Actions Speak Louder Than Words:

The Valuation of Green Commitment in the Corporate Bond Market

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1. Introduction

The dramatic shift in societal attention towards climate change and corporate environmental performance creates major challenges for investors. They are increasingly facing investment mandates that require portfolios to screen out or reduce exposures to issuers with unsatisfactory environmental credentials.[1] Investors see information on the intentions of firms to manage and mitigate climate-related regulatory risk (e.g., Krueger et al. [2020] and Seltzer et al. [2022]) and transition risk (Boushey et al. [2021]).[2] At the same time, the ability of investors to assess firms' environmental credentials is limited by the voluntary nature of most ESG disclosures, the incentives for firms to greenwash and the difficulties firms face in establishing clear and credible commitment to manage and mitigate risks linked to climate change. In this context, green bond issuance has a potentially important role to play as a green commitment mechanism (Flammer [2021] and Lu [2021]). However, to date the evidence on the consequences of green bond issuance for valuation and expected returns is mixed and inconclusive. In this paper we contribute new evidence on the consequences of corporate green bond issuance for the conventional corporate bond market, revealing that the secondary corporate bond market reacts positively and that socially responsible investors increase their conventional bond holdings.

Our main sample comprises 349 green bonds and 1,832 conventional bonds, issued by 73 unique US corporations. We exploit variation in the timing of the green bond issuance and adopt a staggered difference-in-differences (DiD) design incorporating a comprehensive set of fixed effects (i.e., bond or bond-quarter, credit rating and time fixed effects). Our evidence indicates that the first-time issuance of corporate green bonds leads to a permanent reduction in secondary bond market yields

[1] Similar considerations can apply to social and governance performance, but S and G are beyond the scope of this paper.
[2] Transition risk arises "…from the shifts in policy, consumer and business sentiment, or technologies associated with the changes necessary to limit climate change." (FSOC [2021])

for the same issuer's conventional bonds. After controlling for issuer and bond-specific characteristics and time fixed effects, the reduction in conventional bond market yields is economically significant at around 8 basis points on average. This is equivalent to an average increase in the market value of issuers' debt of around 5.6 percent, equivalent to an average increase of $47 million across all conventional bond issues.

Consistent with the market interpreting the issuance of green bonds as a permanent commitment to environmental sustainability, the favorable pricing effect is persistent and does not reverse. The positive pricing effect of green bonds is driven by first-time green bond issues, with any subsequent green bond issues by the same issuer having no further impact on conventional bond yields. Our results are robust to including a vector of time-varying issuer fundamentals to control for the possibility that new debt issuance increases leverage and default risk (Admati et al. [2018]; Demarzo and He [2021]), or dilutes existing debtholders' claims (Leland [1998] [1994]; Leland and Toft [1996]). Our results are also robust across different sample sub-periods (e.g., eliminating the Covid-19 pandemic period).

The conventional bond market benefits of green bond issuance are considerably higher for issuers with relatively low ESG ratings. If green bonds commit issuers to environmental initiatives and transformation to more environmentally-friendly business activities, the pricing effects are expected to be more pronounced for issuers with weaker environmental credentials, as reflected in ESG ratings. We show that green bond issuance decreases the yield spreads of issuers with low ESG performance by 26 basis points relative to those with high ESG performance. These results further support the commitment role of corporate green bond issuance proposed by Lu [2021].

We examine three potential channels through which a decrease in conventional bond yields associated with green bond issuance might arise. The first channel links the reduction in conventional bond yields to wealth transfer from green bond investors to existing bondholders. If green bonds are overpriced because green investors are willing to pay a premium (see, e.g., Baker et al. [2022]), a wealth transfer from green investors to shareholders and existing conventional bondholders occurs. In the latter case wealth transfers manifest as higher bond prices and lower yields. However, if green bonds are systematically overpriced, conventional bondholders would realize similar wealth transfer benefits if further green bond issues are made by the same firm. Our results indicate that the positive pricing effects on conventional bonds are confined to the first-time green bond issues; the yield spreads of conventional bonds are unchanged if the same firm makes another green bond issue. This result suggests that systematic overpricing of green bonds by a green investor clientele cannot explain the reduction in conventional bond yields associated with initial green bond issuance.

We then test whether green bond issuance is associated with increases in conventional bond market liquidity or reductions in credit risk, the two fundamental determinants of bond risk premia (Chen et al. [2007]; Longstaff et al. [2005]). We report evidence that conventional bond market liquidity increases after green bonds are issued, but the increase in liquidity accounts for only a small proportion of the positive pricing effect of green bond issuance observed in the secondary bond market. Further, we find that default risk proxied by CDS spreads does not change as a result of green bond issuance and therefore cannot explain the lower conventional bond yields after first-time green bond issuance.

To shed further light on the mechanism driving the positive pricing effects of green bonds on conventional bonds, we examine institutional ownership of conventional bonds, focusing on the responses of socially responsible investors (SRIs) after companies issue green bonds. Our results indicate that SRI's not only invest in green bonds (Baker et al. [2022]]), but they also increase their holdings of the conventional bonds of green bond issuers through secondary market purchases. These results suggest that an important channel through which the positive pricing effects of green bond issuance arise is increased demand by SRIs for conventional bonds. Increased demand from investors with environmental preferences is also consistent with green bond issuance serving to reduce bond market expectations of climate change-related regulatory and transition risk exposure. In additional cross-sectional tests we find that the positive pricing effects are found primarily for green bond issuers with lower environmental performance ratings, where other forms of green commitment (e.g., CSR reports, science-based emissions targets and compensation linked to environmental performance) are less likely to be in place.

Our focus on the secondary bond market pricing effects of green bond issuance has three main advantages. First, we are able to focus on green bonding pricing effects in the corporate bond market, whereas for reasons of sample size and statistical power most prior research on the pricing of green bonds has considered the municipal bond market (e.g., Baker et al. [2022]; Larcker and Watts [2020]; Lu [2021]). While the municipal market is interesting and important, the information environment and potential mechanisms for monitoring and enforcing municipal environmental policies are quite different from those applicable to corporations. The environmental performance of companies is central to the current climate change debate and corporations now account for two-thirds of overall green bond issuance. Hence it is relevant to understand the economic role that green bonds play in the corporate debt market. A second advantage of examining the secondary bond market pricing effects green bond issuance is that results should not be confounded by underpricing of initial and seasoned bond offerings in the primary market reported by Cai et al. [2007].[3] Finally, if conventional and green bond markets are integrated through no-arbitrage pricing (Larcker and Watts [2020]) and therefore climate risk and the environmental credentials of issuers are important in both green and

[3] Cai et al. [2007] attribute primary market bond underpricing to market uncertainty about future market liquidity and the effects of book-building by underwriters.

conventional bond markets, the secondary market for conventional bonds offers a more powerful setting for testing and calibrating the bond market's valuation of green commitment.

Our paper contributes to the rapidly growing climate finance literature studying the asset pricing implications of climate risk and the financing of investment to mitigate climate change (for recent reviews see, e.g., Giglio et al. [2021]; Hong et al. [2020]). It also contributes directly to the stream of literature examining whether there is a green bond premium (Baker et al. [2022]; Larcker and Watts [2020]; Lu [2021]). While these papers study the initial yields on green municipal bonds along with simultaneously issued conventional municipal bonds, our evidence on the secondary corporate bond market informs directly about the pricing effects of first-time green corporate bond issuance for the secondary market for corporate bonds. Our results confirm the green commitment role of corporate green bond issuance proposed by Lu [2021] and indicate that the cost of public debt is lower for firms after they issue green bonds.

The remainder of the paper proceeds as follows. In Section 2 we discuss the related literature on which we build. We describe the data and present summary statistics in Section 3. We report the main results on the secondary bond market effects of green bond issuance in Section 4. In Section 5 we report the cross-sectional analysis conditioning bond market outcomes on green bond issuers' environmental performance ratings. In Section 6 we report the results of examining the potential channels through which green bond issuance can affect conventional bond yields. Finally, we conclude in Section 7.

2. Related Research

The dramatic shift in societal attention towards climate change risk and corporate environmental performance creates a major challenge for investors. Asset owners are demanding that institutional investors establish the environmental credentials of investees and in some mandates exclude those with unsatisfactory environmental profiles or constrain portfolios in other ways. Yet currently investors in US securities must currently manage their portfolios in the absence of mandated environmental reporting standards and without systematic monitoring and enforcement that would ensure more reliable and transparent disclosure of companies' green credentials. Instead, investors must rely on self-reported and often unaudited voluntary disclosures, or on environmental ratings based on those same voluntary disclosures. A voluntary disclosure regime implies that investors face uncertainty about the commitment of firms to disclosure and to mitigate the negative externalities of their business activities (Christensen et al. [2021]). Emphasizing the nature of investors' uncertainty recent research has questioned the reliability of voluntary disclosures by companies because incentives for greenwashing may be strong (Laufer [2003]); and the informativeness of environmental ratings from ratings agencies has also been called into question (Christensen et al. [2022]; Serafeim and Yoon [2022].

Given the limitations in relying on voluntary disclosure to reveal the green credentials of investees, researchers have turned their attention to the role of other commitment mechanisms through which firms provide reassurance about their intentions to mitigate negative environmental externalities and establish their green credentials. Recent research has considered the commitment roles played by CSR reporting (both qualitative and quantitative) (Christensen et al. [2021]), governance mechanisms and board processes designed to manage environmental and social risks (Kim et al. [2019]), science-based emissions targets, and executive compensation linked to CSR performance (Eccles et al. [2011]; Edmans et al. [2022]).

Green bond issuance can serve as a credible green bonding commitment mechanism. Green bond issuance requires issuers to commit to applying the issue proceeds to green projects consistent with the entity's environmental sustainability objectives and providing clear environmental benefits

(ICMA [2018]). It also requires issuers to commit to increased reporting, enforcement by external reviewers and some exchanges and, monitoring by investors with environmental preferences and the media (Lu [2021]). Several papers have also examined whether green bond issuance affects equity market prices and returns (Tang and Zhang [2020]) or is associated with future environmental performance outcomes (Flammer [2021]). The line of research most closely related to our paper examines the pricing of green bonds relative to conventional bonds from the same issuer with the same cash flows and credit risk, and specifically whether green bond investors pay a premium (or "greenium"), i.e., whether they receive a lower yield compared to holding similar conventional bonds. Evidence of a premium would suggest that investors with preferences for environmental sustainability are willing to forego pecuniary benefits in favor of environmental performance. The evidence on the pricing of green bonds is mixed. While Baker et al. [2022] report a premium (lower initial yield) on green bonds relative to similar conventional bonds of around 6 basis points, Larcker and Watts [2020] find that the pricing of green bonds is no different to the pricing of nearly identical conventional bonds issued on the same day by the same municipality. Lu [2021] confirms the results of Larcker and Watts [2020] but shows additionally that the primary market yield for conventional bonds issued simultaneously with green bonds is lower than when municipalities issue conventional bonds without contemporaneous green bond issuance. Lu [2021] interprets this as evidence of that green bond issuance represents a credible green commitment mechanism that is valued in both the primary green bond and the primary conventional municipal bond markets.

