated with collateral requirements (0.0822^{***}) and quick ratios (0.0987^{***}), suggesting they may be utilized by firms with specific financial characteristics.

The correlation between green labeling and firm characteristics provides insight into selection patterns. Green loans show weak negative correlations with firm size measures and ROE (-0.0445^*), consistent with our hypothesis that these instruments may be particularly valuable for smaller or lower-profitability firms. The positive correlation with the COP26 indicator (0.0671^{***}) confirms the temporal concentration of green loan activity following the climate conference.

Other correlations align with standard loan pricing relationships. Larger loans are associated with lower spreads (-0.385^{***}), reflecting economies of scale in lending. Longer maturity loans carry higher spreads (0.0791^{***}), consistent with term structure effects. The negative correlation between asset size and spreads (-0.189^{***}) reflects the lower risk associated with larger borrowers.

³ For more information about the United Nations Framework Convention on Climate Change, please see: <https://unfccc.int/resource/docs/convkp/conveng.pdf>.

Table 3.Correlation matrix.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 LoanSpread	1														
2 Green	-0.176***	1													
3 MarketLed	0.211***	-0.0297	1												
4 ln(Amount)	-0.385***	0.0232	-0.261***	1											
5 NumCovenant	-0.0237	-0.0657***	0.00180	-0.0699***	1										
6 Yrs2Maturity	0.0791***	0.0183	0.00956	0.333***	-0.138***	1									
7 Collateral	-0.139***	0.0822***	-0.0242	0.112***	-0.138***	0.000170	1								
8 ln(Asset)	-0.189***	-0.0206	-0.0679***	0.293***	-0.107***	0.0992***	-0.0340	1							
9 ln(Cash)	-0.162***	0.0311	-0.0649***	0.195***	-0.149***	0.0163	0.00559	0.752***	1						
10 ROE	0.135***	-0.0445*	-0.0638***	-0.0397*	-0.0478*	-0.0203	0.0772***	0.241***	0.222***	1					
11 QuickRatio	-0.141***	0.0987***	-0.0114	-0.0233	-0.0250	-0.119***	-0.00212	-0.0255	0.196***	0.178***	1				
12 Financials	-0.108***	0.00221	-0.0739***	0.0716***	-0.0568**	0.0173	-0.149***	0.278***	-0.0722***	0.250***	0.0492**	1			
13 Utilities	0.0423*	0	0.0343	0.0975***	0.0536**	0.147***	-0.0670***	-0.0101	-0.128***	-0.0575**	-0.242***	-0.0887***	1		
14 ClimateChange	-0.223***	0.0499**	-0.113***	-0.0573**	0.0576**	-0.434***	0.0861***	0.0398*	0.00627	-0.0249	0.131***	-0.0200	-0.243***	1	
15 COP26	-0.184***	0.0671***	-0.109***	-0.0683***	0.0386*	-0.283***	0.0340	0.0805***	0.0253	0.0386*	0.0997***	0.0440*	-0.206***	0.831***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.2 Estimation approaches

To formally model causal relationships, we propose a structural model to account for endogeneity. Since green bond labels are self-selected rather than randomly distributed, we use the two-step endogenous treatment effect model (e.g., Akins et al., 2016; Cumming et al., 2019). The first step estimates the selection equation:

$$Pr(Green=1) = \Phi(\alpha'_z \mathbf{z} + \alpha'_x \mathbf{x}), \quad (1)$$

Green is a dummy variable which identifies whether the loan has a green label; $\mathbf{z}$ is a vector of excluded instruments (*COP26*), where *COP26* identifies whether the loan is activate year is after the 26th UN Climate Change Conference of the Parties (COP26); $\mathbf{x}$ is a vector of other explanatory variables including *ln(Amount)*, *Yrs2Maturity*, *ln(NetSales)*, *ln(Cash)*, *ROE Quick-Ratio*, *Collateral*, *MarketLed*, *ConsumerPriceIndex*, and *NumCovenant*. We compute the inverse Mills' ratio *IMR* based on Equation (1) and include it in the second step, i.e., outcome Equation (2), to correct for the self-selection bias:

$$\ln(Spread) = \delta D + \gamma IMR + \beta' \mathbf{x} + \epsilon, \quad (2)$$

in which the IMR is generated through:

$$IMR = \begin{cases} \frac{\phi(\hat{\alpha}'_z \mathbf{z} + \hat{\alpha}'_x \mathbf{x})}{\Phi(\hat{\alpha}'_z \mathbf{z} + \hat{\alpha}'_x \mathbf{x})} & \text{if } D = 1 \\ -\frac{\phi(\hat{\alpha}'_z \mathbf{z} + \hat{\alpha}'_x \mathbf{x})}{1 - \Phi(\hat{\alpha}'_z \mathbf{z} + \hat{\alpha}'_x \mathbf{x})} & \text{if } D = 0 \end{cases}, \text{ where } \phi(\cdot) \text{ is the normal PDF.} \quad (3)$$

This endogenous treatment effect model is similar to, but not to be confused with, the Heckman selection model, which deals with sample selection rather than self-selection bias. In the Heckman selection model, the dependent variable is not observable when untreated ($D = 0$). The endogenous treatment effect model is superior to the matching methods such as the nearest neighbor matching and the propensity score matching, as the matching methods do not control for the non-randomness in the green labels. The “matched” counterparts in the treated and control groups are still systematically different due to the self-selection bias. In contrast, the endogenous treatment model explicitly integrates the selection Equation (1) into the estimation of the Heckman outcome model, Equation (2).

The estimation results of Equations (1) and (2) are used to examine Hypothesis [H1], while the effects of green loan issuance on investor attention are evaluated using a difference-in-

differences (DiD) framework corresponding to the competing predictions in Hypotheses [H2a] and [H2b]. The treatment effect on investor attention can be estimated based on Equation (4):

$$InvestorAttention = \sum_{\tau=-2}^2 d_{\tau} D_{t+\tau} + \mathbf{b}' \tilde{\mathbf{x}} + \zeta. \quad (4)$$

The lag and lead periods ($\tau = -1, 0, 1$ months) relative to the loan activate day (D) are included to gauge the persistence of the impact on investors' attention. The vector of control variables $\tilde{\mathbf{x}}$ are the same as variables in $\mathbf{x}$.

4. Empirical results

4.1 Green loans vs. conventional loans: Cost of capital

We use the endogenous treatment effect model to address endogeneity concerns arising from structural differences between green and conventional loans, following methodologies established in corporate finance for handling self-selection in financing decisions (e.g., Bharath et al., 2007; Lemmon and Roberts, 2010). **Table 4** reports the corresponding estimation results. Panel A presents the treatment effect estimates, with column (1) modeling borrowers' selection into green loans and column (2) reporting the outcome equation that identifies the effect of green labels on loan spreads. For comparison, Panel B reports ordinary least squares estimates that do not correct for self-selection.

The first-stage results in column (1) indicate strong non-random adoption of green loan labels. The COP26 indicator enters positively and is statistically significant, with a coefficient of 2.384***, suggesting that loans originated after the climate conference are substantially more likely to be labeled as green. This pattern is consistent with heightened global policy momentum following COP26 and its influence on firms' financing choices (Stern and Valero, 2021). The climate change index also loads positively and significantly, with a coefficient of 1.885**, indicating that time variation in environmental policy attention contributes to green loan adoption and provides additional exogenous variation for identification.

Examining borrower characteristics in the selection equation, firms with higher cash holdings and stronger liquidity positions are more likely to select into green loans, while more profitable firms are less likely to do so. This pattern is consistent with the view that green loans may be particularly relevant for firms undertaking environmental investments while facing transitional financing needs investments (Almeida and Campello, 2007).

Table 4. Impact of green loan label on the cost of borrowing.

	<i>Panel A: Treatment effect</i>		<i>Panel B: OLS</i>
	(1) Green	(2) ln(Spread)	(3) ln(Spread)
COP26	2.384*** (2.967)		
ClimateChange	1.885** (2.379)		
Green		-1.229*** (-2.887)	0.024 (0.295)
IMR		0.739*** (2.254)	
ln(Amount)	-0.135*** (-3.558)	-0.160*** (-5.885)	-0.138*** (-4.651)
Yrs2Maturity	-0.010 (-0.415)	0.066*** (2.916)	0.077*** (3.582)
ln(NetSales)	0.201*** (3.492)	0.088** (2.033)	0.015 (0.426)
ln(Cash)	0.135** (2.098)	-0.017 (-0.299)	-0.101* (-1.770)
ROE	-0.034*** (-4.604)	0.002 (0.288)	0.013*** (2.635)
QuickRatio	0.687*** (4.039)	0.008 (0.093)	-0.156* (-1.664)
Collateral	-0.279* (-1.806)	-0.053 (-0.413)	0.068 (0.545)
MarketLed	-0.342* (-1.812)	-0.383*** (-2.957)	-0.202 (-1.486)
ConsumerPriceIndex	-0.423** (-2.097)	-0.024 (-0.444)	-0.108** (-2.288)
NumCovenant	-0.209*** (-4.006)	-0.062 (-1.430)	0.018 (0.511)
Cons.	-9.493*** (-2.625)	7.583*** (7.130)	8.554*** (9.179)
Fixedeffects	YES	YES	YES
N	2,868	2,868	2,868
PseudoR ²	0.119		
AdjustedR ²		0.756	0.750