The main focus of the green bond premium literature has been on the initial pricing of municipal green bonds compared to conventional municipal bonds also issued at the same time. This has the advantage that there are many such instances of simultaneous issuance of green and conventional bonds in the municipal market, contributing to statistical power. Equally powerful tests using primary bond market data have not been possible for corporate bonds because simultaneous issuance of green and conventional bonds is much less common. However, the main focus of attention in climate finance is on the role of corporations, not municipalities. We contribute to this literature by estimating the effects of corporate green bond issuance on secondary corporate bond market outcomes. This enables us to avoid potential initial offering mispricing (Cai et al. [2007]) effects test and to calibrate the value of green bond commitment for the cost of public debt.

3. Data and Summary Statistics

We collect information on green bond issuance from Refinitiv Eikon, and obtain complementary bond characteristics from Mergent FISD by matching on CUSIP identifiers. Among 478 green bonds we identify in FISD, nearly 90% are senior unsecured debt, suggesting that most green bonds are *pari passu* with conventional senior unsecured bonds. Restricting our analysis to corporate issuers reduces the number of green bonds to 349. In the final sample, the first corporate green bond was issued in November 2013 and the last one in September 2021. Figure 1 plots the total offering amount of green bonds (in billions of dollars) in our sample, indicating that corporate issuance of green bonds has increased dramatically, with the trend accelerating since 2018.

We identify conventional bonds issued by the green bond issuers and bond characteristics, including (monthly) credit ratings and outstanding amount, in the Mergent FISD database. To minimize the potential confounding effects of contractual features on bond yields, we apply standard filtering rules and exclude bonds that are denominated in foreign currencies, issued under Rule 144a, inflation-linked, payment-in-kind, pass-through securities, corporate strips, or corporate unit investment trusts. As our primary analysis focuses on bond yields from secondary market trading, we also exclude floating-rate notes. Our final primary sample consists of 1,832 unique conventional bonds issued by 73 unique green issuers. In additional tests described in the Online Appendix we include conventional bonds from firms that do not issue green bonds in our sample period as a control sample. This approach affects the efficiency of estimates of time and credit rating fixed effects, but our main results are qualitatively unchanged.

Bond market yields and trading activities are obtained from the Enhanced Trade Reporting and Compliance Engine (TRACE Enhanced). We follow the recommendations in Dick-Nielsen [2014] in cleaning the data, excluding cancelled or corrected trades and removing reversal trades. As the bond market is known for its infrequent trading and illiquidity compared to the stock market, we conduct our empirical analysis at the monthly level, and employ two measures of bond market yields. Following Goldsmith-Pinkham et al. [2021], our baseline measure is the trade volume-weighted market yield within a month. Our second measure follows Becker and Ivashina [2015] and Anderson and Stulz [2017], and uses monthly median yields. The two measures cross-validate each other, and provide reassurance on the robustness of our empirical results. To compute corporate bond yield spreads over comparable Treasury yields, we obtain daily term structures of par yields for Treasuries based on the method of Gürkaynak et al. [2007]. If in month t corporate bond i's yield equals $y_{i,t}$ and the par yield on a Treasury bond of the same maturity equals y_t, the corporate bond yield spread equals $s_{i,t} = y_{i,t} - y_t$.[4]

We supplement the sample of corporate bonds with data on issuer fundamentals. First, we take advantage of the WRDS bond-equity crosswalk and collect from Compustat the size and financial leverage of bond issuers, both of which are important determinants of corporate bond yield spreads. Issuer size is measured as the natural logarithm of total assets, and financial leverage is defined as the ratio of total debt (current liability plus long-term debt) to total assets. Second, since green bond

[4] Daily term structure of US Treasuries par yields for maturities at annual horizons between 1 year and 30 years can be downloaded from the Federal Reserve website https://www.federalreserve.gov/data/nominal-yield-curve.htm. We follow Xu and Pennacchi [2021] and use cubic spline interpolation to obtain yields for every maturity between each annual horizon.

issuance is also related to issuer ESG performance, we collect ESG ratings from Refinitiv Eikon, focusing on scores related to environmental performance. Although not all issuers are identified in Compustat or have ESG ratings in Eikon, this does not pose a serious empirical challenge because, as we show below, bond fixed effects, time fixed effects and their interactions supersede issuer covariates.

Credit risk is also a major determinant of bond yields. To assess the role of the credit risk, we obtain from Markit single-name CDS spreads for the reference entities covered in our corporate bond sample. For each bond in our sample that has a reference entity in Markit, we take the CDS contract with the 'doc clause' of No Restructuring (XR14) and the default tier of senior unsecured debt (SNRFOR). Markit provides a term structure of CDS spreads with a range of maturities, and we focus on maturities of 3, 5 and 10 years. While 5-year CDS contracts are typically assumed to be the most liquid, 3-year and 10-year CDS spreads can pick up the differential effects of the green bond issuance on a firm's short-term and long-term credit risk and cost of debt, respectively. As the CDS spreads are quoted daily in Markit, we take the monthly average to be consistent with our sample of bond yield spreads.[5]

Previous papers have shown that credit risk does not fully explain variation in bond yields (Huang and Huang [2012]). Bond liquidity also plays a critical role. As there is no consensus on the optimal bond liquidity measure (Schestag et al. [2016]), we follow Dick-Nielsen et al. [2012] and compute four popular bond liquidity measures. The first is the Amihud [2002] measure. Suppose a particular bond trades N_t times during period t, and the j^{th} trade is at price P_j. If this trade is for a face value amount in \$millions of q_j, the Amihud liquidity measure for period t equals

[5] We also employ an alternative measure of median over daily CDS spreads within a month as a robustness test, and the results stand very similar.

$$\frac{1}{N_t}\sum_{j=1}^{N_t}\frac{|r_j|}{q_j} \tag{1}$$

where $r_j = \frac{P_j - P_{j-1}}{P_{j-1}}$ is the return from the j^{th} trade. The second is the Roll [1984] measure. He shows that the percentage bid-ask spread is twice the square root of minus the covariance between consecutive returns

$$Roll_t = 2\sqrt{-cov(r_j, r_{j-1})} \tag{2}$$

Note that the measure is only well-defined if $\text{cov}(r_j, r_{j-1}) \leq 0$. The third measure is the imputed roundtrip cost based on Feldhütter [2012]. If two or three trades in a given bond with the same trade size take place on the same day, and there are no other trades with the same size on that day, then

$$IRC_t = \frac{P_{\max} - P_{\min}}{P_{\max}} \tag{3}$$

where $P_{\max}$ ($P_{\min}$) is the largest (lowest) price among the trades. For these three measures, we first calculate the daily liquidity measures and then aggregate to the monthly measures by taking the median of daily measures within a month. The final liquidity measure is the zero-trading days (ZTD) measure defined as the percentage of days on which a bond is not traded during a month. The calculation of the bond liquidity measures takes advantage of the trade data from TRACE and closely follows Dick-Nielsen et al. [2012].

Table 1 presents the summary statistics variables in our sample. Panel (A) covers the entire sample periods with bond trades running from January 2010 to June 2021. As we make clear later, the full sample period enables us to study the effects of both first and subsequent green bond issues. The sample period, however, also covers the Covid-19 pandemic and post-pandemic period during which

Federal Reserve support policies, e.g., Primary Market Corporate Credit Facility (PMCCF) and Secondary Market Corporate Credit Facility (SMCCF), affect the US corporate bond market, potentially biasing bond liquidity and credit quality measures. To mitigate potential confounding effects due the pandemic and associated monetary and fiscal policy responses, we also examine a subsample for which trading of conventional bonds occurs before 2020 and a firm's first green bond was issued before 2020, requiring matching conventional bond(s) to be traded at least once before the first green bond is issued. This eliminates potential confounding effects of the pandemic and guarantees that each sample bond is "treated" once. Panel (B) reports the summary statistics for pre-pandemic subsample. Despite different sample periods, Panel (A) and Panel (B) report very similar bond characteristics, e.g., yield spreads and amount outstanding, with Panel (B) showing slightly higher median of assets and leverage ratios. Our analysis of liquidity and credit risk channels primarily makes use of the pre-pandemic subsample.

4. The Effects of Green Bond Issuance on Conventional Bonds

To study how green bond issuance affects the pricing of other conventional bonds from the same issuer, we exploit the time variation in the green bond issuance and identify the causal effects by adopting a staggered difference-in-differences approach. When a firm first issues a green bond, existing conventional bonds are potentially affected, and the conventional bonds form the treatment group. Conventional bonds of non-green issuers at a point in time serve as the control group.[6] Our baseline regression specification is as follows:

[6] As there might be unobservable characteristics that drive a firm's decision of green bond issuance, our sample only include green bond issuers. In other words, all conventional bonds eventually belong to the treatment group. In the appendix A.1, we introduce conventional bonds issued by non-green issuers in the same four-digit SIC industries as the green issuers, and weight the green and non-green issuers with the entropy balancing on their ESG and environmental scores. In the end, the results remain very similar to our baseline estimates.

$$s_{i,j,t} = \alpha \times PostGreen_{j,t} + \Phi_{i,j,t} + \Omega_{j,t} + \mu_i + \rho_t + \epsilon_{i,j,t} \quad (4)$$

where $s_{i,j,t}$ is the yield spread in month t of bond i issued by firm j. $PostGreen_{j,t}$ is the treatment dummy and equals 1 if month t is after firm j issues its first green bond.[7] $\Phi_{i,j,t}$ is a vector of time-varying covariates for bond i, i.e., credit rating, trading volume and amount outstanding. $\Omega_{j,t}$ represents the issuer's fundamentals, including total assets, leverage ratio and ESG ratings. We include bond fixed effects μ_i to account for time-invariant heterogeneity across bonds, and time fixed effects ρ_t to control for time-varying common shocks to corporate bond prices. As shown below, we also augment our specification with the interaction of bond and time fixed effects, i.e., bond-by-quarter fixed effects. $\epsilon_{i,j,t}$ is the error term. The estimated coefficient α therefore captures the impact of green bond issuance on the yield spreads of conventional bonds of the same issuer.

We report the baseline regression results in Table 2. Robust standard errors are clustered at the bond level. Column (1) only includes the treatment dummy without any fixed effects, and shows that issuing green bonds reduces yield spreads of other conventional bonds by 23 basis points. Column (2) controls for bond and month fixed effects, and the magnitude of the point estimate drops to 8 basis points, but this is still highly significant at the one percent level. In Column (3), we further account for multiple time-varying bond characteristics, including amount outstanding, trading volume, and credit ratings. All covariates have strong explanatory power for variation in bond yield spreads. The amount outstanding is positively associated with higher yield spreads, while trading volume is negatively associated with yield spreads, as expected. Nonetheless, despite adding these controls the *PostGreen* coefficient of interest remains almost identical, and is significant at the one percent level.

[7] For the time being, we only consider the impact of first green bond issuance. We will extend the discussion to subsequent issuances in Section 6.1.

Column (4) of Table 2 additionally controls for the issuer's fundamentals, e.g., asset size, financial leverage and ESG ratings. Similar to Column (3), while the newly added covariates further explain variation in bond yield spreads, as evidenced by the significant coefficients and the increased adjusted R-squared statistic, the coefficient of the treatment dummy is still statistically significant and remains around 8 basis points. However, around 10,000 observations are excluded in Column (4) because of missing issuer characteristic information– not all bond issuers can be located in Compustat and some do not have ESG ratings. To overcome this empirical challenge, in Column (5) we augment the baseline specification and include bond-by-quarter fixed effects. Since the issuer's fundamentals and ESG ratings are updated annually, the bond-by-quarter fixed effects absorb the issuer level covariates. However, even using such a saturated fixed effect design, the coefficient of interest barely changes, having a magnitude of 7 basis points. Overall, our results show that green bond issuance reduces the secondary market yield spreads of conventional bonds of the same issuers. The magnitude of the effect is also very similar to estimates of green bond premia relative to newly issued conventional bonds reported in Baker et al. [2022], John and Rapp [2022] and Pástor, Stambaugh, and Taylor [2022]. Given that the average duration of bonds in the sample is 6.9 years and the average outstanding amount of bonds is $849 million, the decrease of yield spreads increases the market value of bonds by around $4.69 million per issue. The increase in the market value of public debt at the issuer level is even greater and increases by around $48 million, considering that a representative issuer in the sample has $8.6 billion bonds outstanding.

We conduct several tests to demonstrate the robustness of our empirical findings. Table 3 reports the result of these tests. First, instead of using the yield spreads calculated from trading volume weighted bond yields, we employ an alternative measure of bond yield spreads calculated from median daily bond yields within a month. Column (1) of Table 3 shows that the point estimate is similar to Column (5) of Table 2, suggesting that the green bond issuance decreases the yield spreads of other conventional bonds by 6 basis points. Second, given the significant effects of the Covid-19 pandemic and the series of Federal reserve bond market interventions, we restrict the sample period to end before 2020, reducing the sample size from 83,307 to 67,915 observations. However, as Column (2) of Table 3 shows, the coefficient of interest hardly changes. Yield spreads fall by 5.3 basis points and the effect is significant at the one percent level. Third, in Column (3) and (4), we focus on the refined subsample as in Panel (B) of Table 1. Although the subsample has only half as many as observations as the original sample, the results are comparable to Column (3) and (5) in Table 2. Column (3) of Table 3 includes the full set of covariates but bond-by-quarter fixed effects, and shows that green bond issuances bond yield spreads by 15 basis points, while Column (4) also includes the bond-by-quarter fixed effects and suggests the reduction is around 5 basis points. It is worth noting that through all robustness tests, the coefficients of interest are all significant at the one percent level or better.

The underlying assumption of our staggered DiD approach is that the yield spreads of treated and untreated bonds would move in parallel in the absence of green bond issuance. To provide evidence on the validity of this assumption, we estimate the following regression:

$$s_{i,j,t} = \sum_{\tau} \alpha_{\tau} \times PostGreen_{j,t}^{\tau} + \Phi_{i,j,t} + \Omega_{j,t} + \mu_i + \rho_t + \epsilon_{i,j,t} \tag{5}$$

where $PostGreen_{j,t}^{\tau}$ is an indicator variable that equals 1 if firm j issues the first green bond τ months from date t, replacing the treatment dummy in the baseline specification. The coefficient α_{τ}, therefore, captures the dynamics of the impacts of green bond issuance. In particular, the results from the regression provide an indication of whether the effects we document in Table 2 are transient or long-lived. To increase the power of our tests, we aggregate τ (s) into quarterly bins. For instance, for $\tau = 0,1,2,3$ we estimate the coefficient α_0 that captures the average effects during the quarter following green bond issuance. Moreover, given the long period of our bond sample, we cap the granular horizons we consider to two years before and two years after green bond issuance. This implies that the coefficient estimates of α_9 accounts for the long-term effect beyond two years.

Figure 2 plots the coefficients $\{\alpha_\tau\}_{\tau=-9,\dots,9}$ and their 95 percent confidence intervals. Quarter (-1) before the first green bond issuance serves as a benchmark and its coefficient is normalized to zero. The figure suggests that the yield spreads of treated and non-treated bonds are similar before the issuance of the green bonds, supporting the parallel trends assumption and validating our staggered DiD approach. It also shows that the yield spreads immediately drop after issuance of the first green bonds. Moreover, the effects are not transient but become stronger over time and are still present two years after issuance of the first green bond. This analysis highlights that the issuance of green bonds has long-term consequences for the pricing of conventional bonds and for conventional bond investors.

5. Cross Sectional Analysis: Green Bond Issuance and ESG Ratings

The positive pricing effects of green bond issuance on conventional bonds might differ across issuers. In particular, if green bonds commit issuers to environmental initiatives and transformation to more environmentally-friendly business activities, the green bonding effects are expected to be more pronounced for issuers with weaker perceived environmental performance. In this section, we examine cross-sectional variation in issuers' ESG performance, and study the heterogeneity in green bonding effects conditional on ESG performance.

In addition to an overall ESG grade rating, Refinitiv also provides a numeric ESGC score capturing the issuer's ESG performance and related controversies. Refinitiv also reports an environment pillar score that specifically rates the issuer's environmental performance. The environment pillar score considers several factors including emission reduction, environmental innovation, and environmental resource use, each of which has received an individual score. The environment pillar score combines these factor scores with appropriate weights.[8] All scores are updated annually. Each score has a range between 0 and 100, with higher scores indicating better ESG performance. Table 4 compares the summary statistics of the ESG scores for all US firms rated by Refinitiv with those for our sample firms. Unsurprisingly green bond issuers (our sample firms) typically have better environmental performance, regardless of which metric is considered.

To study the difference in the green bonding effects of green bond issuance across issuers, we first obtain the list of issuers whose bonds are traded in the market during a quarter and their ESG scores. We then partition all bond issuers (hence the traded bonds) into two groups of low and high ESG performance using the median score. Our empirical specification conditioning on ESG performance is then as follows:

$$\begin{aligned} s_{i,j,t} = {} & \alpha \times PostGreen_{j,t} + \beta \times PostGreen_{j,t} \times LowScore_{j,t} + LowScore_{j,t} + \\ & \Phi_{i,j,t} + \Omega_{j,t} + \mu_i + \rho_t + \epsilon_{i,j,t} \end{aligned} \tag{6}$$

In other words, we augment our baseline specification with a variable $LowScore$ and its interaction with the variable of interest $PostGreen$. $LowScore_{j,t}$ is a dummy variable and equal to 1 if the issuer j is in the low score group at time t. If green bond issuance has a more pronounced effect on issuers with low ESG performance, we should expect a significant negative coefficient β .

[8] Each factor is called a category in Refinitiv, and takes into account multiple themes. Emission reduction includes emissions, waster, biodiversity, and environmental management systems; environmental innovation includes product innovation and green revenues, research and development and capital expenditures. The category of resource use includes themes of water, energy, sustainable packaging, and environmental supply chain.

One caveat is that that ESG scores have a strong industry component (Gillan et al. [2021]). The disparity is particularly pronounced in comparing financial firms and industrial companies. Figure 3 compares the distribution of environmental pillar scores of financial and industrial companies in our sample, and clearly highlights that financial companies have better environmental performance than industrial firms. Therefore, a simple partition of firms by ESG scores effectively partitions firms by industries. To mitigate the confounding industry effects, we also include an interaction between a financial firm indicator and the year fixed effects in equation (6).

Table 5 reports the results of our cross-sectional analysis. Column (1) considers overall ESGC scores of the issuers and reveals that green bond issuance indeed has a stronger effect for issuers with lower ESGC scores. The coefficient of the interaction term is negative and significant, suggesting that green bond issuance decreases the yield spreads of issuers with low ESGC score by 26 basis points relative to green bond issuers with high ESGC scores. The treatment variable of *Post Green* now has a positive coefficient, and indicates that our baseline results in Table 2 are mainly driven by issuers with low ESG performances. The *LowScore* indicator has a positive and significant coefficient, suggesting that bond yields are higher when environmental performance is relatively low, consistent with the secondary bond market pricing climate change risk.

Columns (2) to (5) of Table 5 study granular constituent scores capturing different aspects of an issuer's environmental performance, and very similar results obtain. For the environment pillar score, emission reduction, environmental innovation, and environmental resource use, we find that issuers with low scores experience greater reductions in conventional bond yield spreads after the green bond issuance. All coefficients of interest are negative and significant at five percent level or better, with a magnitude of between 9 basis points and 15 basis points. Column (6) considers the controversy score which captures the reputational risk of poor ESG performance, and echoes previous results. Issuers with more frequent ESG controversies experience a larger decrease in the bond yield spreads after issuing green bonds. The magnitude of the coefficient estimate is on par with the ESGC score result in Column (1), and is around 25 basis points.

Similar to our prior analysis, we also consider more demanding specifications as robustness tests. Section A.2 of the Online Appendix reports the results from alternative specifications with credit ratings-by-quarter fixed effects and with bond-by-quarter fixed effects, respectively. While the credit ratings-by-quarter fixed effects account for time-varying demand for bonds of different credit rating segments, bond-by-quarter fixed effects control for time-varying firm characteristics and supersede the industry-by-year fixed effects in equation (6). Despite the exhaustive set of fixed effects and the smaller coefficient estimates, we still find that issuers with poor ESG performance metrics experience a larger drop in the yield spreads in the post period of green bond issuance, suggesting that our analysis is robust.

6. Possible Channels Underlying the Reduction in Bond Yield Spreads

Having documented that green bond issuance leads to reductions in the secondary market yield spreads of conventional bonds, we now turn to the possible channels underlying the decrease. We consider three potential channels. The first conjectures that overpricing of green bonds reflecting the non-pecuniary preferences of green bond investors transfers wealth to conventional bond holders, and this leads to lower conventional bond yields. The second potential channel predicts that the deployment of green assets after green bond issuance reduces the priced risk of conventional bonds, and hence bond yields. The third channel we consider predicts that yield spreads fall because conventional bonds become "greener", reflecting the pricing of green commitment in the conventional bond market. In the following sub-sections, we test these channels. We discover no evidence supporting the first or second channels, but we do find evidence supporting the prediction that conventional bonds become greener. Specifically, we find that socially responsible investors increase their holdings of the same issuer's conventional bonds after green bond issuance.