Note: Results from the treatment effect model (in Panel A) and OLS model (in Panel B). In which column (1) analysis factors may impact loan borrowers' selection to the green label (*GreenLoan*) and estimates the *IMR* for the column (2). Meanwhile, we follow (e.g., Bharath et al., 2007; Lemmon and Roberts, 2010) to apply the lag of climate change index (*ClimateChange*) and the event of COP26 as exogenous variables. Columns (2) and (3) examines the determinations to the loan all-in spread drawn bps. We not only control the borrower and time fixed effects, but also control fixed effects of the main lender country, loan purpose, loan base rates, and industries. Robust *t* statistics in parentheses are clustered at the borrower level. Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The second-stage results in column (2) show that green loan labels are associated with significantly lower borrowing costs. The coefficient on the green loan indicator is -1.229^{***} , implying that green-labeled loans reduce borrowing costs by approximately 123 basis points relative to comparable conventional loans after correcting for selection. This magnitude is economically substantial and exceeds typical estimates reported in the green bond literature, where yield differentials are generally in the range of 10-20 basis points (e.g., Baker et al., 2022; Zerbib, 2019).

The inverse Mills ratio is positive and highly significant, confirming the presence of self-selection and supporting the use of the endogenous treatment framework. In contrast, the OLS estimates reported in Panel B yield a small and insignificant coefficient on the green loan indicator, indicating that conventional regression approaches substantially understate the pricing differences associated with green loan labels when selection is ignored. Similar self-selection concerns have been documented in studies of green bonds and other sustainable debt instruments (Zhou et al., 2024), underscoring the importance of explicitly modeling selection into green financing.

Taken together, the results in **Table 4** indicate that green loan labels are associated with economically meaningful reductions in borrowing costs, and that accounting for self-selection is essential for accurately quantifying this effect.

4.2 Investor attention responses to green loan issuance

This section examines whether green loan issuance is associated with changes in investor attention, corresponding to the competing predictions outlined in [H2a] and [H2b]. Prior studies on green bonds document pronounced increases in investor attention following issuance, reflected in higher trading activity, analyst coverage, and institutional ownership (e.g., Flammer, 2021; Tang and Zhang, 2020). Whether similar attention responses arise in private loan markets, however, remains an open empirical question.

Table 5 reports the difference-in-differences estimates of investor attention around green loan activation dates. Across alternative measures of investor attention, the estimated treatment effects are small in magnitude and statistically insignificant. In particular, the coefficients on the post-activation indicators do not differ significantly from zero, indicating no detectable change in investor attention following green loan issuance.

Table 5. Impact of green label on abnormal investor attention.

	(1) PSM DiD AIA	(2) Stacked DiD AIA
Month(-1)	0.116 (0.914)	0.292 (1.635)
Month(0)	0.111 (0.948)	0.071 (0.433)
Month(+1)	0.188 (1.090)	-0.102 (-0.889)
Control variables	YES	YES
Fixed Effects	YES	YES
<i>N</i>	2,512	2,512
AdjustedR ²	0.183	0.364

Note: PSM DiD and stacked DiD regressions to the impact of borrowing green loan on the abnormal institutional investor attention. In which AIA is a dummy variable that equals 1 when the issuers' Bloomberg news heat score is 3 or 4, and 0 otherwise. Fixed effects and control variables are the same as the variables used in **Table 4**. Robust t statistics in parentheses are clustered at the borrower level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The absence of statistically significant effects is robust across alternative attention proxies and model specifications. These results suggest that green loan activation is not accompanied by observable shifts in market-wide investor attention as captured by media coverage, analyst activity, or institutional investor measures. Meanwhile, the findings are more consistent with the limited-visibility view of private loan markets emphasized in [H2a], while providing limited support for the alternative prediction in [H2b] that green loan labels may attract investor attention through enhanced monitoring or ESG-related coverage channels. Importantly, these results do not rule out forms of attention that operate through private, relationship-based mechanisms and are not captured by public information measures.