6.1 Does Green Bond Mispricing and Wealth Transfer Explain the Lower Yield Spreads?

Baker et al. [2022] and John and Rapp [2022] suggest that green bonds are priced at a premium on offering relative to other bonds. If green bonds are overpriced, there will be a wealth transfer from the green bond holders to shareholders and other capital providers, including conventional bond holders, causing the yield spreads of conventional bonds to fall. If green bonds are systematically overpriced, perhaps because of green bond investors' non-pecuniary preferences, wealth transfers should not be specific to the first instance of green bond issuance by a firm. We should also see further conventional bond market pricing effects for the second and subsequent green bond offerings. Therefore, in order to test this first channel, we study whether the observed decrease in yield spreads of the conventional bonds also occurs with later green bond offerings by the same issuer.

More than one third (38%) of the green bond issuers in our sample offer a second green bond at a later date. The goal of our empirical analysis here is to capture secondary bond market pricing effects specific to the second green bond offering, controlling for any persistent effects from the first green bond issuance. We adopt two complementary approaches. We first estimate the following regression specification:

$$s_{i,j,t} = \alpha \times Post\,Second\,Green_{j,t} + \Phi_{i,j,t} + \Omega_{j,t} + \mu_i + \rho_t + \epsilon_{i,j,t} \tag{7}$$

where $PostSecondGreen_{j,t}$ is a dummy variable and equals one if month t is after firm j issues a second green bond. To avoid catching any persistent impact of the first green bond issuance, we only include in the sample observations from periods after the first green bond issuance. Hence, the coefficient α in Equation (6) captures the marginal effect of the second green bond issue, conditional on there having been a first green bond offering at an earlier date. Under the hypothesis that green bond issuance transfers value to other bondholders and hence lowers the yield spreads, α is expected to be negative.

We also estimate a second empirical specification:

$$s_{i,j,t} = \alpha_1 \times PostGreen_{j,t} + \alpha_2 \times PostSecond\ Green_{j,t} + \Phi_{i,j,t} + \Omega_{j,t} + \mu_i + \rho_t + \epsilon_{i,j,t} \qquad (8)$$

In contrast to the first approach, in this specification we study the whole sample period and account separately for both the first and the second green bond offerings. Hence the coefficient α_2 captures the incremental effect on conventional bond yields of the second green bond issue. If wealth transfers associated with green bond overpricing are important, α_2 will be negative.

Table 6 shows the results from these two tests. Column (1) uses the first specification and does not account for bond-by-quarter fixed effects. Contrary to the prediction based on green bond overpricing, we observe a positive coefficient, suggesting that the second green bond issuance increases the yield spreads of other conventional bonds by 4 basis points, possibly due to increases in leverage and credit risk. Column (2) uses the most saturated version of the first specification by including bond-by-quarter fixed effects. The coefficient of interest still shows a positive sign, but it is no longer significant at conventional levels. Column (3) uses the second specification. Similar to Column (2), the coefficient on *PostSecondGreen* is positive but not statistically significant, suggesting that the yield spreads of conventional bonds do not fall after the issuance of the second green bonds. Despite a smaller sample size, we still observe a significant negative coefficient on *PostGreen* and the magnitude of the coefficient estimate is comparable to Column (5) in Table 2, confirming that the first green bond offering reduces the yield spreads of conventional bonds by 8 basis points.

In summary, the results reported in Table 6, suggest that the documented reduction in yield spreads of conventional bonds is driven by the issuance of the first green bond. This result is consistent with findings of Lu [2021] for the municipal bond primary market. These results suggest it is unlikely that mispricing of green bonds and resulting wealth transfer give rise to the reduction in yield spreads of conventional bonds.

6.2 Does Green Bond Issuance Reduce Priced Risk?

Bond yields depend on both credit risk and liquidity risk (Chen et al. [2007]; Longstaff et al. [2005]). Hence green bond issuance could affect conventional bond yields because green bonds and the related acquisition of green assets are related to reductions in credit risk or liquidity risk. Conventional bond investors, for instance, may expect that the green bond issuers would have less difficulty rolling over maturing debt, giving rise to lower credit risk. Alternatively, conventional bond investors may expect higher liquidity in the conventional bond market after green bond issuance, leading to a reduction in the expected liquidity risk premium. We are unaware of prior research that has examined possible links between green bond issuance and credit and liquidity risk. Hence, whether reduced credit or liquidity risk can explain changes in bond yields after green bond issuance remains an open question which we now investigate.

For the purposes of this analysis we focus on the subsample of observations comprising issuers that issued first green bonds before 2020, conventional bonds that are issued before the first green bonds, and all bond trades that occurred before 2020. We restrict the sample in this way to show that our results are not driven by issuance or trading during the abnormal Covid-19 pandemic period.

6.2.1 Credit Risk

We first test whether the credit risk of conventional bonds declines following the issuance of green bonds. Our regression follows specification (4) but replaces bond yield spreads as the dependent variable by CDS spreads, the measure of an issuer's credit risk. Table 7 reports the results of the regressions of CDS spreads on the treatment dummy *PostGreen*. Column (1) controls the issuer, month and CDS maturity fixed effects, and reveals a negative coefficient of 31 basis points. However, when we further control for issuer fundamentals in Column (2) by including issuer-by-year fixed effects, we find a significantly positive coefficient, suggesting that green bond issuance increases CDS spreads by 7 basis points. This increase in CDS spreads is not consistent with lower credit risk following the green bond issuance. If anything, it is consistent with the marginal issuance of new debt increasing leverage and issuers' default risk. To be consistent with the results of bond yield spreads reported in Table 2, Column (3) substitutes issuer-by-year fixed effects with issuer-by-quarter fixed effects. Despite the coefficient of interest having a negative sign, it is not statistically significant at any conventional level. Finally, Colum n (4) introduces a more conservative specification, including maturity-by-quarter fixed effects which account for possible curvature in the term structure of credit spreads. Neither the coefficient of interest nor the adjusted R-squared statistic differ materially when compared to Column (3).

In summary, we fail to find strong evidence that green bond issuance is associated with systematic reductions in issuers' credit risk. We conclude that it is improbable that the lower credit risk underlies the reduction in conventional bond yield spreads.

6.2.2 Liquidity Risk

Similar to our analysis of credit risk, we first study whether bond liquidity improves following the issuance of green bonds. As there is no consensus on the best bond (il)liquidity measure (Schestag et al. [2016]), we calculate four liquidity measures popular in the literature, including the Amihud [2002] measure, the Roll [1984] measure, the imputed roundtrip cost (IRC) (Feldhütter [2012]) and the number of zero trading days (ZTD) (Chen et al. [2007]). As Table 8 reveals, these four measures are positively correlated, but the correlations between ZTD and the other liquidity measures are weaker. Figure 4 plots the four liquidity measures over time. It shows that secondary market bond liquidity improves over the sample period, particularly in the case of the Amihud, IRC and Roll measures.

Our empirical analysis of liquidity initially follows specification (4), but replacing bond yield spreads with the liquidity measures. For each measure, we estimate models with and without the bond-by-quarter fixed effects. Table 9 reports the results of bond liquidity regressions. For the Amihud measure, we find evidence that issuing green bonds improves the liquidity of conventional bonds. The coefficient of interest is significantly negative, and the magnitude is very similar when bond-by-quarter fixed effects are included. In contrast, using the other three liquidity measures bond liquidity appears to improve after the green bond issuance, but after controlling for time-varying firm fundamentals by including bond-by-quarter fixed effects, there is no evidence that liquidity improves significantly.

To further investigate the role played by bond liquidity, we include the estimated bond liquidity measures as additional control variables in the bond yield spread regressions. This approach provides complementary evidence to our bond liquidity regressions shown in Table 9. Moreover, it also quantitively gauges the role of improvement of bond liquidity, if any, in driving the yield spreads to edge lower. Table 10 presents the results. Similar to our prior analysis, for each liquidity measure, we estimate specifications with and without bond-by-quarter fixed effects. As Table 10 highlights, all liquidity measures demonstrate strong explanatory power for variation in bond yield spreads, corroborating the validity of all measures. This is particularly true for Amihud and IRC measures, and for specifications without bond-by-quarter fixed effects. Nevertheless, the coefficients of the *PostGreen* treatment indicator remain similar across different liquidity measures. The magnitude of the coefficients is around 16 basis points for specifications without bond-by-quarter fixed effects, and around 4 basis points for the most saturated specifications with bond-by-quarter fixed effects. Notably, the coefficient estimates are almost the same as in Table 3, suggesting that bond liquidity changes associated with green bond issuance do not fully explain changes in yield spreads after green bond issuance.

6.3 Do Changes in Bond Yield Spreads Reflect Investor Preferences for Green Bonding?

Baker et al. [2022] show that the ownership of green bonds is more concentrated among a set of socially responsible investors (SRI). By definition, the proceeds of green bond issuance will be used for green purpose and acquisition of green assets. Green bondholders, however, do not enjoy exclusive claim over the green assets. Instead, once green assets are in place, the asset value will accrue to other conventional bonds as well, effectively rendering the firm "greener." Additionally, the green bond issuance establishes more credible commitment by issuers to mitigate and manage regulatory and transition risk (Christensen et al. [2021]) and to reporting, enforcement and monitoring of their environmental externalities (Lu [2021]). If the conventional bond market prices regulatory and transition risk, we predict that green bond issuance will have a direct positive pricing effect because the market perceives lower risk.[9] Green commitment through green bond issuance effectively reclassifies an issuer's conventional bonds as quasi-green bonds. Hence, we predict that green bond issuance increases demand for conventional bonds by investors for whom environmental performance is important, i.e., socially responsible investors (SRI's), and the positive demand shock reduces yield spreads.

To test this implication, we obtain bond ownership data from the Thomson Reuters eMaxx database. This data provides quarterly corporate bond holdings of both US and international bond

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[9] Green bond issuance may be subject to certification and external reviews on how well the green bond commitment align with the green bond principle proposed by the International Capital Market Association. After the issuance, the issuers have to provide periodic disclosure in accordance with international standards (Lu [2021]).

investors including mutual funds, pension funds and insurance companies. The bond holdings of mutual funds are obtained from SEC disclosures, the positions of insurance companies are collected from National Association of Insurance Commissioners (NAIC) disclosures, and pension fund holdings are taken and compiled from voluntary disclosures.[10] The eMaxx data reports bond holdings at both the institutional investor group level and at the fund level (Dass and Massa [2014]). A "fund" is a segregated pool of assets or portfolio that an institutional investor manages according to a specific mandate. The investor group bond holdings comprise the aggregate of all funds managed by institutional investor group. Since an institutional investor can potentially manage both ESG funds and funds with different (non-ESG) mandates (e.g., mandates targeting specific maturities, credit risks or industries), we conduct our analysis at the fund level. To identify green or ESG funds, we follow Baker et al. [2022] and scrutinize whether a fund's name contains key words associated with socially responsible investing.[11] Our empirical specification is

$$\frac{holdings_{i,j,k,t}}{amt\,out_{i,t}} = \alpha_1 \times PostGreen_{j,t} \times SRI_k + \alpha_2 \times PostGreen_{j,t} + \Phi_{i,j,t} + \mu_i + \rho_t + \xi_k + \epsilon_{i,j,k,t} \qquad (9)$$

where $holdings_{i,j,k,t}$ is the par value of bond *i* (of firm *j*) held by fund *k* at time *t*, $amt\,out_{i,t}$ is the amount outstanding of bond *i* at time *t*. The ratio of $\frac{holdings_{i,j,k,t}}{amt\,out_{i,t}}$ thus measures the proportion of available amount of bond *i* held by the fund *k* at time *t*. SRI_k is a dummy variable equal to 1 if fund *k* is classified as a socially responsible fund. $\Phi_{i,j,t}$ is a set of bond characteristics, e.g., amount outstanding and credit rating. In addition to bond fixed effects μ_i and time fixed effects ρ_t, the bond ownership

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[10] The eMaxx database has been used to study bondholder behavior in several recent studies, e.g., Bai, Massa, and Zhang [2022]; Bretscher et al. [2022]; Zhu [2021].