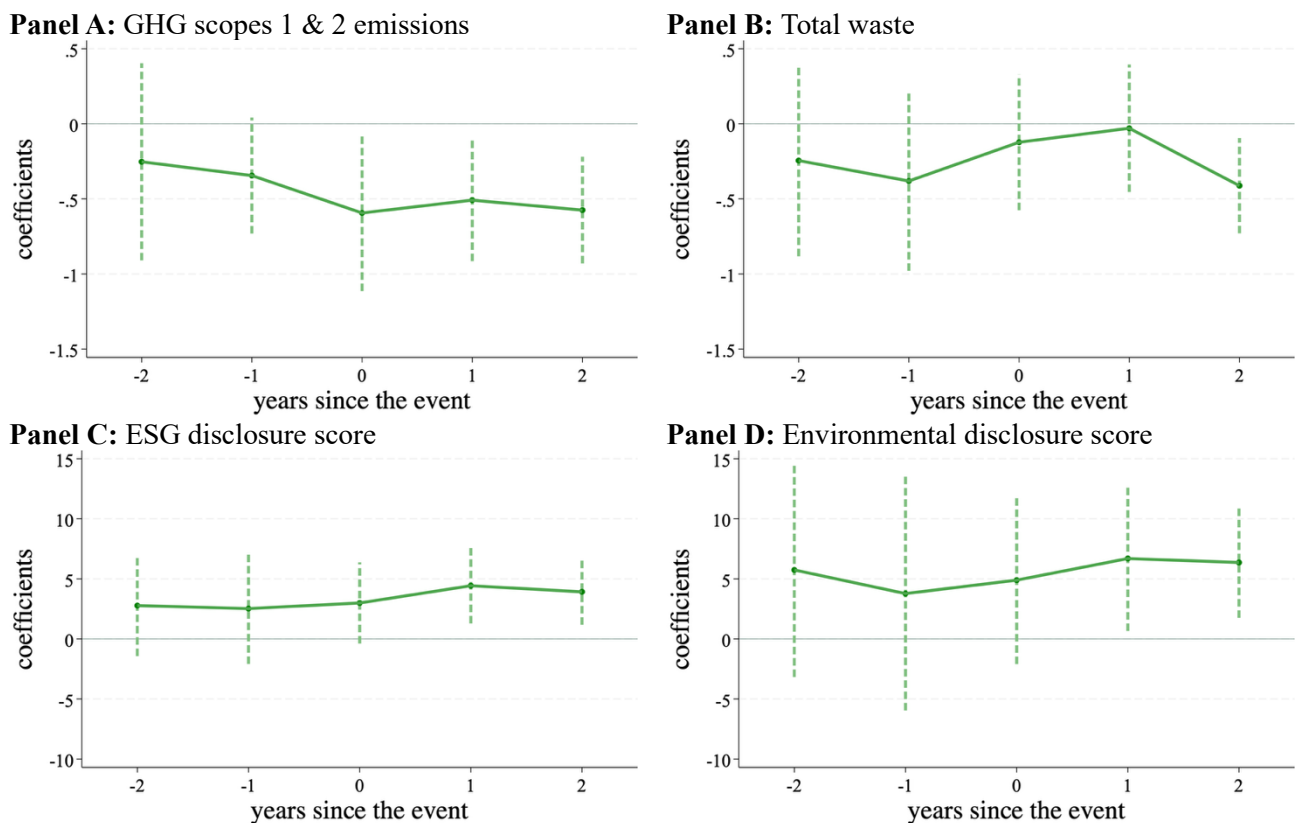
4.3 *Why do firms choose green loans rather than green bonds?*

The results in Sections 4.1 and 4.2 reveal an apparent contrast between pricing outcomes and market visibility. While green loan labels are associated with economically meaningful reductions in borrowing costs, green loan issuance does not generate the investor attention effects commonly documented for green bonds (e.g., Flammer, 2021; Tang and Zhang, 2020). This divergence raises a natural question regarding firms' choice of sustainable financing instruments and motivates a closer examination of whether green loans are associated with substantive environmental engagement.

A related concern is whether green loans, which operate in less transparent and less liquid markets than green bonds, may allow firms to adopt sustainability labels without undertaking meaningful environmental actions. Such concerns are central to the greenwashing and selective disclosure literature, which emphasizes that firms may strategically disclose favorable environmental information when external verification is weak (Lyon and Maxwell, 2011). To assess whether green loan adoption is accompanied by observable environmental improvements, we examine changes in firms' environmental performance following green loan issuance.

Figure 1 presents the evolution of key environmental performance indicators around green loan activation. The figure shows that green loan borrowers experience systematic post-issuance improvements in environmental outcomes, including reductions in emissions and waste as well as increases in ESG-related disclosure measures. These patterns suggest that green loan adoption is associated with measurable changes in environmental performance rather than remaining purely symbolic.

Figure 1. Performance comparison of green loan and non-green loan borrowers.

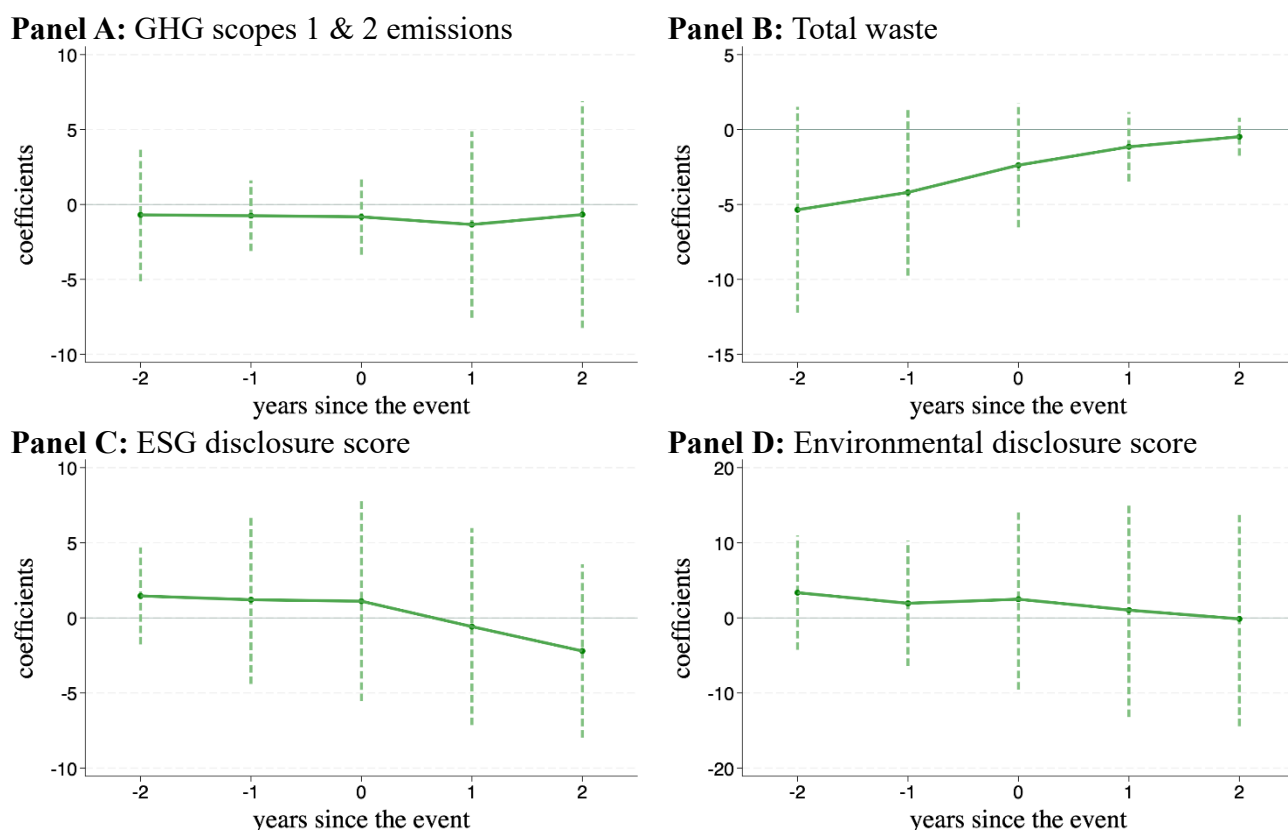


Note: This figure shows the dynamics of green loan borrowers' environmental performance, as measured by GHG emissions in scopes 1 and 2 (in Panel A), total waste generated (in Panel B), ESG disclosure score (in Panel C), and Environmental disclosure score (in Panel D). Fixed effects and control variables are the same as the variables used in **Table 4**. The vertical bars are 95% confidence intervals and robust t statistics are clustered at the borrower level.

While **Figure 1** establishes that green loan adoption is associated with substantive improvements in environmental performance, this evidence alone does not explain why firms choose green loans rather than green bonds as their preferred sustainable financing instrument. If both instruments are linked to comparable post-issuance environmental outcomes, differences in firms' financing choices are unlikely to be driven solely by environmental commitment or credibility considerations.