[11] The key words are: Calvert, Catholic, Church, Clean, Domini, Environ, ESG, Faith, Green, Impact, KLD, Parnassus, Social, SRI and Walden.

regression also includes fund fixed effects ξ_k. Similar to our earlier analysis, we also augment our specifications with interactions of fixed effects. If SRI demand for an issuers' conventional bonds increases after green bond issuance the coefficient α_1 on the interaction term *PostGreen x SRI* is expected to be positive.

Table 11 reports the summary statistics of the bond holding shares. It shows great variation in bond ownership across funds and bonds. The first quartile of bond holding shares is 0.01% and the third quartile rises to 0.27%. Table 12 presents the results of from estimating Equation (9). Column (1) displays the result from our baseline specification without controlling for bond characteristics, and shows that the SRI holdings of conventional bonds increase after green bond issuance. On average, a bond's ownership by a representative SRI rises by 0.07 percentage points. As there are 69 unique SRIs in the data, back-of-envelope calculations suggest that following the issuance of green bonds SRIs, in aggregate, increase their holdings of a conventional bond by 4.6% more relative to other funds. This translates into an average increase in the nominal investment of $73 million for a bond.[12] Column (2) further includes bond characteristics, and reports very similar results. Both point estimates are significant at the one percent level, confirming our expectation for the third channel that conventional bonds become more attractive to SRI investors once the issuance of green bonds.

In the remainder of the analysis in Table 12, we account for more confounding factors by gradually adding more saturated fixed effects. Column (3) includes bond-by-time fixed effects controlling for issuers' fundamentals that are likely to update quarterly, e.g., ESG ratings and financial leverage. Results are very similar result.[13] Column (4) instead includes fund-by-time fixed effects, and controls for time-varying unobservable characteristics of funds, e.g., fund inflows and outflows affecting the

[12] The average outstanding amount of bonds in our sample is $1.59 billion.
[13] Although Refinitiv updates its ESG ratings annually, some other ESG rating agencies update their ratings more frequently.

magnitude of total assets under management. The coefficient of interest increases to 0.09%, suggesting an even a greater impact of green bond issuance on SRI ownership. In Column (5), we include both interactions of fixed effects, and the result is similar to Column (4). A bond's ownership by a typical SRI increases by 0.1 percentage points, and the result is still significant at the one percent level. The magnitude of the coefficient estimate indicates that an SRI raises its holdings of a conventional bond by $1.6 million more than an average fund in the market. Finally, Column (6) uses the most saturated specification by including bond-by-fund fixed effects. Unlike previous specifications that exploit the fund and bond variations independently, the bond-by-fund fixed effects design indicates that the identifying variation stems from bond-fund pairs. Thus, it is worth noting that the fixed effects also control for the attributes specific to a bond-fund pair, e.g., whether or not a fund has invested in a bond before. Overall, the total number of fixed effects in Column (6) is 290,000.[14] This, of course, significantly increases the explanatory power of the model as evidenced by the adjusted R-squared statistic. However, our main finding still holds: more conventional bonds are acquired by SRIs after green bonds issuance, and the result is significant at the five percent level.[15]

7. Conclusion

In this paper we study the effects of green bond issuance on the yield spreads of other conventional bonds from the same issuers traded in the secondary market. A traditional view of new bond issuance suggests that new bond issuance (whether green or brown) will increase secondary market bond yields if higher leverage increases default risk and dilutes creditors' claim over assets. However, green bond issuance will lead to a reduction in secondary market bond yields if (i) regulatory and transition risk

[14] The inclusion of fund-by-time interactions generates approximately 140,000 fixed effects. The inclusion of bond-by-time interactions generates roughly 11,800 fixed effects. The interactions of fund-by-bond give rise to approximately 140,000 fixed effects.

[15] In Section A.3 of Online Appendix, we conduct a cross-sectional analysis on the change of bond ownership, and show that the increase in SRI ownership is more prominent for bond issues and issuers with weaker ESG performance.

associated with environmental externalities are priced; and (ii) green bond issuance is perceived by the market as enhancing the issuer's commitment to mitigating and managing environmental risks. We find that the issuance of green bonds reduces conventional bond yield spreads by 8 basis points in secondary markets, on average. The effect is long-lasting beyond two years, and is robust to different regression specifications and to alternative sample periods. In addition, in the cross-sectional analysis, we find that the positive pricing effect of green bond issuance on conventional bonds is substantially more pronounced for issuers with weaker ESG scores.

We consider and test three candidate channels that might explain the reduction in conventional bond yields after green bond issuance. Neither mispricing of green bonds, nor increases in credit quality and liquidity are able to account for the lower yield spreads of conventional bonds. Instead, we show that socially responsible investors increase their demand and hold more conventional bonds in their portfolios following the issuance of green bonds. This is consistent with green bond issuance being interpreted as a credible green commitment and suggests that increased demand from investors with a preference for environmental performance plays a significant role in the pricing of green commitment.

Our analysis suggests that the benefits to green bond issuers do not depend on there being a greenium. Green bond issuance is associated with a material reduction in the cost of public debt capital, suggesting that corporate commitment to green investment is beneficial to both firms as well the environment.

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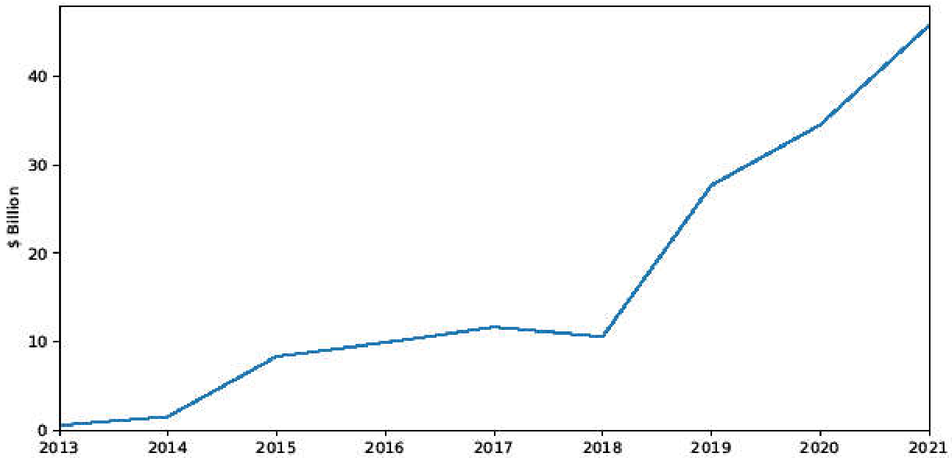

Figure 1: Aggregate Green Bond Issuance in the U.S., 2013-2021

Data source: Refinitiv Eikon

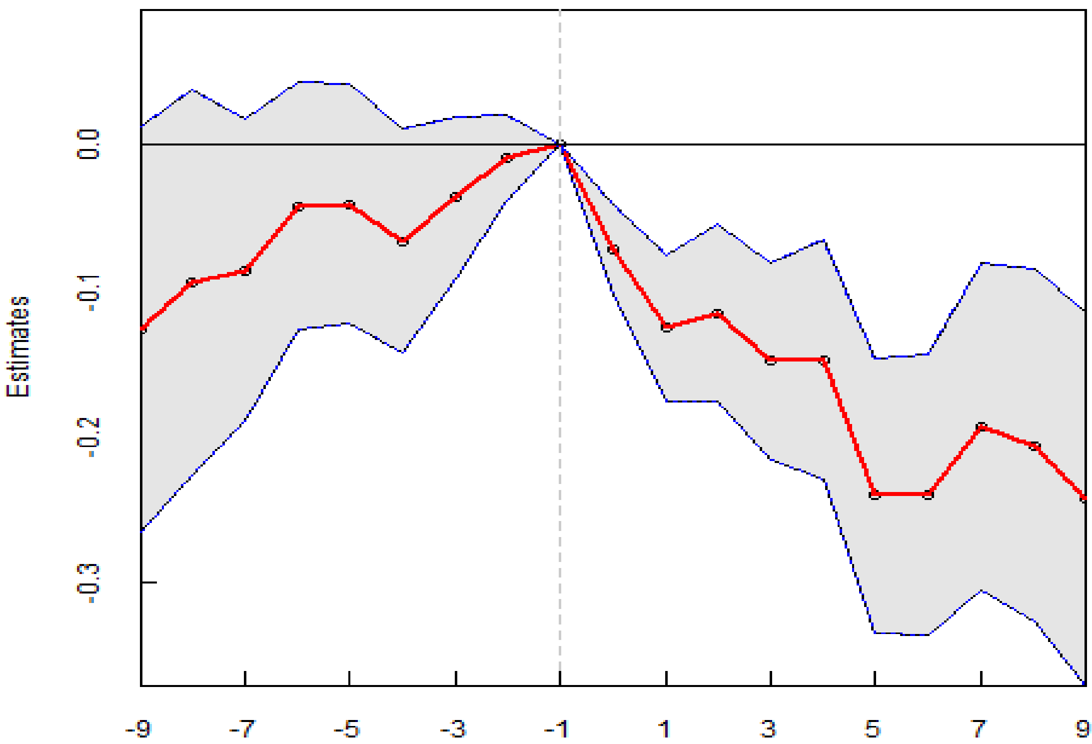

Figure 2: Corporate Bond Yield Dynamics Around Green Bond Issuance

This figure plots the coefficient estimates from regressions estimating the dynamic effects of green bond issuance on the yield spreads of other conventional bonds. The black dots (and the red line) are point estimates $\{\alpha_\tau\}_{\tau=-9,\ldots,9}$ from the regression

$$s_{i,j,t} = \sum_{\tau} \alpha_\tau \times PostGreen^{\tau}_{j,t} + \Phi_{i,j,t} + \Omega_{j,t} + \mu_i + \rho_t + \epsilon_{i,j,t}$$

The shaded area represents the 95 percent confidence intervals. The data are monthly trade volume weighted yield spreads from 2010 to 2021. α_{-1}, i.e., the quarter preceding the month of green bond issuance is normalized to zero and serves as a benchmark. Data 2 years after (before) the green bond issuance are capped into the same bin of 9 (-9). The specification includes bond, month, and bond-by-quarter fixed effects. Robust standard errors are clustered at the bond level.