Figure 2 extends the analysis in **Figure 1** by directly comparing the environmental performance of green loan borrowers and green bond issuers. The figure shows that green loan borrowers and green bond issuers exhibit broadly comparable improvements in environmental outcomes following issuance. In particular, both groups experience reductions in emissions and waste, accompanied by increases in ESG-related disclosure measures. The estimated post-issuance effects are similar in magnitude and statistical significance across the two samples, indicating that green loans are associated with environmental performance dynamics that closely resemble those observed for green bonds.

Figure 2. Performance comparison of green loans and green bonds borrowers.



Note: Consistent with the method in Figure 1, this figure further compares the environmental performance of green loan borrowers and green bond issuers, as measured by GHG emissions in scopes 1 and 2 (in Panel A), total waste generated (in Panel B), ESG disclosure score (in Panel C), and Environmental disclosure score (in Panel D). Fixed effects and control variables also follow the variables used in **Table 4**, but exclude some loan-specific variables (e.g., number of covenants, main lender country, and loan base rate). The vertical bars are 95% confidence intervals and robust t statistics are clustered at the borrower level.

These results suggest that, despite operating in less transparent and less liquid markets, green loans do not appear to be associated with weaker environmental outcomes than green bonds. Instead, the evidence indicates that green loan contracts, like green bonds, are linked to substantive post-issuance environmental improvements. This finding is consistent with the view that third-party certification and use-of-proceeds monitoring embedded in green loan contracts provide credible safeguards against opportunistic behavior, as emphasized in the greenwashing and selective disclosure literature (Lyon and Maxwell, 2011).

Taken together, **Figures 1** and **2** rule out explanations based on purely symbolic labeling or weaker environmental commitment. Green loans are associated with substantive post-issuance environmental improvements, and these improvements are comparable to those observed for green bonds. If environmental engagement alone does not account for firms' choice between green loans and green bonds, remaining differences are likely to reflect variation in firms' financing conditions and access to capital markets. To explore this possibility, we next examine whether firms that rely on green loans differ systematically from green bond issuers in terms of observable firm characteristics and financing profiles.

Table 6 compares key borrower and deal characteristics between green loan borrowers and green bond issuers. In which Column (1) examines the determinants of firms' choice between green loans and green bonds. The results indicate that firms choosing green loans tend to demand significantly larger financing amounts and shorter maturities. The coefficient on loan amount is positive and highly significant (1.246***), while the coefficient on maturity is negative and significant (-0.370**), suggesting that green loans are more frequently used to meet sizeable but relatively short-term financing needs. In addition, firms with lower profitability are more likely to rely on green loans, as reflected by the negative and significant coefficient on return on equity (-0.055**). These patterns are consistent with prior evidence that firms with limited access to public debt markets rely more heavily on bank-intermediated financing. (e.g., Bharath et al., 2007; Sufi, 2007).

Column (2) further compares the cost of capital associated with green loans and green bonds after correcting for self-selection. The coefficient on *GreenLoan* is negative and statistically significant (-2.625**), indicating that, conditional on observable characteristics and selection effects, green loans are associated with lower borrowing costs than comparable green bonds. Thus, the evidence in **Table 6** indicates that firms' reliance on green loans rather than green bonds is closely related to differences in financing scale, maturity preferences, and profitability, as well as to relative cost-of-capital considerations. These findings reinforce the view that green loans and green bonds serve distinct but complementary roles within sustainable debt markets, rather than acting as close substitutes differentiated only by environmental commitment.

Table 6. Drivers of green loans and green bonds choices.

	(1) GreenLoan	(2) Cost of Capital
ClimateChange	-6.321 (-0.748)	
COP26	-13.340*** (-3.405)	
GreenLoan		-2.625** (-2.438)
IMR		0.494 (1.252)
ln(Amount)	1.246*** (6.206)	0.156 (0.970)
Yrs2Maturity	-0.370** (-2.288)	0.010 (0.147)
ln(NetSales)	0.152 (0.624)	-0.261 (-0.789)
ln(Cash)	-0.167 (-0.499)	-0.226 (-1.045)
ROE	-0.055** (-2.335)	-0.008 (-0.509)
ConsumerPriceIndex	3.146*** (2.738)	-0.893 (-1.554)
Fixed Effects	YES	YES
N	2,868	2,868
PseudoR ²	0.730	
AdjustedR ²		0.487