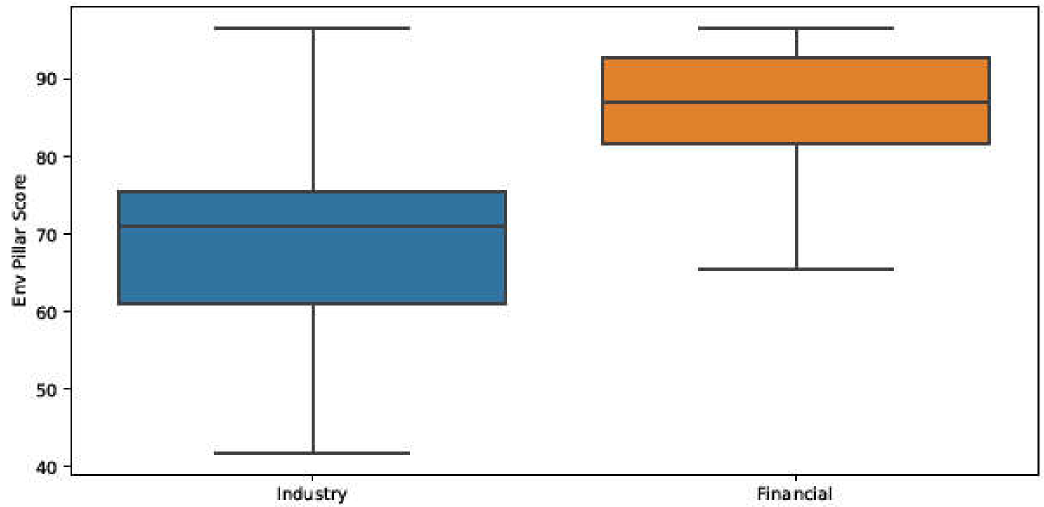

Figure 3: Distribution of Refinitiv Environmental Pillar Scores of Financial and Industrial Firms, 2010-2021

This figure shows the box-and-whisker plot of environment pillar scores between financial and industry companies. Data is from 2010 to 2021 and collected from Refinitiv Eikon. The box areas indicate the pillar scores between 25 percentiles and 75 percentiles.

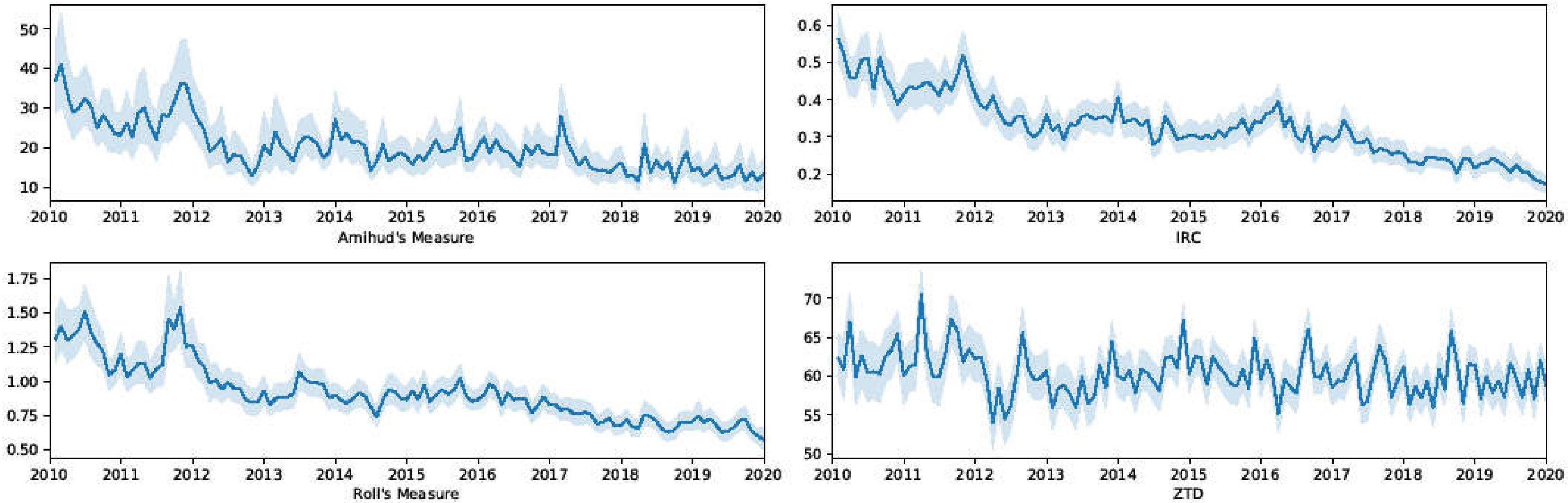

Figure 4: Distribution of Ahmihud, Roll, IRC and ZTD Bond Liquidity Measures, 2010-2020

This figure plots the four monthly measures of bond liquidity from 2010 to the end of 2019. See the main text for computation detail. The shaded areas are the 95 percent confidence interval of the monthly bond liquidities.

Table 1: Summary Statistics

Panel (A)

Panel (A) presents summary statistics of data used in the baseline empirical analysis. It shows several statistics of bond yield spreads (calculated from trade volume weighted yields and median yields, respectively), bond outstanding amount (in $billion), total par-value volume (in $billion), total assets (in $ billion), and debt ratio. Data are from January, 2010 to June, 2021. Bond yield spreads are measured as the difference between the bond yields and U.S. Treasury par yields of the same maturity during the same trading month. Debt is defined as the ratio of total debt (current liability plus long-term debt) to total assets. Monthly bond yields and trade quantities are from TRACE. Bond and issuer characteristics are from Mergent FISD and Compustat. Data are winsorized at the 1st and 99th percentiles to remove outliers.

Statistic	N	Mean	St. Dev.	Q1	Median	Q3
Yield Spreads (Trading Vol Weighted)	83,313	1.173	0.888	0.638	1.040	1.511
Yield Spreads (Median)	83,313	1.197	0.856	0.656	1.049	1.517
Amt Outstanding	83,307	0.849	0.898	0.300	0.500	1.000
Trading Volume	83,313	0.066	0.240	0.002	0.015	0.058
Assets	74,060	568.606	713.108	35.711	167.489	851.733
Debt	74,060	0.339	0.123	0.271	0.358	0.413

Table 1: Summary Statistics

Panel (B)

Panel (B) presents summary statistics of the subsample used in the robustness tests and in the analysis of credit risk and liquidity risk. In addition to the variables included in Panel (A), it also reports the statistics for CDS spreads (in percentage points) and bond liquidity measures. To be included in the subsample, 1) bond trades have to occur between January, 2010 and December, 2019; 2) the issuer offers the first green bond before 2020; 3) the conventional bond is at least traded once before the green bond issuance. Bond yield spreads are measured as the difference between the bond yields and U.S. Treasury par yields of the same maturity during the same trading month. Debt is defined as the ratio of total debt (current liability plus long-term debt) to total assets. Monthly bond yields and trade quantities are from TRACE. Bond and issuer characteristics are from Mergent FISD and Compustat. CDS spreads are from Markit. Bond liquidities are calculated following Dick-Nielsen, Feldhütter, and Lando [2012]. Data are winsorized at the 1st and 99th percentiles to remove outliers.

Statistic	N	Mean	St. Dev.	Q1	Median	Q3
Yield Spreads (Trading Vol Weighted)	38,624	1.171	0.892	0.652	1.038	1.490
Yield Spreads (Median)	38,624	1.191	0.868	0.668	1.044	1.492
Amt Outstanding	38,619	0.827	1.009	0.250	0.500	1.000
Trading Volume	38,624	0.068	0.279	0.001	0.012	0.054
Assets	36,238	477.501	581.803	39.054	230.461	807.698
Debt	36,238	0.375	0.111	0.340	0.392	0.434
CDS Spreads	14,512	1.004	0.618	0.567	0.869	1.265
Bond Liquidity: Amihud Measure	35,338	19.011	43.332	1.583	6.519	19.969
Bond Liquidity: IRC	33,576	0.311	0.333	0.089	0.196	0.418
Bond Liquidity: Roll's Measure	35,085	0.871	0.855	0.338	0.641	1.121
Bond Liquidity: ZTD	36,298	60.156	23.478	35.484	60	83.333

Table 2: The Effects of Green Bond Issuance on Conventional Bonds

This table shows coefficient estimates from regressing monthly bond yield spreads on PostGreen, the treatment dummy equals 1 if the trading month is after an issuer offers its first green bond. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. Ln(asset) is the natural logarithm of the issuer's total assets. Debt is the ratio of total debt to total assets. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads				
	(1)	(2)	(3)	(4)	(5)
Post Green	-0.234***	-0.078***	-0.072***	-0.077***	-0.069***
	(0.024)	(0.023)	(0.022)	(0.022)	(0.016)
Amt Outstanding			0.167***	0.146***	0.037
			(0.048)	(0.043)	(0.057)
Trading Volume			-0.253***	-0.248***	-0.548***
			(0.044)	(0.047)	(0.036)
Ln(Asset)				0.147*	
				(0.075)	
Debt				3.577***	
				(0.298)	
Bond FE	No	Yes	Yes	Yes	No
Month FE	No	Yes	Yes	Yes	Yes
Credit Ratings FE	No	No	Yes	Yes	Yes
ESG Ratings FE	No	No	No	Yes	No
Bond × Quarter FE	No	No	No	No	Yes
Observations	83,313	83,313	83,307	74,058	83,307
Adjusted R^2	0.015	0.640	0.645	0.657	0.893

Table 3: The Effects of Green Bond Issuance on Conventional Bonds: Robustness Tests

This table presents the results of several robustness tests for Table 2. Column (1) employs median daily bond yields within a month to calculate the bond yield spreads; Column (2) restricts bond trades to those before 2020; Column (3) and (4) focus on the subsample described in Panel (B) of Table 1. PostGreen is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. Ln(asset) is the natural logarithm of the issuer's total assets. Debt is the ratio of total debt to total assets. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads			
	(1)	(2)	(3)	(4)
Post Green	-0.057***	-0.053***	-0.153***	-0.047***
	(0.013)	(0.009)	(0.034)	(0.009)
Amt Outstanding	0.012	0.110**	0.105**	0.113***
	(0.035)	(0.045)	(0.048)	(0.040)
Trading Volume	0.006	-0.531***	-0.144***	-0.369***
	(0.005)	(0.038)	(0.045)	(0.046)
Bond FE	No	No	Yes	No
Month FE	Yes	Yes	Yes	Yes
Credit Ratings FE	Yes	Yes	Yes	Yes
Bond × Quarter FE	Yes	Yes	No	Yes
Remark	Median Bond Yields	Before 2020	Before 2020 Issued Before First Green Bond	Before 2020 Issued Before First Green Bond
Observations	83,307	67,915	38,619	38,619
Adjusted R^2	0.923	0.905	0.611	0.901

Table 4: The Distribution of Refinitiv ESG Scores

This table shows the summary statistics of the Refinitiv ESG Scores. The left five columns display the statistics of US firms rated by Refinitiv. The right five columns display the statistics of green bond issuers in the sample. There are 18436 firm-year observations from Refinitiv and 606 firm year observations from the green bond issuer sample.