Note: Results from the treatment effect model. In which column (1) analysis factors may impact a firm's selection to the green loan (*GreenLoan*) or green bonds, and estimates the *IMR* for the column (2). Meanwhile, we follow Cevik and Jalles (2022) to apply the lag of climate change index (*ClimateChange*) and the event of COP26 as exogenous variables. Columns (2) examines whether green loans can bring lower cost of capital than paired green bonds. The dependent variable *Cost of Capital* refers to the (base rate bps + all-in spread drawn bps)*100 of green loans, and the yield at issuance of green bonds. Fixed effects and control variables also follow the variables used in **Table 4**, but exclude some loan-specific variables (e.g., number of covenants, main lender country, and loan base rate). Robust t statistics in parentheses are clustered at the borrower level.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4 Heterogeneity in green loan pricing effects

The baseline results in Section 4.1 indicate that green loan labels are associated with lower borrowing costs on average. To clarify which firms drive this pricing effect and what this implies for the positioning of green loans relative to green bonds, we next examine heterogeneity across issuer characteristics. The heterogeneity patterns provide evidence consistent with a complementary segmentation between green bond and green loan markets, rather than a uniform pricing effect across all borrowers.

Table 7 shows that the borrowing-cost advantage of green loan labels is concentrated among firms with lower ESG scores and those with higher leverage. In the low-ESG subsample, the coefficient on *Green* is -1.216***, whereas the corresponding estimate for high-ESG firms is small and statistically insignificant (-0.148). A similar pattern emerges for financial constraints proxied by leverage. For high-leverage firms, the estimated green loan effect is -1.827***, while it becomes statistically insignificant for low-leverage firms (-0.861). These results indicate that the pricing benefits of green loans are primarily driven by borrowers that are more financially constrained or exhibit weaker ESG performance, a group that prior research shows relies more heavily on bank-intermediated and relationship-based financing rather than public debt markets (e.g., Bharath et al., 2007; Frank and Goyal, 2009; Sufi, 2007).

Table 7. Heterogeneity tests based on the treatment effect model.

	(1) Low ESG Score ln(Spread)	(2) High ESG Score ln(Spread)	(3) High Leverage ln(Spread)	(4) Low Leverage ln(Spread)
Green	-1.216*** (-3.152)	-0.148 (-0.862)	-1.827*** (-3.827)	-0.861 (-1.315)
IMR	0.844** (3.290)	0.094 (0.996)	1.140*** (3.567)	0.543 (1.332)
Cons.	6.027*** (6.032)	12.791*** (7.936)	10.390*** (7.832)	7.572*** (5.280)
Control	YES	YES	YES	YES
Fixed Effects	YES	YES	YES	YES
<i>N</i>	2,138	730	1,754	1,114
AdjustedR ²	0.781	0.891	0.708	0.847

Note: Heterogeneity tests to the underlying mechanisms behind the impact of green label on the loan spread. In which columns (1) to (4) are sub-sample regressions to the column (2) of **Table 4**. Robust t statistics in parentheses are clustered at the borrower level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8 further refines this picture by considering heterogeneity related to ESG disagreement and default risk. ESG disagreement is measured as the standardized absolute difference between firms' Bloomberg ESG scores and BESG ESG scores, capturing the extent to which ESG assessments vary across major data providers. Such disagreement reflects greater uncertainty or ambiguity in how firms' sustainability performance is evaluated. When firms are split based on this measure, the borrowing-cost advantage of green loans is concentrated among those with higher ESG disagreement, while the corresponding effect for firms with more aligned ESG ratings is weaker and statistically insignificant.

Table 8. Heterogeneity test based on ESG disagreement and default risk level

	(1) Low ESG Disagreement ln(Spread)	(2) High ESG Disagreement ln(Spread)	(3) Low Default Risk ln(Spread)	(4) High Default Risk ln(Spread)
Green	-0.812*** (-3.033)	-0.125 (-0.346)	-0.878*** (-3.063)	0.261 (0.439)
IMR	0.489*** (2.840)	0.051 (0.218)	0.379*** (2.737)	-0.099 (-0.277)
Cons.	10.189*** (7.282)	4.999*** (7.058)	5.826*** (4.582)	10.584*** (8.158)
Control	YES	YES	YES	YES
Fixed Effects	YES	YES	YES	YES
N	1,348	691	1,032	1,007
AdjustedR ²	0.845	0.892	0.860	0.836

Note: Heterogeneity tests to the underlying mechanisms behind the impact of green label on the loan spread. In which columns (1) to (4) are sub-sample regressions to the column (2) of **Table 4**. Robust t statistics in parentheses are clustered at the borrower level. * p < 0.1, ** p < 0.05, *** p < 0.01

Importantly, these firms are not characterized by poor information environments overall. As shown in **Table 8**, the green loan pricing effect is strongest among firms with higher ESG disclosure transparency, proxied by Bloomberg ESG disclosure scores, where the coefficient on Green is -0.812***, compared with an insignificant estimate (-0.125) for firms with lower transparency. In addition, the pricing advantage is concentrated among firms with lower default risk (-0.878***), and disappears among firms with higher default risk (0.261). Taken together, these patterns suggest that green loans deliver the largest borrowing-cost benefits for firms that face greater ESG-related uncertainty or financial pressure, yet maintain relatively strong disclosure practices and sound credit quality.

Overall, the heterogeneity results are consistent with a complementary relationship between green loan and green bond markets. Green loans appear to provide a viable sustainable financing channel for firms that may be less suited to issuing green bonds due to weaker ESG scores or tighter financial conditions, while still possessing sufficient transparency and creditworthiness to access relationship-based bank lending on favorable terms. These findings complement the earlier evidence on pricing and instrument choice by highlighting how green loans fill a distinct niche within sustainable debt markets.

5. Conclusion

This study provides a comprehensive global analysis of green loans, examining their pricing effects, investor attention, and environmental outcomes in syndicated loan markets. Using a matched sample of 2,868 green and conventional loans issued between 2017 and 2024, we document a substantial borrowing-cost advantage associated with green loan labels. On average, green loans are priced at significantly lower spreads than comparable conventional loans, while generating no detectable increases in market-wide investor attention.

Our findings extend the sustainable finance literature beyond the well-documented green bond market (e.g., Flammer, 2021; Tang and Zhang, 2020; Zerbib, 2019) by providing large-scale evidence from private credit markets. In contrast to prior studies emphasizing public market transparency and investor demand, we show that green loan pricing effects arise in settings characterized by relationship-based lending and private monitoring. Moreover, green loans are associated with post-issuance improvements in firms' environmental outcomes that are comparable to those observed for green bonds, indicating that green loan adoption is not merely symbolic.

By jointly examining pricing effects, environmental outcomes, and instrument choice, this study identifies a clear segmentation between green loan and green bond markets. The borrowing-cost advantages associated with green loans are concentrated among firms with weaker ESG scores and higher leverage, while these firms simultaneously exhibit relatively strong ESG disclosure transparency and low default risk. This combination of characteristics indicates that green loans and green bonds serve complementary roles in sustainable debt markets, rather than acting as substitutes differentiated solely by environmental performance or investor recognition.

Our results also complement recent micro-level evidence on the risk profile of green lending. For example, Neagu et al. (2024) show that green loans in an emerging European economy are not necessarily associated with lower ex-post credit risk relative to conventional loans. While their analysis focuses on realized credit outcomes within a domestic banking system, our study

examines ex-ante loan pricing across global syndicated markets. Taken together, these findings suggest that observed green loan pricing discounts are not driven by mechanically lower credit risk, but instead reflect features of green loan contracting and certification that are valued by lenders at origination.

Overall, this study highlights the importance of recognizing heterogeneity and market segmentation within sustainable finance. Rather than rewarding only established environmental leaders, green loan markets appear to provide financing opportunities for firms that face tighter financial constraints or lower ESG scores, while still maintaining sufficient transparency and credit quality to access bank-intermediated credit. This complementary structure expands the reach of sustainable finance by offering financing pathways to firms at different stages of their environmental transition.

Finally, our findings have important implications for multiple stakeholders. For corporate managers, the results suggest that green financing strategies can be relevant throughout the sustainability transition, not only for firms with strong ESG reputations. For financial institutions, green loans represent commercially viable instruments that align environmental objectives with relationship-based lending practices. For policymakers, our evidence supports the development of green loan taxonomies and standards that acknowledge the distinct role of private credit markets in facilitating corporate environmental transitions. These implications resonate with broader perspectives in climate economics emphasizing the role of financial systems in addressing environmental externalities. As argued by Nordhaus (2019), climate change represents a profound market failure that requires coordinated responses across public and private sectors. By embedding environmental objectives, verification, and monitoring into loan contracts, green loan markets provide a mechanism through which private credit can contribute to the internalization of climate-related externalities and support sustainable growth.

Future research could explore the longer-term environmental and financial performance of green loan borrowers, examine heterogeneity across certification standards and contractual frameworks, and investigate how regulatory developments affect firms' choices between green loans, green bonds, and other sustainable financing instruments. Further work on the design of green loan covenants and monitoring mechanisms may also help enhance the effectiveness of these instruments in promoting environmental outcomes.

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