	Universe					**Sample**				
	Mean	St. Dev.	Q1	Median	Q3	Mean	St. Dev.	Q1	Median	Q3
ESG Combined Score	37.151	17.426	24.00	34.305	47.990	52.797	17.986	39.208	51.764	68.343
Environmental Pillar Score	23.324	26.698	0.00	12.970	40.780	60.978	28.307	41.921	69.992	84.096
Emissions Score	24.205	30.528	0.00	8.070	44.940	60.842	31.880	40.836	71.090	86.499
Environmental Innovation Score	15.603	26.390	0.00	0.000	26.840	49.806	34.275	17.532	54.000	82.951
Resource Use Score	25.162	31.818	0.00	5.360	48.130	60.533	32.808	38.506	71.230	87.909
ESG Controversies Score	91.031	22.878	100.00	100.000	100.000	71.555	35.948	38.579	100.000	100.000

Table 5: Cross-sectional Analysis: Green Bond Issuance and ESG Scores

This table shows coefficient estimates from regressing monthly bond yield spreads on the dummy variable of Post Green and its interaction with ESG scores from Refinitiv. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Low score is defined as the issuer having a score below the median during a quarter. Industry is a dummy variable and equals 1 if the issuer is not a financial company. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads					
	(1)	(2)	(3)	(4)	(5)	(6)
Post Green	0.057***	-0.028	-0.002	-0.036*	-0.016	0.066***
	(0.018)	(0.020)	(0.018)	(0.020)	(0.020)	(0.018)
Post Green × Low ESGC	-0.262***					
	(0.027)					
Low ESGC	0.069***					
	(0.022)					
Post Green × Low Env Pillar		-0.154***				
		(0.033)				
Low Env Pillar		0.002				
		(0.020)				
Post Green × Low Emission Reduction			-0.145***			
			(0.027)			
Low Emission Reduction			0.035			
			(0.030)			
Post Green × Low Env Innovation				-0.089**		
				(0.035)		
Low Env Innovation				0.038		
				(0.024)		
Post Green × Low Resource Use					-0.121***	
					(0.028)	
Low Resource Use					-0.008	
					(0.019)	
Post Green× High Controversy						-0.253***
						(0.024)
High Controversy						0.046**
						(0.023)

Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Credit Ratings FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	83,307	83,307	83,307	83,307	83,307	83,307
Adjusted R^2	0.679	0.678	0.678	0.677	0.678	0.679

Table 6: The Effects of Second Green Bond Issuance

This table shows coefficient estimates from regressing monthly bond yield spreads on the dummy variable of Post Green and/or Post Second Green. Data are bond trades of which the issuers have issued a second green bond. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Post Second Green is an indicator variable and equals 1 if the trading month is after an issuer offers its second green bond. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads		
	(1)	(2)	(3)
Post Second Green	0.039*	0.016	0.020
	(0.022)	(0.023)	(0.022)
Post Green			-0.076***
			(0.023)
Amt Outstanding	0.014	-0.277	0.059
	(0.068)	(0.367)	(0.064)
Trading Volume	-0.597***	-0.731***	-0.548***
	(0.057)	(0.061)	(0.056)
Bond FE	Yes	No	No
Month FE	Yes	Yes	Yes
Credit Ratings FE	Yes	Yes	Yes
Bond × Quarter FE	No	Yes	Yes
Observations	11,398	11,398	30,664
Adjusted R^2	0.774	0.881	0.888

Table 7: The Effects of Green Bond Issuance on Credit Risk

This table shows coefficient estimates from regressing monthly CDS spreads on the dummy variable of Post Green. Data are monthly spreads of 3-year, 5-year and 10-year CDS contracts, respectively. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Robust standard errors are clustered at the issuer level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	CDS Spreads			
	(1)	(2)	(3)	(4)
Post Green	-0.308**	0.071*	-0.021	-0.020
	(0.112)	(0.038)	(0.022)	(0.022)
Issuer FE	Yes	No	No	No
Month FE	Yes	Yes	Yes	Yes
Maturity FE	Yes	Yes	Yes	No
Issuer × Year FE	No	Yes	No	No
Issuer × Quarter FE	No	No	Yes	Yes
Maturity × Quarter FE	No	No	No	Yes
Observations	14,512	14,512	14,512	14,512
Adjusted R^2	0.670	0.832	0.870	0.874

Table 8: Correlation Coefficients between Bond Liquidity Measures

This table reports the correlation coefficients between the four measures of bond liquidity. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Amihud Measure	IRC	Roll's Measure	ZTD
Amihud Measure	1			
IRC	0.477***	1		
Roll's Measure	0.384***	0.554***	1	
ZTD	0.131***	0.148***	0.297***	1

Table 9: The Effects of Green Bond Issuance on Bond Liquidity

This table shows coefficient estimates from regressing monthly bond liquidities on the dummy variable of Post Green. Data are monthly measures of bond liquidities from January, 2010 to December, 2019. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Illiquidity							
	Amihud Measure		IRC		Roll Measure		ZTD	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post Green	-6.249***	-5.063**	-0.062***	-0.024	-0.103***	0.015	-1.630***	0.283
	(1.419)	(2.509)	(0.012)	(0.016)	(0.022)	(0.033)	(0.536)	(0.531)
Amt Outstanding	-1.705	-2.738**	-0.030***	-0.016*	-0.072***	-0.042**	-4.644***	-7.724***
	(1.042)	(1.252)	(0.009)	(0.009)	(0.022)	(0.020)	(1.149)	(1.930)
Trading Volume	-1.310**	-3.431***	-0.002	-0.039***	-0.051*	-0.153***	3.999***	7.570***
	(0.580)	(0.514)	(0.007)	(0.007)	(0.030)	(0.015)	(0.674)	(0.810)
Bond FE	Yes	No	Yes	No	Yes	No	Yes	No
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Credit Ratings FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bond × Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	35,338	35,338	33,576	33,576	35,085	35,085	36,293	36,293
Adjusted R^2	0.236	0.449	0.359	0.547	0.430	0.617	0.870	0.918

Table 10: The Effects of Green Bond Issuance on Conventional Bonds: With Bond Liquidity

This table shows coefficient estimates from regressing monthly bond yield spreads on the dummy variable of Post Green and measures of bond liquidity. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post Green	-0.158***	-0.040***	-0.156***	-0.041***	-0.162***	-0.038***	-0.159***	-0.042***
	(0.033)	(0.009)	(0.033)	(0.009)	(0.034)	(0.008)	(0.034)	(0.009)
Amt Outstanding	0.102**	0.121***	0.106**	0.119***	0.108**	0.116***	0.110**	0.077**
	(0.046)	(0.043)	(0.044)	(0.044)	(0.046)	(0.042)	(0.049)	(0.030)
Trading Volume	-0.148***	-0.367***	-0.151***	-0.364***	-0.146***	-0.370***	-0.159***	-0.369***
	(0.045)	(0.046)	(0.045)	(0.046)	(0.044)	(0.046)	(0.047)	(0.045)
Amihud's Measure	0.001***	0.001***						
	(0.000)	(0.000)						
IRC			0.267***	0.044***				
			(0.026)	(0.009)				
Roll's Measure					0.081***	-0.014		
					(0.012)	(0.012)		
ZTD							0.002**	-0.000
							(0.001)	(0.000)
Bond FE	Yes	No	Yes	No	Yes	No	Yes	No
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Credit Ratings FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bond × Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	35,338	35,338	33,576	33,576	35,085	35,085	36,293	36,293
Adjusted R^2	0.650	0.918	0.663	0.920	0.635	0.910	0.611	0.904

Table 11: Summary Statistics: Bond Ownership

This table presents the summary statistics of bond ownership data. Holding share is the proportion (in percentage) of a bond's outstanding amount held by a fund, defined as $\frac{holdings_{i,j,k,t}}{amt\,out_{i,t}}$, where $holdings_{i,j,k,t}$ is the par value of bond i (of firm j) held by fund k at time t, and $amt\,out_{i,t}$ is the amount outstanding (in $billion) of bond i at time t. SRI is a dummy variable equal to 1 if the fund k is classified as a socially responsible fund. Maturity is the bond's remaining time to maturity in years. Data are bond ownership of eMaxx from January 2010 to December, 2019.

	N	Mean	St. Dev.	Q1	Median	Q3
Holding Share (%)	1,194,080	0.379	0.998	0.011	0.055	0.265
SRI	1,194,080	0.010	0.100	0.000	0.000	0.000
Amount Outstanding	1,194,080	1.594	1.591	0.500	1.000	2.250
Maturity	1,194,080	9.133	8.759	3.297	6.047	9.517

Table 12: Changes in Bond Ownership by SRI Investors

This table reports the coefficient estimates from

$$\frac{holdings_{i,j,k,t}}{amt\,out_{i,t}} = \alpha_1 \times PostGreen_{j,t} \times SRI_k + \alpha_2 \times PostGreen_{j,t} + \Phi_{i,j,t} + \mu_i + \rho_t + \xi_k + \epsilon_{i,j,k,t}$$

$holdings_{i,j,k,t}$ is the par value of bond *i* (of firm *j*) held by fund *k* at time *t*, $amt\,out_{i,t}$ is the amount outstanding of bond *i* at time *t*. The dependent variable is the proportion of a fund holding of a bond to its principal amount outstanding, in percentage points. SRI_k is a dummy variable equal to 1 if the fund *k* is labeled as socially responsible fund. $\Phi_{i,j,t}$ is a set of bond characteristics including amount outstanding and credit ratings. μ_i is bond fixed effects; ρ_t is time fixed effects. ξ_k is fund fixed effects. Data are bond ownership of eMaxx from January 2010 to December, 2019. Robust standard errors are clustered at the fund level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Share of the Amt Outstanding					
	(1)	(2)	(3)	(4)	(5)	(6)
Post Green× SRI	0.067***	0.068***	0.066***	0.093***	0.106***	0.023**
	(0.022)	(0.022)	(0.024)	(0.031)	(0.033)	(0.011)
Full Controls	No	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	No	Yes	No	No
Fund FE	Yes	Yes	Yes	No	No	No
Quarter FE	Yes	Yes	Yes	Yes	No	No
Fund × Quarter FE	No	No	No	Yes	Yes	Yes
Bond × Quarter FE	No	No	Yes	No	Yes	Yes
Bond × Fund FE	No	No	No	No	No	Yes
Observations	1,194,080	1,194,080	1,194,080	1,194,080	1,194,080	1,194,080
Adjusted R^2	0.509	0.509	0.512	0.474	0.477	0.941

Actions Speak Louder Than Words:

The Valuation of Green Commitment in the Corporate Bond Market

Peter Pope[1], Yang Wang[2], Hui Xu[3]

Online Appendix

A.1 Bonds from Non-green Issuers

As there might be unobservable characteristics driving a firm's decision of green bond issuance, our baseline analysis only focuses on green bond issuers. All conventional bonds eventually belong to the treatment group. As a robustness check, in this section we introduce conventional bonds issued by non-green firms into the control group.

Specifically, we first locate firms in Mergent FISD that operate in the same four-digit SIC industries as the green issuers, obtain their eligible conventional bonds satisfying the standard filtering rules as in Section 3, and collect the secondary market bond trades. As there are plenty of bond trades from non-green issuers, we follow Hainmueller [2012]'s approach of entropy balancing, and reweight the non-green issuers such that the green and non-green issuers have similar mean ESGC scores, environmental pillar scores, and credit ratings. Given the expanding

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coverage of Refinitiv's ESG ratings, we focus on the issuers' scores and credit ratings in 2019. By entropy balancing on ESG scores, we primarily restrict the issuers to those rated by Refintiv.

We repeat our baseline specification (4), and report the results with the augmented sample in Table A.1. Note the greater sample size due to the bond trades from the non-green issuers. However, the results are very similar to those in Table (2) and Table (3). When the bond-by-quarter fixed effects are not included, green bond issuance reduces the yield spreads by 14 bps, while the magnitude of the effect falls to 9 bps when bond-by-quarter fixed effects are included.

A.2 Cross-sectional Analysis: Green Bond Issuance and ESG Scores

The baseline cross-sectional analysis in Section 5 shows that the spillover effect of green bond issuance is more pronounced for ESG laggards. However, Table 5 only includes bond, month and credit rating fixed effects. This section shows that our results are robust to two alternative augmented specifications of fixed effects.

First, we augment our baseline specification (4) by including credit ratings-by-quarter fixed effects. The fixed effects account for time-varying demand for bonds of different credit rating segments. Table A.2 reports the regression results. Second, to be consistent with our analysis on bond yield spreads, Table A.3 reports the results after accounting for bond-by-quarter fixed effects. Both tables show that issuers with poor ESG performance metrics experience a larger drop in the yield spreads after green bond issuance, confirming the robustness of our results.

A.3 Cross-sectional Analysis: Changes in Bond Ownership and ESG Scores

Section 6.3 of the main text demonstrates that SRIs acquire more conventional bonds after the firms issue the green bonds. The effect is presumably more pronounced for issuers with poor ESG performance. To test the conjecture, we augment the specification of (9):

$$\frac{holdings_{i,j,k,t}}{amt\,out_{i,t}} = \alpha_1 \times PostGreen_{j,t} \times SRI_k \times Low\,ESGC\,Score_{j,t} + \alpha_2 \times PostGreen_{j,t} \times SRI_k + PostGreen_{j,t} \times Low\,ESGC\,Score_{j,t} + SRI_k \times Low\,ESGC\,Score_{j,t} + PostGreen_{j,t} + Low\,ESGC\,Score_{j,t} + \Phi_{i,j,t} + \mu_i + \rho_t + \xi_k + \epsilon_{i,j,k,t} \quad (1)$$

where $Low\,ESGC\,Score_{j,t}$ is defined the same as in Section 5, i.e., an indicator variable equal to 1 if firm j has an ESGC score lower than the median at time t. The coefficient of α_1 captures the change in holdings by SRI investors of ESG laggard bonds relative to ESG leader bonds after the green bond issuance.

Table A.4 presents the results of regression (1). In addition to the fixed effects in Table 12, similar to Table 5, we also include an interaction term between a dummy variable indicating industry companies and years, accounting for different trends between industry and financial companies.[4] Table A.4 indicates that the main effect documented in Table 12 stems from the increased ownership of ESG laggard bonds by SRIs, supporting our hypothesis. In fact, the magnitudes of the triple interaction terms in Table A.4 are on par with those of the main effects in Table 12.

Reference

HAINMUELLER, JENS. "Entropy Balancing for Causal Effects: A Multivariate Reweighting Method to Produce Balanced Samples in Observational Studies." *Political Analysis* 20 (2012): 25–46. https://doi.org/10.1093/pan/mpr025.

[4] The results remain similar if we drop the industry-by-year fixed effects.

Table A.1: The Effects of Green Bond Issuance on Conventional Bonds

This table shows coefficient estimates from regressing monthly bond yield spreads on the dummy variable of Post Green. Data are bond trades of green and non-green issuers from 2010 to 2021. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads	
	(1)	(2)
Post_Green	-0.143***	-0.089***
	(0.024)	(0.013)
Amt Outstanding	0.163***	0.060
	(0.046)	(0.048)
Trading Volume	-0.238***	-0.548***
	(0.041)	(0.032)
Bond FE	Yes	No
Month FE	Yes	Yes
Credit Ratings FE	Yes	Yes
Bond×Quarter FE	No	Yes
Observations	265,406	265,406
Adjusted R^2	0.652	0.904

Table A.2: Green Bond Issuance and ESG Scores (w/ credit ratings-by-quarter FEs)

This table shows coefficient estimates from regressing monthly bond yield spreads on the dummy variable of Post Green and its interaction with ESG scores from Refinitiv. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Low score is defined as the issuer having a score below the median during a quarter. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. All specifications include credit ratings-by-quarter fixed effects. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads					
	(1)	(2)	(3)	(4)	(5)	(6)
Post_Green	0.008	-0.064***	-0.029*	-0.077***	-0.050**	0.023
	(0.018)	(0.020)	(0.018)	(0.020)	(0.020)	(0.018)
Post_Green×Low ESGC Score	-0.190***					
	(0.028)					
Low ESGC Score	0.028					
	(0.021)					
Post_Green×Low Env Pillar Score		-0.060*				
		(0.036)				
Low Env Pillar Score		-0.001				
		(0.019)				
Post_Green×Low Emission Reduction Score			-0.142***			
			(0.026)			
Low Emission Reduction Score			0.044			
			(0.028)			
Post_Green×Low Env Innovation Score				0.011		
				(0.039)		
Low Env Innovation Score				-0.037		
				(0.025)		
Post_Green×Low Resource Use Score					-0.080***	
					(0.029)	
Low Resource Use Score					-0.010	
					(0.020)	
Post_Green×High Controversy Score						-0.205***
						(0.025)
High Controversy Score						0.038*
						(0.021)
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Credit Ratings×Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	83,307	83,307	83,307	83,307	83,307	83,307
Adjusted R^2	0.711	0.710	0.711	0.710	0.710	0.712

Table A.3: Green Bond Issuance and ESG Scores (w/ bond-by-quarter FEs)

This table shows coefficient estimates from regressing monthly bond yield spreads on the dummy variable of Post Green and its interaction with ESG scores from Refinitiv. Post Green is the treatment dummy and equals 1 if the trading month is after an issuer offers its first green bond. Low score is defined as the issuer having a score below the median during a quarter. Amt Outstanding is a bond's par-value amount outstanding. Trading volume is a bond's total par-value trading volume during a month. All specifications include bond-by-quarter fixed effects. Robust standard errors are clustered at the bond level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Bond Yield Spreads					
	(1)	(2)	(3)	(4)	(5)	(6)
Post_Green	-0.033	-0.051***	-0.052***	-0.051***	-0.050***	-0.061
	(0.023)	(0.019)	(0.019)	(0.018)	(0.017)	(0.049)
Post_Green×Low ESGC Score	-0.087***					
	(0.030)					
Post_Green×Low Env Pillar Score		-0.085**				
		(0.035)				
Post_Green×Low Emission Reduction Score			-0.077**			
			(0.035)			
Post_Green×Low Env Innovation Score				-0.088**		
				(0.036)		
Post_Green×Low Resource Use Score					-0.125**	
					(0.051)	
Post_Green×High Controversy Score						-0.057
						(0.053)
Bond FE	No	No	No	No	No	No
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond × Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Credit Ratings FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	83,307	83,307	83,307	83,307	83,307	83,307
Adjusted R^2	0.893	0.893	0.893	0.893	0.893	0.894

Table A.4: Changes in Bond Ownership and ESG Scores

This table reports the coefficient estimates from

$$\frac{holdings_{i,j,k,t}}{amt\,out_{i,t}} = \alpha_1 \times PostGreen_{j,t} \times SRI_k \times Low\,ESGC\,Score_{j,t} + \alpha_2 \times PostGreen_{j,t} \times SRI_k + PostGreen_{j,t} \times Low\,ESGC\,Score_{j,t} + SRI_k \times Low\,ESGC\,Score_{j,t} + PostGreen_{j,t} + Low\,ESGC\,Score_{j,t} + \Phi_{i,j,t} + \mu_i + \rho_t + \xi_k + \epsilon_{i,j,k,t}$$

$holdings_{i,j,k,t}$ is the par value of bond *i* (of firm *j*) held by fund *k* at time *t*, $amt\,out_{i,t}$ is the amount outstanding of bond *i* at time *t*. The dependent variable is the proportion of a fund holding of a bond to its principal amount outstanding, in percentage points. SRI_k is a dummy variable equal to 1 if the fund *k* is labeled as socially responsible fund. $Low\,ESGC\,Score_{j,t}$ is an indicator variable equal to 1 if firm *j* has a ESGC score lower than the median at time *t*. $\Phi_{i,j,t}$ is a set of bond characteristics including amount outstanding and credit ratings. μ_i is bond fixed effects; ρ_t is time fixed effects. ξ_k is fund fixed effects. Data are bond ownership of eMaxx from January 2010 to December, 2019. Robust standard errors are clustered at the fund level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	Share of the Amt Outstanding					
	(1)	(2)	(3)	(4)	(5)	(6)
Post_Green× SRI ×Low ESGC Score	0.066**	0.065**	0.105***	0.086***	0.132***	0.066*
	(0.030)	(0.029)	(0.035)	(0.033)	(0.039)	(0.037)
Post_Green× SRI	-0.049	-0.046	-0.079**	-0.032	-0.046	-0.039
	(0.030)	(0.029)	(0.034)	(0.032)	(0.032)	(0.029)
Full Controls	No	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	No	Yes	No	No
Fund FE	Yes	Yes	Yes	No	No	No
Quarter FE	Yes	Yes	Yes	Yes	No	No
Industry ×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Fund × Quarter FE	No	No	No	Yes	Yes	Yes
Bond × Quarter FE	No	No	Yes	No	Yes	Yes
Bond × Fund FE	No	No	No	No	No	Yes
Observations	785,869	785,869	785,869	785,869	785,869	785,869
Adjusted R^2	0.481	0.481	0.492	0.443	0.455	0.887